Environmental Impact Assessment Report

Killoshulan Windfarm, Co. Kilkenny

Chapter 8 – Land, Soils and Geology

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GLOSSARY OF TERMS AND ACRONYMS

Glossary of Terms and Acronyms used in this chapter are shown in the Table below.

Construction Phase	
Term	**Definition**
Aquifer	A geological formation capable of storing and transmitting groundwater in sufficient quantities to support water supplies or groundwater-dependent ecosystems.
Bedrock	Solid geological material underlying the subsoil and superficial deposits.
Borrow Pit	A pit resulting from the excavation of material used in construction of the Proposed Wind Farm
Drainage Network	Natural and artificial drains, ditches and watercourses that convey surface water.
EPA	Environmental Protection Agency
Environmental Impact Assessment Report (EIAR)	The report prepared to identify, describe and assess the likely significant environmental effects of a proposed development.
Factor of Safety (FoS)	Ratio of resisting forces to driving forces used to assess slope or peat stability. Values greater than 1.0 indicate stability.
Geological Heritage Site	A site recognised for its geological importance at county or national level.
GSI	Geological Survey of Ireland
Ground Investigation	Field investigations including soil probing, trial pits, boreholes, geophysical surveys and laboratory testing undertaken to characterise ground conditions.
Groundwater	Water occurring beneath the ground surface within soil, subsoil or rock.
Hydrogeology	The study of groundwater occurrence, movement and interaction with geological materials.
Karst	A landscape formed by dissolution of limestone characterised by features such as swallow holes, sinkholes, caves and underground drainage.
Land Take	Permanent or temporary occupation of land by the proposed development.
Made Ground	Artificially placed material resulting from previous construction or industrial activities.
mbgl	Metres below ground level

Mineral Resource	Naturally occurring rock or mineral deposit with existing or potential economic value.
Mitigation Measures	Measures incorporated into the project to avoid, reduce or offset adverse environmental effects.
Natural Resources	Naturally occurring environmental resources including land, soils, geology and minerals.
Permeability	The ability of soil or rock to transmit water.
Residual Effect	The environmental effect remaining after implementation of mitigation measures.
Sensitivity	The importance or vulnerability of an environmental receptor to change.
Significance	The importance of an environmental effect after considering receptor sensitivity and magnitude of impact.
Subsoil	Unconsolidated geological material between the topsoil and bedrock.
Topsoil	The uppermost soil layer containing organic matter and supporting vegetation growth.
Trial Pit	A shallow excavation undertaken to inspect and sample soils and subsoils.

8. LAND SOILS AND GEOLOGY

8.1 Introduction

8.1.1 Background and Objectives

Hydro-Environmental Services (HES) was engaged by MKO to carry out an assessment of the potential likely and significant effects (if any) of the Killoshulan Wind Farm (Proposed Project) at Killoshulan and adjacent townlands near Freshford, Co. Kilkenny, on the Land, Soils and Geology aspects of the receiving environment.

The Proposed Project (Proposed Wind Farm and Proposed Grid Connection Route) is described in full in Chapter 4 of this EIAR.

Where the 'Proposed Wind Farm' is referred to, this refers to the 10 no. turbines and associated foundations and hardstanding areas, including entrances and access roads, underground cabling, permanent meteorological mast, temporary construction compounds, turbine delivery accommodation areas, spoil management areas, borrow pit, tree felling, site drainage, operational stage signage, battery energy storage system (BESS), biodiversity enhancement areas and all ancillary works and apparatus.

The "Proposed Grid Connection" relates to the on-site Proposed 110kV Substation, all ancillary works and 12.6km Proposed 110kV Underground Cabling connecting to the existing Ballyragget 110kV Substation, Co. Kilkenny, and all ancillary works and apparatus.

Where the 'Site' is referred to, this relates to the primary study area for the EIAR, the EIAR Site Boundary encompasses both the Proposed Wind Farm and Proposed Grid Connection. Where the 'Proposed Wind Farm site' is referred to, this relates the EIAR Site Boundary without the Proposed 110kV Underground Cabling.

This report provides a baseline assessment of the environmental setting of the Proposed Project, as described in Chapter 4, in terms of Land, Soils and Geology and discusses the potential likely and significant effects (if any) that the construction, operation and decommissioning of the Proposed Project will have. Where required, appropriate mitigation measures to avoid any identified significant effects to Land, Soils and Geology (i.e. natural resources) are recommended and the residual effects of the Proposed Project post-mitigation are assessed.

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 include 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 David Broderick.

Michael Gill (P. Geo., B.A.I., MSc, Dip. Geol., MIEI) is an Environmental Engineer/Hydrologist with over 24 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms in Ireland. He has also managed EIAR assessments for infrastructure projects and private residential and commercial developments. In

addition, he has substantial experience in wastewater engineering and site suitability assessments, contaminated land investigation and assessment, wetland hydrology/hydrogeology, water resource assessments, surface water drainage design and SUDs design, and surface water/groundwater interactions. For example, Michael has worked on the EIS/EIARs for Seven Hills Wind Farm, Garrane Wind Farm, and Ballydermot Wind Farm, and over 100 other wind farm related projects across the country.

David Broderick (P. Geo., BSc, H. Dip Env Eng, MSc) is a Hydrogeologist with over 19 years' experience in both the public and private sectors. Having spent two years working in the Geological Survey of Ireland working mainly on groundwater and source protection studies David moved into the private sector. David has a strong background in groundwater resource assessment and hydrogeological/hydrological investigations in relation to developments such as quarries and wind farms. David has completed numerous geology and water sections for input into EIARs for a range of commercial developments. David has worked on the EIS/EIARs for Clonberne Wind Farm, Cooloo Wind Farm, White Hill Wind Farm and Ballyouskill Wind Farm, and over 60 other wind farm related projects across the country.

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. Regard has also been taken of the requirements of the following legislation:

- Planning and Development Act, 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, including Circular Letter PL 1/2017: Implementation of Directive 2014/52/EU on the effects of certain public and private projects on the environment (EIA Directive);
- S.I. No. 296/2018 European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2018;
- The Heritage Act 1995, as amended; and,
- European Communities (Environmental Impact Assessment) Regulations 1989 to 2006.

8.1.4 Relevant Guidance

The Land, Soils and Geology chapter of this EIAR was prepared in accordance with, where relevant, the guidance contained in the following documents:

- 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 Assessment Methodology

8.2.1 Desk Study

A desk study of the Proposed Project site ('Site') and land, soils and geology Study Area (refer to Section 8.2.6 for description) was completed in advance of undertaking the walkover survey, field-based mapping and site investigations. This involved collecting all relevant geological data for the Site and receiving environment. This included 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, Geological Survey of Ireland;
- Geological Survey of Ireland (2003) – Groundwater Body Initial Characterization Reports;
- General Soil Map of Ireland 2nd edition (**www.epa.ie**); and,
- Aerial Photography, OSI 1:5000 and 6 inch base mapping.

8.2.2 Field Mapping and Site Investigations

A walkover survey, including geological mapping, field-based karst mapping and investigations of the Site, were undertaken by David Broderick of HES (refer to Section 8.1.2 above for qualifications and experience) on 3rd August 2022, 17th January 2023 and 20th & 21st January, 4th June, 23rd September and 2nd October 2026.

Five phases of site investigation were carried out at the Proposed Wind Farm site since 2022 as described below:

- Phase 1 investigations comprised of 13 no. trial pits carried out by Gavin & Doherty Geosolutions (GDG) between 15th and 17th November 2022 (refer to **Appendix 8-1** for the GDG logs).
- Phase 2 investigations, consisting of monitoring well drilling at 2 no. locations (MW1 and MW2), was undertaken on 20th and 21st January 2026, under the supervision of Hydro-Environmental Services (HES). (refer to **Appendix 8-4** for the well logs).
- Phase 3 investigations, consisting of rotary core drilling (10 no. locations BH1, BH2, BH3, BH4, BH4A, BH5, BH5B, BH6, BH7 and BH8), was undertaken in May 2026 by Ground Investigations Ireland Ltd (GII). During April 2026 geophysical surveys were carried out by Apex Geophysics Limited (Apex). Refer to **Appendix 8-2** for the GII and Apex reports.
- Phase 4 investigations, consisting of additional rotary core drilling (3 no. locations BH4-T4-NW, BH4-ALT-T4 and BH5-ALT-T5) and geophysical surveying (1 no. location) was undertaken in July 2026 by GII and Apex respectively (**Appendix 8-2**).
- Phase 5: follow-up confirmatory drilling on 2nd October 2026 where 5 no. investigation holes were drilled by downhole hammer under the supervision of HES and FT. The boreholes were carried out at locations recommended by the Apex geophysical survey (T01-PBH1, T02-PBH1 and T02-PBH2) and micro-siting purposes (BH2A & BH2B). Refer to **Appendix 8-4** for the drilling logs.

The following assessment/investigation reports were prepared by Fehily Timoney and Company (FT) as part of the EIAR.

- Ground Investigation Report (**Appendix 8-2**), (FT, 2026a); and,
- Karst Assessment Report (**Appendix 8-3**), (FT, 2026b.)

The objectives of the intrusive site investigations and geophysical surveys (described further below) included mapping the distribution and depth of mineral subsoils at the Proposed Wind Farm site along

with assessing the mineral subsoil / bedrock conditions at key Proposed Project locations (i.e. proposed turbines, temporary construction compound, existing and proposed access roads, spoil repository area, grid cable, borrow pit and substation/BESS). This data was used to inform the impact assessment and final layout design.

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

- Walkover surveys and geological mapping of the Site area were undertaken to assess general ground conditions;
- Trial pitting (13 no.) by GDG and gouge cores (10 no.) by HES to investigate soil and mineral subsoil lithology as well as depth to bedrock;
- Field based karst feature mapping by FT and follow-up surveys by HES;
- Investigation drilling (7 no. boreholes and 13 no. rotary coreholes) to determine the full geological profile of the Site (i.e. soil, mineral subsoil and bedrock profile) and groundwater conditions;
- 2D Resistivity (ERT) Survey and Seismic Survey at each of the 10 no. turbine locations by Apex;
- Microgravity geophysical survey (1 no. location) by Apex; and,
- Subsoil analysis (9 no. Atterberg limit tests, 10 no. moisture content tests and 11 no. particle size distribution tests).

8.2.3 Scope and Consultation

The scope for this chapter of the EIAR has also been informed by consultation with statutory consultees, bodies with environmental responsibility and other interested parties. This consultation process and the list of Consultees is outlined in Section 2.7 of this EIAR.

No matters or concerns were raised by Consultees with respect to the land, soil and geology environment. The response from the GSI and HSE was informative in nature and is summarised in **Table 8-1** below.

Table 8-1: Summary Scoping Responses.

Consultee	Matters Raised - Description	Addressed in Sections
Geological Survey of Ireland (GSI)	*"With reference to your email received on the 13 May 2026, concerning the Updated EIAR Scoping Report for Killoshulan Wind Farm, Co Kilkenny, we recommend using our various data sets when conducting the EIAR, SEA, planning and scoping processes for developments, plans and policies. For more detailed information on how to access this data please access 'Data and Maps' Data & Maps (gsi.ie) on our 'Geoscience for planning' webpage. Use of our data or maps should be attributed correctly (please refer to each individual dataset's metadata for correct attribution)".*	Used throughout Section 8.3 of this Chapter
Health Service Executive (HSE)	*"The EIAR should include a map and a description of the proposed location of each of the proposed wind turbines. Details of the foundations for the wind turbine including depth, quantity and material to be used should be included in the EIAR".*	Sections 8.3 and 8.4

8.2.4 Impact Assessment Methodology

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

The impact assessment presented in Section 8.5 is based on the assessment of the magnitude of the predicted impact on the geological attributes as detailed in **Table 8-3.**

Table 8-4 below then presents a matrix of significance versus magnitude (NRA, 2008) which allows for the determination of the resulting significance of effects.

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

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

Importance	Criteria	Typical Example
	moderate on a local scale.	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.

Table 8-3: Criteria for Rating Impact Significance – Estimation of Magnitude of Impact on Geology attributes (Source: NRA, 2008).

Magnitude of Effect	Criteria	Typical Example
Large Adverse	Results in loss of attribute	Loss of high proportion of future quarry or pit reserves Irreversible loss of high proportion of local high fertility soils Removal of entirety of geological heritage feature Requirement to excavate / remediate entire waste site Requirement to excavate and replace high proportion of peat, organic soils and/or soft mineral soils beneath alignment
Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute	Loss of moderate proportion of future quarry or pit reserves Removal of part of geological heritage feature Irreversible loss of moderate proportion of local high fertility soils Requirement to excavate / remediate significant proportion of waste site Requirement to excavate and replace moderate proportion of peat, organic soils and/or soft mineral soils beneath alignment
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute	Loss of small proportion of future quarry or pit reserves Removal of small part of geological heritage feature Irreversible loss of small proportion of local high fertility soils and/or high proportion of local low fertility soils Requirement to excavate / remediate small proportion of waste site

Magnitude of Effect	Criteria	Typical Example
		Requirement to excavate and replace small proportion of peat, organic soils and/or soft mineral soils beneath alignment
Negligible	Results in an impact on attribute but of insufficient magnitude to affect either use or integrity	No measurable changes in attributes
Minor Beneficial	Results in minor improvement of attribute quality	Minor enhancement of geological heritage feature
Moderate Beneficial	Results in moderate improvement of attribute quality	Moderate enhancement of geological heritage feature
Major Beneficial	Results in major improvement of attribute quality	Major enhancement of geological heritage feature

Table 8-4: Rating of Significant Environmental Impacts in an EIS (EIAR) (Source: NRA, 2008).

Importance of Attribute	Magnitude of Impact			
	Negligible	Small Adverse	Moderate Adverse	Large Adverse
Extremely High	Imperceptible	Significant	Profound	Profound
Very High	Imperceptible	Significant / Moderate	Profound / Significant	Profound
High	Imperceptible	Moderate / Slight	Significant / Moderate	Profound / /Significant
Medium	Imperceptible	Slight	Moderate	Significant
Low	Imperceptible	Imperceptible	Slight	Slight / Moderate

Following on, EPA 2022 Guidelines 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 identification and assessment of impacts and is presented in Section 8.5.

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 affected), context (is the effect unique or being increasingly experienced), probability (likely or unlikely), duration (momentary to permanent), frequency and reversibility.

The descriptors used in this chapter are those set out in the EPA 2022 Guidelines glossary of effects as shown in Chapter 1 of this EIAR.

8.2.5 Limitations and Difficulties Encountered

No limitations or difficulties were encountered during the preparation of this chapter. There are substantial desktop records detailing the characteristics of the Site. The site investigations, which included a combination of intrusive (i.e. drilling and trial pits) and non-intrusive methods (geophysical surveys), as well as systematic karst field-based surveys were comprehensive, thus allowing a thorough geological and geotechnical baseline assessment of the Site.

