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 impacts of a proposed 20 (total) no. turbine wind farm, grid connection and all other associated site works. The Northern Cluster of the Proposed Development includes 7 no. turbines and is situated ~1.6 km northeast of Dysart, Co. Roscommon, while the Southern Cluster of the Proposed Development includes a further 13 no. turbines and is located ~3.3 km southeast of Dysart. A full description of the Proposed Development is provided in Chapter 4 of this EIAR.

This chapter report provides a baseline assessment of the environmental setting of the application site in terms of land, soils and geology and discusses the potential impacts that the construction and operation of the Proposed Development will have on them. Where required, appropriate mitigation measures to limit any identified likely significant impacts to soils and geology are outlined.

Please note, for the purposes of this chapter, where:

- The 'Proposed Development', is referred to, this relates to all the project components described in detail in Chapter 4 of this EIAR.
- The 'Wind Farm' is referred to, this relates to all infrastructure for the wind farm as detailed in Chapter 4 in both the Northern and Southern Clusters. In some instances, the Northern and Southern Clusters are differentiated for ease of baseline description assessment.
- The 'Grid Connection' is referred to, this relates to all grid infrastructure, as detailed within Chapter 4, outside the Wind Farm site, within the local road network to Athlone 110 kV substation in Monksland.
- Where 'the site' is referred to, this relates to the EIAR Site Boundary as shown on all associated figures. Other elements of the Project are referenced accordingly (i.e. the turbine delivery route etc).

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, 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 Oweninny WF, Cloncreen WF, Derrinlough WF and Yellow River WF, and over 120 other wind farm-related projects.

Adam Keegan (B.Sc., M.Sc.) is a hydrogeologist with 3 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 Limestone bedrock aquifers and experience in trial and production well drilling within areas mapped as Regionally Karstified. Adam has worked on several wind farm EIAR projects, including Croagh WF, Lyrenacarriga WF (SID), Cleanrath WF, Carrownagowan WF (SID), and Fossy WF.

8.1.3 Relevant Legislation

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

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

- S.I. No. 30 of 2000 the Planning and Development Act, 2000 as amended; and,
- S.I. No. 296 of 2018 European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2001-2018;
- European Communities (Environmental Impact Assessment) Regulations 1989 to 2006; and,
- S.I. No. 4 of 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 to guidance contained in the following documents:

- Environmental Protection Agency (2017): Draft Guidelines on the Information to be Contained in Environmental Impact Assessment Reports;
- Environmental Protection Agency (September 2015): Draft - Advice Notes on Current Practice (in the preparation of Environmental Impact Statements;
- Environmental Protection Agency (September 2015): Draft – Revised Guidelines on the Information to be Contained in Environmental Impact Statements;
- Environmental Protection Agency (2003): Advice Notes on Current Practice (in the Preparation of Environmental Impact Statements);
- Environmental Protection Agency (2002): Guidelines on the Information to be Contained in Environmental Impact Statements;
- 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);
- Guidance on the preparation of the EIA Report (Directive 2011/92/EU as amended by 2014/52/EU), (European Union, 2017); and,
- Institute of Environmental Management and Assessment (IEMA) (2022): A New Perspective on Land and Soil in Environmental Impact Assessment.

8.2 Assessment Methodology

8.2.1 Desk Study

A desk study of the site and the surrounding area was largely 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 databases (www.epa.ie);
- Geological Survey of Ireland – Geological and Groundwater Databases (www.gsi.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 7 (Geology of Sligo - Leitrim). Geological Survey of Ireland (GSI, 1996);
- Geological Survey of Ireland – 1:25,000 Field Mapping Sheets; and,
- General Soil Map of Ireland 2nd edition (www.epa.ie).

8.2.2 Baseline Monitoring and Site Investigations

Detailed walkover surveys, geological mapping and baseline monitoring of water levels in nearby turloughs and private wells was conducted between 21st – 23rd January 2020. At this time the water levels in the turloughs were still low (for that year, as it varies every year depending on the rainfall amounts), and in order to start monitoring of winter turlough water levels these dates were chosen. During this time observations were made on near surface geological features and any accessible bedrock was mapped. Water level monitoring equipment was also installed in the surrounding turloughs and within a selection of accessible nearby groundwater wells.

Site investigations and a review of historical site investigations in the Proposed Development site and surrounding area to address the land, soil and geology section of the EIAR included the following:

- 3 no. geological logs were obtained from Roadstone-Cam Quarry boreholes near the Southern Cluster of the Wind Farm site;
- 9 no. summaries of geological logs were obtained from Roadstone-Cam Quarry boreholes near the Southern Cluster of the Wind Farm site (the original logs could not be obtained);
- 3 no. geological logs were obtained for GSI exploration boreholes near the Wind Farm site;
- 21 no. trial pits were excavated within the Northern Cluster of the Wind Farm site in June 2010 (with maximum depth of 2.1m);
- 7 no. trial pits were conducted within the Southern Cluster of the Wind Farm site in April 2011 (with maximum depth of 1.06m);
- 6 no. rotary core boreholes were drilled across the Northern and Southern Clusters of the Wind Farm site in April 2015;
- Logging of bedrock outcrops and subsoil exposures was carried out at and in the local area near the Wind Farm site during site visits by HES between January 2020 and May 2021 and mineral subsoils were logged according to BS: 5930;
- 40 no. Geophysical 2D resistivity profiles and 40 no. Seismic refraction profiles were carried across the turbine locations at the Wind Farm site. This geophysical survey was undertaken by Apex Geophysics between November 2020 and January 2021;
- 6 no. down the hole hammer boreholes were drilled by HES at the Northern and Southern Clusters of the Wind Farm site in May 2020;
- 16 no. boreholes were drilled by IGSL within the Northern Cluster, on behalf of MWP (Malachy Walsh & Partners - engineering design consultants) in December 2020 – January 2021. Bedrock was encountered in 6 of these 16 no. boreholes.
- 26 no. boreholes were drilled at the Southern Cluster by IGSL in December 2020 – January 2021. Bedrock encountered in 19 of these 26 no. boreholes.

- 10 no. slit trenches were excavated along the proposed grid route by IGSL between 21st May – 02nd June 2021;
- 3 no. down hole hammer boreholes were drilled along the proposed grid route by IGSL between 4th – 6th June 2021;
- 3 no. rotary core boreholes were drilled along the proposed grid route by IGSL between 08th – 12th July 2021;
- 16 no. trial pits were excavated and logged by Malachy Walsh and Partners (MWP) within the Northern Cluster of the Wind Farm site (including at the proposed met mast) in November 2021 (maximum depth of 3.5m);
- 27 no. trial pits were excavated and logged by MWP within the Southern Cluster of the Wind Farm site (including at the proposed substation) in December 2021(maximum depth of 3.7m);
- 52 no. PSD analyses were completed on subsoil samples from the 2021 MWP trial pitting;
- 28 no. trial pits were excavated and logged by HES within the Southern Cluster of the Wind Farm site in December 2021 (maximum depth 2.1m);
- 11 no. trial pits were excavated and logged by HES within the Northern Cluster of the Wind Farm site in December 2021 (maximum depth 2.0m);
- 38 no. PSD analyses were completed on subsoil samples from the 2021 HES trial pitting; and,
- 12 no. density and permeability tests were completed on subsoil samples from the 2021 HES trial pitting.

As outlined above, a series of site investigation works have been completed across the proposed Wind Farm site, and along the Grid Connection route. These comprise, a comprehensive site investigation programme completed across the current Wind Farm layout and the proposed Grid Connection route, data from an adjacent quarry site, and the initial investigation from the historic applications for a previous project on the site (refer to Chapter 2 for the planning history of the site).

Our analyses of the available site investigation data has focused on determining the following:

- The thickness, composition and variability, and ground bearing capacity (ground strength and stability) of overlying (over bedrock) overburden deposits through intrusive site investigation works (boreholes and trial pits, dynamic probes, supported by geophysics);
- The depth to bedrock and nature of the bedrock type *(i.e.* solid limestone bedrock, karst limestone) through intrusive site investigation works (boreholes and trial pits, dynamic probes, supported by geophysics). Geological logs were produced for each borehole and were used to calibrate the geophysical interpretation of the nature and extent of the bedrock;
- Characterising the overburden type and variation in physical characteristics through laboratory analysis and Particle Size Distribution (PSD);
- The presence or absence of any karst or epikarst features within the underlying Limestone bedrock, particularly focused at proposed turbine foundation locations and wind farm infrastructure;
- The distribution and depths of overburden deposits across the site in order to characterise the groundwater vulnerability of the underlying bedrock aquifer; and,
- All of the above technical data is required to define the design and foundation type for proposed infrastructure, and also feeds into the decision making process for the iterative design process to generate the optimum layout.

The duration of time spent on site (318 site hours from January 2020 to December 2021), and the accumulation of a significant geological dataset, gathered during many site visits demonstrates that this work is robust and comprehensive.

