8. LAND SOILS AND GEOLOGY

8.1 Introduction

8.1.1 Background and Objectives

Hydro-Environmental Services (HES) was engaged by MKO Ireland (MKO) to carry out an assessment of the potential effects of the Proposed Project. This chapter relates to potential effects on Land, Soils and Geology due to the construction, operation and decommissioning of the Proposed Laurclavagh Renewable Energy Development. Section 1.1.1 of Chapter 1 of this EIAR has set out the terminology used to describe each of the elements of the Proposed Project. The terminology of project elements used within this chapter is outlined below:

- The 'Proposed Wind Farm' refers to the 8 no. turbines and supporting infrastructure which is the subject of this Section 37E application.
- The 'Proposed Grid Connection' refers to the 110kV substation and supporting infrastructure which will be the subject of a separate Section 182A application.
- The 'Proposed Project' comprises the Proposed Wind Farm and the Proposed Grid Connection, all of which are located within the EIAR Site Boundary (the 'Site') and assessed together within this EIAR.

This report provides a baseline assessment of the environmental setting of the Site in terms of land, soils and geology and discusses the potential effects that the construction, operation and decommissioning of the Proposed Project will have on them. Where required, appropriate mitigation measures to limit any identified significant effects to soils and geology are recommended.

8.1.2 Statement of Authority

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

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

This chapter of the EIAR was prepared by Michael Gill and Adam Keegan.

Michael Gill PGeo (BA, BAI, MSc, Dip. Geol., MIEI) is an Environmental Engineer with over 18 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 including private residential and commercial developments which are occasionally sited within areas of known karstification, particularly in the East Galway/Clare area. In addition, he has substantial experience in intrusive site investigation and site suitability assessments, karst and epikarst hydrology/hydrogeology within proposed wind farm sites, water resource assessments for commercial and public water supplies including trial and production well drilling within a karst environment, surface water drainage design and SUDs design, and surface water/groundwater interactions. In addition, Michael has worked on the EIARs for Seven Hills WF, Oweninny WF, Cloncreen WF, Derrinlough WF and Yellow River WF, and over 120 other wind farm-related projects.

Adam Keegan PGeo (B.Sc., M.Sc.) is a hydrogeologist with 5 years environmental consultancy experience in Ireland. Adam has worked on numerous Environmental Impact Assessments for

infrastructure projects, such as wind farms, strategic housing developments and quarries. Adam has experience in intrusive site investigation works within mapped karst environments and experience in trial and production well drilling within areas mapped as Regionally Karstified. Adam has worked on several wind farm EIAR projects, including Seven Hills WF, Croagh WF, Lyrenacarriga WF (SID), Cleanrath WF, Carrownagowan WF (SID), and Coole WF.

8.1.3 Relevant Legislation

The EIAR is prepared in accordance with the requirements of European Union Directive 2014/92/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:

- S.I. No. 296/2018 European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2001-2018 (as amended);
- European Communities (Environmental Impact Assessment) Regulations 1989 to 2006 (as amended);
- S.I. No. 30/2000 the Planning and Development Act, 2000 (as amended); and,
- S.I. No. 4/1995: The Heritage Act 1995 (as amended).

8.1.4 Relevant Guidance

The land, soils and geology section of this EIAR is carried out in accordance with the 'EIA Directive' as amended by Directive 2014/52/EU and having regard where relevant to 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 Preparation of Soils, Geology & Hydrogeology Chapters in 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 Union, 2017).

8.2 Schedule of Works

8.2.1 Desk Study

A desk study of the Site and the surrounding area was completed in advance of undertaking the walkover surveys and site investigations. This involved collecting all relevant geological data for The Site and surrounding area. This included consultation of the following:

- Environmental Protection Agency database (www.epa.ie);
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Met Eireann Meteorological Databases (www.met.ie);
- National Parks & Wildlife Services Public Map Viewer (www.npws.ie);
- EPA/Water Framework Directive Map Viewer (www.catchments.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 11 (Geology of South Mayo) and Sheet 14 (Geology of Galway Bay). Geological Survey of Ireland (GSI, 2005 & 2004);
- Geological Survey of Ireland (2004) – Clare-Corrib Groundwater Body Initial Characterization Reports;

- Groundwater Karst Viewer (GSI online mapping portal - www.gsi.ie);
- OPW Flood Hazard Mapping (www.floodinfo.ie);
- Environmental Protection Agency – "Hydrotool" Map Viewer (www.epa.ie);
- GSI Groundwater Flood mapping (www.gsi.ie);
- CFRAM flood maps (www.cfram.ie);
- Department of Environment, Community and Local Government on-line mapping viewer (www.myplan.ie); and,
- Group Water Scheme ZOC Reports; Anbally & District GWS, Balrobuckneg GWS, Caherlea GWS, Cahermorris-Glenreevagh GWS, Cluide (Cahermorris) GWS and Rusheens GWS.

8.2.2 Baseline Monitoring and Site Investigations

A comprehensive geological, hydrological and hydrogeological dataset has been collected as part of this EIAR study.

Initial walkover surveys, geological/hydrogeological mapping and baseline monitoring of water levels in nearby public and private wells were conducted on 14th-15th December 2021, 01st December 2022, 25th April 2023, 9th August 2023 and 4th- 5th December 2023. During this time observations were made on near surface geological features including exposed or visible quaternary features such as eskers/drumlins which might affect the hydrological regime, during 5 no. site walkover surveys. Water level monitoring equipment was also installed within a selection of accessible nearby public (GWS) wells and domestic groundwater wells.

Intrusive and extrusive site investigations have been conducted between December 2021 – April 2023, to provide detail and clarity on the nature and extent of subsoils and bedrock and evidence for potential karstification of the Limestone bedrock. These include:

- 3 no. groundwater monitoring boreholes drilled at locations MW21-01, MW21-02 and MW21-03 in December 2021;
- 1 no. geophysical survey conducted in June 2022;
- A further 1 no. follow up geophysical survey was carried out in December 2022;
- 10 no. rotary core boreholes drilled between 20th March – 27th April 2023;
- 7 no. trial pits excavated by machine between 22nd March – 17th April 2023;
- 35 no. peat probes carried out along the Proposed Grid Connection underground cabling route;
- 13 no. further infiltration trial pits excavated between 20th March – 25th April with 13 no. accompanying infiltration (k) tests; and,
- 46 no. indirect CBR tests across the Proposed Project site.
- In total 230m of drilling has been completed to determine the nature of the soil, subsoil and bedrock across the Site, with targeted locations chosen, informed by the 2 no. geophysical surveys.

In addition to the above site investigation, the following is a summary of the seasonal hydrological and hydrogeological monitoring that has been undertaken, which has also aided in forming an understanding of the underlying quaternary and bedrock geology:

- Anbally GWS - 12 months of monitoring groundwater levels at 15 minute intervals;
- Ballroebuckbeg GWS - 24 months of monitoring groundwater levels at 15 minute intervals;
- Cluide Cahermorris GWS - 24 months of monitoring groundwater levels at 15 minute intervals;
- Cahermorris Glenrevagh GWS - 24 months of monitoring groundwater levels at 15 minute intervals;
- Caherlea GWS - 24 months of monitoring groundwater levels at 15 minute intervals;

- Rusheens GWS - 11 months of monitoring groundwater levels at 15 minute intervals;
- Biggeramore GWS – 21 months of monitoring groundwater levels at 15 minute intervals;
- MW21-01 - 24 months of monitoring groundwater levels at 2 hour intervals;
- MW21-02 - 24 months of monitoring groundwater levels at 2 hour intervals;
- MW21-03 - 24 months of monitoring groundwater levels at 2 hour intervals;
- Domestic Well 1 (DW1) - 24 months of monitoring groundwater levels at 2 hour intervals;
- Domestic Well 2 (DW2) - 12 months of monitoring groundwater levels at 2 hour intervals;
- Domestic Well 3 (DW3) - 12 months of monitoring groundwater levels at 2 hour intervals;
- Groundwater sampling completed at 4 no. locations in August 2023;
- Groundwater sampling completed at 4 no. locations in December 2023;
- Surface water sampling completed at 2 no. locations in August 2023;
- Surface water sampling completed at 2 no. locations in December 2023; and,
- Downloads and collation of surface water level and flow data in River Clare (2021-2023).

8.2.3 Scoping and Consultation

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

Table 8-1: Summary of Scoping Responses Relating to Land, Soils and Geology

Consultee	Description	Addressed
GSI	Our records show that there are County Geological Sites CGSs close to the proposed EIAR Site Boundary of the proposed Renewable Energy Development. - Knockmaa, Co. Galway (GR 134737, 247715), under IGH themes: IGH1 Karst, IGH3 Carboniferous to Pliocene Palaeontology, IGH7 Quaternary, IGH12 Mesozoic and Cenozoic. - Pollnahallia, Co. Galway (GR 133735, 246895), under IGH themes: IGH7 Quaternary, IGH12 Mesozoic and Cenozoic. A deep, abandoned sand pit, on the southern footslopes of the hills west of Knockmaa Hill - Knockmaa Quarries, Co. Galway (GR 136933, 248357), under IGH themes: IGH1 Karst, IGH8 Lower Carboniferous, IGH12 Mesozoic and Cenozoic. This site includes two large working quarries, side-by-side, on the southeastern slopes of Knockmaa Hill	- The County Geological Sites within the surrounding area of the Proposed Project were identified during the desk study phase, detailed in Section 8.3.6 and assessed within Section 8.5.2.5.
HSE	The Environmental Health Service recommends that a detailed Peat	- There are no underlying peat soils at the Proposed Wind Farm

Consultee	Description	Addressed
	Stability/Geotechnical Assessment of the proposed site should be undertaken to assess the suitability of the soil for the Proposed Project. The EIAR should include provision for a peat stability monitoring programme to identify early signs of potential bog slides	site, which is broadly situated on improved grassland. There are minor recorded observations of peat along the Proposed Grid Connection underground cabling route, however the peat is very superficial and shallow and this area will not be subject to any above ground works which are at risk from peat slides. › Nevertheless, intrusive investigations on the soil/subsoil type and geotechnical analysis including dynamic cone penetration testing has been undertaken at the Proposed Wind Farm site, as well as peat probing along the Proposed Underground Grid Connection Route which is included within Section 8.3.3. The potential significant effects are addressed in Section 8.5.2.4.

8.2.4 Impact Assessment Methodology

The EPA guidelines on the Information to be contained in Environmental Impact Assessment Reports (EPA, 2022) require that the baseline environment be described in terms of the context, character, significance and sensitivity of the existing environment. The description of the baseline environment is Step 5 of the information which must be included in an EIAR as per EPA 2022.

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

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

Importance	Criteria	Typical Example
Very High	Attribute has a high quality, significance or value on a regional 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.	Contaminated soil on site with previous heavy industrial usage. Large recent landfill site for mixed

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

EPA, 2022 states that there are 7 no. steps in the preparation of the EIAR. The initial steps relate to screening, scoping, the consideration of alternatives and the description of the project. Step 5 related to the description of the baseline environment which is presented in Section 8.3 for the land, soils and geological environment. Step 6 relates to the assessment of impacts and is presented in Section 8.5. The guideline criteria for the assessment of effects states that the purpose of an EIAR is to identify, describe and present an assessment of the likely significant effects. The likely effects are described with respect to their quality (positive, neutral or negative), significance (imperceptible to profound), extent (i.e. size of area or number of sites effected), context (is the effect unique 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 glossary of effects as shown in Chapter 1 of this EIAR. In addition, the two impact characteristics, proximity and probability are described for each impact and these are defined in Table 8-3.

In order to provide an understanding of this descriptive system in terms of the geological/hydrological environment, elements of this system of description of effects are related to examples of potential likely significant effects on the geology and morphology of the existing environment, as listed in Table 8-4.

Table 8-3: Additional Impact Characteristics.

Impact Characteristic	Degree/ Nature	Description
Proximity	› Direct	An impact which occurs within the area of the Proposed Development, as a direct result of the Proposed Development.
	› Indirect	An impact which is caused by the interaction of effects, or by off-site developments.
Probability	Unlikely	The effect can reasonably be expected not to occur.
	Likely	The effect can be reasonably expected to occur.

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

Impact Characteristics		Potential Geological and Hydrological Impacts
Quality	Significance	
Negative only	› Profound	Widespread permanent impact on: › The extent or morphology of a cSAC. › Regionally important aquifers. › Extents of floodplains. Mitigation measures are unlikely to remove such impacts.
Positive or Negative	Significant	Local or widespread time-dependent impacts on: › The extent or morphology of a cSAC / ecologically important area. › A regionally important hydrogeological feature (or widespread effects to minor hydrogeological features). › Extent of floodplains. Widespread permanent impacts on the extent or morphology of an NHA/ecologically important area. Mitigation measures (to design) will reduce but not completely remove the impact – residual impacts will occur.
Positive or Negative	Moderate	Local time-dependent impacts on: › The extent or morphology of a cSAC / NHA / ecologically important area. › A minor hydrogeological feature. › Extent of floodplains. Mitigation measures can mitigate the impact OR residual impacts occur, but these are consistent with existing or emerging trends
Positive, Negative or Neutral	Slight	Local perceptible time-dependent impacts not requiring mitigation.

Impact Characteristics		Potential Geological and Hydrological Impacts
Quality	Significance	
Neutral	Imperceptible	No impacts, or impacts which are beneath levels of perception, within normal bounds of variation, or within the bounds of measurement or forecasting error.

8.3 Existing Environment

8.3.1 Site Description and Topography

The Proposed Project is primarily within the townlands outlined in Chapter 1, Table 1-1. The approximate centre of the Site is located at E137055, N243681. The Site is situated within a slightly elevated area of ground (~45-60mOD) within a broader area which is generally flat to locally undulating and with elevations generally ~30mOD. The northern section of the Site extends towards Tuam along the N83 road and consists of mainly flat agricultural lands The land is mainly agricultural improved grassland, primarily used for grazing.

A site location map is included as Figure 1-1 of Chapter 1.

8.3.1.1 Proposed Wind Farm

The Proposed Wind Farm is located approximately 8 kilometres (km) southwest of Tuam, and approximately 10km north of Claregalway, Co. Galway.

It is intended to access the Proposed Wind Farm is via a temporary road which will connect the N83 Tuam-Galway National Road and the Proposed Wind Farm site, utilising existing access points and roads thereafter. This proposed entrance is located to the east of the Site, in the townlands of Pollcossaun Eighter and Pollcossaun Oughter.

A site location map of the Proposed Wind Farm site is given in Figure 4-2 of Chapter 4.

8.3.1.2 Proposed Grid Connection

The Proposed Grid Connection will connect to the proposed onsite 110kV substation. It is proposed to then connect this onsite 110kV substation to the existing 110kV Cloon Substation via 14.3km long underground electrical cabling. The Cloon 110kV Substation is located approximately 6.1km northeast of the Proposed Wind Farm site.

A site location map of the Proposed Grid Connection underground cabling route is given in Figure 4-3 of Chapter 4.