8.2.6 Study Area

The Proposed Project study area with regard Land, Soils and Geology is within a minimum 2km distance the EIAR Site Boundary as per IGI (2013) guidance. However, only direct effects within the EIAR Site Boundary are expected with regard the Proposed Project.

8.3 Existing Environment

8.3.1 Site Description and Topography

The Proposed Wind Farm site is located approximately 4km west of the village of Freshford and 3.7km northeast of the village of Urlingford, Co. Kilkenny.

The Proposed Wind Farm site, which is 573 ha (hectares) in area, comprises predominately agricultural grassland on the southern half, while the northern half is predominately coniferous forestry with some grassland on the northeastern portion. Five proposed turbines are located on grassland (T1 to T4 and T9) while five are in forestry (T5 to T8 and T10).

The topography of the Proposed Wind Farm site is hilly with a number of separate high points/peaks ranging in elevations from approximately 300 to 316m OD (metres above Ordnance Datum). The summit ridge of Spa Hill (310m OD) defines the northwestern boundary of the Proposed Wind Farm site. Clomantagh Hill (349m OD) is located to the southwest of the Proposed Wind Farm site.

The surrounding wider landscape is generally flat and low-lying (<150m OD). The Nuenna River valley is located to the southeast of the Proposed Wind Farm site, where the ground elevation along the channel of the river ranges from approximately 100 to 120m OD.

The southern half of the Proposed Wind Farm site slopes steadily in an easterly/southeasterly towards the Nuenna River. The ground elevation at the Proposed Wind Farm site entrance on the R693 at the southeast of the Proposed Wind Farm site is at approximately 120m OD. The northern half of the Proposed Wind Farm site slopes in more moderate manner in an easterly/ northeasterly direction from the summit of Spa Hill (310m OD) at the northwestern Site boundary down to an elevation of approximately 220m OD at the on-site 110kV Substation and BESS location, on the northeast of the Proposed Wind Farm site.

The Proposed 110kV Underground Cabling, which measures approximately 12.6km in length, will connect into the existing Ballyragget 110kV Substation, located approximately 10km to the northeast of the Proposed Wind Farm site ('as the crow flies'). The Proposed 110kV Substation and BESS is located on improved grassland on the northeast of the Proposed Wind Farm site at an elevation of 220m OD.

Approximately 772m of the Proposed 110kV Underground Cabling route is proposed within National Roads (N77), 9.6km proposed within Local Roads, 653m proposed within the Proposed Wind Farm site

internal road network and approximately 1.5km proposed within agricultural lands in Frankford or Ballykieran, and Moatpark, Co. Kilkenny.

In the townland of Ballyconra, the Proposed 110kV Underground Cabling route will leave the N77 public road and travel east through agricultural land for 60m before passing beneath the River Nore via a Horizontal Directional Drilling (HDD) mechanism.

Turbine Delivery Route (TDR) temporary accommodation works are required at 4 no. locations along the R693 to the south of the Proposed Wind Farm site.

8.3.2 Land and Land Use

Based on the Corine (2024) landcover and landuse datasets, the Proposed Wind Farm site is mapped mainly as Agricultural Areas (Pastures) and Coniferous forests (Forest and semi-natural areas).

The Proposed 110kV Underground Cabling and TDR works will be predominately located within the carriageway of the local/regional/national road, with off-road section in Agricultural Areas.

8.3.3 Soils and Subsoils

8.3.3.1 GSI Mapping

Based on the GSI/Teagasc soils mapping (www.gsi.ie), the southern portion of the Proposed Wind Farm site is overlain by shallow well drained mineral soil (BminSW), while the northeastern portion is mapped as poorly drained mineral soil (AminPD) and the northwestern portion mapped as shallow well drained mineral (AminSW).

The GSI subsoils mapping (www.gsi.ie) shows subsoils are thin or absent on the southern portion of the Proposed Wind Farm where the infrastructure is proposed, where karstified bedrock subcrop or outcrop is mainly mapped.

The northeastern portion of the Proposed Wind Farm site is mapped mainly as Till derived from Namurian sandstones and shales (glacial tills), with bedrock subcrop or outcrop [non karstified] mapped on the northwest of the Proposed Wind Farm site at Spa Hill.

According to GSI subsoils mapping, proposed turbine locations T1 to T4 are located on karstified bedrock subcrop or outcrop, proposed turbine T5 to T7 are located on bedrock subcrop or outcrop [non karstified], while turbines T8 to T10 are located on Namurian glacial tills (shales and sandstones). The proposed borrow pit location within the northern portion of the Proposed Wind Farm site is mapped as bedrock subcrop or outcrop [non karstified].

With regard the Proposed 110kV Underground Cabling, the Proposed 110kV Substation and BESS at the Proposed Wind Farm site is located in an area mapped as being underlain by Namurian glacial tills (shales and sandstones) with some localised alluvium.

The Proposed 110kV Underground Cabling route between the proposed 110kV Substation and the existing Ballyragget 110kV Substation, has variable subsoils mapped which comprise mainly Namurian tills with limestone tills and limestone gravels (fluvial deposits) within the River Nore valley near Ballyragget. TDR accommodation works along the R693 to the south of the Proposed Wind Farm site are mapped on limestone tills. The GSI subsoil mapping is shown as **Figure 8-1** below.

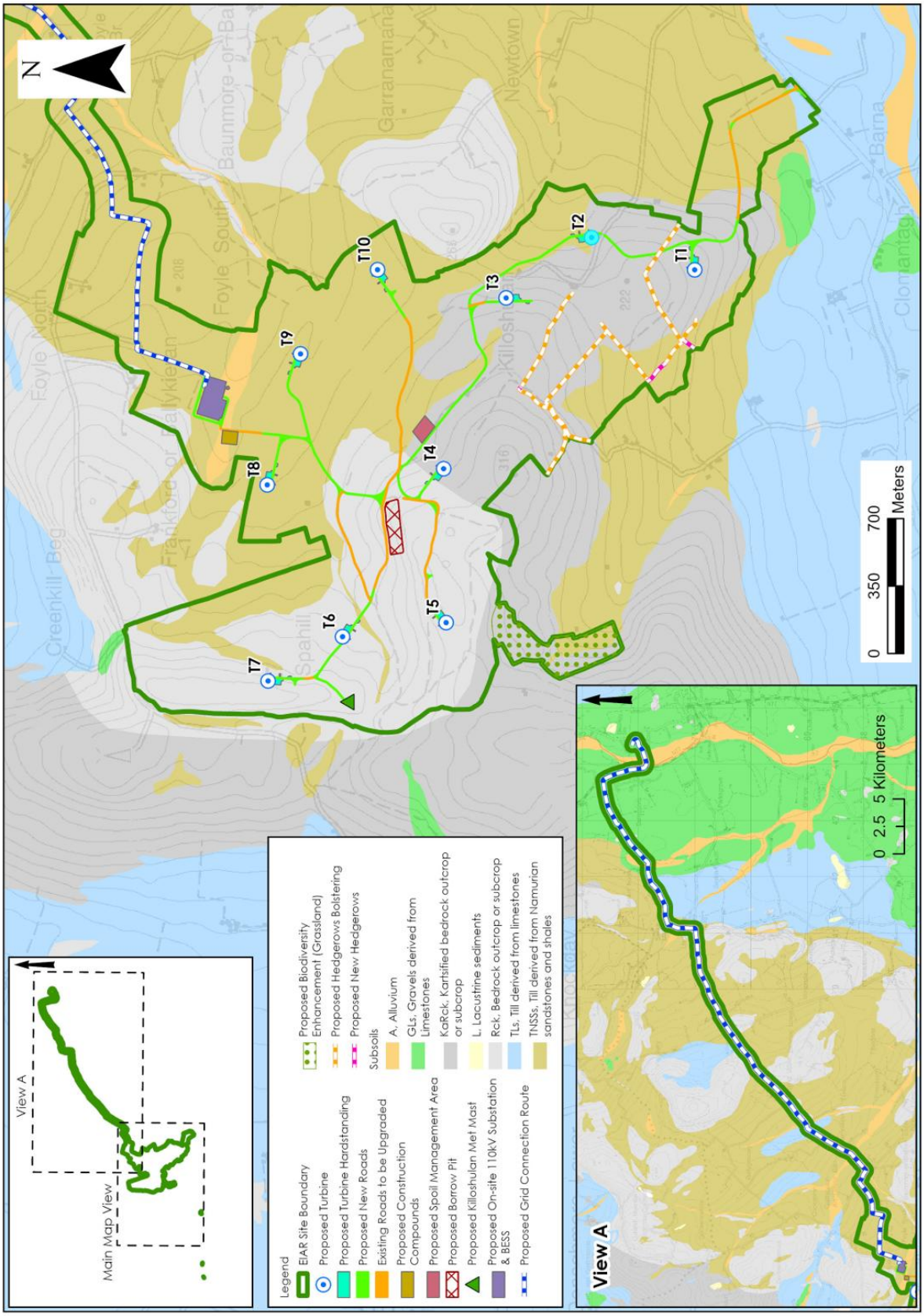


Figure 8-1: GSI Subsoil Mapping

8.3.3.2 Trial Pits

During Phase 1 site investigations in 2022, a total of 13 no. trial pits were carried out by GDG between 15th and 17th November 2022. All trial pits encountered bedrock at depths ranging from 0.5m to 2m below ground level (mbgl), with an average of 1.4m. Refer to **Figure 8-2** (Site Investigation Map) for the trial pit locations.

The dominant subsoil encountered was slightly sandy, slightly gravelly CLAY along with occasional GRAVEL and SAND dominated subsoils.

Due to Proposed Wind farm layout variations since 2022, many of the trial pits are not located close to the Proposed Project layout. The following sections (Sections 8.3.3.3 and 8.3.3.4) are more relevant and accurate with regard overburden conditions and depth to bedrock at proposed infrastructure locations.

8.3.3.3 Investigation Drilling (Overburden)

During the Phase 3 - 5 investigations, targeted drilling by means of rotary core (RC) and downhole hammer (DH) was carried at proposed turbine locations T1 to T4, T9 and the proposed borrow pit. The overburden conditions at these locations are summarised **Table 8-5** below which also provides the drilling method at each location. Refer to **Figure 8-2** for borehole locations.

Please note, Proposed Turbine locations T1 to T4 were targeted for investigation drilling as they are mapped by the GSI to be underlain by pure limestone which has evidence of karstification at the Proposed Wind Farm site. Refer to **Section 8.3.4** below for bedrock geology mapping and details of the bedrock investigations.

Furthermore, drilling at Proposed Turbine T9 was carried out to confirm the presence of non-calcareous bedrock (siltstone/mudstone) which is mapped across the north of Proposed Wind Farm site. Drilling at the proposed borrow pit was carried out to confirm bedrock type and prove its potential as a source of on-site rock.

Approximately 1.1m of GRAVEL overburden was encountered at Proposed Turbine T1 (BH1). Additional confirmatory drilling (recommendation of the geophysical survey) at location T01-PBH1, 50m to the north of Proposed Turbine T1 encountered 4.5m of gravelly CLAY. Refer to **Section 8.3.4** for geophysical and drilling investigations in bedrock.

Drilling carried out at Proposed Turbine T2 encountered 4m (BH2) and 8.5m (BH2B) of sandy gravelly CLAY or clayey sandy GRAVEL below the proposed turbine foundation location. Additional confirmatory drilling (recommendation of the geophysical survey) at a location 40m to the northeast of T2 (T02-PBH1) and 43m to the east of T2 (T02-PBH2) encountered CLAY (boulder clay) down to a depth of 20mbgl at both locations (please refer to **Sections 8.3.4.3** and **8.3.4.4** below which discusses these areas of deep clay and how they will be avoided by the turbine foundation).

The 1 no. borehole carried out at Proposed Turbine T3 (BH3) encountered 0.8m of Sandy gravelly CLAY, while the 3 no. boreholes carried at turbine T4 (BH5, BH5B and BH-ALT-T5) encountered between 2 and 2.5m of sandy gravelly CLAY which got gravelly at depth (logged as possibly weathered bedrock).

Drilling at Proposed Turbine T9 (BH6) encountered 11.5m of Boulder Clay over bedrock, comprising mainly slightly sandy gravelly CLAY with low cobble content.

Bedrock at ground level (i.e. no overburden) was encountered at BH7 which was drilled at the proposed borrow pit location on the north of the Proposed Wind Farm site.

Table 8-5: Summary of Overburden Conditions Encountered During Drilling.

Location	BH ID[1]	Depth Range (m bgl)	Depth to Bedrock (m)	Summary Subsoil Description
T1	BH1 (RC)	0 – 0.25 0.25 – 1.1	1.1	Topsoil Clayey sandy GRAVEL
	T01-PBH1 (DH)	0 – 4.5 4.5 – 7.6 7.6 – 10	4.5	Gravelly CLAY Weathered LIMESTONE Soft, very wet CLAY
T2	BH2 (RC)	0 – 1.7 1.7 – 4.0	4.0	Sandy. gravelly CLAY Clayey, sandy GRAVEL
	BH2A (DH)	0 – 5.0	5.0	Sandy, gravelly CLAY
	BH2B (DH)	0 – 8.5	8.5	Sandy, gravelly CLAY
	T02-PBH1 (DH)	0 – 1.3 1.3 – 20.0	>20.0	Gravelly, silty CLAY Very gravelly CLAY (Boulder Clay)
	T02-PBH2 (DH)	0 – 1.0 1.0 – 20.0	>20.0	Gravelly, silty CLAY Very gravelly CLAY (Boulder Clay)
T3	BH3 (RC)	0 – 0.8	0.8	Sandy gravelly CLAY
T4	BH5 (RC)	0 – 0.69 0.69 – 2.0	2.0	Sandy gravelly CLAY GRAVEL (possibly weathered rock)
	BH5-B (RC)	0 – 2.5	2.5	Sandy gravelly CLAY
	BH-ALT-T5 (RC)	0 – 2.25	2.25	Sandy gravelly CLAY
T9	BH6 (RC)	0 – 11.5	11.5	Sandy gravelly CLAY (Boulder Clay)
Borrow Pit	BH7 (RC)	0	0	Bedrock at Ground Level

Note 1: The drilling method is indicated in brackets (RC – rotary core/DH – Downhole Hammer).

8.3.3.4 Geophysical Surveys (Overburden)

2D Electrical Resistivity Tomography (ERT) and Seismic Refraction profiling were carried out by Apex Geophysics Limited at all 10 no. proposed turbine locations. Refer to **Table 8-6** below for a summary of interpreted overburden conditions at the turbine locations.

For the proposed turbine locations where investigation drilling was carried out (T1 to T4, T9), interpreted overburden depths at the turbine locations and lithology typically align with the drilling data as discussed in **Section 8.3.3.3** above.