8.2.3 Scoping and Consultation

The scope for this assessment has been informed by consultation with statutory consultees, bodies with environmental responsibility, other interested parties as well as the historic reasons for development refusal at this site. This consultation process is outlined in Section 2.4 of this EIAR. Certain issues and concerns highlighted at the scoping stage 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 of response	Relevant Section
Geological Survey Ireland (GSI)	› **Geoheritage** - The GSI have noted 2 no. County Geological Sites (CGS) near the proposed Wind Farm site; Killeglan Karst Landscape RO015 (187960, 242893) and Castlesampson Esker RO010 (192104, 241567). › The Killeglan Karst Landscape comprises an extensive area of bouldery terrain in southern Roscommon covering an area of 5 by 2 kilometres, and includes a number of low amplitude, hummocky ridges. This is the only such area of lowland, boulder-strewn, limestone glacial karst in the country. The Southern Cluster of the Proposed Wind Farm site is situated within the central and eastern area of the Killeglan Karst Landscape. The Killeglan Karst Landscape is situated between 3 distinct areas. The most western of these areas coincides with Killeglan Grassland SAC, but is remote from the Wind Farm site. › The Castlesampson Esker[1] is an example of a complex, multi-crested esker which is comprised of numerous beads. The esker system comprises ten individual segments, which stretch for a distance of just over six kilometres.	› Geological Heritage sites are detailed in **Section 8.3.6.** › The potential impact of the Proposed Development on County Geological Sites is detailed in **Section 8.5.2.6.**
	› **Groundwater** - The proposed wind farm development is underlain by a 'Regionally Important Aquifer - Karstified (conduit)'. The	› The hydrogeological setting of the Proposed Development is outlined in **Chapter 9** of this EIAR.

[1] *Eskers are ridges made of sands and gravels, deposited by glacial meltwater flowing through tunnels within and underneath glaciers*

Consultee	Description of response	Relevant Section
	Groundwater Vulnerability map indicates the area covered is variable. We would therefore recommend use of the Groundwater Viewer to identify areas of High to Extreme Vulnerability and 'Rock at or near surface' in your EIAR. › In the area there is a groundwater drinking water abstraction for which there is a zone of contribution/source protection area: Killeglan Public Water Supply - Tobermore Spring. Key to groundwater protection in general, and protection of specific drinking water supplies, is preventing ingress of runoff to the aquifer. Design of the windfarm drainage will need to be cognizant of the public water scheme and the interactions between surface water and groundwater as well as run-off. Appropriate design should be undertaken by qualified and competent persons to include mitigation measures as necessary, such as SUDs or other drainage mitigation measures. This is discussed in Chapter 9 of this EIAR.	› The potential impact of the Proposed Development on the Killeglan Public Water Supply – Tobermore Spring is discussed in **Chapter 9** of this EIAR.
	› **Geohazards** – the GSI recommend that geohazards and particularly flooding be taken into consideration, especially when developing areas where these risks are prevalent, and encourage the use of GSI data when doing so. Due to the topographical setting of the wind farm, flooding will not be an issue.	› Geohazards are addressed in **Section 8.3.8**. › Flooding is discussed in **Chapter 9** of this EIAR.
Roscommon County Council	Roscommon Co. Co. (Heritage Office) note concerns "that the Proposed Development may impact on two identified sites of County Geological importance – Killeglan Karst Landscape and Castlesampson Esker.	› Geological Heritage sites are detailed in **Section 8.3.6**. › The potential impact of the Proposed Development on County Geological Sites is detailed in **Section 8.5.2.6**.
Irish Water	IW currently does not have the capacity to advise on scoping of individual projects. However, in general we would like the following aspects of Water Services to be considered in the scope of an EIAR where relevant;	› The Proposed Development will not have any potential physical impact on any Irish Water assets. Definition of local water supply assets is addressed in Section 9.3.7 of the Chapter 9, and assessed in Section

Consultee	Description of response	Relevant Section
	Any physical impact on IW assets – reservoir, drinking water source, treatment works, pipes, pumping stations, discharges outfalls etc. including any relocation of assets.	9.4.2.10.
Health Service Executive	A detailed assessment of the current ground stability of the site for the proposed windfarm development together with the necessary mitigation measures should be included in the EIAR. The assessment should include the impact construction work will have on the future stability of ground conditions taking into account extreme weather events, site drainage, and the possibility for soil erosion.	- Ground stability within the site is discussed in **Section 8.3.8.1**.
Inland Fisheries Ireland	We are concerned about soils, their structure and types around all the turbines, turbine pads, associated access roads and site development. In particular we have concerns about the stability of the soils and the impact that works on both the turbines and access roads will have either directly or by vibration on the stability of the soils. The IFI will be very concerned where it is proposed to construct wind turbines on peat soils. Extra caution will be required to prevent deleterious discharges to waters. The IFI strongly recommends that specialist personnel are employed to assess soil strength and suitability of the ground at each site and along any proposed access road. This is particularly important in relation to peat soils. From our experiences we will have serious difficulties with developments on peat soils where there is excessive slope and or where the peat depth exceeds one metre. Excessive slopes will be an issue with all wind farm proposals regardless of soil type. The potential for soil movement and landslides should be assessed fully within the EIS.	- A description of the soils and subsoils within the Wind Farm site is provided in **Section 8.3.3**. - Ground stability within the site is discussed in **Section 8.3.8.1.**
Department of Culture, Heritage and the Gaeltacht	For information on Geological and Geomorphological sites, the Geological Survey of Ireland, should be consulted.	- The Geological Survey of Ireland online databases were consulted throughout the desk based study.

8.2.4 Impact Assessment Methodology

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

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

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

The guideline criteria (EPA, 2022) for the assessment of impacts require that likely impacts are described with respect to their extent, magnitude, complexity, probability, duration, frequency, reversibility and transfrontier nature (if applicable). The descriptors used in this environmental impact assessment report are those set out in EPA (2002) Glossary of Impacts as shown in Chapter 1 of this EIAR.

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

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

Impact Characteristics		Potential Hydrological Impacts
Quality	Significance	
Negative only	Profound	Widespread permanent impact on: › The extent or morphology of a candidate Special Area of Conservation (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.
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 Development, known as 'Seven Hill Wind Farm' is located between Dysart and Brideswell, County Roscommon. The R363 bisects the Northern and Southern clusters of the site. A site location map is included as Figure 1-1 of Chapter 1.

8.3.1.1 Northern Cluster

The Northern Cluster is located ~ 1.6km northeast of Dysart and consists of 7 no. turbines within a ~ 2 km^2 area between the townlands of Cronin, Gortaphuill and Cornalee. The topography is undulating, with elevations ranging between 70-105 m OD, with the turbine locations situated along a northwest-southeast trending ridge. The elevation difference from the top of this ridge can be seen in Site photo 4 of Appendix 8-1. The land is primarily agricultural, primarily used for grazing and varies from rough ground with scrub vegetation and boulders to improved grassland (refer to Site Photos 2 & 3 of Appendix 8-1). The higher ground at the Northern Cluster (i.e. the ridge) is surrounded by low lying agricultural lands, which are appear to be improved and high yielding grasslands. There are a number of turloughs situated within the low-lying areas, with a number of turloughs situated within localised depressions. These turloughs are mostly situated at elevations of <65 m OD.

The Southern Cluster is accessible via a proposed new access junction of the R363 as detailed in Chapter 4.

8.3.1.2 Southern Cluster

The Southern Cluster is located ~ 3.3 km southeast of Dysart, Co. Roscommon and 12 km west of Athlone. Co. Westmeath. The Southern Cluster consists of 13 no. proposed turbine locations over a ~ $5km^2$ area, from the townland of Milltown towards Cuilleenoolagh and Cam Hill. Elevation ranges between 70-110 m OD, along a northwest-southeast range of small hills, which are locally steep in places. The ridgeline of these hills and the lower elevation improved grassland is evident within Site photo 1 of Appendix 8-1. The land above ~90 m OD is mostly scrub vegetation, rough grass and Blackthorn trees, strewn with glacially deposited boulders, with a considerable number of localised depressions and variations in topography (refer to Site photo 5 of Appendix 8-1). The land is primarily agricultural at elevations below ~90 m OD, used for grazing and appears well drained.

The Southern Cluster is accessible via both an existing and a proposed new access junction of the R363 as detailed in Chapter 4.

8.3.1.3 Grid Connection Route

A connection between the onsite electrical substation and the national electricity grid will be necessary to export electricity from the Wind Farm site. It is proposed to construct a 110 kV substation within the site and to connect from here via a 110 kV underground cable connection to the existing Athlone 110 kV substation in Monksland, located approximately 11.3km to the east of the Southern Cluster, via underground cabling. The majority of the Grid Connection route is located within the public road and measures approximately 12km in total. This underground cable connection will originate at the proposed electrical onsite substation, continue along the R363, transitioning to the R362 near the townland of Ballymullavill, travelling north along the L2047 before reaching the Athlone 110 kV substation at Monksland. The route is generally flat, apart from a section of the R363 which passes over Cam Hill. A map of the proposed Grid Connection route is given in Figure 4-15 of Chapter 4.

8.3.2 Land and Landuse

8.3.2.1 Northern Cluster

Landuse within the Northern Cluster of the proposed Wind Farm site is primarily agricultural, under grass pasture and used mainly for grazing of sheep. Areas of scrub grassland exist towards the northern section of the Northern Cluster, near the proposed Turbines T1 and T2. The majority of the site infrastructure, including access roads is situated within grassland pastures.

8.3.2.2 Southern Cluster

Landuse within the Southern Cluster of the proposed Wind Farm site varies between agricultural grassland areas under permanent grazing and rough scrub, which is often strewn with boulders, the majority of the site situated within the latter. The eastern area of the Southern Cluster, near T17-T20 is primarily agricultural land.

8.3.2.3 Grid Connection Route

Landuse along the Grid Connection route is mostly road carriageway with occasional pedestrian paving along the road margins. Adjacent landuse is primarily agricultural along the R363 between Dysart and Bellanamullia, with urban and residential buildings nearer the town of Athlone between Bellanamullia and the Athlone 110kV substation.

8.3.3 Soils and Subsoils

The area of the Wind Farm site is mapped by the GSI as being overlain by Limestone Tills, with smaller areas of Fen peat mapped west of Dysart (which do not coincide with the Wind Farm site) and isolated ribbons of Esker deposits which are mostly oriented in a northwest-southeast direction.