8.3.2 Land and Landuse

8.3.2.1 Proposed Wind Farm

Landuse at the Proposed Wind Farm site is generally agricultural, under grass pasture and used mainly for grazing of sheep and cattle. Small areas of scrub land exist towards western section of the Proposed Wind Farm site near the proposed Turbines T2 and T3. The Proposed Wind Farm infrastructure is located on land used for grassland pastures.

8.3.2.2 Proposed Grid Connection

The Proposed Grid Connection underground cabling route constitutes a 14.3km route from the proposed onsite 110kv substation within the Site, along the L61461 Local Road and N83 National Road and L6141 Local Road before its final termination point at the existing Cloon 110kV substation.

Landuse along the Proposed Grid Connection route underground cabling route is broadly road carriageway with occasional pedestrian paving along the road margins.

8.3.3 Soils and Subsoils

8.3.3.1 Proposed Wind Farm

A map of the local subsoil cover is included as Figure 8-1. This shows the mapped distribution of subsoil deposits around the Proposed Wind Farm site. The majority of the Proposed Wind Farm site is mapped by the GSI as being overlain by Limestone Tills, with smaller areas mapped as Kartsified bedrock outcrop or subcrop. Turbine T1 and Turbine T7 are located on areas mapped as Karstified bedrock or subcrop.

Published soils maps (www.epa.ie) were queried for data on mapped soils across the Proposed Wind Farm site. Deep well drained basic mineral soils (BminDW) are the dominant soil type at the Site and in the local area with smaller pockets of shallow well drained mineral soil (BminSW) mapped on higher elevations. There is no peat mapped at or locally to the Proposed Wind Farm site.

Subsoils have been logged within the 10 no. rotary core boreholes (refer to Table 8-5), and during the drilling of the 3 no. groundwater monitoring wells (as well as the trial pit and infiltration test trial pits discussed below). Throughout the drilling, the subsoils are generally described as soft to firm brown clays, with some sand and gravel within the clay matrix, but generally low cobble and boulder content. The subsoils range in depth between 1.75-5.85mbgl within the 10 no. rotary core boreholes and 1.1-16.5mbgl in the groundwater monitoring wells (MW21-01-MW21-03).

The mean depth of subsoil across the 13 no. locations is 3.8m, with a standard deviation of 2.94m. The depth of subsoils across the Proposed Wind Farm site is shown graphically within the histogram in Plate 8-1, showing the frequency of observation of subsoils within 2 metre ranges (bins). In terms of the assessment of groundwater vulnerability, this depth of subsoil broadly puts the Proposed Wind Farm site within the "high" groundwater vulnerability classification, in line with the local and regional scale mapping.

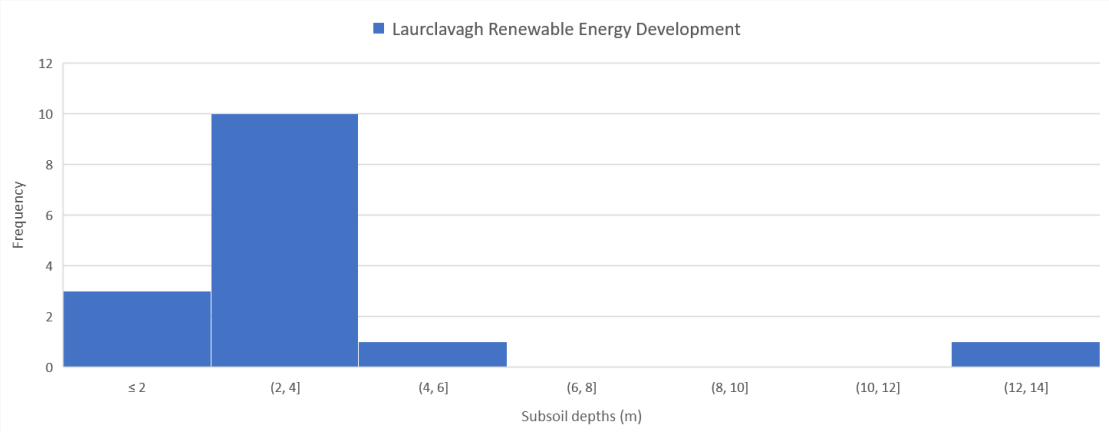


Plate 8-1: Histogram of subsoil depths across the Proposed Wind Farm Site (from borehole data)

The 8 no. trial pits and 14 no. infiltration trial pits also provide detail on the subsoils underlying the Site. Topsoil is described between 0.2-0.3mbgl, occasionally with rootlets. This is generally underlain by firm, orange-brown, sandy to gravelly clay, however some boulder clays do occur (ITP03, and TP05). The depths of the trial pits range between 1.0-3.5m. 5 of the 8 no. trial pits were terminated on "possible bedrock, (with) no groundwater encountered". The termination of all 13 no. infiltration pits was described as "No groundwater encountered, soakaway test completed. Terminated on possible bedrock".

Spoil management areas will be incorporated as part of the development design. These management areas are shown in Figure 8-2 and discussed in Section 8.5.2.2 of this chapter and Section 4.3.3 of Chapter 4.

The borehole and trial pit logs are included in Appendix 8-2, along with photographs of the trial pits and core samples. A map of intrusive site investigations is shown in Figure 8-3.

Table 8-5: Summary of geological logs from site investigation boreholes

Location	Lithological Summary Information
RC01	Soft brown slightly sandy CLAY to 3.5m, GRAVEL from 3.5-4m, Medium strong light grey LIMESTONE. Moderately weathered from 4-10.5m
RC02	Firm brown CLAY to 1.2m, Loose grey cobbles and boulders from 1.2-1.75m, Grey angular limestone GRAVEL to 2.5m, Strong dark grey LIMESTONE with white calcite veins - slightly weathered from 2.5-10m
RC03	Brown CLAY, low cobble and boulder content to 1.2m, Dense grey GRAVEL to 2.7m (possibly weathered bedrock), Strong thickly laminated dark grey LIMESTONE, slightly weathered from 2.7-10m
RC04	Firm brown CLAY to 3.5m, Dense greyish brown fine to medium GRAVEL (possibly weathered bedrock) from 3.5-4.5m, Medium strong to strong dark grey LIMESTONE with white calcite mineralisation from 4.5-10m
RC05	Stiff brown CLAY to 1.2m, Dense brownish grey GRAVEL from 1.2-2.3m, Strong thickly laminated greyish brown LIMESTONE, slightly weathered from 2.3-10m
RC06	Soft brown CLAY to 2.25m, GRAVEL (weathered bedrock) from 2.25-3m, Strong dark grey LIMESTONE with white calcite veins - slightly weathered from 3-10m
RC07	Soft brown CLAY with GRAVEL and SAND to 5.85m, Strong dark grey LIMESTONE with white calcite veins - slightly weathered from 5.85-10m
RC08	Brown CLAY, low cobble and boulder content to 1.2m, dense grey cobbles and boulders to 2.5m, Strong very thinly laminated light grey dolomitised LIMESTONE, moderately weathered from 2.5-10m
RC09	Soft brown CLAY to 3.0m, Strong dark grey LIMESTONE with white calcite mineralisation throughout from 3-10m
RC11	Brown CLAY to 1.2m, Grey GRAVEL and boulders (possibly weathered bedrock) from 1.2-3.5m, Strong thickly laminated brownish grey LIMESTONE, slightly weathered from 3.5-10m
MW21-01	Firm brown TOPSOIL over SAND and GRAVEL to 1.1m, Medium strong weathered grey LIMESTONE to 12m, very hard Limestone from 12-55m.
MW21-02	Firm brown TOPSOIL to 0.3m, Firm to stiff brown silty gravelly CLAY to 13.2m, weak Limestone from 13.2 – 18.8m, hard Limestone from 18.8-24m
MW21-03	Hardcore fill brownish grey sandy gravelly made ground to 0.2m, TOPSOIL from 0.2-0.4m, dense SAND and GRAVEL to 2.5m, very hard Limestone from 2.5-49.6m