With regard the proposed turbine locations where no drilling investigations were carried out (i.e. T5 to T8 and T10), the interpreted depth to bedrock ranged from approximately 3 to 6m at turbines T5, T6, and T7, 9 to 12m at turbine T8 and in excess of 20mbgl at turbine location T10.

The subsoils were typically interpreted as mainly sandy gravelly CLAY along with clayey or silty SAND/GRAVEL.

Table 8-6: Summary Geophysical Interpretations of Overburden Conditions.

Location ID	Summary of Overburden Interpretation	General Description (Comment)
T1	**Layer 1**: Loose material or weathered rock 0.2 to 1.6 m thick (average 1.0 m and 0.5 m at the turbine centre). **Layer 2**: Medium dense soil material or weathered rock which is 0.5 to 3.0 m thick (average 1.8 m and 0.5 m at the turbine centre).	Thin clayey silty sand/gravel and sand/gravel over shallow bedrock. (Bedrock at turbine base confirmed at 1.1mbgl by drilling at BH1).
T2	**Layer 1**: Soft/loose material 0.2 to 1.3 m thick (average 0.7 m and 1.0 m at the turbine centre). **Layer 2**: Firm/medium dense soil material, and possible highly weathered rock towards the base, which is 0.2 to 3.3 m thick (average 2.8 m and 3.8 m at the turbine centre).	Gravelly clay with some clayey silty sand/gravel over bedrock. (Bedrock at turbine base confirmed at between 4 and 8.5mbgl by drilling at BH2 & BH2B).
T3	**Layer 1**: Soft/loose material 0.1 to 0.8 m thick (average 0.7 m and 0.7 m at the turbine centre **Layer 2**: Medium dense soil material and/or highly weathered mudstone 0.5 to 2.6 m thick (average 1.7 m and 1.0 m at the turbine centre.	Thin sandy gravelly clay, clayey silty sand/gravel and minor sand/gravel over. (Bedrock at turbine base confirmed at 0.8mbgl by drilling at BH3).
T4	**Layer 1**: Loose material 0.2 to 1.4 m thick (average 0.9 m and 0.4 m at the turbine centre). **Layer 2**: Firm/medium dense material 0.9 to 4.8 m thick (average 2.1 m and 1.4 m at the turbine centre).	Clayey silty sand/gravel and sand/gravel with some sandy gravelly clay over bedrock. (Bedrock at turbine base confirmed at between 2 and 2.5mbgl by drilling at BH5, BH5B & BH5-ALT).
T5	**Layer 1**: Soft/loose material 0.2 to 1.5 m thick (average 0.9 m and 0.4 m at the turbine centre. **Layer 2**: Firm/medium dense material 0.4 to 3.4 m thick (average 2.0 m and 1.2 m at the turbine centre). **Layer 3:** Stiff to very stiff/dense to very dense material (average 4.4 m and 2.7 m at the turbine centre).	Sandy gravelly clay with small 'pockets' of silt/clay and an area of clayey silty sand/gravel. Depth to bedrock at turbine base interpreted to be approximate 6.5mbgl to 4.3mbgl.
T6	**Layer 1**: Soft material 0.2 to 1.4 m thick (average 0.7 m and 0.6 m at the turbine centre). **Layer 2**: Firm material 0.9 to 3.2 m thick (average 2.5 m and 1.8 m at the turbine centre). **Layer 3:** Stiff to very stiff material 1.8 to 4.5 m thick (average 3.7 m and 3.7 m at the turbine centre).	Sandy gravelly clay with some minor 'pockets' of silt/clay over bedrock. (Depth to bedrock at turbine base interpreted to be approximately 6mbgl).

Location ID	Summary of Overburden Interpretation	General Description (Comment)
T7	**Layer 1**: Loose material 0.2 to 0.9 m thick (average 0.5 m and 0.8 m at the turbine centre). **Layer 2**: Medium dense material or weathered rock 0.9 to 3.4 m thick (average 2.2 m and 2.1 m at the turbine centre).	Sand/gravel and clayey silty sand/gravel over shallow bedrock. (Depth to bedrock at turbine base interpreted to be approximately 2.5 - 3mbgl).
T8	**Layer 1**: Soft material 0.2 to 0.9 m thick (average 0.7 m and 0.4 m at the turbine centre). **Layer 2:** Firm material 0.9 to 3.4 m thick (average 1.7 m and 1.5 m at the turbine centre). **Layer 3: V**ery stiff material 2.2 to 5.2 m thick (average 3.1 m and 2.7 m at the turbine centre).	Sandy gravelly clay or bedrock. (Depth to bedrock at turbine base interpreted to be approximately 9 to 12mbgl).
T9	**Layer 1**: Soft material 0.2 to 1.0 m thick (average 0.7 m and 0.6 m at the turbine centre) **Layer 2:** Material 1.6 to 3.6 m thick (average 2.0 m and 2.2 m at the turbine centre). **Layer 3:** Very stiff material 6.1 to 9.3 m thick (average 8.5 m and 9.0 m at the turbine centre).	Thick sequence of sandy gravelly clay over bedrock. (Bedrock at turbine base confirmed at 11.5mbgl by drilling at BH6).
T10	**Layer 1**: Soft material which is up to 1.2 m thick (average 0.4 m and 0.5 m at the turbine centre). **Layer 2: F**irm material 1.1 to 2.8 m thick (average 1.9 m and 1.8 m at the turbine centre). **Layer 3:** thick sequence of very stiff material with some silt/clay.	Sandy gravelly clay with some silt/clay at depth. (Depth to bedrock at turbine base interpreted to be in excess of 18mbgl).

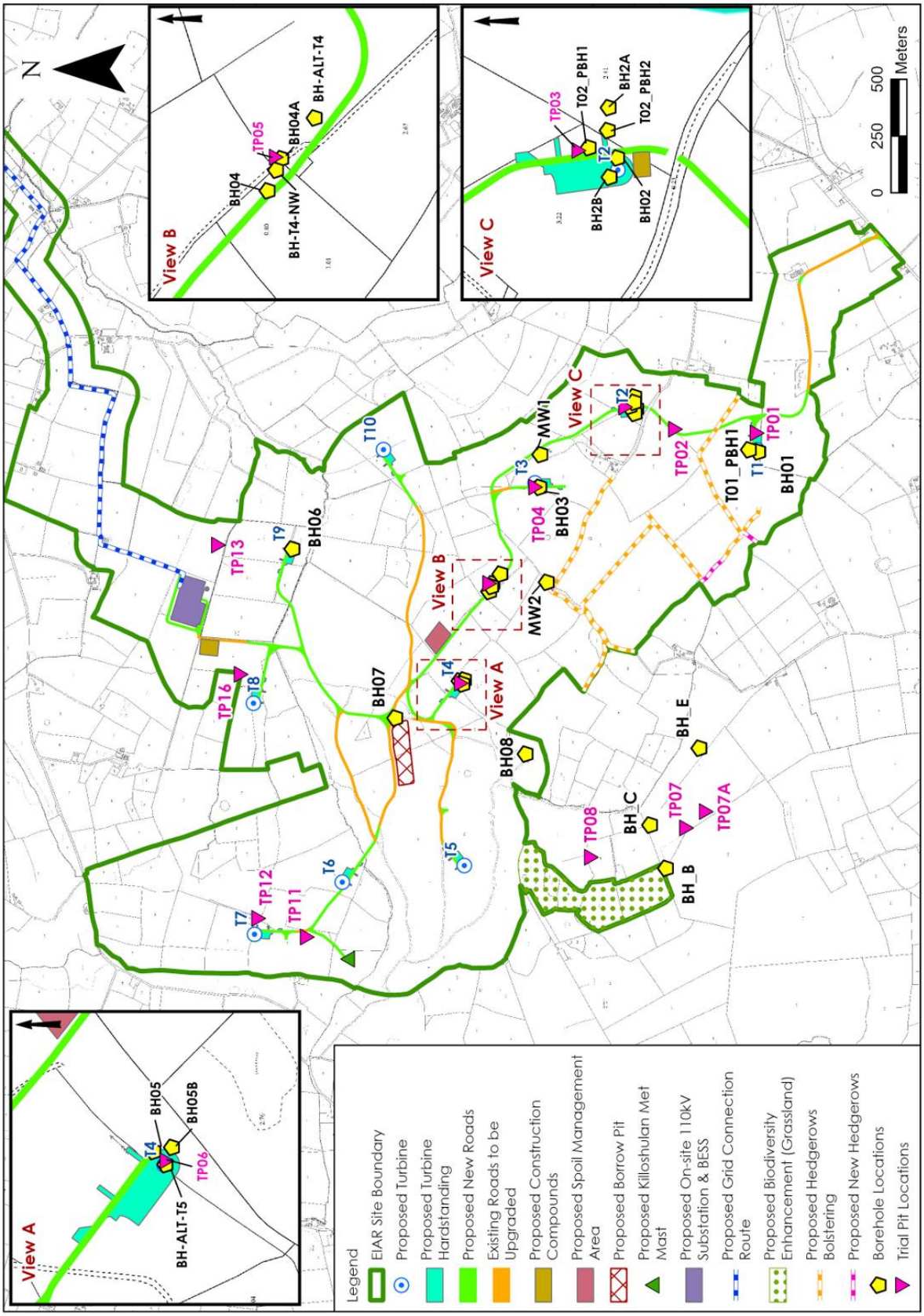


Figure 8-2: Site Investigation Map.

8.3.4 Bedrock Geology

8.3.4.1 GSI Mapping

According to the GSI bedrock mapping, the southern half of the Proposed Wind Farm site (including proposed turbine locations T1 to T4) is underlain by Dinantian Pure Bedded Limestones, while the northern half (including proposed turbine locations T5 to T10, the proposed borrow pit and Proposed 110kV Substation and BESS) is mapped as Namurian Shales. A bedrock geology map is shown as **Figure 8-3** below.

The Dinantian Pure Bedded Limestones within the Proposed Wind Farm site are mapped as the Ballyadams Formation and the Clogrenan Formation.

The Ballyadams Formation, which is mapped on the far south of the Proposed Wind Farm site, comprises Crinoidal wackestone/packstone limestone. The Clogrenan Formation is mapped to the north of the Ballyadams Formation and comprises cherty, muddy, calcarenitic limestone. Proposed Turbine location T1 is mapped to overlie the Ballyadams Formation, while Proposed Turbine locations T2, T3 and T4 are mapped to overlie the Clogrenan Formation.

The Namurian Shale bedrock within the Proposed Wind Farm site is mapped as the Killeshin Siltstone Formation which is described as muddy siltstone & silty mudstone. Proposed Turbine locations T5 to T10 as well as the proposed borrow pit and Proposed 110kV Substation and BESS are mapped to be underlain by the Killeshin Siltstone Formation.

A GSI mapped bedrock fault intercepts the Proposed Wind Farm site in a northeast/southwest alignment. There are no proposed turbines located along the mapped fault.

Keynote: Please note that Proposed Turbine location T4 is mapped to be underlain by the Clogrenan Formation (Pure Bedded Limestone), however investigation drilling and geophysics carried out at T4 revealed that turbine T4 is underlain by the bedrock consistent with the Killeshin Siltstone Formation (refer to Sections 8.3.4.3 and 8.3.4.4 for bedrock investigations. Therefore, only 3 no. Proposed Turbine locations are underlain directly by pure bedded limestone (i.e. T1, T2 and T3).

The bedrock underlying the Proposed 110kV Underground Cabling route is mapped as the Killeshin Siltstone Formation at the Proposed Wind Farm site, with the Bregaun Flagstone Formation (sandstone/siltstone) mapped along the central section and the Ballyadams Formation at the eastern end of the proposed route near Ballyragget.

8.3.4.2 Trial Pit Investigation

A total of 13 no. trial pits carried out by GDG between 15th and 17th November 2022. All trial pits encountered bedrock at depths ranging from 0.5m to 2m below ground level (mbgl), with an average of 1.4m.

No significant weathering or karst weathering (i.e. epi-karst[1]) was recorded in any of the trial pits that encountered limestone.

[1] The epikarst, which consists of highly weathered rock in the upper vadose zone of exposed karst systems, plays a critical role in determining the hydrologic and geochemical characteristics of recharge to an underlying karst aquifer.

8.3.4.3 Investigation Drilling

A summary of bedrock conditions during drilling investigations at proposed turbine locations T1 to T4, T9 and the borrow pit are summarised in **Table 8-7** below. Refer to **Figure 8-2** for the borehole locations.

As stated previously, proposed turbine locations T1 to T4 were targeted for investigation drilling as they are mapped to be underlain by pure limestone bedrock which has evidence of karstification at the Proposed Wind Farm site.

Drilling at proposed T9 and the proposed borrow pit was carried out to confirm the presence of non-calcareous bedrock (siltstone/mudstone) which is mapped across the northern half of Proposed Wind Farm site.

In summary, LIMESTONE bedrock was encountered below turbine locations T1, T2 and T3 which is consistent with GSI bedrock mapping.

MUDSTONE bedrock was encountered below turbines T4 and T9. The proven MUDSTONE below turbine T4 is contrary to the GSI mapping which has limestone mapped at T4 (bedrock below turbine T4 is discussed further below in this section).

SILTSTONE was encountered at the proposed borrow pit which is also consistent with GSI mapping. MUDSTONE and SILTSTONE variations are consistent with the Killeshin Siltstone Formation.

A commentary of bedrock conditions at the investigation locations is provided below.

Turbine T1

At turbine location T1 (BH1) medium strong argillaceous LIMESTONE was encountered at 1.1m which was recorded as moderately weathered down to 4.2mbgl and from 4.2m to 13mbgl was slightly to moderately weathered. Below 13mbgl, the LIMESTONE was extremely strong, so much so, downhole hammer (DH) drilling method had to be employed instead of rotary core in order to progress drilling down to 22mbgl (End of Hole).

A second borehole (recommended geophysics confirmatory borehole T01-PBH1) was drilled by downhole hammer approximately 50m to the north of T1 to investigate the presence of clay infill along a geophysical survey line (refer to **Section 8.3.4.4**).

T01-PBH1 encountered a clay infill between 7.6mbgl down to the final drilling depth of 10mbgl. It should be noted that the proposed T1 foundation footprint is setback several metres from this clay infill. Refer to Section 8.3.4.4 below for further discussion around clay infill features near turbine T1.

Turbine T2

Drilling investigations carried out at proposed turbine T2 encountered strong weathered LIMESTONE below the proposed turbine foundation at depths starting from 4m (BH2) to 8.5mbgl (BH2B).

At BH2, strong, fresh to slightly weathered LIMESTONE was encountered the full depth of the rotary core hole (4 - 15mbgl). Some minor clay infilled fractures were encountered but no evidence of karstification was recorded in the core log. BH2B was drilled by DH also below the proposed T2 foundation, where strong, weathered pale grey LIMESTONE was encountered from 8.5mbgl down to the End of Hole (EoH) at 18mbgl.