The most significant force to shape the form of the county as we see it today was the Ice Age which ended about 10,000 years ago. Large ice sheets covered the area for thousands of years and eroded the rocks beneath. As the ice eventually melted away, the meltwaters reorganised the sediments into iconic landforms like eskers, adjacent to large fans and deltas of sand and gravel, such as at the Cloonagh and Errit Lough Deltas in the northwest of Roscommon. The fans and deltas now stand out as high ground with good grass amongst the boggier lake margins. Eskers were formed by sub-glacial rivers, that is, they flowed in tunnels at the base of the ice sheets. The Castlesampson Esker is one of the smaller examples of the landform within County Roscommon.

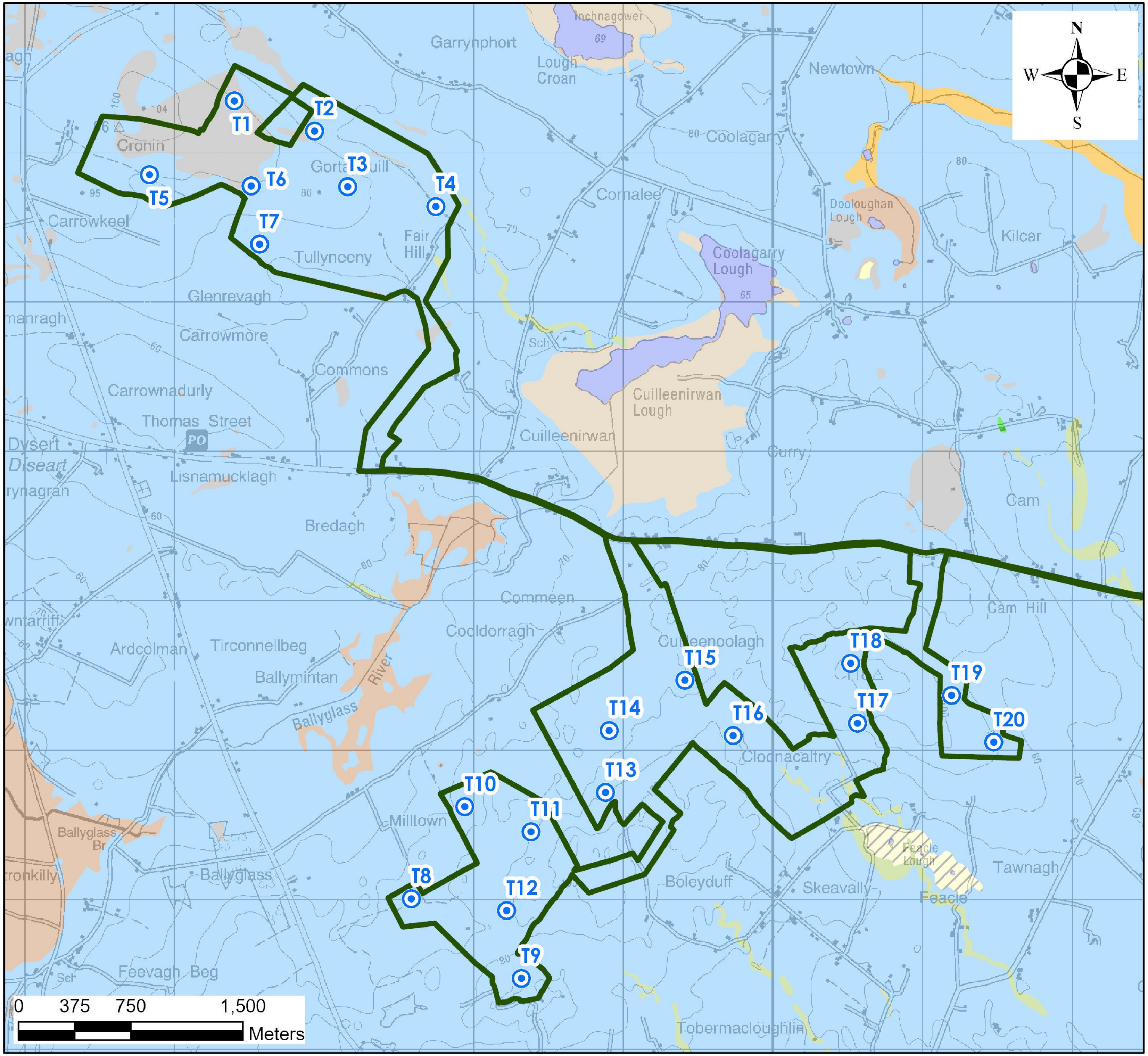
Data sources for the descriptions of soils and subsoils below are taken from referenced desk study sources and site-specific data from various site investigations works. Unless otherwise specified, relevant site investigation reports are included in Appendix 4-3, Appendix 4-4, Appendix 4-5 and Appendix 4-6.

8.3.3.1 Northern Cluster

Published soils maps (www.epa.ie) were queried for data on mapped soils in the Northern Cluster. Deep well drained basic mineral soils (BminDW) is the dominant soil type within the Northern Cluster and in the local area with smaller pockets of shallow well drained mineral soil (BminSW) mapped near the townlands of Cronin and Turrock. A small area of fen peat is mapped near the townland of Garrynaphort, close to Lough Croan.

A map of the local subsoil cover is attached as Figure 8-1 (www.gsi.ie). This shows the mapped distribution of subsoil deposits within the Wind Farm site and in the surrounding lands. The majority of the site is mapped as Tills derived from limestone with some areas of bedrock outcrop mapped on higher ground, particularly near Cronin.

The site investigation data on subsoil types and depths from the Northern Cluster is consistent across multiple instances of borehole and trial pit works between 2010-2021. A total of 22 no. boreholes haven been drilled within the Northern Cluster. In addition, 48 no. trial pits have been excavated, along with the completion of geophysical surveys and PSD and permeability analysis of the subsoils. Site investigation data has revealed that the subsoils consist of sandy CLAY, gravelly SAND and sandy GRAVEL, with a depth of overburden between 1.3m – 16.3m where the full profile was described (*i.e.* at boreholes). A map of the site investigation points within the Northern Cluster is shown as Figure 8-2.



Legend

- EIAR Site Boundary
- Proposed Turbine Layout

Subsoils

- Alluvium
- Eskers comprised of gravels of basic reaction
- Cut over raised peat
- Fen Peat
- Gravels derived from Limestones
- Kartsified bedrock outcrop or subcrop
- Lacustrine sediments
- Lake marl
- Bedrock outcrop or subcrop
- Till derived from limestones
- Water

HYDRO ENVIRONMENTAL SERVICES

22 Lower Main St
Dungarvan
Co.Waterford
Ireland

tel: +353 (0)58 44122
fax: +353 (0)58 44244
email: info@hydroenvironmental.ie
web: www.hydroenvironmental.ie

Client: Energia Renewables ROI Ltd

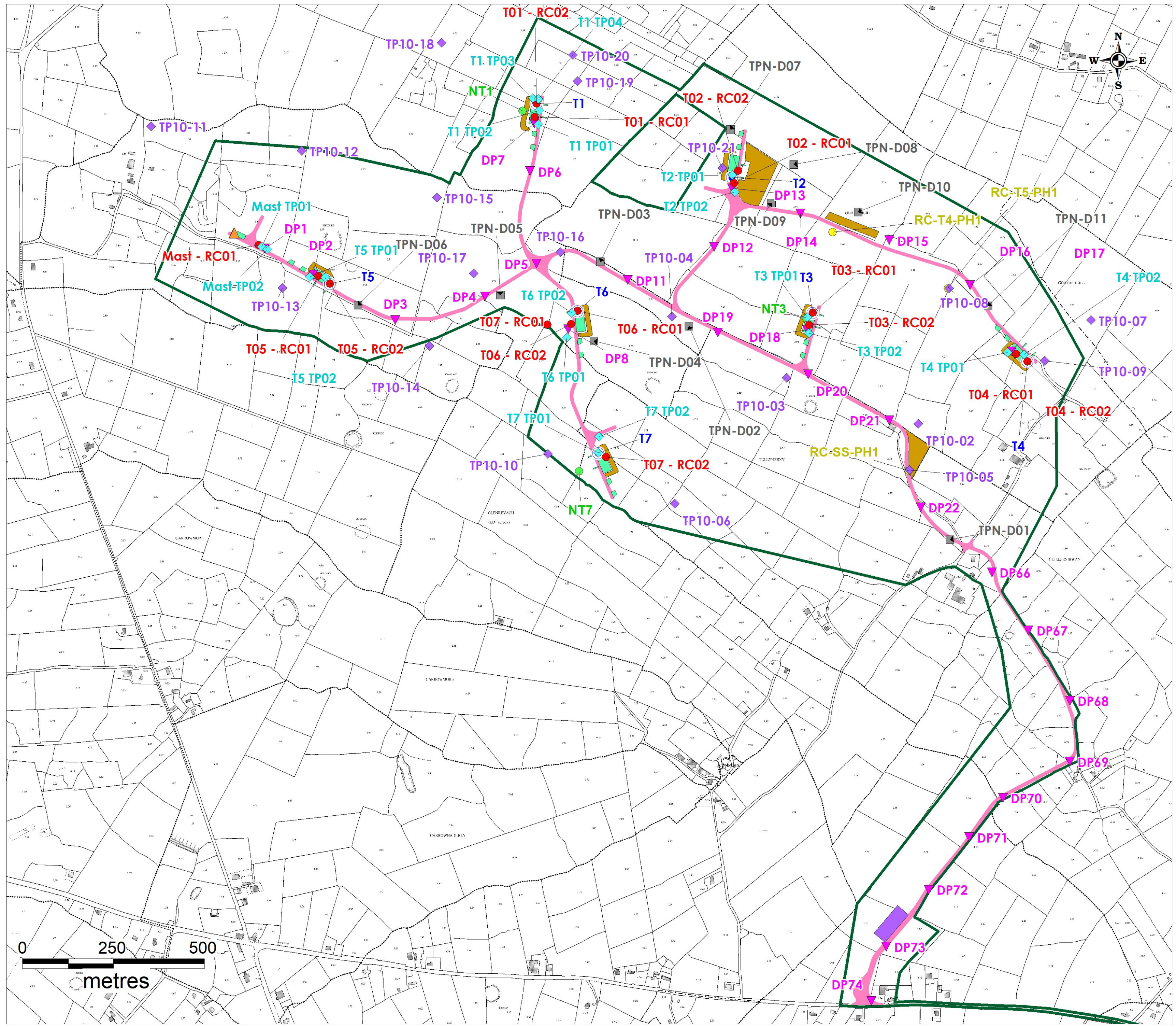
Job: Seven Hills WF, Co. Roscommon

Title: Local Subsoils Map (Wind Farm)