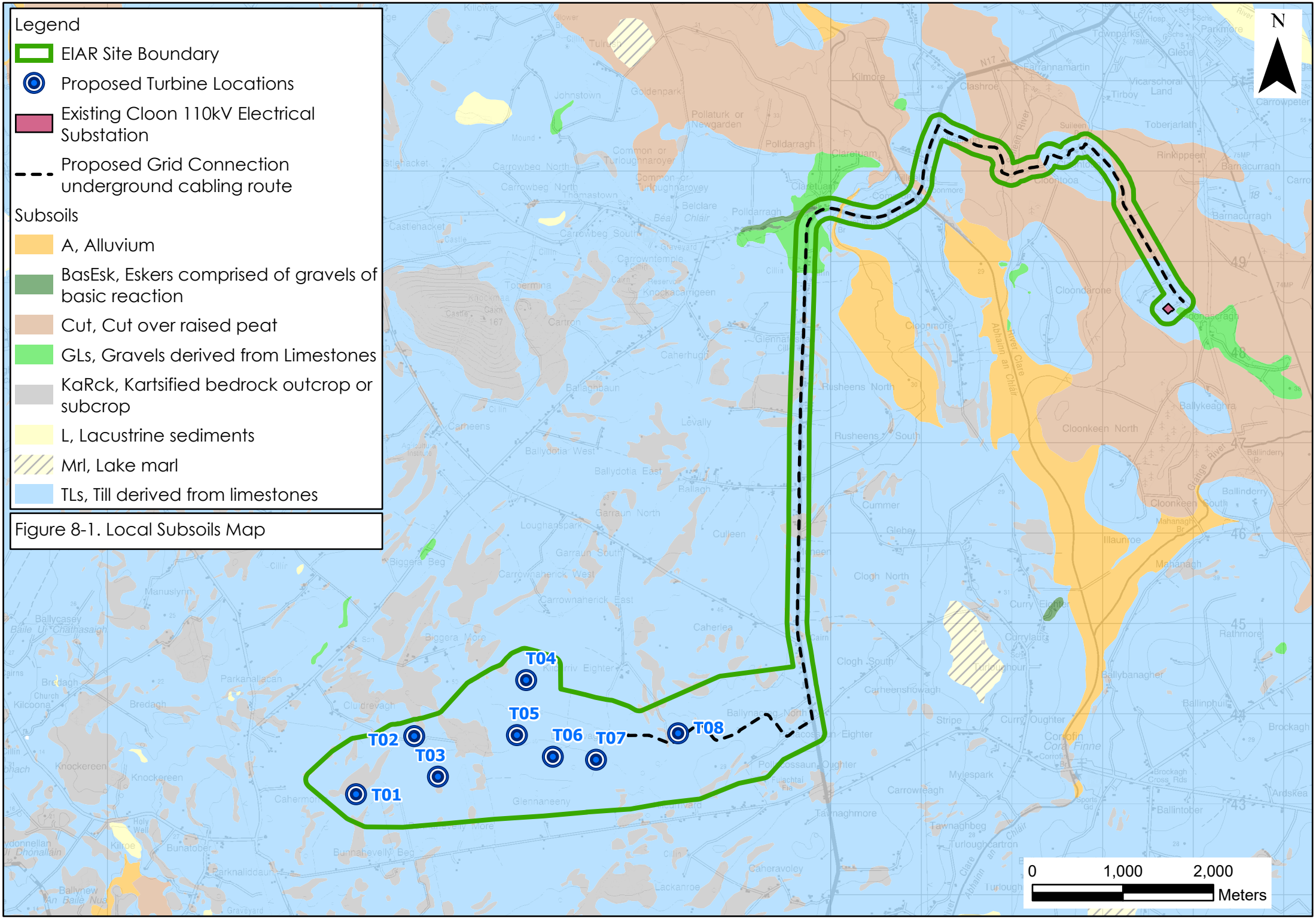


Figure 8-1. Local Subsoils Map

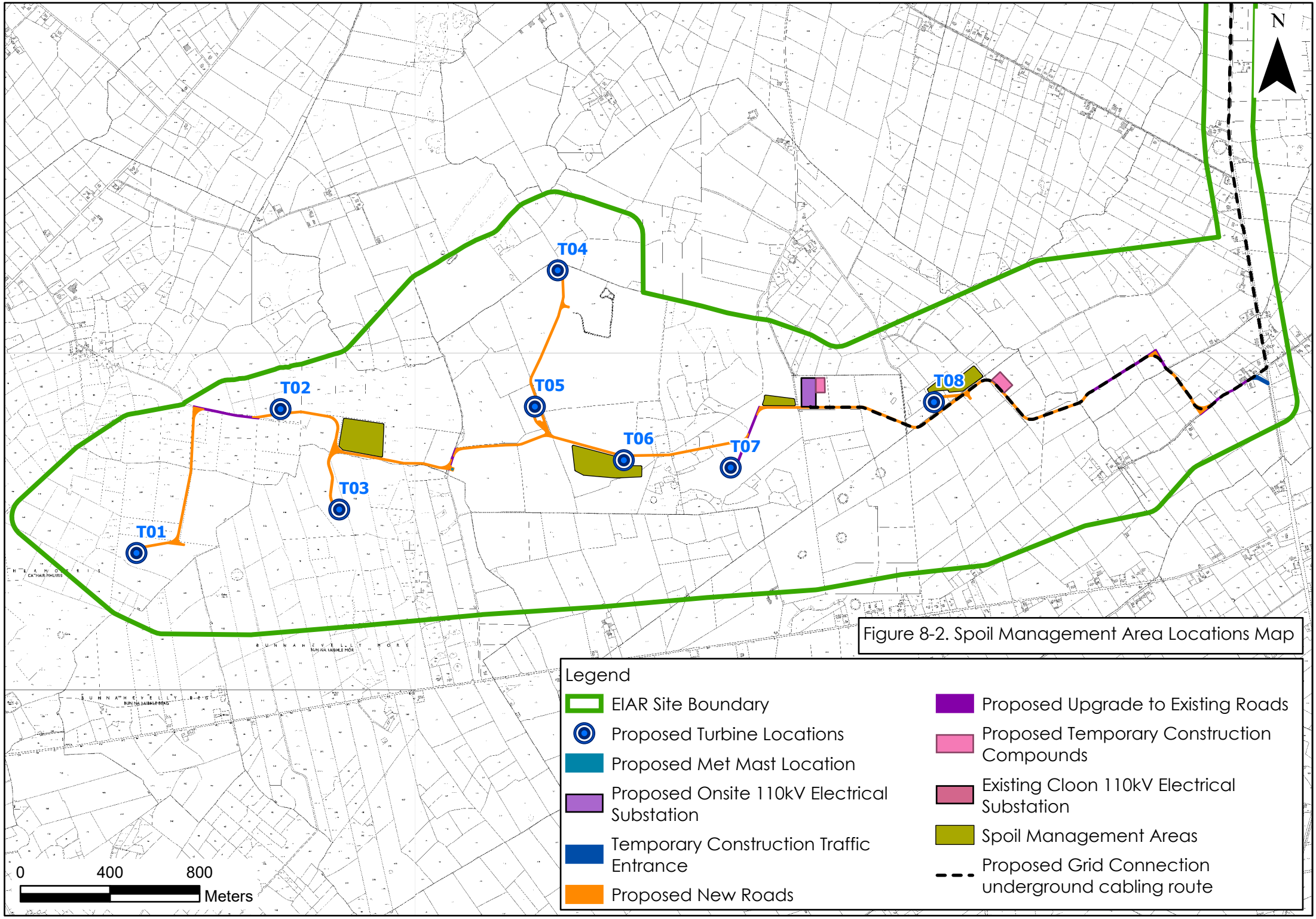


Figure 8-2. Spoil Management Area Locations Map

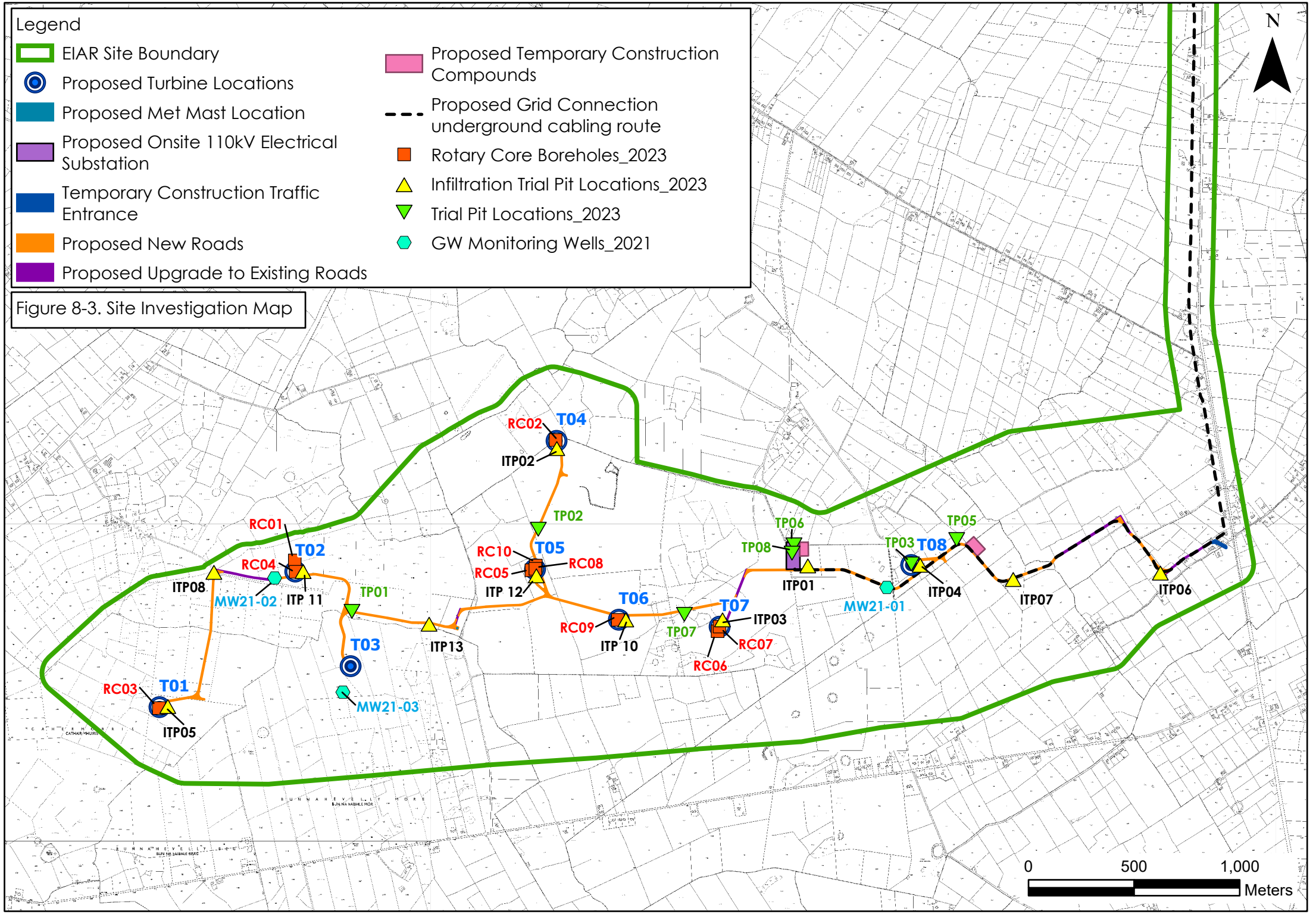


Figure 8-3. Site Investigation Map

8.3.3.2 Proposed Grid Connection

Soils along the Proposed Grid Connection underground cabling route are broadly mapped as deep, well drained mineral soils (BminDW), with occasional pockets of shallow, well drained mineral soils (BminSW). Towards the north and northeast of the Proposed Grid Connection underground cabling route, there are peat soils mapped near the N83 road and by local roads located in the townlands of Cloontoa and Cloondarone, however these have already been cut through by the existing roadways.

Where peat soils have been mapped, peat probing has been completed along the Proposed Grid Connection underground cabling route to determine the depth and nature of the peat soils. 35 no. peat probes were carried out along the Proposed Grid Connection underground cabling route.

The 35 no. peat probes were conducted at locations shown on Figure 8-4. The peat depths recorded range between 0.1-0.7m, with an average depth of 0.23m. As such, it is considered that much of the peat in these areas has been cut-over and removed (as supported by the subsoil mapping of "cut-over peat". As expected, the cutting through of the existing roads has removed much of the peat along the route, with only minor depths of less than 0.7m remaining in the roadside verges.

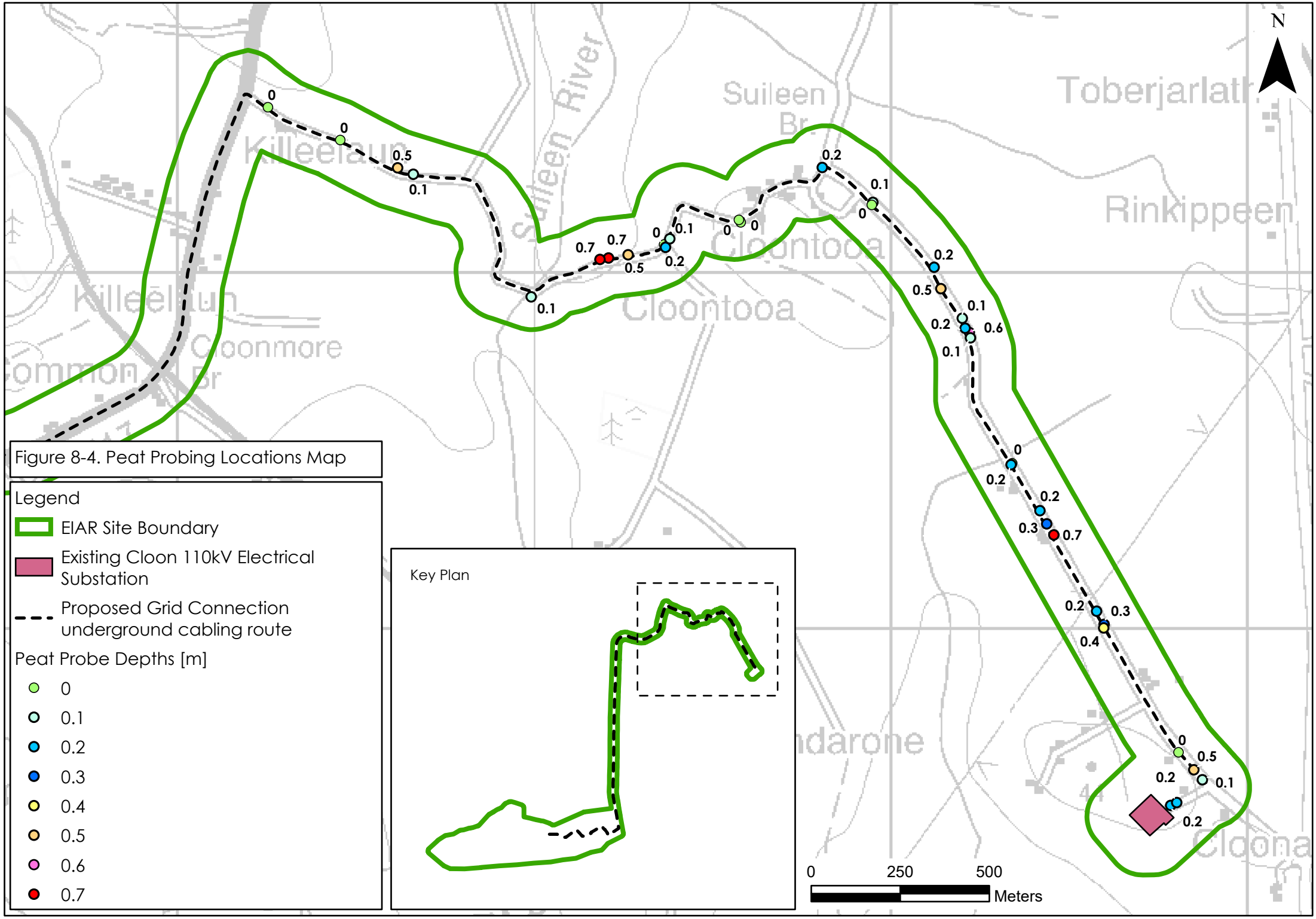


Figure 8-4. Peat Probing Locations Map

Legend

- EIAR Site Boundary
- Existing Cloon 110kV Electrical Substation
- Proposed Grid Connection underground cabling route

Peat Probe Depths [m]

- 0
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 0.6
- 0.7

8.3.4 Bedrock Geology

8.3.4.1 Proposed Wind Farm

Bedrock geology across the Proposed Wind Farm site is mapped as Burren Formation Limestone, which consist of pale grey, clean skeletal Limestone. The formation is typified by pale-grey packstones and wackestones, but also contains intervals of dark cherty limestones, often associated with oolitic grainstones. There is some bedrock outcrop mapped across the Site and in the surrounding area. The bedrock is mapped as dipping at 3° to the southeast. The local geological map of the area is shown as Figure 8-5.

The bedrock geology has been further described through intrusive investigation, including the drilling of the 10 no. rotary core boreholes, the 3 no. rotary (DTH) groundwater monitoring wells, as well as information contained within the logs of the 8 no. trial pits and 13 no. infiltration trial pits.

Bedrock was encountered in all 10 no. rotary core boreholes at depths ranging between 1.75 – 5.85mbgl. Bedrock at MW21-01 to MW21-03 was encountered at 1.1m, 13.2m and 2.5m respectively. The bedrock is described as medium-strong light grey to dark grey Limestone, which is moderately weathered in parts. The bedrock geology is outlined within Table 8-5. The original logs are included within Appendix 8-1, In general, the bedrock encountered during the intrusive site investigations is consistent with the mapped geology.

The bedrock geology has been further described through intrusive investigation, including the drilling of the 10 no. rotary core boreholes, the 3 no. rotary (DTH) groundwater monitoring wells, as well as information contained within the logs of the 8 no. trial pits and 13 no. infiltration trial pits.

Two geophysical surveys have been carried out at the Proposed Wind Farm site, completed by Apex Geophysics Ltd. in June 2022 and December 2022. The initial survey included 18 no. ERT surveys, 18 no. seismic refraction profiles (S1-S18) and 18 no. 1D MASW profiles.

The follow up survey included a further 11 no. of ERT surveys, 11 no. seismic refraction profiles and 11 no. 1D MASW profiles.

The geophysics broadly aligns with the findings of the intrusive site investigations. Thin subsoils are present across the geophysical profiles, overlying a layer of moderately weathered bedrock, over competent Hard Limestone. The results of the geophysical survey are detailed further in Section 8.3.9.

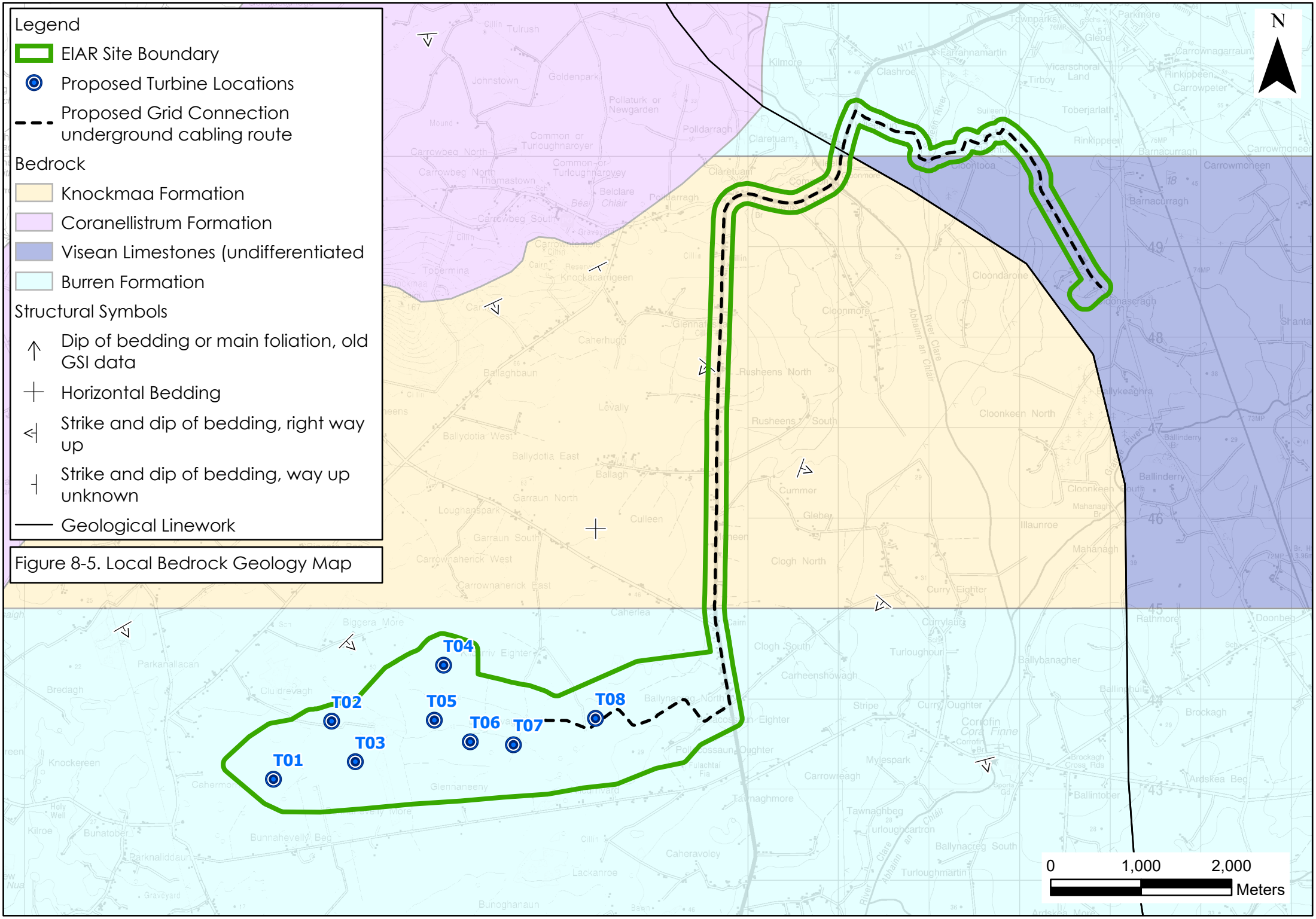


Figure 8-5. Local Bedrock Geology Map

8.3.4.2 Proposed Grid Connection

The bedrock geology mapped along the grid route is generally mapped within the Knockmaa Formation Limestones, described by the GSI as Thick-bedded, pale grey, clean limestone similar to that in the Coranellistrum Formation. The northeastern section of the Proposed Grid Connection underground cabling route is mapped within an area of undifferentiated Visean Limestone and the Burren Limestone Formation.