Two recommended geophysics confirmatory boreholes (T02-PBH1 & T02-PBH2) were drilled approximately 40m to the northeast and 43m to the east of turbine T2 respectively to investigate the presence of potential clay infill along the geophysical survey lines (**Section 8.3.4.4**). Both boreholes encountered clay infill (boulder clay) from ground level down to 20mbgl (EoH). Please note that

neither of the clay infill underlie the proposed T2 turbine foundation. Refer to Section 8.3.4.4 below for further discussion around clay infill features near turbine T2.

Turbine T3

At turbine location T3, BH3 encountered nearly 2m of weak, weathered MUDSTONE over argillaceous LIMESTONE, which was described as medium strong weathered between 2.68 and 3.88mbgl. For the remainder of hole down to 15mbgl, argillaceous LIMESTONE with some interbed MUDSTONE was encountered which was described mainly as very weak to medium strong and weathered. Impurities in the LIMESTONE in the form cherty nodules were recorded below 4.6mbgl.

No follow up confirmatory drilling was required at turbine T3 as no bedrock anomalies were identified in the geophysical surveys (refer to Section 8.3.4.4 below).

Turbine T4

3 no. rotary core boreholes (BH5, BH5B and BH-ALT-T5) were carried out at proposed turbine location T4 during the layout optimisation. The aim of the optimisation was to move T4 away from an area of enclosed depressions which is located to the southeast of the proposed turbine location (karst features are discussed in **Sections 8.3.5** below). The proposed T4 location now keeps at least 30m distance from these karst features, while in fact the proposed turbine sits over mudstone bedrock and not limestone.

The bedrock below turbine location T4 is mapped as pure bedded limestone by the GSI. However, the investigation drilling shows that there is a geological contact (overlap) between the LIMESTONE and MUDSTONE at this location with MUDSTONE overlapping the LIMESTONE.

BH-ALT-T5 was drilled at the proposed T4 turbine base location where 18m of MUDSTONE (2.25 to 20.2mbgl) overlies LIMESTONE. The MUDSTONE is described as weak to very weak and weathered.

The underlying LIMESTONE is described as strong and slightly weathered. The other two rotary core boreholes drilled in the area of turbine T4 (BH5 and BH5B) encountered MUDSTONE down to the maximum drilling depths of 10 and 15mbgl respectively.

Turbine T9

Proposed Turbine T9 is located on the north of the Proposed Wind Farm site where the Killeshin Siltstone Formation is mapped underneath. BH6 drilled at turbine T9 encountered MUDSTONE at 11.5mbgl which was recorded as weak and weathered down to final drilling depth of 15mbgl.

Borrow Pit

The proposed borrow pit is also located on the north of the Proposed Wind Farm site where the Killeshin Siltstone Formation is mapped. BH7 was drilled at the lowest point within the proposed borrow pit footprint where weathered SILTSTONE was encountered from ground level down to the final drilling depth of 7mbgl.

Table 8-7: Summary of Investigation Drilling in Bedrock.

Location	BH ID	Depth Range (m bgl)	Summary Description
T1	BH1 (RC)	0 - 1.1	Overburden
		1.1 – 4.2	Medium strong, argillaceous, moderately weathered LIMESTONE
		4.2 – 13.0	Strong, argillaceous, slightly to moderately weathered LIMESTONE
		13.0 - 22.0	Very strong LIMESTONE (drilled by downhole hammer, gravel returns)
	T01-PBH1 (DH)	0 – 4.5	Overburden
		4.5 – 7.6	Weathered LIMESTONE
		7.6 – 10	Soft, very wet CLAY
T2	BH2 (RC)	0 – 4.0	Overburden
		4.0 - 15.0	Strong, fresh to slightly weathered LIMESTONE with occasional clay infilled fracture.
	BH2A (DH)	0 – 5.0	Overburden
		5.0 - 9.2	Strong weathered LIMESTONE
		9.2 – 13.4	Strong pale grey LIMESTONE
		13.4 - 17.4	Clay infilled cavity
	BH2B (DH)	0 – 8.5	Overburden
		8.5 – 10.5	Strong weathered LIMESTONE
		10.5 – 18.0	Strong pale grey LIMESTONE
	T02-PBH1 (DH)	0 - 20.0	Clay/Boulder Clay, no bedrock encountered at 20mbgl.
	T02-PBH2 (DH)	0 - 20.0	Clay/Boulder Clay, no bedrock encountered at 20mbgl.
T3	BH3 (RC)	0 - 0.8	Overburden
		0.8 -2.68	Weak, fine grained, weathered MUDSTONE
		2.68- 3.88	Medium strong, thickly bedded, argillaceous, weathered LIMESTONE
		3.88 - 4.63	Very weak, argillaceous, weathered LIMESTONE (with MUDSTONE)
		4.6 – 15.0	Medium strong, thickly bedded, argillaceous, weathered LIMESTONE
T4	BH5 (RC)	0 – 2.0	Overburden (possible weathered rock)
		2.0 - 5.5	Extremely weak, bedded, weathered MUDSTONE
		5.5 – 10.0	Weak, bedded, partially weathered MUDSTONE (with clay lenses)
	BH5B (RC)	0 – 2.5	Overburden
		2.5 - 15.0	Very weak to weak, bedded, fine grained, weathered MUDSTONE
	BH ALT-	0 – 2.25	Overburden
		2.25 -5.7	Very weak, fine grained, weathered MUDSTONE (with clay lenses)

Location	BH ID	Depth Range (m bgl)	Summary Description
	T5 (RC)	5.7- 8.75 8.75 – 20.2 20.2 – 30.0	Weak, fine grained, weathered MUDSTONE Weak, fine grained, partially weathered MUDSTONE Strong, slightly weathered LIMESTONE
T9	BH6 (RC)	0 – 11.5 11.5 – 15.0	Overburden Weak, bedded, fine grained, weathered MUDSTONE
Borrow Pit	BH7 (RC)	0 – 7.0	Weak to very weak, thickly laminated, weathered SILTSTONE
N/a	BH8 (RC)	0 – 5.0	Extremely weak to weak dark grey thinly to thickly bedded fine grained MUDSTONE

Note 1: The drilling method is indicated in brackets (RC – rotary core/DH – Downhole Hammer).

8.3.4.4 Geophysical Survey

2D Electrical Resistivity Tomography (ERT) and Seismic Refraction profiling were carried out by Apex Geophysics Limited at all 10 no. proposed turbine locations. Refer to **Table 8-8** below for a summary of interpreted bedrock conditions at the turbine locations.

The bedrock below turbine locations T5 to T10 is interpreted at MUDSTONE which is consistent with GSI mapping (Killeshin Siltstone Formation). Other than BH6 at proposed turbine T9, no follow up drilling was carried out at these turbines to confirm the geophysical interpretations, as there is no risk of karst features within the mudstone bedrock which underlies the northern half of the Wind Farm site.

As described above, MUDSTONE also directly underlies proposed turbine T4 which was also proven by investigation drilling, albeit mapped as limestone by the GSI.

The geophysical surveys carried out at proposed turbines T1 to T3 interpreted LIMESTONE which is also proven by investigation drilling and consistent with GSI mapping.

However, in addition to limestone bedrock, anomalies in the limestone were detected locally at proposed turbine locations T1 and T2, which were initially interpreted as possible clay infill or DOLOMITISED LIMESTONE. Follow-up confirmatory drilling was carried out at proposed turbines T1 and T2 to investigate the anomalies which is described below.

In order to illustrate the extent of the Proposed Turbine base works and its interaction with the bedrock geology interpretations, the proposed depth and extent of the turbine base excavation is superimposed on the ERT and Seismic Refraction profiles for turbine locations T1 to T3 (refer to **Appendix 8-5** for illustrations). These illustrations show that the turbines can be constructed on competent bedrock away from these clay infills.

Turbine T1

Geophysical surveys carried out at turbine T1 interpreted '*moderately to slightly weathered/fractured/karstified LIMESTONE'* over *'weathered/fractured to fresh LIMESTONE'* below the proposed turbine foundation.

The investigation drilling carried out at turbine T1 (BH1) encountered strong, argillaceous, slightly to moderately weathered LIMESTONE with no evidence of shallow (epikarst) or deep karst weathering.

In addition, the trial pit carried out locally by GDG (TP01) identified no epikarst weathering at the location of turbine T1.

However, anomalies in the geophysics surveys indicated possible clay infill or DOLOMITISED LIMESTONE approximately 20m to the north of turbine T1. A second such anomaly was detected at a significant depth below ground level (approximately 12-15mbgl) at the turbine location itself.

Geophysics recommended confirmatory borehole T01-PBH1, which was drilled by downhole hammer approximately 50m to the north of T1, encountered clay infill between 7.6 and 10mbgl. The deeper underground anomaly was not investigated by drilling due to it being approximately 12 to 15mbgl, which will ensure at least 6m of competent LIMESTONE below the turbine base foundation.

As illustrated on the ERT and Seismic Refraction profile (**Appendix 8-5**), the T1 turbine foundation can be constructed on competent limestone and will have no interaction with either of these clay infills.

Turbine T2

Geophysical surveys carried out at turbine T2 interpret *'Moderately to slightly weathered /fractured /karstified LIMESTONE'* below the proposed turbine foundation.

However, the investigation drilling carried out at turbine T2 (BH2) encountered strong, fresh to slightly weathered LIMESTONE with occasional clay infilled fracture with no evidence of shallow (epikarst) or deep karst weathering. In follow up investigation drilling at the T2 foundation location (BH2B), strong, pale grey weathered LIMESTONE was encountered down to a depth of 18mbgl with no evidence of karst.

Also, the trial pit carried out by GDG (TP03) identified no epikarst weathering at the location of turbine T2.

Similar to turbine location T1, anomalies in the geophysics surveys indicated possible clay infill or DOLOMITISED LIMESTONE were detected at ground level 15m to the north and 5m to the east of the proposed turbine location.

Two geophysics confirmatory boreholes (T02-PBH1 & T02-PBH2) were drilled approximately 40m to the northeast and 43m to the east respectively of turbine T2 to investigate the presence of a clay infill along the geophysical survey lines. Both boreholes encountered clay infill (boulder clay) from ground level down to 20mbgl (EoH) which was the maximum drilling depth.

However, as illustrated on the ERT and Seismic Refraction profile (**Appendix 8-5**), the T2 turbine foundation can be constructed on competent limestone and will have no interaction with either of these clay infills.

Turbine T3

The geophysical surveys carried out at turbine T3 interpret *'moderately to slightly weathered/fractured LIMESTONE'* over '*slightly weathered to fresh LIMESTONE'.* The bedrock interpretation across the profiles is uniform fresh limestone with no anomalies indicating karst or otherwise.

The investigation drilling carried out at T3 (BH3) are consistent with the geophysical survey, where medium strong, thickly bedded, argillaceous, weathered LIMESTONE was encountered. In addition, some shallow MUDSTONE was encountered above the LIMESTONE.

Table 8-8: Summary Geophysical Interpretations of Bedrock Conditions.

Location ID	Summary of Bedrock Interpretation	Corresponding BH Summary
T1	**Layer 3:** Moderately to slightly weathered/fractured/karstified LIMESTONE (Average depth of 2.7mbgl and 2.5mbgl at the turbine centre) **Layer 4**: Weathered/fractured to fresh LIMESTONE (average 7.3 m bgl and 6.3 mbgl at the turbine centre).	BH1: Strong to medium strong, argillaceous, moderately weathered LIMESTONE
T2	**Layer 3**: Moderately to slightly weathered /fractured/karstified LIMESTONE (average depth of 2.3 mbgl and 1.7mbgl at the turbine centre) **Layer 4**: Moderately to slightly weathered /fractured /karstified LIMESTONE at the turbine centre (average depth is 5.3mbgl and 5.0mbgl at the turbine centre).	BH2: Strong, bedded, fine grained, fresh to slightly weathered LIMESTONE
T3	**Layer 3**: Moderately to slightly weathered /fractured LIMESTONE (average 2.3mbgl and 1.7mbgl at the turbine centre). **Layer 4**: Slightly weathered to fresh LIMESTONE (average 4.6mbgl and 3.6mbgl at the turbine centre).	BH3: Weak, fine grained, thinly laminated MUDSTONE at 0.8mbgl over Medium strong, thickly bedded, argillaceous, weathered LIMESTONE
T4	**Layer 3**: Moderately weathered MUDSTONE (Average depth of 3.1mbgl and 3.0mbgl at the turbine centre). **Layer 4**: Slightly weathered MUDSTONE (Average depth 5.7mbgl and 6.7mbgl at the turbine centre).	BH5, BH5B and BH-ALT-T5: Weak to very weak MUDSTONE from approximately 2 - 2.5mbgl down to a proven depth of 20.2mbgl.
T5	**Layer 3**: Overburden layer **Layer 4**: Slightly weathered to fresh MUDSTONE (average 6.5mbgl and 4.3mbgl at the turbine centre)	
T6	**Layer 3**: Overburden layer **Layer 4:** Slightly weathered to fresh Mudstone (Average depth of 6.5mbgl and 6.6mbgl at the turbine centre)	
T7	**Layer 3**: Moderately to slightly weathered **MUDSTONE** (average depth of 2.9mbgl to 2.5mbgl at the turbine centre) **Layer 4**: Slightly weathered to fresh MUDSTONE **(**Average depth 5.4mbgl and 4.4mbgl at the turbine centre).	
T8	**Layer 3:** Overburden layer **Layer 4** Slightly weathered to fresh MUDSTONE (average depth 9.2 and 12.2mbgl at the turbine centre).	

Location ID	Summary of Bedrock Interpretation	Corresponding BH Summary
T9	**Layer 3:** Overburden layer **Layer 4:** Slightly weathered to fresh MUDSTONE (average 9.2mbgl and 12.2mbgl at the turbine centre).	BH6: Weak, bedded, fine grained, weathered MUDSTONE at 11.5mbgl.
T10	No bedrock was interpreted at the maximum survey depth of c. 20mbgl.	