Figure No: 8-1

Drawing No: P1500-0-0422-A4-801-0A

Sheet Size: A4	Project No: P1500-0
Scale: 1:35,000	Drawn By: GD
Date: 20/04/2022	Checked By: MG



Legend

EIAR Site Boundary

Proposed Turbine Layout

Proposed Met Mast

Proposed Substation

Proposed Temporary Construction Compound

Proposed Spoil Storage Area

Proposed Hardstand

Proposed Access Roads

Trial Pits 2010

Trial Pits 2020/2021 (IGSL)

Trial Pit 2021 (HES)

Boreholes 2015

Boreholes 2020 (HES)

Boreholes 2020/2021 (IGSL)

Dynamic Probes 2020/2021 (IGSL)

HYDRO ENVIRONMENTAL SERVICES

22 Lower Main St
Dungarvan
Co.Waterford
Ireland

tel: +353 (0)58 44122
fax: +353 (0)58 44244
email: info@hydroenvironmental.ie
web: www.hydroenvironmental.ie

Client: Energia Renewables ROI Ltd	
Job: Seven Hills WF, Co. Roscommon	
Title: Site Investigation Map - Northern Cluster	
Figure No: 8-2	
Drawing No: P1500-0-0422-A3-802-0A	
Sheet Size: A3	Project No: P1500-0
Scale: 1:10,000	Drawn By: GD
Date: 20/04/2022	Checked By: MG

3 no. boreholes were drilled within the Northern Cluster of the Wind Farm site in May 2020 by Petersen Drilling Services, with full time supervision and geological logging from HES staff. The subsoil deposits logged range in depth between 1.8-16.25m and consisted of silty SAND, sandy GRAVEL, sandy gravelly CLAY and occasional Limestone boulders. The original logs from the 2020 HES boreholes are attached as Appendix 8-2.

16 no. rotary core boreholes were drilled at the Northern Cluster of the Wind Farm site between December 2020 – January 2021. The boreholes were drilled at the 7 no. turbine locations and at the proposed met mast location. The boreholes ranged in depth from 5 -14.6mbgl, bedrock was met in 6 of the 16 no. boreholes. The subsoils encountered during the drilling of the boreholes were described in the geological logs as sandy gravelly cobbly CLAY, sandy cobbly GRAVEL and gravelly SAND. The original logs from the 2020-2021 boreholes are included within Appendix 4-3.

The subsoils encountered at the Northern Cluster during the drilling of 3 of the 6 no. total rotary core boreholes conducted in April 2015 range in depth between 12.3-16.1m, with little bedrock encountered during the drilling of these rotary core boreholes. The subsoil is described as silty SAND, sandy gravelly CLAY and sandy GRAVEL amongst other variations of the same constituent particles. The subsoil depths across both the Northern and Southern Clusters are summarised in Figure 8-3, with subsoil depths plotted against a reference ground level (0 mbgl). The original logs from the 2015 boreholes are included as Appendix 8-3.

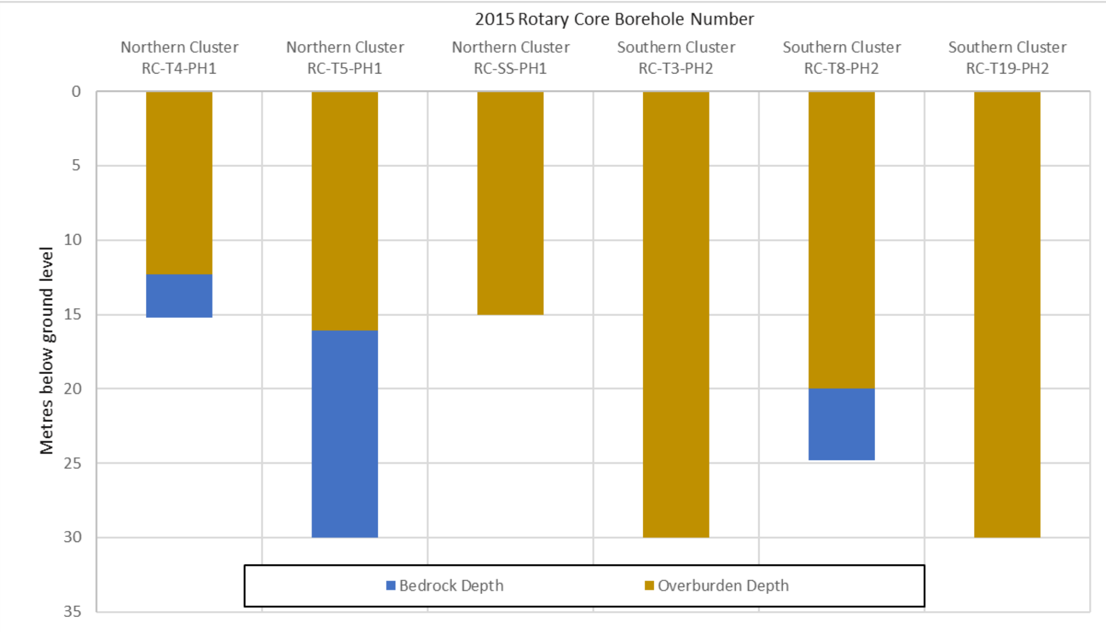


Figure 8-3: Subsoil depths during rotary core drilling – 2015 (Northern and Southern Clusters)

A histogram depicting the subsoil depth across the Northern Cluster is shown in Figure 8-3. This graph is based on the recorded depth to bedrock from 22 no. boreholes drilled in the Northern Cluster (16 no. boreholes logged by MWP in December 2020, 3 no. boreholes logged by HES in May 2020 and 3 no. rotary core boreholes completed in 2015 as part of previous site investigation works). The depth ranges in 2m intervals *e.g.* >2m, 2-4m etc. are shown on the X-axis, with the frequency of subsoils depths between these intervals depicted on the Y-axis. The graph shows a variation in subsoils depths across the northern cluster, with the majority of subsoil depths recorded being >6m. The mean depth of subsoil across the northern cluster from the borehole data is 7.41m with a standard deviation (σ) of 4.95m.

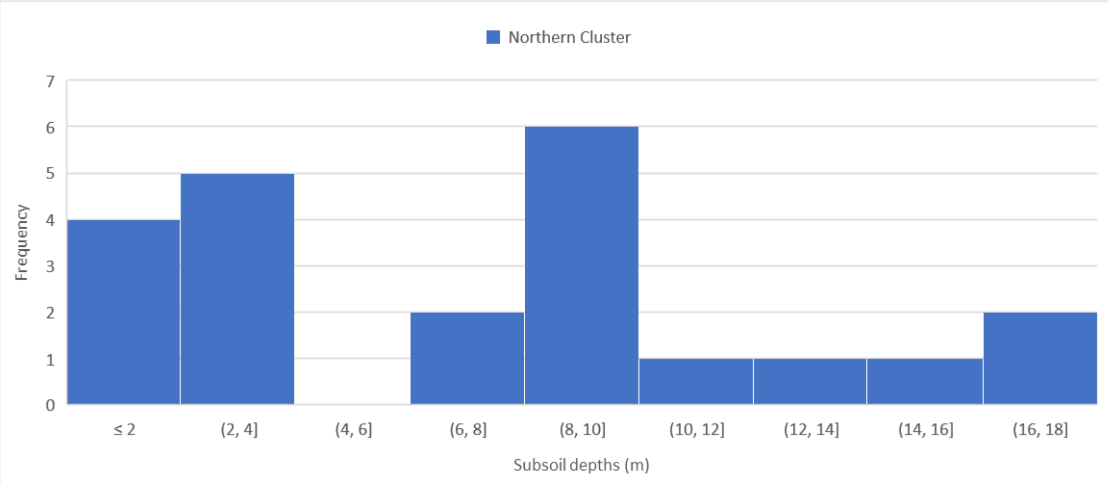


Figure 8-4: Histogram of subsoil depths across Northern Cluster

16 no. trial pits were excavated and logged by MWP/IGSL across the Northern Cluster to a maximum depth of 3.5m. Bedrock was not met in any of the trial pits, however several pits encountered large boulders and were unable to proceed deeper. The subsoils were described as a combination of brown gravelly CLAY/TOPSOIL, medium dense brown gravelly SAND, medium dense greyish brown sandy GRAVEL, firm light yellowish brown sandy gravelly CLAY, with boulders at the base of some trial pits. These trial pit logs are included within Appendix 4-3.