No deep, intrusive investigations, such as rotary core boreholes were carried out along the Proposed Grid Connection underground cabling route, due to the depth and nature of the excavation (a ~1.3m deep trench, cut and backfilled). Due to the shallow nature of the cabling route works, peat probes were determined to provide the required data in relation to the potential effects on the land, soils and geology along the proposed route.

8.3.5 Geological Resource Importance

There is 1 no. active quarry, Mortimers Quarry mapped ~ 4km north of the Proposed Wind Farm site where the Limestone bedrock is extracted and crushed for aggregate material. The Limestone bedrock in the area is considered to be of moderate to high resource importance.

There are several mapped mineral localities north of the Proposed Wind Farm site, near Mortimers Quarry. Micrite is mapped and referred to as a source of dimension stone. There are no mineral localities mapped within the Proposed Wind Farm site or along the Proposed Grid Connection underground cabling route.

The GSI online Aggregate Potential Mapping Database shows that the Proposed Wind Farm site is not located within an area mapped as containing granular aggregate potential. The Proposed Wind Farm site is mapped as having “Very High Potential” in terms of crushed rock aggregate potential.

Crushed rock aggregate potential along the Proposed Grid Connection underground cabling route is broadly mapped as being of moderate to high resource potential.

Granular aggregates are mapped towards the north of the Proposed Grid Connection underground cabling route.

8.3.6 Geological Heritage and Designated Sites

8.3.6.1 Proposed Wind Farm

There are no recorded Geological Heritage sites, mineral deposit sites or mining sites (current or historic) within the Proposed Wind Farm site. The Knockmaa CGS (GY082) is located ~2km north of the Proposed Wind Farm site and it is a geological heritage site. The Knockmaa geological heritage site is described by the GSI as "*A large area of landscape with glacial deposits which have slightly modified a much older landscape".* The landscape does not extend past the local road which is mapped ~2km north of the Proposed Wind Farm site.

Within the boundary of the Knockmaa geological heritage site, two further geological heritage sites are defined. The Pollnahallia CGS (GY116) is situated towards the southwest of the Knockmaa geological heritage site and consists of "A deep, abandoned sand pit, on the southern footslopes of the hills west of Knockmaa Hill". Towards the northeast of the Knockmaa geological heritage site, the Knockmaa Quarries (GY083) is mapped, consisting of "Two large working quarries, side-by-side, on the southeastern slopes of Knockmaa Hill".

The Proposed Wind Farm site is not located within any designated site. The nearest SAC is the Lough Corrib SAC which is located ~5.1km east of the Proposed Wind Farm site and ~6.5km west of the Site also. East of the Site, the boundaries of the Corrib SAC extend along the River Clare.

There are several turloughs, which are listed as pNHA's located to the north and northwest of the Proposed Wind Farm site. Belclare and Killower turlough as well as Turlough O'Gall are situated between 5-7km north of the Site, while Turlough Monaghan, Turlough Cor and Lough Hackett are mapped between 3-7km west/northwest of the Proposed Wind Farm site. Designated sites near the Proposed Wind Farm site are listed in Table 86.

Table 8-6: Designated sites near the proposed Wind Farm site

Site	Designations	Distance from Proposed Wind Farm
Lough Corrib SAC	SAC	5.1km east
	pNHA	
	SPA	
Belclare Turlough	pNHA	5km north
Killower Turlough	pNHA	6.5km north
Turlough O'Gall	pNHA	6.5km north
Turlough Monaghan	pNHA	3.3km northwest
Turloughcor	pNHA	5.5km west
Lough Hackett	pNHA	6.9km northwest

A Geological heritage sites map is included as Figure 8-6 and a designated sites map is included as Figure 8-7.

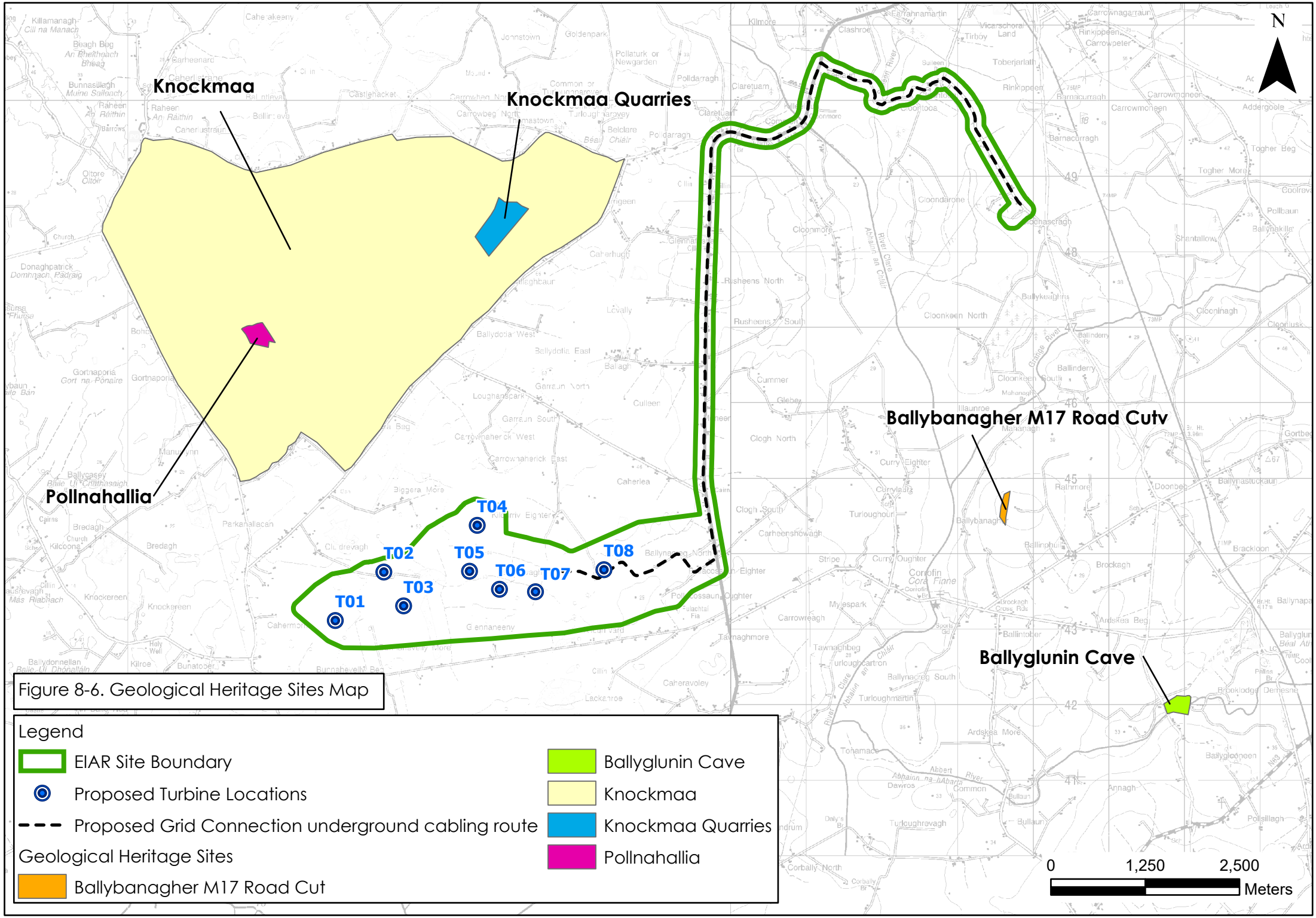


Figure 8-6. Geological Heritage Sites Map

Legend

- EIAR Site Boundary
- Proposed Turbine Locations
- Proposed Grid Connection underground cabling route

Geological Heritage Sites

- Ballybanagher M17 Road Cut
- Ballyglunin Cave
- Knockmaa
- Knockmaa Quarries
- Pollnahallia

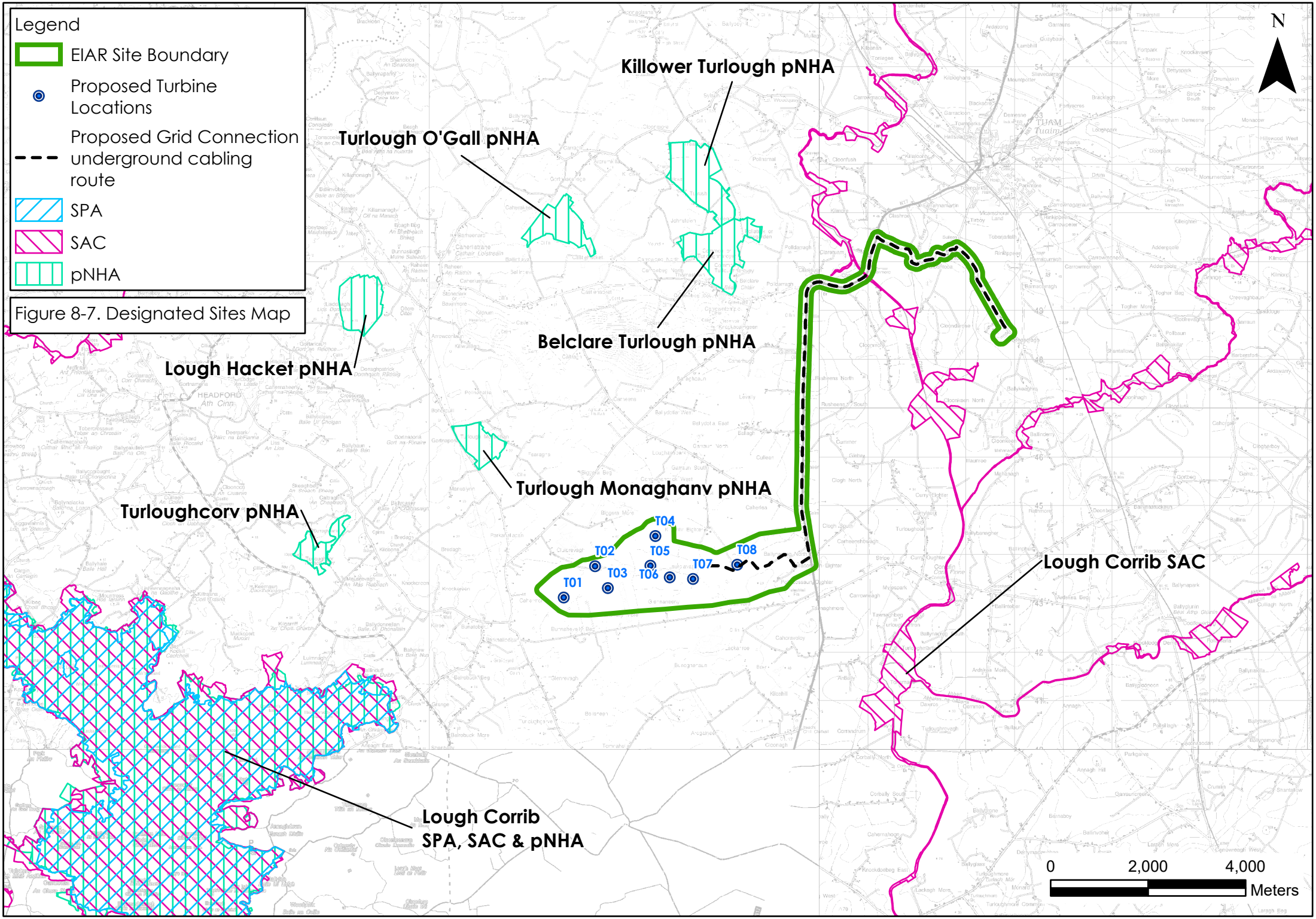


Figure 8-7. Designated Sites Map

8.3.6.2 Proposed Grid Connection

There is one designated site situated along the Proposed Grid Connection underground cabling route, where the River Clare, mapped as part of the Lough Corrib SAC is crossed at Cloonmore bridge (~3.1km southwest of Tuam). This location can be seen in Figure 8-7, towards the northern section of the Proposed Grid Connection underground cabling route.

There are no geological heritage sites along the route of the Proposed Grid Connection underground cabling route.

8.3.7 Soil Contamination

8.3.7.1 Proposed Wind Farm

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

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

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

8.3.7.2 Proposed Grid Connection

There are no known areas of soil contamination along the Proposed Grid Connection underground cabling route. During the site walkover of this area, no areas of contamination concern were identified.

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

8.3.8 Geohazards

8.3.8.1 Slope Stability

8.3.8.1.1 *Proposed Wind Farm*

There are no landslide areas or events mapped within the area of the Proposed Wind Farm site on the GSI Landslide events online mapping viewer. The area is mapped as Low on the Landslide susceptibility classification (GSI). The site investigation data indicates that there are no peat soils present at the Proposed Wind Farm site. The overburden is typically sandy gravelly clay.

8.3.8.1.2 *Proposed Grid Connection*

There is 1 no. historic landslide mapped within an area of cut peat ~ 1.6km northwest of the existing Cloon 110kV substation situated in the townland of Cloondarone at the termination point of the Proposed Grid Connection underground cabling route (~5km northeast of the Proposed Wind Farm site), which dates back to 1909 recorded in Feehan “The Bogs of Ireland”. There was no apparent impact recorded as a result of this event.

8.3.8.2 Peat Soils

8.3.8.2.1 *Proposed Wind Farm*

No peat is recorded at the Proposed Wind Farm site, either from desk study sources, or from the significant number of site investigation points completed as part of this study.

8.3.8.2.2 *Proposed Grid Connection*

Towards the north and northeast of the Site along the Proposed Grid Connection underground cabling route, there are peat soils mapped. Peat probing was completed at 35 no. locations along the relevant sections of the route. The depth of peat ranges between 0-0.7m, with an average depth of 0.23m. As the Proposed Grid Connection underground cabling route will be installed within a trench ~1.3m deep predominantly with the public road corridor, any peat soils encountered will only occur within the top section of the trench and the trench.

8.3.8.3 Karst

Karst features are mapped by the GSI and available through the GSI online viewer. There are several karst features mapped near the Proposed Wind Farm site. The closest mapped karst feature is a spring, situated between T7 and T8. There are also 3 no. depressions and a cave mapped ~0.8km south of the southwestern corner of the Proposed Wind Farm site.