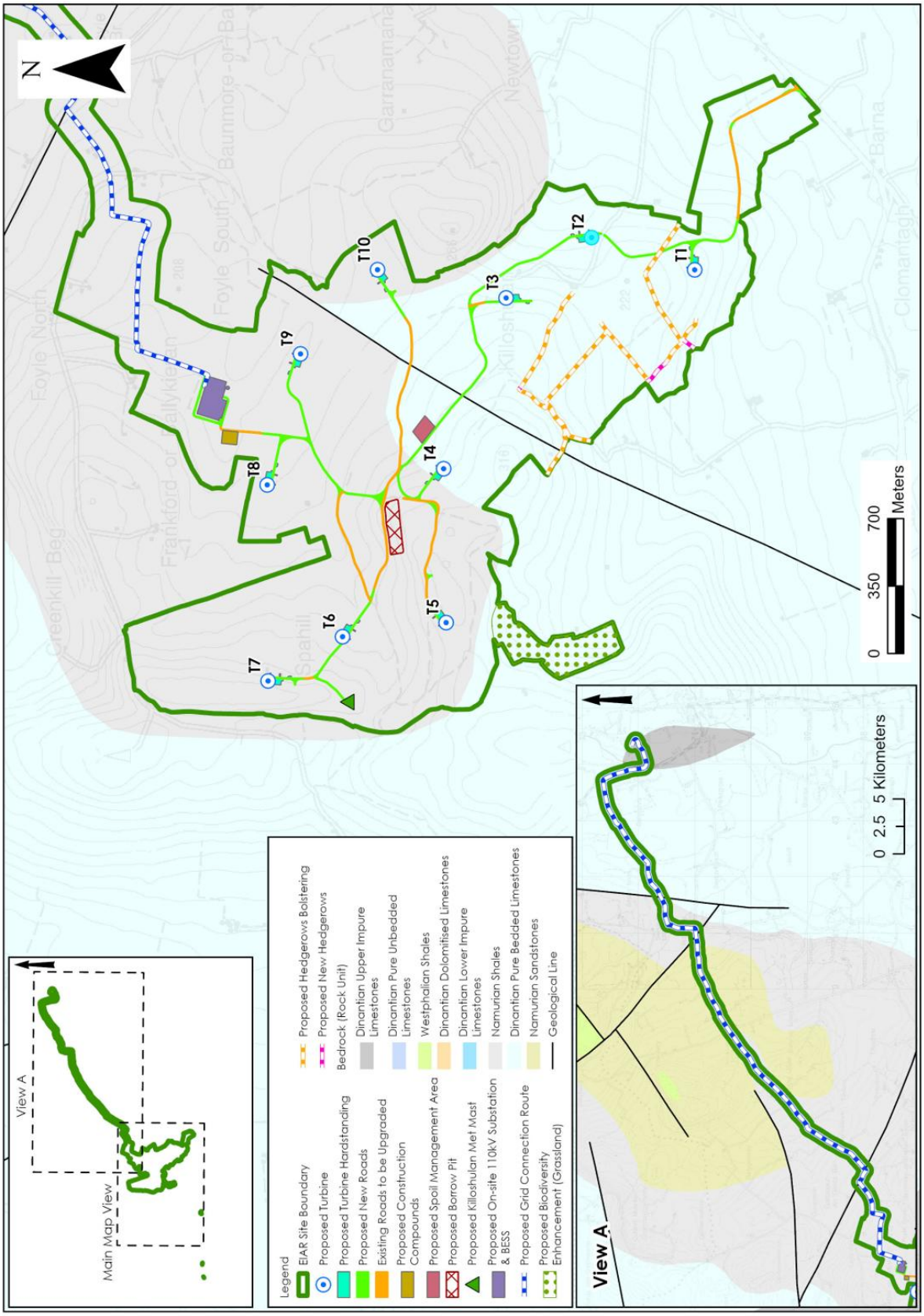


Figure 8-3: GSI Bedrock Geology Map.

8.3.5 Karstification

8.3.5.1 Introduction

Karst is defined by Drew (2018)[2] as a "terrain with distinctive hydrology and landforms due to the high solubility of the rock and the high degree of development of secondary permeability in the aquifer". The development of karstic landscapes occurs most frequently in very pure, well-fractured limestone, such as the Carboniferous limestone in Ireland, but can form in any carbonate rock susceptible to dissolution.

Solution of the limestone by acidified runoff is the dominant process by which karstic weathering occurs. The degree of solutional erosion varies both across the surface and below the ground. These variations in intensity, combined with the areal variability of the solution processes on different limestone lithologies and structures, produce a variety of karstic landforms on both large and small scales.

There is evidence of karstification at ground surface (i.e. karst features) on the southern portion of the Wind Farm site which is expected given the underlying bedrock geology (i.e. pure bedded limestone).

As investigated in Section 8.3.4, only Proposed Turbine locations T1 to T3 are underlain by limestone bedrock. The remainder of the turbine locations (T4 - T10), included the proposed borrow pit and Proposed 110kV Substation and BESS are underlain by mudstone with the possibility also of siltstone (i.e. no risk of karstification).

8.3.5.2 GSI Karst Database

In summary, a total of 25 no. karst features are mapped by GSI (online karst database) within the Proposed Wind Farm site EIAR boundary, or very close to its boundary. GSI mapped karst features are shown in **Figure 8-4** below.

The southern portion of the Proposed Wind Farm site is located in the Clomantagh/Killoshulan ('Balief') Group Water Scheme groundwater source protection area (refer to Chapter 9 Hydrology and Hydrogeology for details) and therefore field-based mapping has been completed by the GSI (or its subcontractors) in the past within the Wind Farm site.

The GSI mapped features include:

- 16 no. enclosed depressions (dolines)
- 5 no. swallow holes; and
- 4 no. springs

Firstly, the GSI map a cluster of 13 no. enclosed depressions (dolines) within grassland centrally on the southern portion of the Proposed Wind Farm site. Several of these enclosed depressions are arranged in a general north-south trending alignment which suggest a north-south trending structural feature (fault/fracture line) that has potentially been subject to solution weathering (i.e. karstification). This feature might be related to the GSI mapped fault discussed in Section 8.3.4.1 above).

Hydrogeology of the Proposed Wind Farm site is discussed in Chapter 9 (Hydrology and Hydrogeology). A further 3 no. enclosed depressions are mapped on the southwest of the Proposed Wind Farm site which are remote from all proposed infrastructure.

All Proposed Wind Farm infrastructure is setback more than 100m from the centrally located enclosed depressions, with the closest turbine location being T3 (~100m away). Turbine location T3 has been

[2] *Drew, D. 2018. Karst of Ireland: Landscape Hydrogeology Methods. Published by Geological Survey Ireland.*

investigated by drilling and geophysical surveys (Section 8.3.4), with no evidence of subsurface karst features detected by either method.

4 no. swallow holes are mapped approximately 350 - 400m to the east/ northeast of proposed turbine T4, with 1 no. located in grassland and the other 3 no. in the adjacent forestry. Field based surveys carried out by HES/FT (Section 8.3.5.3 below) did not find any evidence of the 3 no. swallow holes in the adjacent forestry which suggests that they might have been backfilled during forestry operations. There was also no evidence of any past surface water drainage function either which suggests that they may have just been dolines.

The 1 no. swallow hole mapped within grassland, approximately 350m to the northeast of proposed turbine T4 exists (as confirmed by field-based surveys). Again this 'swallow hole' has no surface water drainage function which suggests it may be only a collapsed doline. This swallow hole is discussed further in Section 9.3 9 of Chapter 9 (Hydrology and Hydrogeology).

There is another swallow hole mapped on the southwest of the Proposed Wind Farm site (in separate surface water catchment to that of the Proposed Wind Farm site), approximately 250m to the south of the proposed turbine location T5. As investigated in Section 8.3.4.4 above, turbine T5 is underlain by mudstone. This swallow hole is discussed further in the Chapter 9 (Hydrology and Hydrogeology).

There are 4 no. 'karst springs' mapped along the western facing slopes of SPA Hill on the northwest of the Proposed Wind Farm site (the springs are located just outside of the EIAR Site Boundary). One of these springs (referred to 'Spa Well') has an archaeological/heritage significance as it has apparent health healing properties due to minerals such iron being rich in the water.

However, field hydrochemistry analysis of the water by HES would suggest it's not a karst spring due to low dissolved mineral content (i.e. low electrical conductivity). The source of the spring water is likely from the mudstone bedrock and not the pure limestone, hence the high iron levels which is evident as residue at the spring outfall. This spring is discussed further in Section 9.3.11 of Chapter 9 (Hydrology and Hydrogeology).

Overall, all GSI surface mapped karst features at Proposed Wind Farm site have been avoided by the proposed turbine layout. All proposed turbine locations on the south of the Proposed Wind Farm site (i.e. T1 to T4) are at least 30m from GSI mapped karst feature.

8.3.5.3 Field Based Karst Mapping

As the GSI karst database is not exhaustive, systematic field-based mapping was carried out by FT as part of the Karst Assessment (**Appendix 8-3),** along with follow up field-based surveys by HES. Refer to Figure 8-5 for features surveyed during the field-based mapping.

The systematic field-based mapping was focused around the area of turbine locations T1 to T4 where most of the GSI mapped features are located. All other Proposed Wind Farm infrastructure located outside this area is underlain by mudstone/siltstone as confirmed by the site investigations.

The purpose of the field-based survey was to:

- Verify the presence of potential surface karst features identified as part of the aerial photography and previous GSI surveys; and
- Where possible, to identify additional karst features not visible on aerial photography (if present) or mapped by the GSI.

In total 19 no. out of the 25 no. features previously identified were visited. The remaining 6 no. locations were not visited as they are either outside of the Site boundary or not close to proposed infrastructure but have been considered when assessing the potential karst risk at specific locations.

Previously unmapped features were identified within a 100m distance of proposed turbine location T4, which included enclosed depressions and karstified bedrock outcrop.

Proposed Turbine T4, which is underlain by mudstone and not limestone as confirmed by site investigation (Section 8.3.4), is setback at least 30m from these mapped features. Turbine T4 location was micro-sited further to the north away from these features.

As discussed above, of the 4 no. swallow holes mapped by the GSI approximately 350m to the northeast of proposed turbine T4, only 1 no. was identified on the ground. This suggests that the others might have been backfilled during forestry operations. There was no evidence of any past surface water drainage function either which suggests that they may have just been dolines.

Some additional dolines, possible sink hole and losing stream were identified on the southwest of the Proposed Wind Farm site, at locations remote from proposed Wind Farm infrastructure and in a separate surface water catchment. However, please refer to the Chapter 9 (Hydrology and Hydrogeology) for the hydrological/hydrogeological significance of these features in terms of potential groundwater pathways for off-site effects.

All proposed Wind Farm infrastructure located on or adjacent to limestone bedrock (i.e. turbines T1 to T4 and associated access roads) have undergone systematic field-based karst surveys.

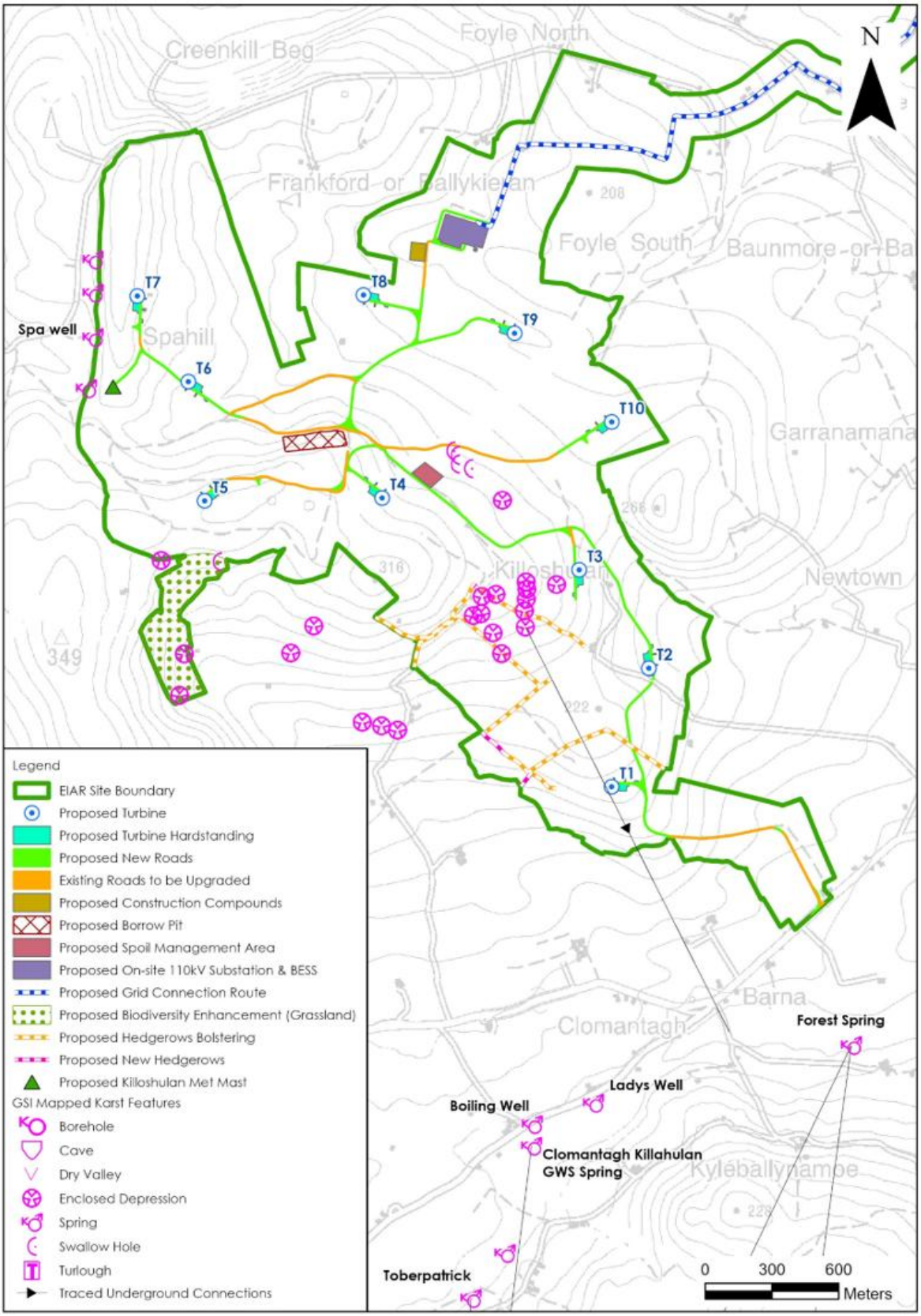


Figure 8-4: GSI Mapped Karst Features.