An additional 11 no. trial pits excavated and logged by HES (December 2021 – Appendix 4-6) across the Northern Cluster. These trial pit excavations ranged from 1.15 to 2.0mbgl. The trial pits did not encounter any bedrock, however several pits encountered large boulders and were unable to proceed deeper. The soils/subsoils comprised of a brown gravelly clay TOPSOIL overlying yellowish brown sandy gravelly CLAY and greyish brown gravelly SAND and sandy GRAVEL with frequent cobbles and boulders of limestone.

Previous trial pit investigations (21 no. trial pits), dating from 2010/2011, revealed that tills are present across the Northern Cluster of the proposed Wind Farm site. These historic trial pit investigations found that underlying the brown topsoil there is typically 0.6m layer of clay/sand-clay, which is in turn underlain by more gravelly clay with an increasing limestone gravel content. The subsoil encountered during the excavation of these trial pits is in line with more recent trial pit and borehole data (2020-2021) and consists of light brown sandy gravel or sandy clay. The 2010 Northern Cluster trial pits extended to a maximum depth of 2.1m. In some cases, weathered bedrock was logged at the base of the trial pits. In light of the recent site investigations where HES logged the occurrence of limestone boulders during trial pit excavations and borehole drilling at shallow depths, it is likely that the weathered bedrock recorded during the 2010 trial pit investigations may have been misinterpreted Limestone boulders. The 2010 trial pits provide valuable corroboration of the lateral extent of the sandy overburden but any previous interpretation of bedrock/weathered bedrock at the base of the trial pits will be disregarded in favour of more recent deeper trial pit and borehole data which indicates a depth to bedrock of 1.3m – 16.3m.

A geophysical survey of turbine locations was undertaken by Apex Geophysics on behalf of MWP (Malachy Walsh & Partners) between November 2020 – January 2021. The interpretation of the geophysical survey is in line with the data from the boreholes and trial pits.

At turbine T1, the geophysical survey indicates subsoils of between ~3-5m above Limestone bedrock, consistent with the 2021 borehole logs of 3.2 and 1.7m of subsoils at T1-RC01 and T1-RC02 respectively. At turbine T2, the geophysical profile indicates limited bedrock at ~15-20mbgl, with the majority of the profiles displaying lower resistivity values, interpreted as unconsolidated subsoil, consistent with the borehole subsoil depths of >10m at both T2-RC01 and T2-RC02.

The geophysical profiles at turbine T3 indicate low resistivity material underlying the majority of the profile. This is consistent with subsoil depths of >11 and >10m in boreholes T3-RC01 and T3-RC02 at Turbine 3 and 16.3m at borehole NT3 drilled by HES in 2020. The geophysical profiles at T4 are similar to those observed at T3, with low resistivity material underlying the majority of the profiles and no indication of bedrock. Subsoil depths of 9.6m and >10m were recorded at boreholes T4-RC01 and T4-RC02.

Bedrock was interpreted in the geophysical profile at T5 at a depth of ~ 2-5m, with resistivities of >2000 ohm-m below this depth. The relatively shallow depth of subsoil is consistent with the borehole logs for this area, with subsoil depths of 6.8m and 1.3m recorded at T5-RC01 and T5-RC02 respectively. Shallow subsoils were also logged in boreholes T6-RC01 and T6-RC02 (1.8m and 2.5m respectively), which corroborates the geophysical profile which shows relatively shallow subsoils above bedrock.

The profiles at Turbine T7 indicate shallow subsoils, with a possible layer of weathered bedrock with an undulating profile in profile T07-R1. The undulating layer, with a lower resistivity of ~1000 ohm-m may indicate a localised clay filled zone as no broken/weathered rock was identified in the cores from the borehole logs. Subsoil depth ranged between >10m and 4.4m in T7-RC01 and T7-RC02, while similar subsoils were logged to a depth of 6.4m at HES borehole NT7.

PSD analysis was completed at 25 no. locations within the Northern Cluster. 16 of the 25 no. samples were described as sandy GRAVEL. 5 of the 25 no. samples were described as gravelly SILT, while the remaining 4 were described as either gravelly or slightly gravelly silty CLAY. The PSD data for the Northern Cluster is shown graphically in Figure 8-5.

(Please note that 6 no. PSD analyses were completed using a hydrometer to define the complete finer fraction of the material, that's why the remainder of the distributions on the graph below end at the 0.06mm size).

Laboratory permeability tests were completed on 3 no. subsoil samples within the Northern Cluster. 2 no. samples were described as sandy GRAVEL and the recorded permeability ranged from 1.24×10^{-7} – 1.88×10^{-7} m/sec. 1 no. sample was described as gravelly SILT and recorded a lower permeability of 1.21×10^{-8} m/sec. Subsoil density was also recorded in these 3 no. subsoil samples, with bulk density ranging from 2.234mg/m^3 to 2.26mg/m^3. The full results of these laboratory tests are included in Appendix 4-3.