The spring between T7 and T8 has been investigated during the walkover surveys of the Proposed Wind Farm site. There have been recent excavations near the spring, to extract aggregates for farm roads. This has created a number of pits whereby the soil/subsoil can be examined. Photographs of these pits are included as Photos 9-11 of Appendix 8-2, which show the gravel deposits surrounding the mapped spring. As the water level in the pit sits ~20m above the typical water level in MW21-02, and the spring itself is surrounded by these gravel deposits, the spring is considered to be related to the overlying sand/gravel deposits rather than being a Limestone karst spring. This spring is further detailed in Section 9.3.7.4 of Chapter 9 in terms of the groundwater flow at the spring site.

Further away (2.5-5km) from the Proposed Wind Farm site, turloughs are mapped to the north and east, particularly near the eastern edge of Lough Corrib. In general the mapped karst feature to the west/northwest of the Proposed Wind Farm site are turloughs and springs, whereas localised depressions are mapped predominantly to the east and northeast of the Proposed Wind Farm site. Mapped karst features (GSI) near the Proposed Wind Farm site are shown on Figure 8-8.

During walkover surveys conducted between December 2021-December 2023, no karst features were observed across the Proposed Wind Farm site. During a walkover survey in December 2023, 2 no. areas of standing water were observed, however the hydrochemistry of this water demonstrated a low conductivity (98.3µS/cm) unlike the local groundwater conductivity (440-550µS/cm) indicating it was not groundwater at the surface (*i.e.* a turlough) but rainfall which had ponded.

There are minor karst depressions situated within fields adjacent to the N83 road, along the Proposed Grid connection underground cabling route. There is also 1 no. turlough mapped towards the north of the underground cabling route. Historical mapping of this turlough, as well as GSI groundwater flooding maps, show the extent of the turlough does not reach the road carriageway.

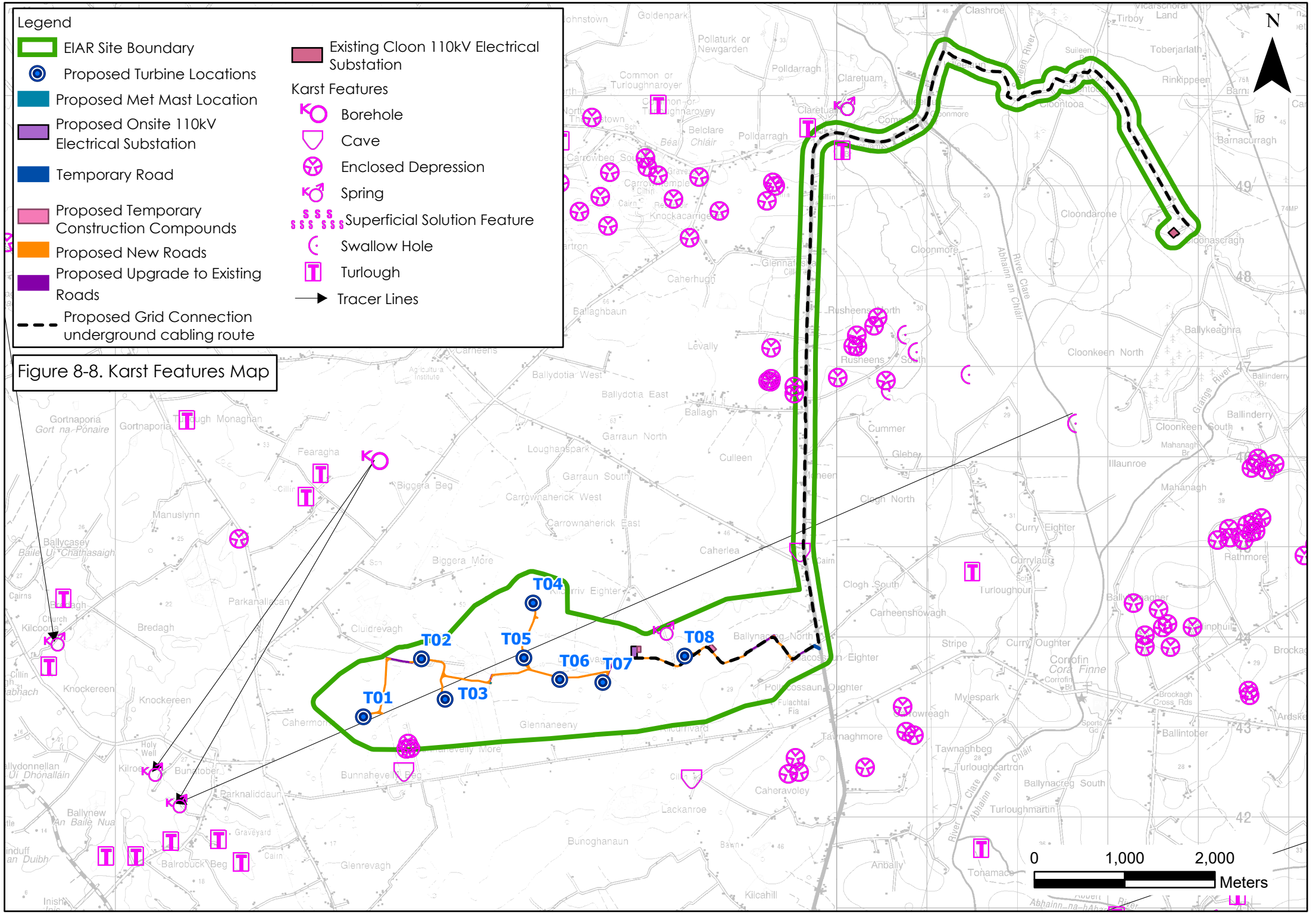


Figure 8-8. Karst Features Map

8.3.9 Geological Site Model

A geological site model is detailed below, which incorporates the various intrusive site investigation (trial pits, infiltration trial pits and borehole drilling) along with the 2 no. geophysical surveys performed at the Proposed Wind Farm site and builds a conceptual understanding of the underlying geology at the Site.

The geology of the Site, which is detailed further below in Table 8-8

Table 8-8 can be summarised as follows:

- There is no peat present at the Proposed Wind Farm site;
- There are shallow soils/subsoils across the Proposed Wind Farm site, which are derived from Limestone parent material and are typically 0.5 - 2.0m thick but extend to ~3 – 4m depth in parts. The only exception to this is at MW21-02, which encountered 13.2m of silty gravelly clay. This borehole is situated ~100m from the nearest turbine (T02) and was avoided during iterative design. The bedrock at T02 is Limestone met at 3.5m with harder Limestone met at 4.5m;
- The soil/subsoil is underlain by a layer of typically moderately weathered Limestone which generally exists within the top 1-3m of the Limestone bedrock; and,
- Below this zone of moderate weathering, the Limestone bedrock becomes hard and competent. No evidence of wide scale karstification was observed.

As part of the design process for the Proposed Project, numerous intrusive and non-intrusive site investigations were undertaken across the Proposed Wind Farm site, to provide detail and clarity on the nature and extent of subsoils and bedrock as a means of characterising the Proposed Wind Farm site and provide information on the limestone bedrock. This assisted in providing additional information on the most suitable location for turbines and associated infrastructure.

Apex Geophysics Ltd carried out a Phase 1 Geophysical Investigation on the Proposed Wind Farm site, with the purpose being to assess the sub-soil conditions at the proposed turbine bases and at the proposed onsite 110kV substation location. The objectives of the geophysical investigation were to provide information on soil type, thickness and stiffness, depth to and type of bedrock, weathering and excitability of the bedrock, to identify potential karst features and fault/fissure zones within the bedrock and to propose locations for intrusive investigations.

The Phase 1 Geophysical Investigation was carried out between the 9th and 12th May 2022. Based on the results of the Phase 1 Geophysical Investigation, recommendations were made for the completion of specific intrusive direct investigations, which were completed.

Apex Geophysics Ltd. Subsequently conducted a Phase 2 geophysical investigation for the Proposed Project between the 29th September and 21st November 2022. The purpose of this Phase 2 survey was to assess the subsoil conditions at 6 no. of the proposed turbine bases. The objective of the geophysical investigation were the same as that of the Phase 1 Geophysical assessment. The results of the above-mentioned site investigation works incorporated into the study methodology for the Phase 2 geotechnical assessments. The geophysical investigation consisted of 2D Electrical Resistivity Tomography (ERT), Seismic Refraction profiling and Multi-channel Analysis of Surface Waves to examine the subsoil conditions at 6 no. turbine bases.

The results of the first geophysical survey and the interpretation of the data collected are summarised below in Table 8-7. The survey lines completed are included in Figure 8-9.

Table 8-7: Summary of Geophysical Survey Data (Survey 1)

Location	Soils	Bedrock geology	Other
Turbine Base T1	› 0.4 – 1.3m soft loose soil over 0.5-2.4m medium dense soil – getting dense for 0.5 – 0.8m. › Soil Type: Interpreted as clayey silty sand/gravel with small area of sandy gravelly clay.	Limestone bedrock interpreted 0.7m – 3.7m bgl (1.5m at turbine centre).	
Turbine Base T2	› 0.7 to 4.0m of soft/loose soil. › Soil Type: Primarily sandy gravelly clay and small areas of silty sand/gravel.	Limestone bedrock interpreted at 2mbgl of turbine centre.	
Turbine Base T3	› 0.3 – 0.9m of loose soil over 0.3 – 1.6m medium dense soil. Becoming dense in places for 0.1 to 1m. › Soil Type: interpreted as clayey silty sand/gravel.	Limestone bedrock interpreted at 0.7m to 3m bgl (1.8m below at turbine centre).	
Turbine Base T4	› Interpreted as comprising of 0.4m to 1.4m of loose soil over an intermittent layer of medium dense soil up to 0.3 – 1.5m thick. › Soil Type: Interpreted to be clayey silty sand/gravel.	Limestone bedrock is interpreted at depths of 0.4 m to 5.2 m bgl (2 m at the turbine centre).	
Turbine Base T5	› Interpreted as comprising of 0.2 – 1.8m loose soil Soil Type: Interpreted primarily as clayey silty sand/gravel	Limestone bedrock is interpreted to be 0.4m.	
Turbine Base T6	› Interpreted as compromising of 0.4 – 2.4m loose soil. › Soil Type: Interpreted as clayey silty sand/gravel		

Location	Soils	Bedrock geology	Other
Turbine Base T7	› Interpreted as compromising of 0.2 to 0.5m soft/loose soil over 0.7 – 1.1m firm/medium dense soil becoming dense for 0.5 – 2.1m. › Soil is interpreted primarily as clayey silty sand/gravel.	Limestone bedrock has been interpreted at depths of 1.6 – 3.4mbgl (2.2m at turbine centre).	
Turbine Base T8	› Interpreted as compromising of 0.1 – 1m soft/loose soil over 0.4 – 1.4m firm/medium dense soil. 0.2 – 2.6m of dense soil becoming very dense in places.. › Soil is interpreted primarily as clayey silty sandy gravel.	Limestone bedrock has been interpreted at depths of 1.2 – 5.5mbgl (4.2m at turbine centre).	
Substation	› Interpreted as compromising of 0.3 – 1.4m soft/loose soil, 0.7 – 1.4m firm/medium dense soil over 1.4 – 2m stiff/dense soil over 1.6 – 2.2m of very dense soil. › Soil is interpreted primarily as clayey silty sandy gravel.	Limestone bedrock has been interpreted as 1.3 – 3.8m of moderately to slightly weathered limestone.	

The results of the second updated geophysical survey, completed between 29th September to 21st November 2022, and the interpretation of the data collected, are summarised below in Table 8-8. A map of the geophysical survey lines is included as Figure 8-10.

Table 8-8: Summary of Geophysical Survey Data (Survey 2) and Site Investigations

Location	Soils	Bedrock geology
Turbine Base T1a	› 0.3m – 0.8m thick of loose soil interpreted over an intermittent layer of medium dense soil up to 3.3m thick. › Soil Type: Interpreted as clay silty sand/gravel.	Limestone bedrock interpreted 0.4m – 3.8m bgl (0.4m at turbine centre).
Turbine Base T2a	› 0.2m – 2.4m of soft/loose soil interpreted over an intermittent layer of firm/medium dense soil up to 3.2m thick becoming stiff/very stiff and dense/very dense with depth. › Soil Type: Interpreted as sandy gravelly clay with a small amount of clayey silty sand west of the base.	Limestone bedrock interpreted at depths of 0.9m – 7.7m (2.2m below the turbine centre).
Turbine Base T4a	› Intermittent layer of loose soil 0.7m thick over 0.5m to 2.6m of medium dense soil. › Soil Type: interpreted as clayey silty sand/gravel.	Limestone bedrock interpreted at 0.9m to 7.7m bgl (2.2m below at turbine centre).
Turbine Base T5a	› Interpreted as comprising of 0.2m to 0.6m of loose soil over an intermittent layer of medium dense soil up to 0.4m thick. › Soil Type: Interpreted to be clayey silty sand/gravel.	Limestone bedrock is interpreted at depths of 0.3 m to 1.0 m bgl (0.8 m at the turbine centre).
Turbine Base T6a	› Interpreted as comprising of 0.3m to 1.0m of soft/loose soil over firm/medium dense soil becoming stiff-very stiff/dense-very dense with depth. Soil Type: Interpreted primarily as clayey silty sand/gravel with a small area of sandy gravelly clay close to the turbine centre.	Undulating limestone bedrock has been interpreted at depths of 0.87m to 7.8m bgl (6.8m bgl at the turbine centre).
Turbine Base T7a	› Interpreted as compromising of an intermittent layer of loose soil up to 1.55m thick over a layer of 0.7m to 3.9m of firm/medium dense soil becoming dense with depth.	Limestone bedrock has been interpreted at depths of 0.8m to 3.9m bgl, (0.8m at turbine centre).

Location	Soils	Bedrock geology
	› Soil Type: Interpreted as clayey silty sand/gravel with a small area of sandy gravelly clay east of the turbine centre.	