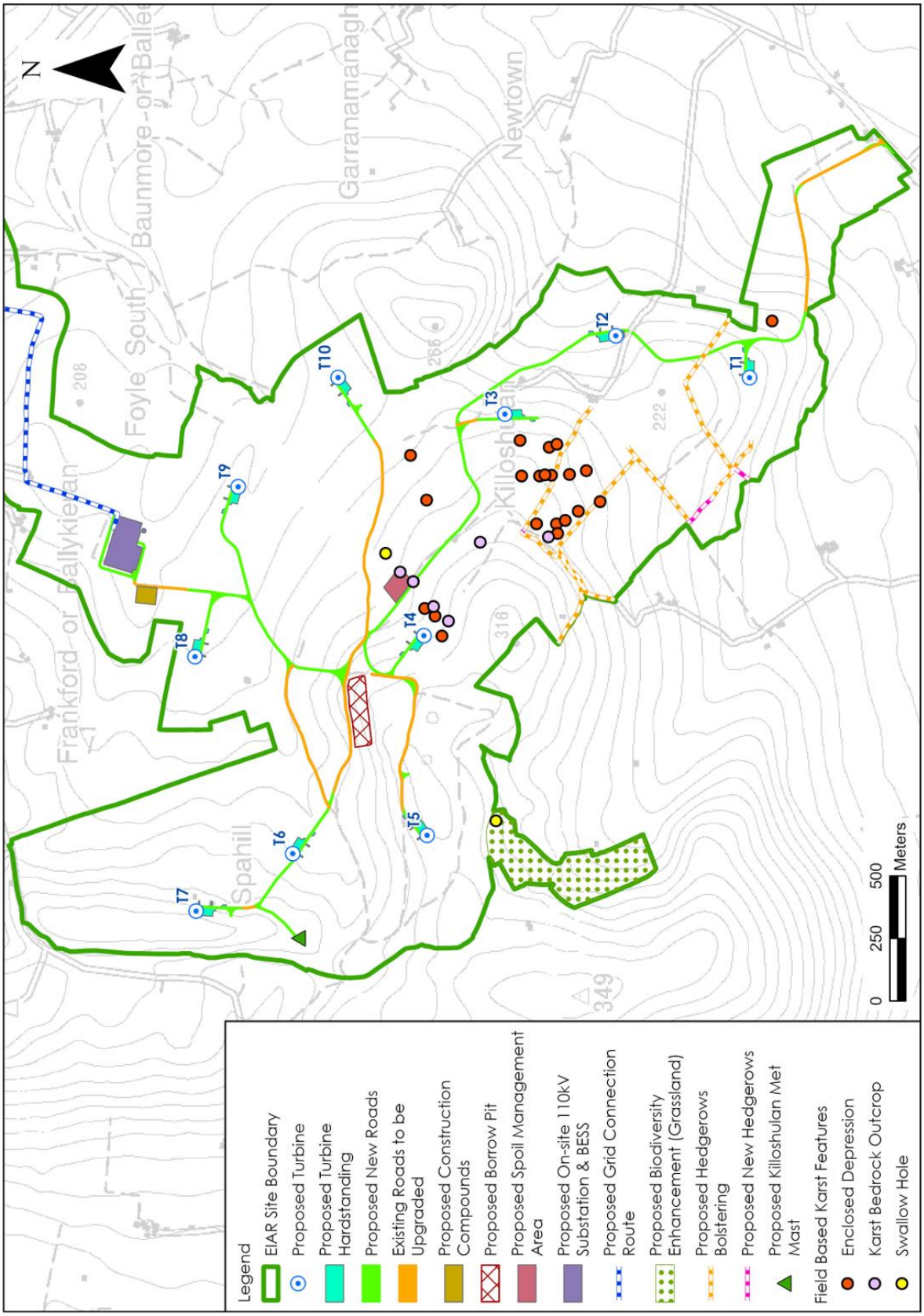


Figure 8-5: Field Based Karst Feature Mapping.

8.3.5.4 Karst Risk Assessment Summary

The following is a summary of the Karst Assessment Report carried out by FT at the Proposed Wind Farm site (refer to (**Appendix 8-3)**

The karst risk has been based on assessment of the following geological and evidence-based risks:

- Underlying rock type;
- Thickness of overburden cover / depth to bedrock (the greater the overburden thickness the less chance for surface water to infiltrate through to the rock to cause solution weathering);
- Proposed depth of excavations (removal of cover over potential karst features);
- Overburden cover type; the nature of the material overlying the limestone bedrock can affect the type and severity of collapse. In granular materials, sinkholes develop slowly causing shallow depressions rather than sudden collapse. In more cohesive materials, failure can be catastrophic and sudden (drop out) and as such a higher risk score is often appropriate.
- Proximity to known karst features e.g. swallow hole, pond or concentration of features in one particular section of the route, or areas where streams were noted on historic maps which may have disappeared underground e.g. dry stream beds.
- Logged feature in rotary core boreholes e.g. cavity, low/no TCR (Total Core Recovery), brecciated / broken zone of rock etc.
- Anomalies noted in the Geophysical Survey (sharp changes in resistivity may indicate voids or in filled cavities).
- Buried topsoil/organic matter at depth in cable percussive boreholes or trial pits (indicative or disturbed ground, infilled hollows or cavities).

The risk ratings adopted are as follows:

- Negligible Risk: No karst risk (bedrock is not limestone);
- Low Risk: Little to no karst risk, very unlikely that any karst features are present. Mitigation measures are unlikely to be required;
- Medium Risk: Some karst development is possible which may lead to unstable ground or cavities. Following inspection of formation levels, design mitigation measures may be required;
- High Risk: Karst development is likely and active unstable ground and cavities already exist or may exist. Detailed assessment of the data, additional ground investigation and geophysical surveying is required, and mitigation or avoidance is likely to be required. Where specific features are encountered, and depending on the circumstances, possible solutions may include bridging across the void at shallow depth or plugging the conduit at greater depth and backfilling over the plug.

The FT assessment is shown in **Table 8-9** below applies both to the turbine locations and the sections of access roads between the relevant turbines.

Table 8-9: Summary of Karst Assessment (Source: FT 2026).

Turbine ID	Risk Rating	Summary
T1	High	Weathered bedrock and clay infill indicated from geophysical survey and boreholes, indicating the presence of a subsurface karst feature to the north of the turbine location, with a feature also present at a depth of 10m below the proposed base of excavation for the turbine. Presence of intact bedrock directly below proposed turbine excavation will provide sufficient engineering support for the construction of the turbine. **However, as illustrated on the ERT and Seismic Refraction profile (Appendix 8-5), the T1 turbine foundation can be constructed on competent limestone and will have no interaction with either of these identified clay infills.**
T2	High	Weathered bedrock and clay infill indicated from geophysical survey and boreholes, indicating the presence of a subsurface karst feature to the north and northeast of the turbine base. Turbine founded on gravel above weathered bedrock. ***However, as illustrated on the ERT and Seismic Refraction profile (Appendix 8-5), the T2 turbine foundation can be constructed on gravel subsoil/competent limestone and will have no interaction with either of these identified clay infills.***
T3	Medium	No evidence of karst on geophysical survey or from boreholes but is in an area of recorded karst features. Turbine founded on weathered/intact limestone bedrock as illustrated in **Appendix 8-5**.
T4	Low	Limestone present at depth (20m bgl) below mudstone, but no significant risk associated with this given the thickness of mudstone present below the turbine base excavation (c. 16m).
T5	Negligible	Mudstone present, non-carbonate rock, negligible risk.
T6	Negligible	Mudstone present, non-carbonate rock, negligible risk.
T7	Negligible	Mudstone present, non-carbonate rock, negligible risk.
T8	Negligible	Mudstone present, non-carbonate rock, negligible risk.
T9	Negligible	Mudstone present, non-carbonate rock, negligible risk.
T10	Negligible	Mudstone present, non-carbonate rock, negligible risk.
Borrow Pit	Negligible	Siltstone present, non-carbonate rock, negligible risk.

8.3.5.5 Former T4 Proposed Turbine

Investigations (drilling and geophysics) at a former turbine T4 location (turbine now dropped from Proposed Project layout) encountered significant evidence of subterranean karst features. Please note that this does not relate to the current turbine T4 in the Proposed Project layout which is in a different location of the Proposed Wind Farm site that's underlain by mudstone bedrock.

Rotary core drilling locations BH04 and BH4NW at the former T4 location encountered significant clay filled cavities and potential faulting. In addition, the geophysical surveys indicated more widespread karst zones in the vicinity of the former T4 turbine location which led to this turbine being omitted from the final layout. Refer to **Figure 8-2** (View Box B) for the borehole locations carried out at the former T4 location

The area of the Proposed Wind Farm site at the former T4 location was identified as a geological/hydrogeological constraint and no further turbine development was considered for this area. Please refer to the Chapter 9 (Hydrology and Hydrogeology) for further discussion on the former turbineT4 location.

8.3.6 Geological Heritage & Designated Sites

Within the Republic of Ireland designated sites include Natural Heritage Areas (NHAs), Proposed Natural Heritage Areas (pNHAs), Special Areas of Conservation (SAC) and Special Protection Areas (SPAs). A map of designated sites in the local area is shown as **Figure 8-6** below.

Spahill and Clomantagh Hill SAC (Site Code:000849) is located immediately to the northwest and southwest of the Proposed Wind Farm site. Proposed Wind Farm site infrastructure is setback more than 0.3km from this designated site, with the closest turbine being T5 on the southwest of the Proposed Wind Farm site.

The Loughans SAC (Site Code:000407), which is a turlough (karst), is located approximately 2.3km to the southwest of the Proposed Wind Farm site. The closest proposed turbine (T5) is 3km away from the SAC. The proposed TDR works on the R693 at Balief Cross Roads is approximately 100m from the SAC boundary

The River Barrow and River Nore SAC (Site Code:002162) is located approximately 9km to the east and downstream of the Proposed Wind Farm site via the Nuenna River.

Also, the Proposed 110kV Underground Cabling crosses under the River Nore SAC near Ballyragget where horizontal directional drilling (HDD) will be employed to place the cable below the river channel to avoid any physical contact with the river or the River Nore SAC. The River Nore/Abbeyleix Woods Complex pNHA (Site Code 002076) is also located along the River Nore.

There are no geological heritage sites within 5km of the Site.

Due to the setback distance/avoidance design measures to geological heritage sites and designated sites, no direct or indirect effects are likely with regard Land, Soils and Geology.

All designated sites and geological heritage sites are screened out for further assessment with regard land, soils and geology due to lack of potential direct effects. Indirect hydrological and hydrogeological effects are assessed in Chapter 9 (Hydrology and Hydrogeology).

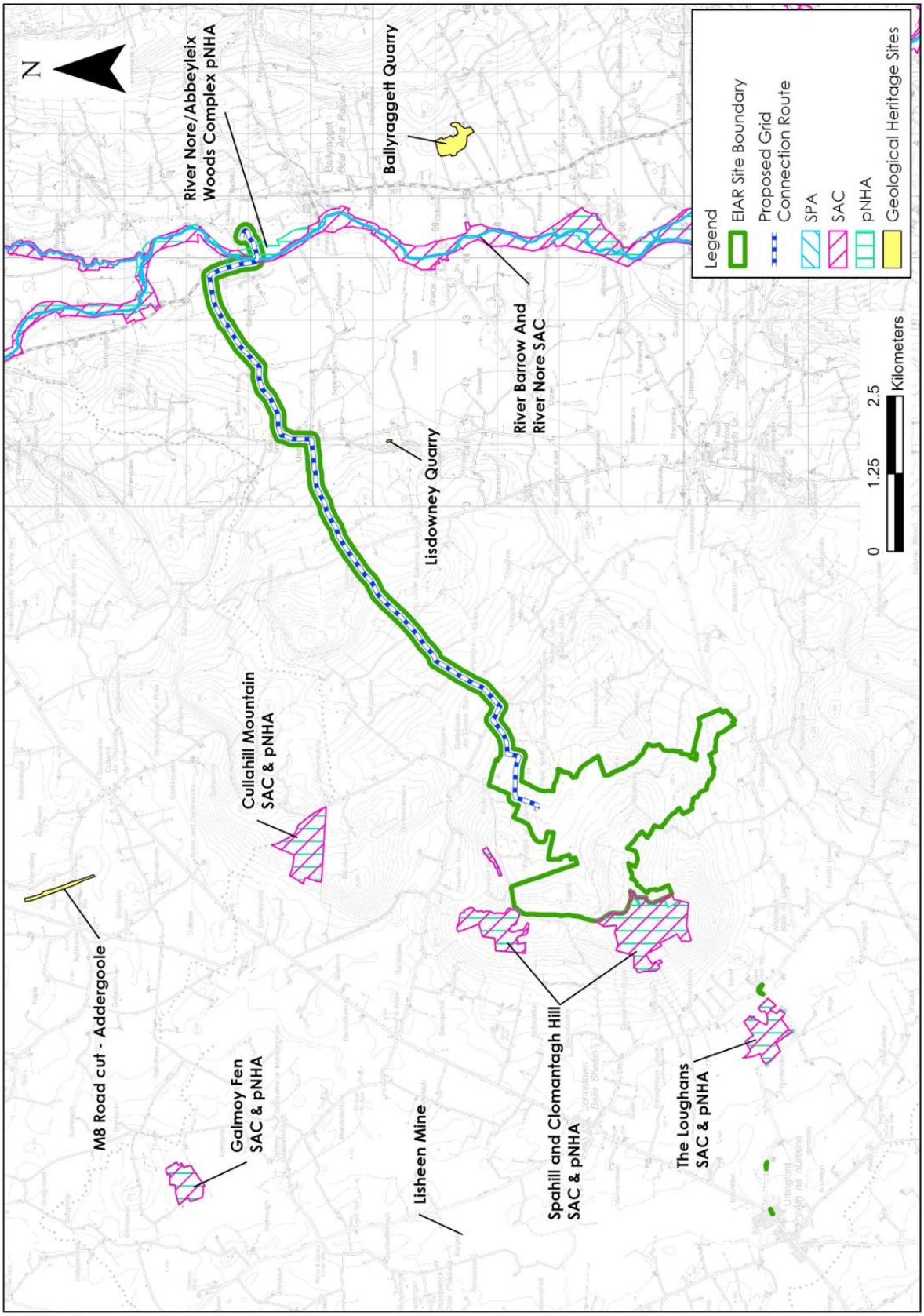


Figure 8-6: Designated Sites and Geological Heritage Sites.

8.3.7 Soil Contamination

There are no known areas of soil contamination on the Site. During the site walkovers or intrusive investigations, no areas of contamination concern were identified. This was also confirmed by the groundwater sampling and laboratory analysis conducted on monitoring well MW1 located at the Proposed Wind Farm site (refer to the Chapter 9 Hydrology and Hydrogeology).

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

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

8.3.8 Economic Geology

The GSI online Crushed Rock Aggregate Potential mapping shows that the Proposed Wind Farm site is mapped as being Low to Moderate on the north (i.e. mudstone/siltstone) and High to Very High on the south (i.e. limestone). Along the Proposed 110kV Underground Cabling, the mapped potential ranges from Low to Very High.

In terms of Granular Aggregate Potential, no areas are mapped within the Proposed Wind Farm site. Along the Proposed 110kV Underground Cabling Very High potential is mapped along the River Nore where sands and gravels of glaciofluvial origin are deposited.

8.3.9 Geohazards

The GSI Landslide database (www.gsi.ie) does not record any historic landslides in the vicinity of the Site or in the surrounding lands.

The GSI Landslide Susceptibility Map (www.gsi.ie) classifies the probability of a landslide occurring at a given location. The Proposed Wind Farm site is mapped as having low to high susceptibility, with the higher rating associated with the upper slopes of the Proposed Wind Farm site. The Proposed 110kV Underground Cabling route is mainly along public roads and therefore landslide does not pose a risk. There is no peat present at the Site.