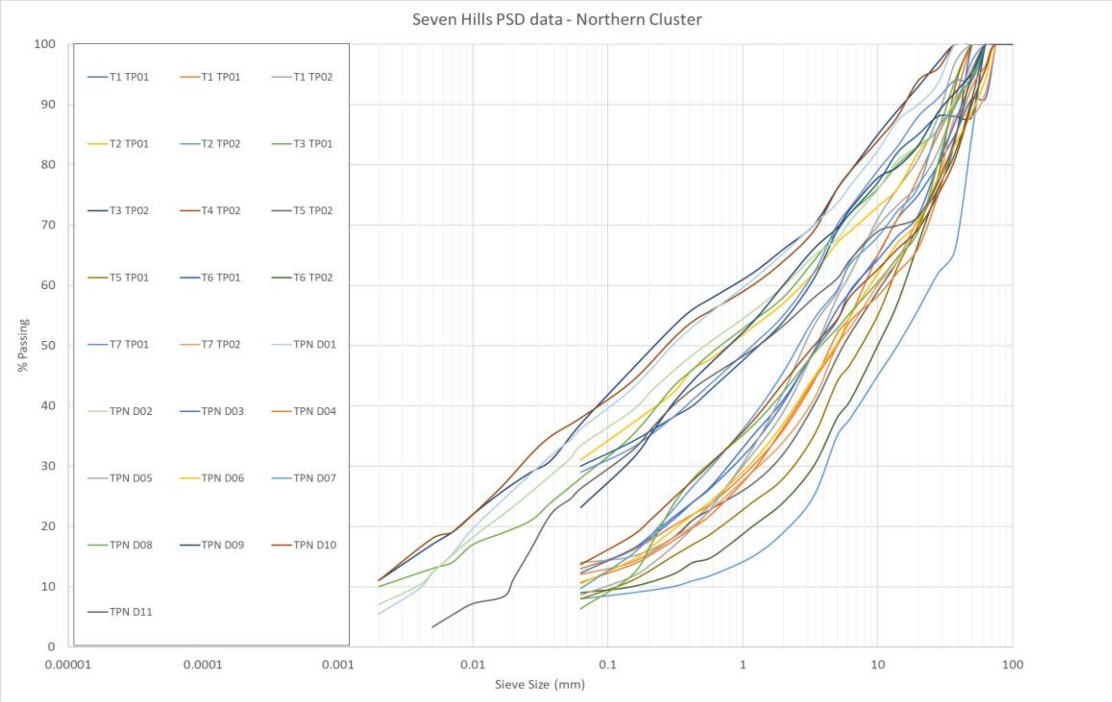


Figure 8-5: PSD analysis – Northern Custer

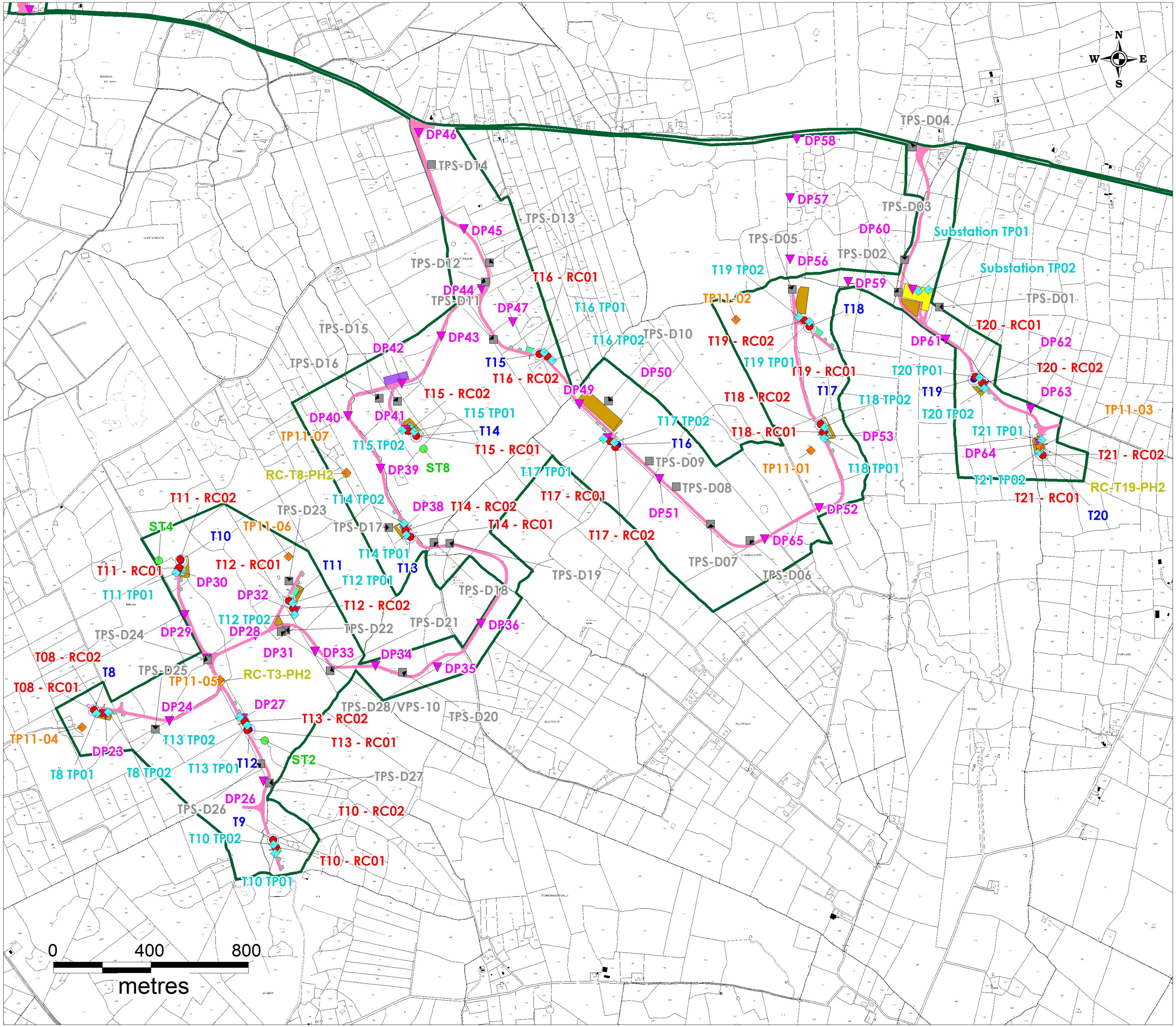
8.3.3.2 Southern Cluster

Published soils maps (www.epa.ie) were queried for data on mapped soils in the Southern Cluster. Deep well drained basic mineral soil (BminDW) is the dominant soil type at this portion of the site and in the general local area. There are some areas of poorly drained basic mineral soils, particularly on higher ground.

A map of the local subsoil cover is attached as Figure 8-1 (www.gsi.ie). This shows the mapped distribution of subsoil deposits around the site. The majority of the site is mapped as Tills derived from Limestone. There are eskers mapped east and southeast of the site near the townlands of Boleyduff and Cloonacaltry.

The site investigation data on subsoil types and depths from the Southern Cluster is consistent across multiple instances of borehole and trial pit works between 2010-2021. A total of 32 no. boreholes have been drilled within the Southern Cluster. In addition, 61 no. trial pits have been excavated, along with the completion of geophysical surveys and PSD and permeability analysis of the subsoils. The subsoils consist of sandy CLAY, clayey gravelly SAND and sandy clayey GRAVEL, with a depth of overburden between 1.3m – 30m where the full profile was described (*i.e.* at boreholes). A map of site investigation points with the Southern Cluster is shown as Figure 8-6.

An example of subsoil profile (with large boulder near the surface is shown in Photos 10-12 of Appendix 8-1. These site photos illustrate the size of the boulders at or near the surface, but also shows the underlying glacial till deposits over actual limestone bedrock. These photos are taken at an exposed profile in Cam quarry.



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Proposed Substation
- Proposed Spoil Storage Area
- Proposed Temporary Construction Compound
- Proposed Hardstand
- Proposed Access Roads
- Trial Pits 2011
- Trial Pits 2020/2021 (IGSL)
- Trial Pits 2021 (HES)
- Boreholes 2015
- Boreholes 2020 (HES)
- Boreholes 2020/2021 (IGSL)
- Dynamic Probes 2020/2021 (IGSL)

HYDRO ENVIRONMENTAL SERVICES

22 Lower Main St
Dungarvan
Co.Waterford
Ireland

tel: +353 (0)58 44122
fax: +353 (0)58 44244
email: info@hydroenvironmental.ie
web: www.hydroenvironmental.ie

Client: Energia Renewables ROI Ltd	
Job: Seven Hills WF, Co. Roscommon	
Title: Site Investigation Map - Southern Cluster	
Figure No: 8-6	
Drawing No: P1500-0-0422-A3-806-0A	
Sheet Size: A3	Project No: P1500-0
Scale: 1:15,000	Drawn By: GD
Date: 20/04/2022	Checked By: MG

3 no. boreholes were drilled within the Southern Cluster of the site in May 2020 by Petersen Drilling Services, with full time supervision and geological logging from HES staff. The subsoil deposits logged ranged in depth between 1.8-6.2m and consisted of brownish grey gravelly SAND, brown silty SAND and occasional Limestone boulders. The original logs from the 2020 HES boreholes are attached as Appendix 8-2.

26 no. rotary core boreholes were drilled at the Southern Cluster of the site between December 2020 – January 2021. The boreholes were drilled at the 13 no. turbine locations. The boreholes ranged in depth from 3.5-11 mbgl, bedrock was met in 20 of the 26 no. boreholes. The subsoils encountered during the drilling of the boreholes were described in the geological logs as sandy GRAVEL, sandy gravelly CLAY and sandy gravelly COBBLES. The original logs from the 2020-2021 boreholes are included as Appendix 4-3.

The subsoils encountered at the Southern Cluster during the drilling of 3 of the 6 no. total rotary core boreholes (RC-T3-PH2, RC-T8-PH2 and RC-T19-PH2) conducted in April 2015 range in depth between 24.8m – 30m, with bedrock encountered at RC-T8-PH2 only at a depth of 20 mbgl. The subsoil is described as sandy gravelly CLAY and Limestone GRAVEL with some sandy gravelly clays with Limestone boulders frequently encountered. The subsoil depths across the Southern Cluster are shown in the 3 columns on the right of Figure 8-3, with subsoil depths plotted against a reference ground level (0 mbgl). The original logs from the 2015 boreholes are included as Appendix 8-3. The subsoil depths recorded during these drilling works in 2015 vary from more recent data, with a much deeper subsoil layer (24.8-30m) recorded in these boreholes, however it must also be noted that where bedrock was not encountered in the more recent 2021 boreholes after 10-11m, the borehole was terminated and so subsoil depths are likely greater than the 10-11m recorded.

A histogram depicting the subsoil depth across the Southern Cluster is shown in Figure 8-7. This graph is based on the recorded depth to bedrock from 32 no. boreholes drilled in the Southern Cluster (26 no. boreholes logged by MWP in December 2020-January 2021, 3 no. boreholes logged by HES in May 2020 and 3 no. rotary core boreholes completed in 2015 as part of previous site investigation works). The graph shows a variation in subsoils depths across the southern cluster, with the majority of subsoil depths between >6m. The mean depth of subsoil across the southern cluster from the borehole data is 7.32m with a standard deviation(σ) of 6.91m, which indicates more variance than the Northern Cluster.

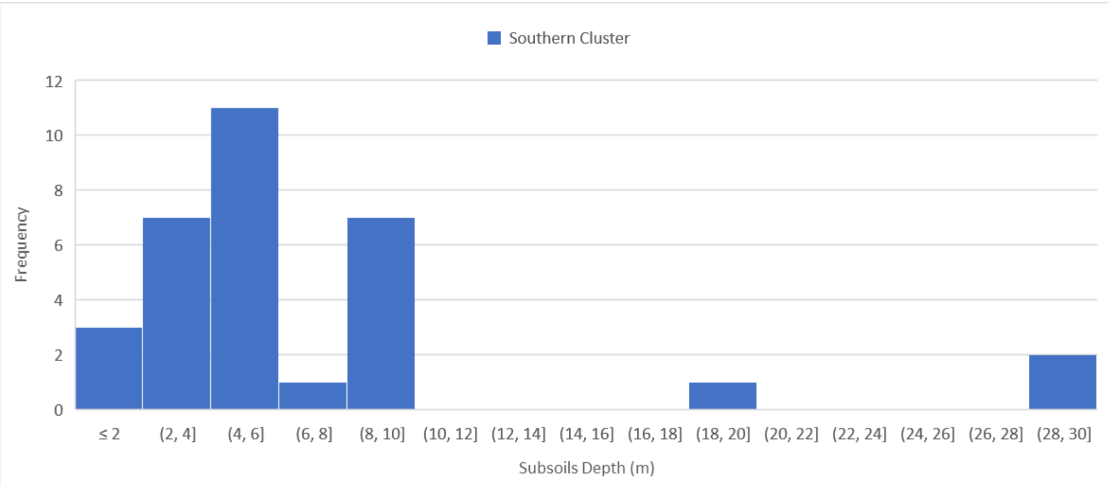


Figure 8-7: Histogram of subsoil depths across Southern Cluster

27 no. trial pits were excavated across the Southern Cluster to a maximum depth of 3.7m. Bedrock was not met in any of the trial pits, however several pits encountered large boulders and were unable to proceed deeper. The subsoils were described as a combination of brown sandy gravelly CLAY TOPSOIL, clayey sandy GRAVEL, medium dense greyish brown sandy GRAVEL and sandy gravelly CLAY with boulders at the base of some trial pits. These trial pit logs are included as Appendix 4-3.

Previous trial pit investigations, dating from 2010/2011, revealed that tills are present across the Southern Cluster of the proposed Wind Farm site. It was found that underlying the typically rich to light brown sandy topsoil there is a layer of gravelly sand, which is in turn underlain by a sandy clay. The subsoil encountered during the excavation of these trial pits is in line with more recent trial pit and borehole data (2020-2021). The 2011 Southern Cluster trial pits extended to a maximum depth of 1.06m. As occurred in the Northern Cluster trial pits from the same period, in some cases weathered bedrock was logged at the base of the trial pits, which may have been misinterpreted Limestone boulders, which have since been logged at similar shallow depths during borehole drilling within the Southern Cluster conducted by HES in 2020 and by IGSL in 2020/2021. The 2010 trial pits provide valuable corroboration of the lateral extent of the sandy, gravelly overburden but any previous interpretation of bedrock/weathered bedrock at the base of the trial pits will be disregarded in favour of more recent deeper trial pit and borehole data.