Location	Drilling Results
Turbine Base T1a	Drilling at RC-03 demonstrates strong, thickly laminated grey Limestone from 2.7-10m (slightly weathered)
Turbine Base T2a	Drilling at RC04 (demonstrates Medium-Hard Limestone from 4.5-10m. Drilling at T01 (50m north of T2 – Clay to 3.5m, Gravel from 3.5-4.0m, Medium strong light grey Limestone, moderately weathered from 4m.
Turbine Base T4a	Drilling at RC-02 demonstrates strong dark grey Limestone from 2.5-10m
Turbine Base T5a	Drilling at borehole RC-11 demonstrates strong thickly laminated brownish grey Limestone from 3.5-10m (slightly weathered)
Turbine Base T6a	Drilling at RC-09 demonstrates strong dark grey Limestone bedrock from 3.0-10m
Turbine Base T7a	Drilling at RC-07 demonstrates strong dark grey Limestone at 5.85m

The ground conditions at the turbine bases are summarised below in relation to the 2 no. Apex geophysical surveys (Appendix 4-2 and 4-3) along with information from the intrusive site investigations (Appendix 4-4):

- Turbine T1 – Geophysics interpreted overburden up to 3.3m thick over competent Limestone bedrock below. Drilling at RC03 (T1) encountered brown clay to 1.2m, gravel from 1.2-2.7m and hard grey Limestone at 2.7m. Core photos show competent dark grey Limestone from 2.7m to the base of the hole at 10m. All data indicate competent hard Limestone underlying the turbine base;
- Turbine T2 – Geophysics interpreted up to 3.2m of overburden over Limestone bedrock, as well as an area of highly weathered Limestone ~50m north of the turbine base. Drilling at RC04 (T2) recorded clay to 3.5m, Gravel from 3.5-4m and medium-hard Limestone from 4m. The core photos from RC04 indicate competent grey Limestone underlying the turbine base. A further rotary core borehole was drilled 50m north of T2 (RC01) which encountered clay to 3.5m, gravel from 3.5-4.0m and medium strong, light grey Limestone, moderately weathered from 4m. This

Limestone is slightly more weathered than that observed at RC04, however no groundwater was met within this weathered Limestone;

- Turbine T3 – The results of the geophysics from the first geophysical survey (June 2022) indicate up to 1.6m of medium dense soil over Limestone bedrock from between 0.7-3.0 mbgl. During the drilling at MW21-03 (100m southwest of T3), very hard Limestone was met at 2.5mbgl and throughout the subsequent drilling to a completed depth of 49.6m (refer to Table 85). All site data near Turbine T3 indicate competent Limestone underlying the turbine base;
- Turbine T4 – Geophysics was carried out at turbine T4 which indicated up to 2.6m of dense subsoil, underlain by Limestone bedrock at 2.2mbgl at the turbine base centre. The drilling at borehole RC02 described firm clay to 1.2m, followed by cobbles and angular gravel to 1.75m which may be interpreted as slightly weathered Limestone bedrock, which was in turn underlain by competent, strong grey Limestone from 2.5mbgl to the end of the borehole at 10m. The site data at T4 indicated competent Limestone underlying the turbine base.
- Turbine T5 – Soils/subsoils interpreted to 0.3-1.0mbgl. The underlying bedrock geology is interpreted as moderately to highly weathered Limestone from 1.0-3.2mbgl, with less weathered, competent Limestone below. A zone of more weathered rock is interpreted ~10-15m west of the turbine base. The drilling of RC11, at the turbine base centre, encountered clay and gravel to 3.5m, followed by hard Limestone with very little weathering. RC05 was ~15m drilled west of the turbine centre and encountered clay and gravel to 2.3m over strong thickly laminated Limestone which was very slightly weathered. RC08 was drilled ~20m north of the turbine base and encountered clay and gravel to 2.5m over strong grey Limestone which was moderately weathered. All site data at T5 show the turbine base is underlain by competent, strong Limestone bedrock;
- Turbine T6 - Geophysics interpreted as 0.3-1.0m of overburden, overlying Limestone bedrock with undulating depth across the survey line from 0.8-7.8m. Borehole RC09 was drilled at the T6 turbine base location and encountered sandy/sandy gravelly clay to 3m, overlying strong, dark grey Limestone with white calcite mineralisation, which was slightly weathered. The core samples show the majority of weathering in the top 1-1.3m of the Limestone bedrock (to ~4.3mbgl), with competent Limestone bedrock below. The site data from turbine T5 indicate the turbine base is underlain by competent Limestone;
- Turbine T7 – Geophysics interpreted as loose soils up to 1.55mbgl, underlain by firmer soils up to 3.9mbgl. The bedrock geology is interpreted as Limestone from 0.9-3.9mbgl, with a weathered layer within the first 1-3m of bedrock, followed by fresh, hard Limestone below. Borehole RC07 was drilled at the centre of the turbine base. The drilling encountered clay to 3m, followed by clayey gravel, sandy clay and clayey sand to 5.85m. This was followed by strong, dark grey Limestone with frequent calcite mineralisation which was slightly weathered in parts. The data indicates that T7 is underlain by competent Limestone;
- Turbine T8 – Geophysics interpreted as 1.2-5.5m of silty sand/gravel and gravelly clay, overlying Limestone bedrock which is moderately weathered. Borehole MW21-01 was drilled ~150m from T8 and encountered Medium hard Limestone at 1.1m, which was medium hard and moderately weathered to 12m and very hard from 12-55m; and,
- Substation – Geophysics interpreted as 0.3-8.0m of clayey silty sand/gravel underlain by Limestone bedrock with the top of bedrock slightly weathered.

Competent, hard to very hard Limestone bedrock generally underlies the Proposed Wind Farm site. Subsoils are relatively shallow, extending to 0.5-2mbgl across much of the Proposed Wind Farm site with areas of deeper subsoils to 3-4mbgl. A layer of moderately weathered Limestone exists at the top of the bedrock which is typically 1-3m deep and likely the result of past glacial action. Below this zone of moderate weathered bedrock, the Limestone is competent and hard in the rotary core boreholes to 10-10.5m depth and up to depths of 55m as demonstrated at MW21-01.

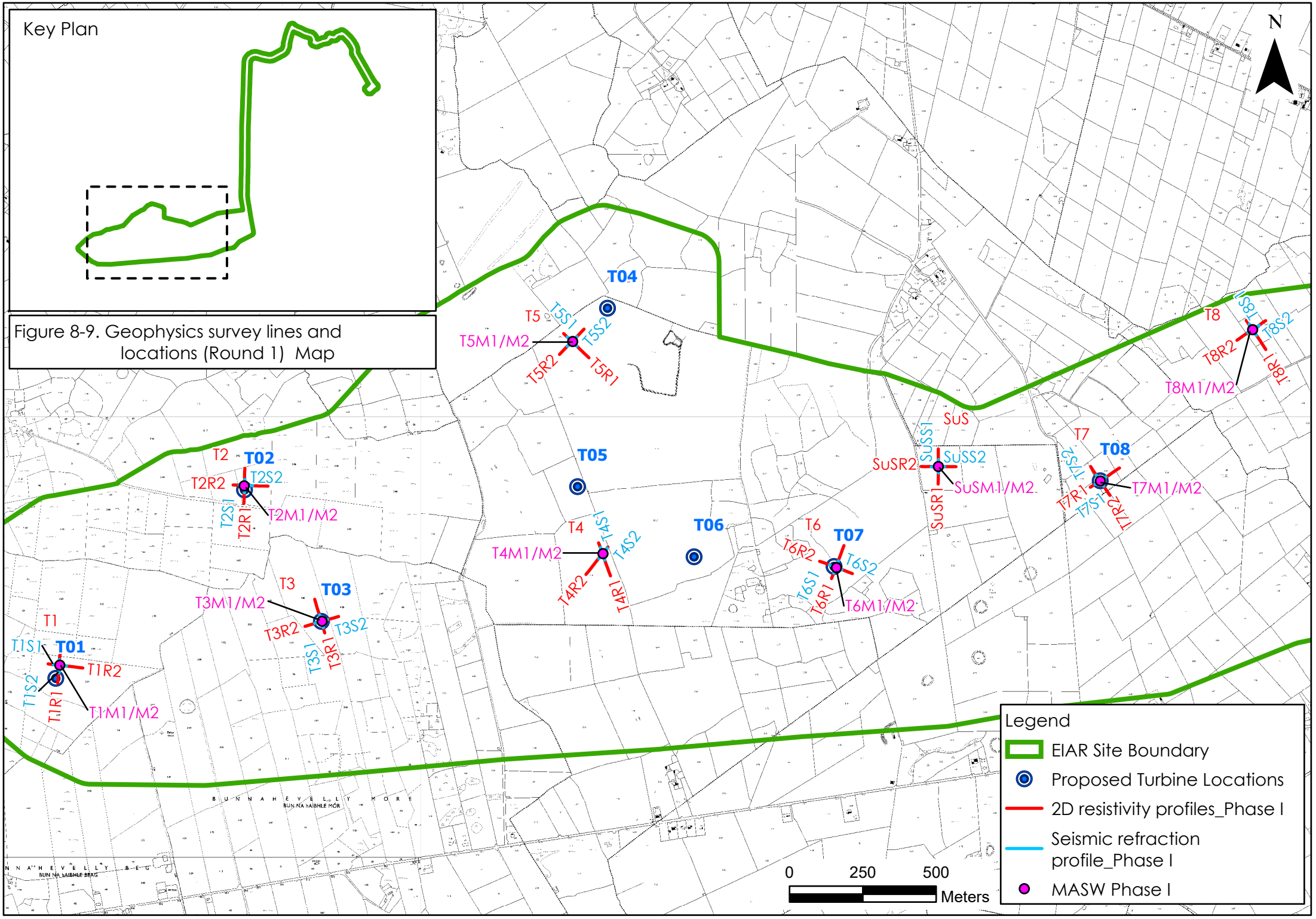
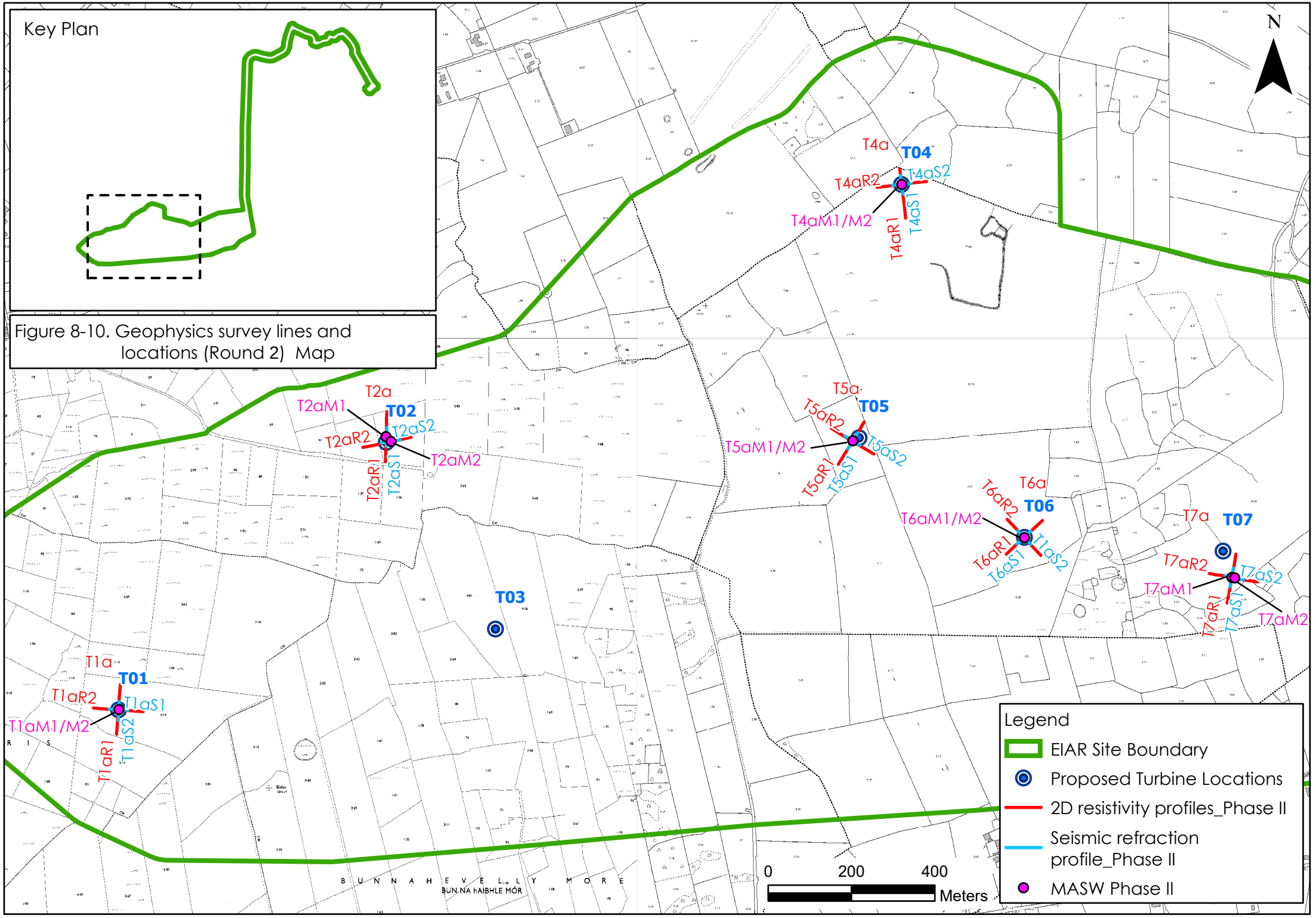


Figure 8-9. Geophysics survey lines and locations (Round 1) Map


Key Plan
Figure 8-10. Geophysics survey lines and locations (Round 2) Map
N
T01
T1a
T1aR2
T1aS1
T1aM1/M2
T1aR1
T1aS2
T02
T2a
T2aM1
T2aR2
T2aS2
T2aM2
T2aR1
T2aS1
T03
T04
T4a
T4aR2
T4aS2
T4aM1/M2
T4aR1
T4aS1
T05
T5a
T5aR2
T5aS2
T5aM1/M2
T5aR1
T5aS1
T06
T6a
T6aR2
T6aS2
T6aM1/M2
T6aR1
T6aS1
T07
T7a
T7aR2
T7aS2
T7aM1
T7aR1
T7aS1
T7aM2
B U N N A H E V E L L Y M O R E
BUN NA hAIBHLE MÓR
0
200
400
Meters
Legend
EIAR Site Boundary
Proposed Turbine Locations
2D resistivity profiles_Phase II
Seismic refraction profile_Phase II
MASW Phase II

8.4 Characteristics of the Proposed Project

8.4.1 Engineering Design

The Proposed Project comprises 8 no. wind turbines with associated infrastructure including hardstands, access roads and onsite 110kV substation, as well as 2 no. temporary construction compounds.

The engineering design of the Proposed Wind Farm is underpinned by a comprehensive site investigation dataset. The Proposed Wind Farm site layout optimisation and the design process was iterative, and through this iterative process, the proposed infrastructure is sited in areas of optimum ground conditions.

Table 8-9 provides a summary of proposed turbine foundation designs (i.e., design response at each turbine base (ground bearing foundation or piled, excavate to rock)).

Table 8-9: Proposed Turbine Foundation Type

ID	Foundation Type	Formation Level (mbgl)	Formation Material (based on SI data)	Stone Upfill Depth (m)
T1	Ground-Bearing Gravity	3.1	Rock	0.1
T2	Ground-Bearing Gravity	3	Clay/Sand	0
T3	Ground-Bearing Gravity	3	Clay/Gravel	0
T4	Ground-Bearing Gravity	4.5	Clay	1.5
T5	Ground-Bearing Gravity	3.0	Rock	0
T6	Ground-Bearing Gravity	3.0	Rock	0
T7	Ground-Bearing Gravity	3.0	Gravel/Rock	0
T8	Ground-Bearing Gravity	3.0	Gravel/Cobbles	0
Substation	Ground-Bearing Gravity	0	Clay	0

Access roads will be founded on competent subsoil. Material volumes for spoil management are outlined below.