A Karst Assessment was completed by FT (refer to Section 8.3.5.4 above for a summary of the karst risk assessment). Refer to **Appendix 8-3** for the Karst Assessment Report.

The karst risk rating for most of the Proposed Wind Farm infrastructure, including Proposed Turbines T5 to T10 as well as the proposed borrow pit is 'Negligible' due to being underlain by mudstone/siltstone bedrock.

The karst risk rating is 'Low' for proposed turbine T4 due to limestone bedrock mapped locally (T4 is directly underlain by mudstone but with limestone at depth, ~20mbgl). T3 is rated as 'Medium'. The risk rating at proposed turbines T1 and T2 is 'High' due to evidence of karst based on site investigations.

Geotechnical mitigation is provided in Section 8.5.2.5 below to manage the Medium to High-risk areas.

8.3.10 Receptor Importance and Sensitivity

Based on the criteria set out in **Table 8-2** (NRA, 2008) above, the soils and subsoils at the Proposed Wind Farm site can be classed as being of medium importance as they sustain agricultural and forestry activities locally in this area.

The soils and subsoils along the Proposed 110kV Underground Cabling can be considered as being of low importance as the underground electrical cabling route is located predominantly along existing public roads, and no soils or subsoil deposits are designated along the Proposed 110kV Underground Cabling route.

As stated previously, the Proposed 110kV Underground Cabling route crosses under the River Nore SAC near Ballyragget where horizontal directional drilling (HDD) will be employed to place the cable below the river channel to avoid any physical contact with the river itself or the River Nore SAC.

The limestone bedrock on the south of the Proposed Wind Farm site can be classed as being of High importance (marginally economic extractable mineral resource) and the mudstone/siltstone on the north of the Proposed Wind Farm site classed as Low importance (Uneconomically extractable mineral Resource).

The land, soil, subsoils and bedrock geological formations underlying the Site are scoped in for impact assessment due to their proximal location to the Proposed Project and the potential effects that the Proposed Project may have on these receptors.

No geological heritage site or designated site will be scoped in for impact assessment due to their distant location from the Proposed Project (i.e. from a land, soils and geology perspective, only direct effects within the Site will occur).

8.4 Characteristics of the Proposed Project

The Proposed Project construction will mainly involve removal of soils, mineral subsoils and bedrock for access roads, underground cabling, turbine hardstanding areas, turbine foundations, substation foundation, BESS foundation, construction compound and drainage works.

Crushed rock for construction purposes (siltstone) will be sourced from a proposed on-site borrow pit. The volume of available rock at the proposed borrow pit is estimated to be 185,000m^3.

Generally during turbine construction, soil, subsoil and bedrock will be excavated to a competent stratum for the concrete turbine foundation and a small working area surrounding the foundation footprint.

Table 8-10 provides a summary of proposed turbine foundation designs (i.e., design response at each turbine base (ground bearing foundation). The depth to bedrock and the composition of subsoils at each turbine, and the foundation type for each turbine are defined based on the comprehensive site investigation data.

Ground bearing foundation will be utilised at all turbines within the Site. Ground bearing foundations are suitable at this Proposed Wind Farm site due to the coherent and stable nature of the subsoil glacial tills or shallow bedrock.

Table 8-10: Proposed Turbine Foundation Type.

ID	Foundation Type	Formation Level (mbgl)	Formation Material (based on SI data)
T1	Ground-Bearing Gravity	3	Limestone bedrock
T2	Ground-Bearing Gravity	3	Gravel above weathered limestone bedrock
T3	Ground-Bearing Gravity	3	Limestone bedrock
T4	Ground-Bearing Gravity	3	Mudstone bedrock
T5	Ground-Bearing Gravity	3	Stiff Clay/Weathered Mudstone*
T6	Ground-Bearing Gravity	3	Stiff Clay/Weathered Mudstone*
T7	Ground-Bearing Gravity	3	Weathered Mudstone*
T8	Ground-Bearing Gravity	3	Stiff Clay/Weathered Mudstone*
T9	Ground-Bearing Gravity	3	Stiff Clay*
T10	Ground-Bearing Gravity	3	Stiff Clay*

* Based on geophysical survey results

Similarly, all turbine crane hardstands will be founded on a suitable bearing material requiring infilling or the excavation of all soil 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 soil can be reused to batter the platform edges and landscape the platform back into the existing topography.

Estimated volumes of spoil generated during construction are presented in the **Table 8-11** below. It is calculated that the total spoil volume will be 133,000m^3.

Spoil generated during construction will be reused or reinstated across the Proposed Wind Farm site. Spoil will be reused for landscaping on edges of constructed infrastructure (including access track verges and around hardstand areas) and shall be placed as soon as reasonably practical after construction. The excess spoil will be used to reinstate the borrow pit with the surplus placed in 1 no. dedicated spoil management area.

Any spoil generated from the Proposed 110kV Underground Cabling trenching within the Proposed Wind Farm site will be stored at the Site.

All road cuttings/spoil from public road section of the cable route will be sent to a licensed waste facility. The TDR haul route works will require minor excavations along the R693.

Table 8-11: Summary of Excavated Spoil Volumes for Proposed Project.

Development Component	Spoil Volume (m3) (approx.)	Crushed Stone Requirement (m3) (approx.)
Proposed Wind Farm		
10 no. Turbines and Hardstanding Areas (including foundations)	27,150	65,100
Access Roads (including met mast hardstand and security cabin)	37,100	68,900
Temporary Construction Compounds	10,700	500
Borrow Pit	20,000	N/A
Total	**94,950**	**134,500**
Proposed Grid Connection		
Proposed 110kV Substation	21,600	26,700
Cabling Trench	14,950	N/A
Total	**36,550**	**26,700**
Turbine Delivery Route		
Temporary Accommodation Areas	1,500	1,500
Total	**1,500**	**1,500**
Total (including 10% contingency)	**133,000**	**162,700**

Note: The volume of material excavated has been estimated using the average depths calculated across the footprint of the structure

Due to the presence of shallow limestone bedrock which might be karstified in the areas around turbines T1, T2 and T3 and locally at T4, the proposed earthworks associated with the access roads and hardstands has been designed in such a way as to minimise the cutting (excavation) extents and depths.

Where possible infilling is emphasised out over cut. Refer to **Table 8-12** which shows that infill volumes significantly exceed cut volumes.

This preserves the existing overburden cover present above the limestone bedrock, maintaining the current topographic regime, and as such does not increase the risk of karst reactivation or exposure.

This has included a bespoke hardstand layout for turbineT3 which omits the blade fingers, in order to avoid significant cutting at this location where there is sloping ground. The alignment of the access roads has also avoided the mapped karst features in this area which lowers the risk of drainage associated with the access roads leading to reactivation of karst.

Table 8-12: Summary of Cut and Fill Volumes at Turbines T1 to T3

	Volume Summary			
Turbine	Area	Cut	Fill	Net
	(sq.m)	(Cu. M.)	(Cu. M.)	(Cu. M.)
T01	5,719.464	559.816	3,488.762	2,928.946 <Fill>
T02	5,445.316	0.589	10,759.575	10,758.987 <Fill>
T03	5,524.803	360.13	11,235.339	10,875.209 <Fill>

8.5 Likely and Significant Impacts on Land, Soils and Geology

8.5.1 'Do Nothing' Scenario

If the Proposed Project were not to proceed, agriculture and forestry plantation operations will continue and may be extended to occupy a larger portion of the Proposed Wind Farm site. Forestry will be felled as forestry compartments reach maturity. Re-planting of these areas is likely to occur. Agricultural practices will continue.

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

8.5.2 Construction Phase - Likely Effects and Mitigation Measures

The likely effects of the Proposed Project and mitigation measures that will be put in place to eliminate or reduce them are shown below.

The impact assessment below assesses the overall Proposed Project as the Proposed Wind Farm and Proposed Grid Connection are not likely to be constructed as separate projects.

8.5.2.1 Effects on Land and Land use (Proposed Project)

There will be no effects on the lands adjoining the Site. Agriculture and forestry will continue during the construction of the Proposed Project.

The loss of forestry lands and agricultural lands amount to 27.5ha and 27ha respectively. The total forestry lands and agricultural lands present at the Proposed Wind Farm site is 266.3ha and 228.5ha respectively.

Overall effects on forestry and agricultural landuse are not significant with a total loss of 10.3% and 11.8% respectively.

The likely magnitude of effects on land and landuse (NRA, 2008), which is given a High Importance, is Small Adverse.

Pathway: Land take

Receptor: Land and Landuse (i.e. the land upon which the Proposed Project will occur)

Potential Pre-mitigation Effect: Negative, moderate, direct, likely, long-term effect on land and landuse.

Impact Assessment/Mitigation

The loss of agricultural land and forestry resulting from the Proposed Project on a local or regional scale is minimal and therefore the wider effects of actual agricultural land loss is negligible.

The overall Proposed Wind Farm area is extensive while the Proposed Project footprint (16.6ha) is approximately 2.9% of the Proposed Wind Farm site area of 573ha.

A Biodiversity Enhancement and Management Plan (BEMP) has been prepared for the Proposed Project and is included as Appendix 6-4 of this EIAR. This plan has been developed to offset the loss of habitats identified within the Site and further enhance the biodiversity of the Proposed Wind Farm site and its environs. Refer to Section 8.5.2.7 for summary details on the BEMP.

Residual Effect: Due to the small footprint of the Proposed Project on a local scale the final effect is negative, direct, slight to moderate, likely, long-term effect on land and landuse. The land and landuse along the Proposed 110kV Underground Cabling will not change (As the cable will be emplaced within an existing roadway).

Significance of Effects: For the reasons outlined above, no significant effects on land or landuse will occur as a result of the Proposed Project.

8.5.2.2 Soil, Subsoil and Bedrock Excavation (Proposed Project)

There will be excavations required for both the Proposed Wind Farm and Proposed Grid Connection (Proposed Project) and therefore both are assessed herein.

Excavation of soil, subsoil and bedrock will be required for construction of works for the installation of access roads, foundations for turbine bases, crane hardstands, substation, construction compounds, grid connection cable, internal cable network and site drainage network.

This will result in a permanent removal and relocation of in-situ soil, subsoil and sometimes bedrock. Estimated volumes of spoil to be relocated are summarised above in

Table 8-11. There will be no net loss of soil or subsoil, it will just be relocated within the Proposed Wind Farm site.

The likely magnitude of effects on soils, subsoils and bedrock (NRA, 2008), which is given a Medium to High Importance, is Small Adverse.

Pathway: Extraction/excavation.

Receptor: Soil, subsoil and bedrock.

Pre-Mitigation Potential Effect: Negative, moderate, direct, likely, permanent effect on soil, subsoil and bedrock due to excavation and relocation within the Site.

Proposed Mitigation Measures by Design:

- Placement of turbines and associated infrastructure in areas with suitable ground conditions/avoidance of karst features (based on detailed iterative site investigation data);
- During earthworks, emphasis on FILL rather than CUT at proposed turbine locations T1 to T3 to preserve the topography in areas of shallow limestone;
- Excavated soils/subsoils shall be excavated and stored separately to topsoil; this will prevent mixing of materials and facilitate reuse afterwards;
- All materials which require storage shall be stockpiled at low angles (< 5-10˚) to ensure their stability and secured using silt fencing where necessary. This will help to mitigate erosion and unnecessary additions of suspended solids to the drainage system;
- Spoil disposal shall take place within a minimal distance of each turbine to avoid excessive transport of materials within the site;
- Spoil shall be deposited, in layers of 0.50m and will not exceed a total thickness of 1m and 2m as indicated on the drawings;
- Spoil shall only be deposited on slopes of less than 5 degrees to the horizontal and greater than 10m from the top of a cutting; and,
- No turbines or Proposed Wind Farm infrastructure shall be constructed within 300m of any European designated sites such as SACs or SPAs.

Cut and Fill Design Measures:

Due to the presence of potential karstified limestone within the bedrock in the area around T01, T02, and T03, the proposed earthworks associated with the access roads and hardstands has been designed in such a way as to minimise the cutting (excavation) extents and depths. Where possible infilling is carried out over cut. Refer to **Table 8-12** above.

Residual Effect Assessment:

The overall Proposed Wind Farm site area is extensive while the Proposed Project footprint (16.6ha) is approximately 2.9% of the overall Proposed Wind Farm site area of 573ha.

The design measures incorporated into the Proposed Project as described above in particular the avoidance of cut where possible means that the residual effect will be negative, slight to moderate, direct, likely, permanent effect on soil, subsoil and bedrock due to disturbance and relocation within the Site.

Significance of Effects: For the reasons outlined above, no significant effects on soil and subsoils will occur as a result of the Proposed Project.

8.5.2.3 Contamination of Soils by Leakages and Spillages of Hydrocarbons or Chemicals (Proposed Project)

Accidental spillage during refuelling of construction plant with petroleum hydrocarbons is a pollution risk at the Proposed Wind Farm and Proposed Grid Connection (Proposed Project) and therefore both are assessed herein.

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 soil, subsoils and pollution of the underlying aquifer) on the geological and water environment.

The likely magnitude of effects on soils, subsoils and bedrock (NRA, 2008), which is given a Medium to High Importance, is Negligible to Small Adverse.

Pathway: Soil and subsoil and underlying bedrock pore space.

Receptor: Soil, subsoil and bedrock.

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

Proposed Mitigation Measures:

- On-site re-fuelling shall be undertaken using a fuel truck with spill kits kept on site for accidental leakages or spillages;
- Only designated trained operatives shall be authorised to refuel plant on-site;
- Taps, nozzles or valves associated with refuelling equipment shall be fitted with a lock system;
- All fuel storage areas will be bunded appropriately for the duration of the construction phase. All bunded areas shall be fitted with a storm drainage system and an appropriate oil interceptor. Ancillary equipment such as hoses, pipes shall be contained within the bunded area;
- Fuel, oil and chemical stores including tanks and drums shall be regularly inspected for leaks and signs of damage;
- The electrical control building (at the substation) shall 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 shall be fitted with a storm drainage system and an appropriate oil interceptor;
- The plant used during construction shall be regularly inspected for leaks and fitness for purpose;
- Safety data sheets for all chemicals used shall be kept on-site;
- No storage of fuels, oils or chemicals will be permitted within the Clomantagh/Killoshulan Group Water Scheme source protection area (SPA);
- Refuelling of mobile plant (i.e. diggers, dumpers etc) will only be permitted outside the SPA;
- Refuelling of large immobile plant (i.e. cranes) will only be carried out with a refuelling truck that will be removed from SPA immediately after use;
- Spill kit stations will be present at each turbine location (T1 to T4); and,
- An emergency response plan for the construction phase to deal with accidental spillages is contained within the Construction and Environmental Management Plan (which is contained in **Appendix 4-3**).

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

Significance of Effects: For the reasons outlined above, and with the implementation of the listed mitigation, no significant effects on soil, subsoils and bedrock will occur as a result of the Proposed Project.