A geophysical survey of turbine locations was undertaken by Apex Geophysics on behalf of MWP between November 2020 – January 2021 at the Southern Cluster. The interpretation of the geophysical survey includes reference (and calibration) to the data from the boreholes and trial pits.

At turbine T8, the geophysical survey indicates subsoils of between ~3-5m above Limestone bedrock, consistent with the 2021 borehole logs of 3.9m and 5.1m of subsoils at T08-RC01 and T08-RC02 respectively.

[Please note, from here onwards the reference numbering for site investigation locations are as per explained in Section 4-3.1.2].

The geophysical profiles at turbine T09 indicates a thickening band of low resistivity material underlying profile T10_R1. This is consistent with subsoil depths of >10m in boreholes T10-RC01 and T10-RC02 at. The geophysical profiles at T10 indicate sections or pockets of low resistivity material to the northwest of profile T11_R1 and within the centre of profile T11_R2. Subsoil depths of 1.7 and 2.0m were recorded at boreholes T11-RC01 and T11-RC02. A further 2 no. boreholes were drilled at turbine location T10 to determine the nature and extent of the geophysical anomalies. At borehole T11-RC03, 9.45m of overburden, consisting of sandy gravelly COBBLES over sandy gravelly CLAY were observed. The bedrock below (9.45-12.3m) was described as strong to very strong thinly bedded, fine-medium grained LIMESTONE. At borehole T11-RC04, 2.2m of overburden was recorded, over strong to very strong thickly to thinly bedded, dark grey/blueish grey, fine to medium grained LIMESTONE.

Bedrock was interpreted in the geophysical profile at T11 at a depth of ~5m, with resistivities of >2000 ohm-m below this depth. The depth of subsoil is consistent with the borehole logs for this area, with subsoil depths of 2.7 and 3.1m recorded at T12-RC01 and T12-RC02 respectively. The geophysical profile at turbine T12 indicates low resistivity unconsolidated materials to the full depth of the profile, with some bedrock interpreted at the southeastern section of T13_R1. The indication of unconsolidated material adjacent to bedrock is consistent with subsoil depths of 1.3 and 8.7m in boreholes T13-RC01 and T13-RC02.

The profiles at Turbine T13 indicate ~5-8m of subsoils. Competent bedrock is interpreted below this. The geophysical survey interpretation is consistent with subsoils depths of 4.5m from both borehole logs T14-RC01 and T14-RC02. The geophysical profile at turbine T14 indicates ~2-4m of overburden (sandy gravelly CLAY and sandy gravelly COBBLES).

The geophysical profiles for turbines T15 – T18 are similar, with ~5-8m of low resistivity material above ~200 ohm-m high resistivity assumed bedrock. The subsoils at these locations range between 2.7m – 5.3m deep, with an average value of 4.3m and are described as sandy gravelly COBBLES or sandy GRAVEL. The geophysical profiles and subsoil depths are consistent within these 4 no. locations.

The geophysical profile at turbine T19 indicates low resistivity material (interpreted as overburden) throughout the majority of the profile, with some bedrock interpreted at the base of both profiles (T20_R1 and T20_R2). The geological logs from boreholes T20-RC01 and T20-RC02 show subsoils greater than 10m deep, consisting of sandy gravelly CLAY, sandy GRAVEL and clayey sandy COBBLES.

The geophysical profile at turbine T20 indicates low resistivities, similar to those seen at T19, with minor amounts of bedrock interpreted along profile T21_R2. The logs from boreholes T21-RC01 and T21-RC02 indicate subsoils greater than 10m deep, consisting of sandy gravelly CLAY, sandy gravelly COBBLES and sandy GRAVEL.

PSD analysis was completed at 65 no. locations within the Southern turbine cluster. 49 of the 65 no. samples were described as sandy or very sandy GRAVEL. 16 of the 65 no. samples were described as gravelly or slightly gravelly SILT. The median particle size across the 65 no. samples was 3.35mm. The PSD data for the Southern cluster is shown graphically in Figure 8-8. (Please note that 8 no. PSD analyses were completed using a hydrometer to define the complete finer fraction of the material, that's why the remainder of the distributions on the graph below end at the 0.06mm size).

Laboratory permeability tests were completed on 9 no. subsoil samples within the Southern Cluster. 6 no. samples were described as sandy GRAVEL and the recorded permeability ranged from 1.15×10^{-7} – 2.78×10^{-8} m/sec. 3 no. samples were described as gravelly SILT and recorded a lower permeabilities ranging from 1.33×10^{-8} to 9.86×10^{-10} m/sec. Subsoil density was also recorded in these 9 no. subsoil samples, with bulk density ranging from 2.221mg/m^3 to 2.327mg/m^3. The full results of these laboratory tests are included in Appendix 4-6.

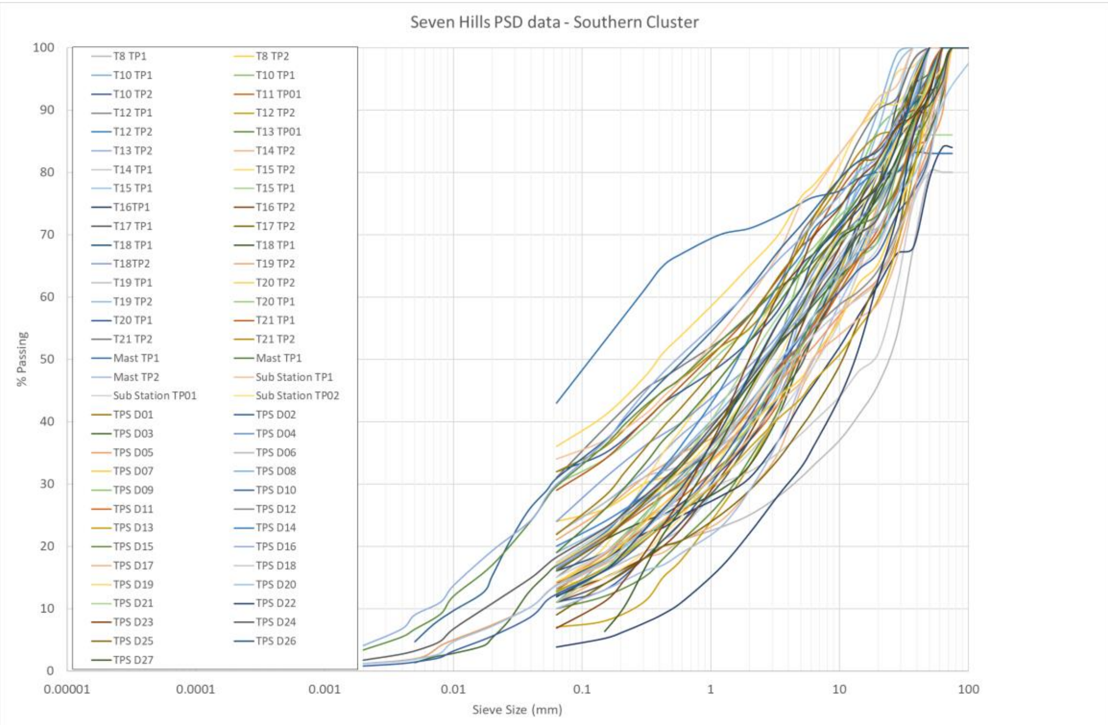


Figure 8-8: PSD analysis – Southern Cluster

8.3.3.3 Grid Route

Soils along the grid route are mapped as deep well drained basic mineral soils between Dysart and Brideswell. The soils mapped between Brideswell and the Monksland substation vary between shallow, well drained basic mineral soil (BminSW), cutover Peat (Cut), Basic Shallow, lithosolic or podzolic type soils potentially with peaty topsoil (BminSRPT), a small section of Alluvium along near the River Cross and Made ground between the R362 and R446.

Subsoils along the grid route are mapped as Tills derived from Limestone (TLs) between Dysart and the townland of Cornageeha. A small area of Esker is mapped between the townlands of Cam and Cornageeha. Limestone gravels (GLs) are mapped just southeast of the Esker deposit between Cornageeha and Brideswell. Cutover raised Peat is mapped between Brideswell and Ballymullavill. The subsoils between Ballymullavill and the Monkland substation are a mixture of Limestone gravels, Limestone Tills and cutover Peat, with some Alluvium mapped along the River Cross. Refer to Figure 8-9.

The soils and subsoils were investigated along the Grid Route by means of Slit trenching, rotary core borehole drilling and down hole hammer borehole drilling completed by ISGL between May-July 2021. The full factual report is included as Appendix 4-4. A summary of the soils and subsoils encountered during the site investigations is included below in

Table 8-4.