8.4.2 Material Quantities/Volumes

During the Proposed Wind Farm site and Proposed Grid Connection works spoil will invariably be generated during excavations for roads, hardstands, wind turbine foundations, drainage swales, trenches etc. Minimisation of the production of this spoil is to be treated as a high priority, but there will be generation of excess spoil in the form of a mixture of topsoil, rock and glacial till.

It is proposed that the majority surplus spoil material will be managed around each turbine and hardstand and roadside berms. The remainder of the excavated spoil will be transported directly from the excavation for placement within one of the identified spoil management areas. This helps reduce

the need for transportation of spoil across large areas and results in a reduced risk of dirty water generation (i.e. from tracking/transporting spoil over large areas with machinery).

A Spoil Management Plan is included within Section 4.3.3 of Chapter 4. For the construction phase of the Proposed Project the activities that are considered likely to generate spoil are as follows:

- Construction of new access roads;
- Excavations for 8 no. turbine bases, crane hardstands, substation and the temporary site construction compounds; and,
- Excavation of the Proposed Grid Connection underground cabling route trench.

Estimated volumes of subsoil and bedrock to be excavated and accommodated within the Site are shown in Table 8-10while the volume of the spoil management areas are shown in Table 8-11. Any bedrock excavated during cut and fill works will be used for hardcore material in construction of the development footprint. There is excess capacity contingency proposed which will be accommodated by the 4 no. spoil management areas.

Table 8-10: Estimated Spoil Management Volumes and crushed stone requirements for the Proposed Project

Development Component	Spoil Volume(m3) (approx.)	Crushed Stone Requirement (m3) (approx.)
Proposed Wind Farm		
8 no. Turbines and Hardstanding Areas (including foundations)	30,080	23,940
Access Roads (including met mast hardstand and security cabin)	16,623	22,165
Temporary Construction Compound	1,332	1,150
Total	48,035	47,255
Proposed Grid Connection		
Onsite Substation (including temporary construction compound)	5,386	7,120
Cabling Trench	11,000	5,150
Total	**16,386**	**12,270**
Total	**64,421**	**59,525**
Total (including 10% contingency)	**70,863**	**65,480**

The total estimated volume of spoil to be managed following excavations during the construction phase of the Proposed Project is approximately 70,000m^3. It is proposed to manage any excess overburden generated through construction activities locally within the Site, through landscaping of the site, by

creating roadside berms where appropriate and grading the remaining spoil across the 4 no. identified spoil management areas (~74,000 m^3), as shown in Figure 4-21 in Chapter 4.

Table 8-11: Proposed Spoil Management Area Volumes

Spoil Management Area	Approx. Volume (m3)
Spoil Management Area 1	27,500 m^3
Spoil Management Area 2	27,500 m^3
Spoil Management Area 3	5,000 m^3
Spoil Management Area 4	14,000 m^3
Total	**74,000**

8.5 Likely and Significant Effects on Land, Soils and Geology

8.5.1 Do Nothing Scenario

If the Proposed Project were not to proceed, the existing uses of small-scale agriculture would continue. The opportunity to harness the wind energy resource of County Galway would be lost, as would the opportunity to contribute to meeting Government and EU targets for the production and consumption of electricity from renewable resources and the reduction of greenhouse gas emissions. The opportunity to generate local employment and investment would also be lost.

8.5.2 Construction Phase - Likely Significant 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 assessment considers the Proposed Project as a whole i.e. both the Proposed Wind Farm and the Proposed Grid Connection. Where this is required to be assessed separately, this is noted in the text.

8.5.2.1 Effects on Land and Landuse

The construction of the Proposed Project will result in the change in land-use of approximately 36.2ha of agricultural land. The Proposed Wind Farm site construction works will result in local topographic changes with the removal of glaciofluvial and glacial overburden and some bedrock from the Site. The Proposed Grid Connection underground cabling route will result in the excavation of a narrow trench to accommodate the cabling. This trench will be reinstated once the cabling is emplaced with a comparable ground surface (tarmacadam).

There will be no effects on the lands adjoining the Proposed Project site.

Pathway: Excavation of soil/subsoil and bedrock.

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

Potential Pre-mitigation Effect: Proposed Wind Farm: Negative, slight, direct, high probability, permanent impact on land and landuse.

Proposed Grid Connection: Negative, slight, direct, medium probability, permanent impact on land and landuse.

Impact Assessment/Mitigation Measures:

- The loss of agricultural land resulting from the Proposed Project on a local or regional scale is minimal and therefore the effects of actual agricultural land loss is negligible.
- Given the undulating nature of local topography resulting from the quaternary deposits and the uneven weathering of the Limestone bedrock, any change in topography is likely to be minimal in the overall landscape.
- No mitigation is proposed.

Residual Effect: Agricultural land used for grazing is the dominant landuse in the area of the Proposed Project. Due to the relatively small footprint of the Proposed Project on a local scale, the residual effect is considered Negative, direct, slight, likely, permanent effect on land and landuse.

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

8.5.2.2 Soil, Subsoil Excavation and Bedrock Excavation

Excavation of soil, subsoil and bedrock will be required for site levelling and for the installation of infrastructure, foundations for the access roads, turbines and substation, and underground cabling trench. This will result in a permanent removal of soil/subsoil and bedrock at excavation locations. Estimated volumes of soil, subsoil and bedrock to be removed are shown in Table 8-10 above.

Mechanism: Extraction/excavation.

Receptor: Soil, subsoil and bedrock within the Proposed Wind Farm site and the Proposed Grid Connection.

Pre-Mitigation Potential Effect: Negative, slight/moderate, direct, likely, permanent effect on soils, subsoil and bedrock.

Impact Assessment:

- The bedrock at the Site is classified as “Medium to High” importance. Excavation volumes of soils and subsoils/bedrock are relatively small in comparison to the scale of the Proposed Wind Farm site (c.70,000m^3 in total, with all soils, subsoils and bedrock re-used within the Site). The soils and subsoil deposits and mineral soil at the Site is classified as “Low to Moderate” importance as these materials are present across the region.

Mitigation Measures:

Proposed Wind Farm

- Placement of turbines and associated infrastructure in areas with suitable ground conditions (based on detailed site investigation data);

- At the identified spoil management areas, the vegetative top-soil layer will be removed to allow for spoil to be placed and upon reaching the recommended height, the vegetative topsoil layer will be reinstated;
- The identified spoil management areas will be developed in a phased approach, with the topsoil removed and temporarily stockpiled within the defined area while the spoil it being placed. The stockpiled topsoil will then be reinstated over the placed spoil, and the exercise will continue within the same spoil management area until the area is full;
- The placement of spoil will be restricted to a maximum height of 1.0m, subject to confirmation by the Geotechnical Engineer;
- Where practical, the surface of the placed spoil is shaped to allow efficient run-off of surface water. Where possible, shaping of the surface of the spoil will be carried out as placement of spoil within the area progresses. This will reduce the likelihood of debris run-off and ensure stability of the placed spoil;
- Finished/shaped side slopes of the placed spoil will be not greater than 1 (v): 2 (h) in the dedicated spoil management zones and not greater than 1 (v): 1 (h) alongside access tracks;
- Inspections of the spoil management areas will be made by a Geotechnical Engineer through regular monitoring of the works. The appointed contractor will review work practices at spoil management areas when periods of heavy rainfall are expected so as to prevent excessive dirty water runoff from being generated;
- An interceptor drain will be installed upslope of the identified spoil management areas to divert any surface water away from these areas;
- Silt fences and double silt-fences will be emplaced down-gradient of spoil management areas and will remain in place throughout the entire construction phase, or until reseeding has been established to a sufficient level;
- The surface of the deposited spoil will be profiled to a gradient to be agreed with the Geotechnical Engineer and vegetated or allowed to vegetate naturally as indicated by the Project Ecologist;
- All the above-mentioned general guidelines and requirements will be confirmed by the Geotechnical Engineer prior to construction;
- The material will be backfilled into the spoil management areas and will be spread evenly across the area;
- It will be compacted to reduce air voids and reduce the migration paths for infiltration by precipitation. This will reduce the amount of potentially silt laden surface water run-off from these spoil management areas. 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 management will 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 management will take place within a minimal distance of each turbine to avoid excessive transport of materials within the Site;

Proposed Grid Connection:

- Soils and subsoils excavated along the Proposed Grid Connection underground cabling route will be temporarily stored in covered stock piles along the edge of the road carriageway.
- Once the emplacement of the 110kV cable has been completed, the stored soils and subsoils will be reinstated, with the minimal amount of compaction required to level the top surface.
- The tarmacadam road surface will be replaced with the same design standard as the surrounding carriageway.

Residual Effect Assessment: The cohesive and granular soil/subsoil at the Proposed Wind Farm site are classified as of "Low to Moderate" importance as they are present across the region. The effect is the disturbance and relocation of c. 70,000m^3 of soil and subsoil during the construction of the Proposed Wind Farm. All work will be in accordance with the Spoil Management Plan outlined in Section 4.3.3 of Chapter 4. The site layout design has been iteratively developed using comprehensive site-specific site investigation dataset, which includes boreholes, trial pits, geophysical survey data and dynamic probe data. The residual effect is negative, slight, direct, high probability, permanent effect on soils/subsoils and bedrock due to disturbance and relocation within the Site.

The cohesive and granular soil/subsoil along the Proposed Grid Connection underground cabling route are classified as of "Low to Moderate" importance. Following the excavation and construction of the grid connection, the area excavated will be reinstated with a comparable ground cover.

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

8.5.2.3 Contamination of Soil by Leakages and Spillages and Alteration of Soil/Subsoil Geochemistry

Accidental spillage during refuelling of construction plant with petroleum hydrocarbons is a pollution risk. The accumulation of small spills of fuels and lubricants during routine plant use can also be a significant pollution risk. Hydrocarbon has a high toxicity to humans, and all flora and fauna, including fish, and is persistent in the environment. Large spills or leaks have the potential to result in significant effects (i.e., contamination of soil, subsoils and pollution of the underlying aquifer) on the geological and water environment. Additionally, waste tar, removed from the road hardstanding along the Proposed Grid Connection underground cabling route has the potential to affect soil/subsoil geochemistry.

Pathway: Soil, subsoil and underlying bedrock pore space.

Receptor: Soil, subsoil and bedrock.

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

Proposed Mitigation Measures:

- Minimal refuelling or maintenance of construction vehicles or plant will take place on site. Where possible, off-site refuelling will occur at a controlled fuelling station;
- On site re-fuelling of plant will be undertaken using a double skinned refuelling truck bowser with spill kits onboard
- On site re-fuelling will be undertaken by suitably trained personnel only under a permit to refuel system;
- Fuels stored on site will be minimised. Storage areas located at the temporary compounds where required will be bunded appropriately for the fuel storage volume for the time period of the construction and fitted with a storm drainage system and an appropriate oil interceptor;
- The onsite 110kV substation will be bunded appropriately to the volume of oils likely to be stored, and to prevent leakage of any associated chemicals and to groundwater or surface water. The bunded area will be fitted with a storm drainage system and an appropriate oil interceptor;
- The plant used during construction will be regularly inspected for leaks and fitness for purpose;
- All waste tar material arising from works on hard top roads will be removed off-site and taken to licenced waste facility; and,

- An emergency plan for the construction phase to deal with accidental spillages is contained within the Construction and Environmental Management Plan (Appendix 4.5 of this EIAR). Spill kits will be available to deal with and accidental spillage in and outside the re-fuelling area.

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

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

8.5.2.4 Ground Instability and Failure

Ground instability or failure refers to a significant mass movement of a body of ground that would have an adverse impact on the environment as a result of the Proposed Project.

A significant amount of site investigation data has been acquired across the Proposed Wind Farm site. These data provide confidence on the depth of subsoil and the subsoil type. Subsoils are logged as generally SAND, sandy CLAY, sandy GRAVEL and GRAVELS, which would not be associated with ground instability or a risk of landslides. There is no peat identified within the Proposed Wind Farm site.

The subsoils range in depth between 1.1-13.5m across the Proposed Wind Farm site. 46 no. dynamic probes have been conducted across the Site which confirm the absence of soft soils or peat across the Proposed Wind Farm site. These data also outline the absence of any significant karst features below the subsoil layers which could impact on ground instability.

An iterative design process involving multiple stages of ground investigations, followed by turbine and infrastructure design has been completed to ensure the areas with optimum ground conditions have been selected.

Site investigations have been completed along the Proposed Grid Connection underground cabling route. 35no. peat probes have been performed along the route, with peat depths ranging between 0.1-0.7m, with an average depth of 0.23m. The peat is shallow and limited in depth with respect to the ~1.3m deep trench which will be excavated for the cable ducting.

Mechanism: Vehicle movement and excavations.

Receptor: Peat soils, subsoils and weathered/karstified bedrock.

Pre-Mitigation Potential Effect: Negative, slight, direct, very low probability permanent effect on subsoils and weathered bedrock.

Impact Assessment:

The findings of the comprehensive site investigation indicate good ground conditions, and all proposed turbines can be founded on subsoils, gravels or bedrock. The engineering design of the Proposed Wind Farm site is underpinned by a comprehensive site investigation dataset. The Proposed Wind Farm layout optimisation and design process was iterative, and through this iterative process the areas with optimum ground conditions have been selected.

Due to the nature of the Proposed Grid Connection underground cabling route, the average depth of 0.23m peat type soils will not have an effect on ground stability. The formation of the underground cabling trench will be within the underlying competent subsoil..

Mitigation Measures:

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

- Appointment of experienced and competent contractors;
- The site will be supervised by experienced and qualified engineering/geotechnical personnel;
- Allocate sufficient time for the project;
- Prevent undercutting of slopes and unsupported excavations;
- Maintain a managed suitable drainage system;
- Ensure construction method statements are followed or where agreed modified/ developed; and,
- Revise and amend the Geotechnical Risk Register as construction progresses.

Residual Effects Assessment: The engineering design of the Proposed Wind Farm site is underpinned by a comprehensive site investigation dataset. The Proposed Wind Farm site layout optimisation and design process was iterative, and through this iterative process the areas with optimum ground conditions have been selected. The risk of ground failure during construction is very low. The residual effect is – No effects on subsoil/weathered bedrock and ground.

The engineering design of the Proposed Grid Connection underground cabling route is underpinned by site investigation data carried out along the route. The peat soils encountered are minimal and shallow, with an average depth of 0.23m recorded. Due to the nature of the underground cabling trench (~1.3m deep narrow trench) the risk of ground failure during construction is negligible. The residual effect is – No effects on peat soils or subsoils.