8.5.2.4 Erosion of Exposed Soils and Subsoils During Construction of Infrastructure (Proposed Project)

Soils and subsoils are at risk of erosion at both the Proposed Wind Farm site and Proposed Grid Connection (Proposed Project) during the construction phase and therefore both are assessed herein.

There is a high likelihood of erosion of soil and spoil during its excavation and during landscaping works at the 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.

The likely magnitude of effects on soils and subsoils (NRA, 2008), which are given a Medium Importance, is Negligible to Small Adverse.

Pathway: Vehicle movement, surface water and wind action.

Receptor: Soil and subsoil.

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

Proposed Mitigation Measures:

- The upper vegetative layer (where still present) of excavated soil shall 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 soil within the spoil storage areas;
- Re-seeding and spreading/planting shall also be carried out in these areas; and,
- Brash/bog mats shall be put in place to support vehicles on soft ground, reducing soil and mineral soils erosion and avoiding the formation of rutted areas, in which surface water ponding can occur

Residual Effect Assessment: Soils and spoil can be eroded by vehicle movements, wind action and by water movement. Spoil material will remain within the Site and reseeding and planting will be completed to bind landscaped soil and spoil together. Following implementation of these measures the residual effects will be negative, imperceptible, direct, short-term, likely effect on soils 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 as a result of the Proposed Project.

8.5.2.5 Karst Related Ground Instability

Due to the nature of the Proposed Grid Connection site and the Proposed 110kV Underground Cabling route being mainly along public roads, potential karst features are not likely to present risk. Therefore, only the Proposed Wind Farm site is assessed herein.

A Karst Assessment was completed by FT (refer to Section 8.3.5.4 above for a summary of the karst risk assessment). Refer to **Appendix 8-3** for the Karst Assessment Report.

The karst risk rating for most of the Proposed Wind Farm infrastructure, including proposed turbines T5 to T10 as well as the proposed borrow pit is 'Negligible' due to being underlain by mudstone/siltstone bedrock.

The karst risk rating is 'Low' for Proposed Turbine T4 due to limestone bedrock mapped locally (T4 is directly underlain by mudstone but with limestone at depth, ~20mbgl). T3 is rated as 'Medium' risk. The risk rating at proposed turbines T1 and T2 is 'High' due to evidence of karst features locally.

In Medium to High-risk areas, additional site investigations and mitigation measures shall be required. Recommendations for additional ground investigation and potential mitigation measures are considered below.

Typical hazards associated with karst environments include:

- Rapid collapse of doline
- Subsidence of doline
- Cavities and voids
- Variable rock head
- Solutional weathered rock

Notwithstanding the above, the management of karst hazards and appropriate protocols and construction practices will be inherent in the construction phase of the Proposed Project to reduce the risk of karst features.

The likely magnitude of effects on soils, subsoils and bedrock (NRA, 2008), which are given a Medium to High Importance, is Small Adverse to Moderate Adverse.

Pathway: Ground collapse and subsidence.

Receptor: Soil, subsoils, bedrock and infrastructure.

Pre-Mitigation Potential Effect: The findings of the karst risk assessment, indicate that the majority of the Proposed Wind Farm site infrastructure areas can be classed as having a negligible risk, with smaller localised areas having low to high risk. Potential effects on land, soils and geology is considered negative, moderate to significant, direct, permanent, unlikely effect.

Proposed Mitigation Measures:

Mitigation measures for karst related ground instability are shown in the karst Assessment Report (FT, 2026) (**Appendix 8-3**). The measures are summarised below.

Mitigation by Design:

Karst Protocol:

A karst protocol for the Proposed Project is provided in the FT Karst Assessment (Appendix 8-3) and is presented below.

The karst risk or potential for karst features along the access road alignments and at turbine locations has been characterised in the Karst Assessment. The designer will further review the risk of features affecting works and outline any change to risk and locations during construction. A standard set of solutions is available in the SED drawings for typical features and dimensions encountered.

A karst protocol, provided in Appendix E [of Karst Assessment Report – Appendix 8-3], has been developed to translate the karst risk to the construction stage. In all cases the formation level is to be checked by the Resident Engineer (RE) for any local soft / weak or loose areas. The RE is to be notified if any soft / weak or loose areas are identified.

Due to potential karst risks around turbines T1 and T2 and extending along the access road towards turbine T4, the following investigations shall be carried out:

- Formations for embankments or cuttings to be proof rolled and observed for signs of weakness; and,
- Formations for structure (turbine) foundations to be proof rolled as above. The excavation shall be extended to rock head (where feasible) in areas where the karst risk is high or where evidence of karst features is encountered during overburden excavation.

Karst features identified within the works areas shall be investigated as shown in the flowchart in Appendix E [of the Karst Assessment Report – **Appendix 8-3**]. The results will be documented for each feature. Where karstic features are encountered, they shall be investigated by excavating a trial pit. Following the findings of this trial excavation the RE shall consider if further additional ground investigation is required. The RE will direct the Contractor on which SED to employ.

Where the feature is more extensive than shown on the SEDs the designer shall design the remediation measures. The design will be certified by an independent Cat III checker before implementation. Each karstic feature and the remediation measures shall be documented and included in the Safety File for the operational phase of the project. Features identified will be investigated by probing or further rolling as appropriate to be agreed between the RE and the Contractor. The RE may request additional ground investigation such as geophysics, rotary boreholes or other intrusive methods, to be agreed on site.

Where karst features are identified the details as shown on the standard earthworks drawings (SEDs) (as illustrated on drawings (P26-112-FT-XX-XX-SD-GE-0001 to 0004 – Appendix B of the Karst Assessment Report- **Appendix 8-3**) will be used as instructed by the RE.

Where a significant karst feature is suspected below a turbine foundation, a structural solution, such as a raft footing spanning over the feature, or a piled foundation, will be considered.

Piled Foundations:

Where small-scale dissolution and voiding are encountered at turbine foundations during detailed ground investigation, one potential mitigation strategy is the use of drilled or grouted piles. The use of piles transfers structural loads to competent rock beneath karst-affected zones. This approach bypasses voids and weak soils, reducing the risk of differential settlement or collapse.

Rock Infill:

This methodology involves 'choking' the throat of the sinkhole with coarse granular fill, and progressive backfilling upwards with progressively finer granular fill. All backfill is to be placed in layers 150mm deep and compacted. Soil around the sinkhole is to be excavated to a radius of 3-5m, before being replaced and compacted with or without incorporation of anchored geogrid.

Grouting:

Pressure grouting can be employed to stiffen soil over limestone and prevent its movement into fissures, to fill localised fissures, and to stabilise fractured rock. It is worth noting that the injection of a fluid grout can result in significant losses into adjacent caves before sealing karstic fissures. The detailed designer/contractor shall consider which grouting method shall be most appropriate and the potential negative consequences for contamination and pollution of the aquifer.

Binding Layers and Geo-grids:

One of the most effective and widely adopted engineering solutions to mitigate the risks of unacceptable settlement and unexpected collapse at access tracks is the use of bridging layers reinforced with geogrids.

Bridging layers are designed to span across potential voids or weak zones, redistributing loads and preventing localised collapse. When combined with geogrid reinforcement, these layers gain enhanced tensile strength and load-spreading capacity, allowing them to maintain structural integrity even in the event of subsurface failure.

Drainage Control:

Surface and subsurface drainage systems will be designed to prevent water ingress into karst features, reducing the potential for solutional enlargement and subsidence. This includes the installation of sub-drainage systems, the use of impermeable liners or membranes, and pumping and dewatering during construction.

As described in the Hydrology and Hydrogeology Chapter (Chapter 9), all Proposed Wind Farm site surface water drainage outfalls at level spreaders will be placed outside the 30m karst feature buffer zones (enclosed depressions and sink holes).

Residual Effect Assessment: A detailed Karst Assessment (FT, 2026) (**Appendix 8-3**) has been completed for the Proposed Project.

With the implementation of the control measures outlined above the residual effect is considered negative, slight, direct, permanent, unlikely effect on ground stability.

Significance of Effects: No significant effects on ground stability will occur.

8.5.2.6 Turbine Delivery Route Accommodation Areas (Proposed Wind Farm)

The TDR accommodation areas only relate to the Proposed Wind Farm element and not the Proposed Grid Connection. Only the Proposed Wind Farm is assessed herein.

Minor earthworks are required for turbine delivery. These include for temporary widening of existing roads and junctions. These TDR accommodation areas are described in Section 4.4.3 of the EIAR.

The likely magnitude of effects on soils, subsoils and bedrock (NRA, 2008), which are given a Medium to High Importance, is Negligible to Small Adverse.

Pathway: Extraction/excavation/landscaping.

Receptor: Soil and subsoil

Potential Pre-Mitigation Effect: Negative, imperceptible to slight, direct, likely, temporary effect on land, soil and subsoil.

Proposed Mitigation Measures:

- All works are minor and localised and cover very small areas;
- These works are distributed over a wide area;
- All works are temporary in nature; and,
- Excavations will be reinstated.

Residual Effect: The TDR related earthworks are minor in nature and will be temporary in duration. They are also separated from each other by considerable distances. Residual effects of the Proposed Project are Negative, imperceptible, direct, likely, temporary effect on land, soil and subsoil.

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

8.5.2.7 Biodiversity Enhancement and Management Plan (BEMP)

A Biodiversity Enhancement and Management Plan (BEMP) has been prepared for the Proposed Project and is included as Appendix 6-4 of this EIAR. This plan has been developed to offset the loss of habitats identified within the Proposed Wind Farm site and further enhance the biodiversity of the Proposed Wind Farm site and its environs. The following enhancement measures are proposed:

- Grassland Enhancement
- Hedgerow Bolstering
- Proposed new hedgerows

Pathway: Enhancement measures and targeted revegetation.

Receptor: Site habitats

Final Effect: Positive, moderate, direct, long term likely effect of BEMP.

Monitoring:

No mitigation is required; however a site-specific monitoring and evaluation programme will be implemented to ensure that the success of the proposed measures remains long-term. It will also assist in situations where the habitat establishment may not have been successful by providing evidence of shortcomings, allowing a revised management plan to be formulated. Monitoring results will be reported by the Project Ecologist within an Annual Environmental Report. Reports detailing the monitoring works carried out, the results obtained and a review of their success, along with any suggestions for amendments to the plan will be prepared. The BEMP will be updated and amended where required to improve the efficacy of the enhancement work.

8.5.3 Operational Phase - Likely Significant Effects and Mitigation Measures (Proposed Project)

There are very few potential direct impacts envisaged during the operational phase of the Proposed Project. The potential impacts 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.

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

Mitigation measures for land, soils and geology during the operational phase include the use of aggregate from authorised quarries for use in road and hardstand maintenance. Oil used in transformers (at the Proposed 110kV Substation and within each Proposed Turbine) and storage of oils in tanks at the substation could leak during the operational phase and impact on ground/soil and subsoils and groundwater or surface water quality.

The Proposed 110kV Substation transformer shall be in a concrete bunded area, capable of holding 110% of the stored oil volume. Turbine transformers are located within the turbines, so any leaks shall be contained within the turbine. These mitigation measures are considered sufficient to eliminate potential risks to ground/soils and subsoils, and groundwater and surface water quality.

8.5.4 Decommissioning Phase - Likely Significant Effects and Mitigation Measures (Proposed Project)

The potential effects associated with decommissioning of the Proposed Project 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 suitable soil 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. However, as noted in the Scottish Natural Heritage report (SNH) Research and Guidance on Restoration and Decommissioning of Onshore Wind Farms (Welstead et al, 2013) reinstatement proposals for a wind farm are made approximately 30 years in advance, so within the lifespan of the wind farm, technological advances and preferred approaches to reinstatement are likely to change. According to the SNH guidance, it is therefore:

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

Mitigation measures applied during decommissioning activities will be similar to those applied during construction phase as shown in Section 8.5.2 above.

Some of the impacts will be avoided by leaving elements of the Proposed Project in place where appropriate. The substation will be retained by EirGrid. The turbine bases will be rehabilitated by covering with local topsoil 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 Project.

8.5.5 Risk of Major Accidents and Disasters

Karst bedrock potentially presents a risk on the southern portion of the Proposed Wind Farm site.

The findings of the Karst Risk assessment indicate that the majority of the Proposed Wind Farm site infrastructure areas can be rated as having a Negligible risk (i.e. turbines T5 to T10, borrow pit and associated access roads) due to it being underlain by mudstone/siltstone bedrock. T4 which is also underlain by mudstone, is assigned a Low risk.

Proposed Turbine location T3 is rated as Medium risk, while T1 and T2 are rated as High risk due to the presence of limestone evidence of karst features nearby. A karst protocol for the Proposed Project is provided in **Appendix 8-3**.

For potential fires at the BESS compound a Fire Risk Management & Emergency Response Plan has been prepared for Proposed Wind Farm (refer to **Appendix 4-4**).

8.5.6 Human Health Effects

Potential health effects arise mainly through the potential for soil and ground contamination. The Proposed Project 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 Project 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.

To safeguard the local environment (and downstream human receptors) from contaminated runoff during a potential fire event, specialised site bunding and a dedicated retention tank will capture

firefighting water so it can be sampled, treated, or safely removed by hazardous waste contractors. Refer to **Appendix 4-4** for the Fire Risk Management & Emergency Response Plan.

8.5.7 Cumulative Effects

The potential for impact between the Proposed Project, and other relevant developments has been carried out with the purpose of identifying what influence the Proposed Project (Proposed Wind Farm, Proposed Grid Connection and TDR works combined) will have on the surrounding environment when considered cumulatively and in combination with relevant existing permitted or proposed projects and plans in the vicinity of the Site, as set out in Chapter 2 of this EIAR. Please see Section 2.9 of Chapter 2 for cumulative assessment methodology.

8.5.7.1 Construction Phase

The nature of the construction works within the Site mean that the effects on the land, soils and geology environment are restricted to the immediate areas of the construction works. The only cumulative effect of the Proposed Project with respect to the lands, soils and geology will be due to the potential removal and transport of material to a licensed waste facility, where required. The environmental effects of the placement of material within the licenced waste facility will have been previously assessed during the licensing process of this facility. There will be no further cumulative effects on the land, soils and geology environment during the construction phase of the Proposed Project.

8.5.7.2 Operational Phase

During the operational phase of the Proposed Project all aspects of the land, soils and geology environment will remain constant, with no alteration of any aspect of this environment. As a result, there will be no cumulative effects due to the Proposed Project.

8.5.7.3 Decommissioning Phase

During the decommissioning phase of the Proposed Project, there will be minimal disturbance of soil/subsoil. The underground electrical cabling ducts will be left in-situ (cables removed by re-opening the joint bays used for the installation of the cabling) and turbine foundations will not be removed but covered over with soil/subsoil. These works will be limited in scale and there is no potential for cumulative effects with other nearby developments.