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

8.5.2.5 Potential Impacts on Geological Heritage Sites

There are a number of geological heritage sites mapped locally to the Proposed Wind Farm site and the Proposed Grid Connection. The Knockmaa Geological Heritage Site (GY116) is mapped 2km north of the Proposed Wind Farm site. The works proposed as part of the Proposed Wind Farm, including turbine base excavations, access road excavation and emplacement and all other works involving movement of soils, subsoils and bedrock are remote from these geological heritage sites.

There are no geological heritage sites mapped along the route of the Proposed Grid Connection underground cabling route.

Pathway: There is no pathway for effects between the Geological Heritage Sites and the Proposed Wind Farm site and Proposed Grid Connection underground cabling route.

Receptor: Geological Heritage Sites -

Pre-Mitigation Potential Effect: No potential for effects.

Residual Effects: There will be no residual effects on geological heritage sites as a result of the Proposed Project.

Significance of effects: No effects

8.5.2.6 Potential Effects on Designated Sites

There are a number of designated sites (SAC's, SPA's NHA's and pNHA's) mapped locally to the Proposed Wind Farm site. The closest SAC is Turlough Monaghan, situated 3.3km northwest of the Proposed Wind Farm site, while Belclare Turlough is situated 5km north of the Proposed Wind Farm site. A detailed list of designated sites within 10km of the Site is show in Table 8-6.

Other designated sites proximal to the Proposed Wind Farm site include:

- Lough Corrib SAC, pNHA and SPA – situated 5.1km east of the Site;
- Killower Turlough pNHA – situated 6.5km north of the Site;
- Turlough O'Gall pNHA – situated 6.5km north of the Site;
- Turloughcor – situated 5.5km west of the Site;
- Lough Hackett pNHA – situated 6.9km northwest of the Site.

There is 1 no. designated site mapped along the Proposed Grid Connection underground cabling route, where the proposed route crosses over the River Clare. The River Clare is mapped as part of the Lough Corrib SAC.

Pathway: Excavation/removal of soils and subsoils.

Receptor: Designated Sites

Pre-Mitigation Potential Effect:

Proposed Wind Farm

Turlough Monaghan pNHA - Neutral, insignificant, indirect, low probability effect on Turlough Monagahan pNHA. The Site is distal to the pNHA with no pathway for effects.

Belclare Turlough pNHA - Neutral, insignificant, indirect, low probability effect on Belclare Turlough pNHA. The Site is distal to the pNHA with no pathway for effects.

Lough Corrib SAC - Neutral, insignificant, indirect, low probability effect on Lough Corrib SAC. The Site is distal to the SAC with no pathway for effects.

Killower Turlough pNHA - Neutral, insignificant, indirect, low probability effect on Killower Turlough pNHA. The Site is distal to the pNHA with no pathway for effects.

Turlough O'Gall pNHA - Neutral, insignificant, indirect, low probability effect on Turlough O'Gall pNHA. The Site is distal to the pNHA with no pathway for effects.

Turloughcor pNHA - Neutral, insignificant, indirect, low probability effect on Turloughcos pNHA. The Site is distal to the pNHA with no pathway for effects.

Lough Hackett pNHA - Neutral, insignificant, indirect, low probability effect on Lough Hackett pNHA. The Site is distal to the pNHA with no pathway for effects.

Proposed Grid Connection

Lough Corrib SAC - Neutral, insignificant, indirect, low probability effect on Lough Corrib SAC. The underground cabling route will be emplaced along the road over an existing bridge. No in-stream works are required.

Proposed Mitigation Measures:

The mitigation measures outlined in terms of the land, soils and geology in relation to designated sites are essentially the same as those outlined in Section 9.4.2.2 of the Water chapter, which deals with suspended sediment entrainment from the excavation works. As the designated sites are distal to the Proposed Wind Farm site, there can be no direct effects on the land soils and geology of the designated sites. There is 1 no. SAC near the Proposed Grid Connection underground cabling route, where the route crosses over an existing bridge over the River Clare. Indirect effects are considered and mitigated by:

- Avoiding physical damage to watercourses, and associated release of sediment;
- Avoiding excavations within close proximity to surface water courses;
- Avoiding the entry of suspended sediment from earthworks into watercourses; and,
- Avoiding the entry of suspended sediment from the construction phase drainage system into watercourses, achieved in part by ending drain discharge outside the buffer zone and allowing percolation across the vegetation of the buffer zone.

The design measures to achieve these mitigation measures are included in detail within Section 9.4.2.2, but briefly include the use of:

- Source controls such as interceptor drains, sandbags and the covering of stockpiles;
- Silt bags and silt fences; and,
- Pre-emptive site drainage management such as the use of general weather forecasts and rainfall radar images to plan and coordinate site works.

Residual Effect Assessment:

Proposed Wind Farm

The residual effects on Turlough Monaghan pNHA are considered to be – no residual effects.

The residual effects on the Belclare Turlough pNHA are considered to be – no residual effects.

The residual effects on the Lough Corrib SAC are considered to be – no residual effects.

The residual effects on the Killower Turlough pNHA are considered to be – no residual effects.

The residual effects on Turlough O'Gall pNHA are considered to be – no residual effects.

The residual effects on Turloughcor pNHA are considered to be – no residual effects.

The residual effects on Lough Hackett pNHA are considered to be – no residual effects.

Proposed Grid Connection

The residual effects pm the Lough Corrib SAC are considered to be – no residual effects.

Significance of Effects For the reasons outlined above, no significant effects on the land soils and geological environments are anticipated at any of the listed designated sites; Turlough Monaghan pNHA, Belclare Turlough pNHA, Lough Corrib SAC, Killower Turlough pNHA, Turlough O'Gall pNHA, Turloughcor pNHA, Lough Hackett pNHA.

8.5.2.7 TDR/Haul Route Works

Works such as road widening are sometimes required along proposed turbine transport routes to accommodate the large turbine components and associated vehicles seeking to access wind farm sites.

The proposed transport route for the Proposed Wind Farm has been the subject of a route assessment to determine if any works are required along its length. Full details of the assessment are included as part of the traffic impact assessment set out in Section 14.1.8 of this EIAR and summarised below. There are sections on the route where the vertical alignment may require specialist transport vehicles. These sections will be further considered by the appointed transport company following turbine procurement process. Accommodation works will be required at various locations on the national and regional road network between the port of arrival in Galway and the Proposed Wind Farm site. These are detailed below:

Locations in Galway

A swept path analysis was undertaken for the section of the turbine delivery route in Galway City and County between the Galway Harbour and the N83 National Road. These locations are as follows:

- Location 1: R339 signalised junction at Thermo King, and,
- Location 2: R336 Tuam Road junction at Trappers Inn.
- Location 3: N17/N6 Bothar na dTreabh junctions
- Location 4 N83/L61461, proposed temporary access for abnormally sized loads and standard HGVs during construction phase;
- Location 5: Proposed access junction off the L61461 for all traffic during construction and operation.

A swept path analysis was undertaken using Autotrack for the blade and tower transporter vehicles, and while traffic lights and street furniture will require to be removed during the delivery of the large plant, the assessment indicates that the large turbine delivery vehicles will be accommodated at these locations.

Pathway: No pathway for potential effects on land, soils and geology

Receptor: Soil and subsoil

Pre-Mitigation Potential Impact:

No potential effect on land, soils and geology along turbine delivery route.

Proposed Mitigation Measures:

No mitigation measures required

Residual Effect Assessment: Due to the limited nature of accommodation works along the turbine delivery route, which include temporary moving of traffic lights and street furniture, before being reinstated, the residual effects on the land, soils and geology environment is considered to be – no residual effect.

Significance of Effects For the reasons outlined above, no significant effects on soils and subsoil permeability will occur, and no significant effects on landcover will occur.

8.5.3 Assessment of Human Health Effects

Potential health effects arise mainly through the potential for soil and ground contamination. A wind farm is not a recognized source of pollution and so the potential for effects during the operational phase are negligible. 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.

8.5.4 Operational Phase - Likely Significant Effects and Mitigation Measures

All aspects of the land, soils and geology environment will remain constant during the operational phase of the Proposed Project. However there may be potential direct effect due to risks of soil contamination, these may include:

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

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

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

8.5.5 Decommissioning Phase - Likely Significant Effects and Mitigation Measures

The potential effects associated with decommissioning of the Proposed Project will be similar to those associated with construction but of reduced magnitude (i.e., soil/subsoil/bedrock excavation; Contamination by Leakage/Spillages).

The wind turbines proposed as part of the Proposed Wind Farm site are expected to have a lifespan of approximately 30 years. Following the end of their useful life, the equipment may be replaced with a new technology, subject to planning permission being obtained, or the Proposed Wind Farm site may be decommissioned fully.

Upon decommissioning of the Proposed Wind Farm site, the wind turbines will be disassembled in reverse order to how they were erected. The turbines will be disassembled with a similar model of crane that was used for their erection. The turbine components will be separated and removed offsite. The turbine materials will be transferred to a suitable recycling or recovery facility. Leaving the turbine foundations in-situ is considered a more environmentally prudent option, as to remove that volume of reinforced concrete from the ground could result in unnecessary environment emissions such as noise, dust and/or vibration.

The underground cabling connecting the turbines to the on-site substation will be removed from the cable ducts. The cabling will be pulled from the cable ducts using a mechanical winch which will extract the cable and re-roll it on to a cable drum. This will be undertaken at the original cable jointing pits which will be excavated using a mechanical excavator and will be fully re-instated once the cables are removed. The cable ducting will be left in-situ as it is considered the most environmentally prudent option, avoiding unnecessary excavation and soil disturbance. The cable materials will be transferred to a suitable recycling or recovery facility.

Site roadways could be in use for purposes other than the operation of the Proposed Project by the time the decommissioning of the Proposed Wind Farm site is to be considered, and therefore it may be more appropriate to leave the Site roads in situ for future use. It is envisaged that the roads will serve as agricultural roads for local landowners.

The Proposed Grid Connection underground cabling route and onsite 110kV substation will remain in place as it will be under the ownership and control of the ESB and Eirgrid.

A Decommissioning Plan has been prepared (Appendix 4-7) the detail of which will be agreed with the local authority prior to any decommissioning. The Decommissioning Plan will be updated prior to the end of the operational period in line with decommissioning methodologies that may exist at the time and will agreed with the competent authority at that time. The potential for effects during the decommissioning phase of the Proposed Project has been fully assessed in the EIAR.

During decommissioning, it may be possible to reverse or at least reduce some of the potential effects caused during construction by rehabilitating construction areas such as turbine bases. This will be done by covering with soils/subsoils and vegetation to encourage vegetation growth and reduce run-off and sedimentation. Other effects such as possible soil compaction and 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 (SNH, 2013) reinstatement proposals for a wind farm are made approximately 30 years in advance, so within the lifespan of the wind farm, technological advances and preferred approaches to reinstatement are likely to change. According to the SNH guidance, it is therefore:

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

Mitigation measures applied during decommissioning activities will be similar to those applied during construction where relevant (i.e., mitigation outlined at Sections 8.5.2.2 and 8.5.2.3). Some of the effects will be avoided by leaving elements of the Proposed Project in place where appropriate *i.e* the 110 kV substation and underground cabling. 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 soils and geology environment are envisaged during the decommissioning stage of the Proposed Project. A Decommissioning Plan is included as Appendix 4-7 of the EIAR.

8.5.6 Potential 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 and Proposed Grid Connection 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 2.8 of Chapter 2 for cumulative assessment methodology.

A dataset of 502 no. planning applications within the defined potential cumulative boundary (defined by boundaries of downgradient water catchments) has been completed. Of the 502 no. applications, 52 no. applications are for agricultural buildings, typically slatted sheds. There are 44 no. commercial units within the dataset and 380 no. residential dwellings.

There are 10 no. energy related projects, which include 2 no. solar farms, upgrade works to grid connection routes and substation works. There are no proposed wind farms within the cumulative boundary.

The proposed planning applications within the dataset have been analysed, with particular emphasis on the larger projects listed. Following this analyses, there will be no cumulative effects on the land, soils and geology environment as a result of the Proposed Project

8.5.7 Summary

The Proposed Project is primarily within the townland of Laurclavagh, between the townlands of Cahermorris and Ballynacreg North. The approximate centre of the Site is located at E137055, N243681. The southern section of the Site is situated within a slightly elevated area of ground (~45-60mOD) within a broader area which is generally flat to locally undulating and with elevations generally ~30mOD. The northern section of the Site extends towards Tuam along the N83 road and consists of mainly flat agricultural lands. The land is mainly agricultural improved grassland, primarily used for grazing.

A comprehensive impact assessment of the Proposed Wind Farm site and associated Grid Connection underground cabling route on the land, soils and geological environment has been undertaken. The assessment is based on a desk study, walkover surveys and a comprehensive data set which was obtained during site investigations. The wind farm design is based on extensive site-specific data, with the layout intended to minimise impacts on the local land, soils and geological environment.

The geology of the Proposed Project site typically consists of sandy gravelly clay overburden, ranging between 1.1 – 16.5m and averaging 3.8m in depth. The overburden is a glacial deposit over typically strong to medium strong, medium grey Limestone, which is occasionally weathered but generally competent. In total over 230m of site investigation drilling has been completed across the Proposed Wind Farm site, with no evidence of karst conduits or voids encountered. Isolated and discrete weathered layers of Limestone were encountered in some boreholes, but this is typical of all Limestone bedrock in Ireland.

Excavation of soil, subsoil and bedrock will be required for site levelling and for the installation of the Proposed Wind Farm infrastructure. This will result in a permanent removal and on-site management of excess soil and subsoil across the site. Excavated soil/subsoils and bedrock will be reused where possible, used for landscaping around turbine bases, or permanently placed in the proposed spoil management areas. Storage and handling of hydrocarbons/chemicals will be carried out using best practice methods. Measures to prevent soil and subsoil erosion during excavation, reinstatement and permanent management in spoil management areas will be undertaken to prevent water quality effects.

No significant effects on the land, soil and geology of the Project Site will occur during construction, operation, or during decommissioning phases of the Proposed Project.

Our assessment confirms there will be no cumulative effects on land soil and geology environment as a result of the Proposed Project.

Ground bearing foundations will be utilised at the 8 no. turbine locations due to the good ground conditions encountered during the comprehensive site investigation works.

Excavation of mineral subsoils and bedrock will be required for site levelling, infrastructure and foundations for the access roads and turbines. Estimated volumes of subsoils/bedrock to be removed at the 8 no. turbine foundations, hardstandings and along access roads is 70,000m^3. The handling and storage of soils and subsoils will be completed in accordance with the Spoil Management Plan.

Storage and handling of hydrocarbons/chemicals will be carried out using best practice methods. Measures to prevent soil and subsoil erosion during excavation, reinstatement and long-term storage of soil/subsoil will be undertaken to prevent erosion and potential water quality impacts.

An assessment of the construction stage, operational stage and decommissioning stage has been completed. Based on the above, and with implementation of the outlined mitigation measures, no likely significant effects on the soils and geology environment are predicted to occur.

Our assessment confirms there will be no cumulative effects on land soil and geology environment as a result of the Proposed Project