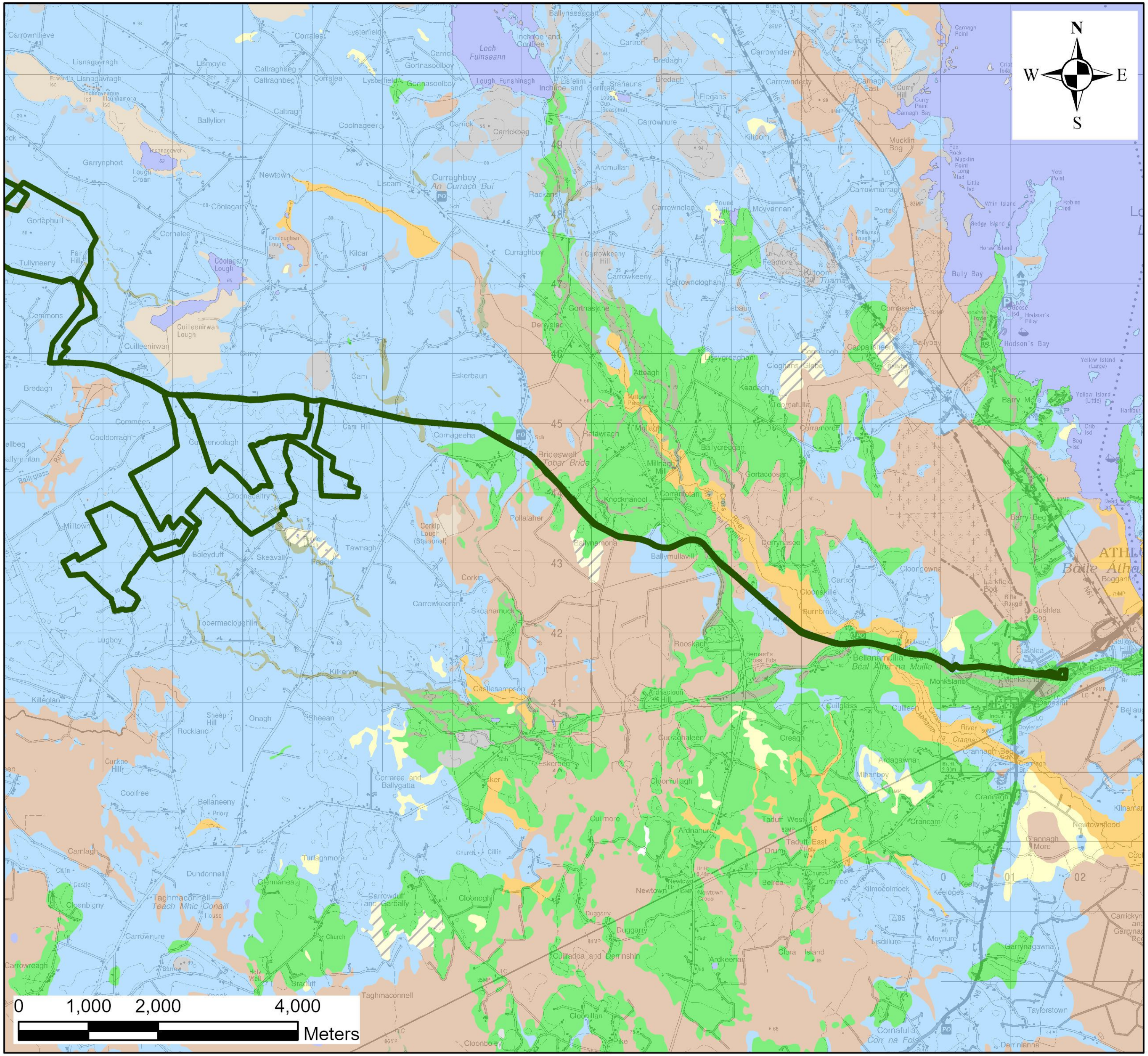
Table 8-4: Summary of Grid Route Site Investigation Data

Location	E	N	Depth	Description
BH01	594335	744307	0-0.1	TOPSOIL
			0.1-1	Soft Brown PEAT
			1-1.9	Soft grey sandy SILT
			1.9-4.5	Grey silty sandy GRAVEL with cobbles
BH03	599347	741782	0-0.1	TARMACADAM
			0.1-0.4	FILL-Hardcore
			0.4-2.0	Soft grey/brown sandy slightly gravelly SILT/CLAY. Gravel is fine.
			2.0-4.2	Stiff grey sandy gravelly CLAY with some cobbles and occasional boulders
BH03A	599346	741782	0-0.1	TARMACADAM
			0.1-0.4	FILL-Hardcore
			0.4-1.8	Soft grey/brown sandy slightly gravelly SILT/CLAY
			1.8-3.4	Firm brown sandy gravelly SILT/CLAY
			3.4-9.6	Stiff brown sandy gravelly CLAY with occasional cobbles
RC-04	599532	741706	0-2.5	No recovery, observed by driller as returns of cobbly GRAVEL
			2.5-3	No recovery, observed by driller as returns

Location	E	N	Depth	Description
				of sandy GRAVEL
			3-4.7	No recovery, observed by driller as returns of GRAVEL
			4.7-5.0	No recovery, observed by driller as returns of BOULDER
			5-7.4	No recovery, observed by driller as returns of GRAVEL
			7.4-10	No recovery, observed by driller as returns of sandy GRAVEL
RC-05	601411	741438	0-0.6	No recovery, observed by driller as returns of MADE GROUND
			0.6-3.6	No recovery, observed by driller as returns of GRAVEL
			3.6-4.5	No recovery, observed by driller as returns of BOULDER
			4.5-6.3	No recovery, observed by driller as returns of SAND
			6.3-9	No recovery, observed by driller as returns of GRAVEL
			9.0-10.0	No recovery, observed by driller as returns of sandy GRAVEL
			10.0-12.0	No recovery, observed by driller as returns of GRAVEL
			12.0-14.0	No recovery, observed by driller as returns of sandy GRAVEL
			14-14.6	No recovery, observed by driller as returns of SAND
			14.6-16	No recovery, observed by driller as returns of sandy GRAVEL
RC-06	601586	741438	0-0.8	No recovery, observed by driller as returns of sandy GRAVEL
			0.8-3.0	No recovery, observed by driller as returns of GRAVEL
			3.0-4.3	No recovery, observed by driller as returns of sandy GRAVEL
			4.3-4.6	No recovery, observed by driller as returns

Location	E	N	Depth	Description
				of BOULDER
			4.6-10	No recovery, observed by driller as returns of sandy GRAVEL
			10-10.5	No recovery, observed by driller as returns of black SAND
			10.5-12.5	No recovery, observed by driller as returns of sandy GRAVEL
			12.5-12.8	No recovery, observed by driller as returns of GRAVEL
			12.8-14.3	No recovery, observed by driller as returns of SAND
			14.3-16.0	No recovery, observed by driller as returns of sandy GRAVEL

The soils and subsoils along the grid route primarily consist of Sand and Gravel with occasional Boulders, Silts and CLAY. At BH01, located near Brideswell village, the lithology is described as Topsoil over 0.9m of Peat over sandy Silt and sandy Gravel. This is the only occurrence of Peat from the site investigation data. BH03 and BH03A encountered hardcore fill over sandy SILT and CLAY. The remaining rotary core boreholes encountered SAND, sandy GRAVEL or GRAVEL. There was no bedrock met within any boreholes which ranged in depth from 4.2m – 16m. The soils and subsoils encountered through the intrusive drilling of 6 no. (total) boreholes was similar to those encountered within the 10 no. slit trenches excavated by IGSL between 21st May – 02nd June 2021, consisting primarily of GRAVEL/Silty GRAVEL/SAND (refer to Appendix 4-4). The locations of the grid route site investigation points are shown on Drawings 1 –5 of Appendix 4-4.



Legend

EIAR Site Boundary

Subsoils

- Alluvium
- Eskers comprised of gravels of basic reaction
- Cut over raised peat
- Fen Peat
- Gravels derived from Limestones
- Kartsified bedrock outcrop or subcrop
- Lacustrine sediments
- Lake marl
- Bedrock outcrop or subcrop
- Till derived from limestones
- Water

HYDRO ENVIRONMENTAL SERVICES

22 Lower Main St
Dungarvan
Co.Waterford
Ireland

tel: +353 (0)58 44122
fax: +353 (0)58 44244
email: info@hydroenvironmental.ie
web: www.hydroenvironmental.ie

Client: Energia Renewables ROI Ltd	
Job: Seven Hills WF, Co. Roscommon	
Title: Local Subsoils Map (Grid Route)	
Figure No: 8-9	
Drawing No: P1500-0-0422-A4-809-0A	
Sheet Size: A4	Project No: P1500-0
Scale: 1:70,000	Drawn By: GD
Date: 20/04/2022	Checked By: MG

8.3.4 Bedrock Geology

The local Visean Limestones are logged by the GSI (included as Appendix 8-4) at several local boreholes (GSI-18-001, GSI-18-004 and GSI-18-110) and are interpreted as being a shallow water limestone succession. The youngest and shallowest limestones underlying the site are that of the Croghan Formation. This formation consists of alternating dark grey argillaceous limestones and medium to coarse grained light grey bioclastic limestones and is approximately 60m thick in this region. This in turn is underlain by the Ballymore (dark-grey well-bedded fine-grained argillaceous limestone with shale intervals) and Oakport Formations (massive coarse-grained bioclastic limestone with intervals of darker finer limestone). This limestone succession was formed in a tropical shallow water environment reflected by the abundance of corals and brachiopods. The Visean Limestones within Roscommon are known to be karstified with ubiquitous conduits or caves throughout the county, such as Pollnagran cave towards the north of the County[2]. The local geological map of the area is shown as Figure 8-10.

Data sources for the descriptions of soils and subsoils below are taken from referenced desk study sources and site-specific data from various site investigations works. Unless otherwise specified, relevant site investigation reports are included in Appendix 4-3, Appendix 4-4, Appendix 4-5 and Appendix 4-6.

8.3.4.1 Northern Cluster

The underlying bedrock in the Northern Cluster is mapped by the GSI as Visean Limestones (Undifferentiated). The GSI 1:100,000 bedrock map records a considerable amount of bedrock outcrop north of Dysert, towards Four Roads, while there is little outcrop mapped south of Dysert. There are no mapped faults in the area. The closest mapped fault is a large northwest to southeast orientated fault, located approximately 7km southwest of the Northern Cluster.

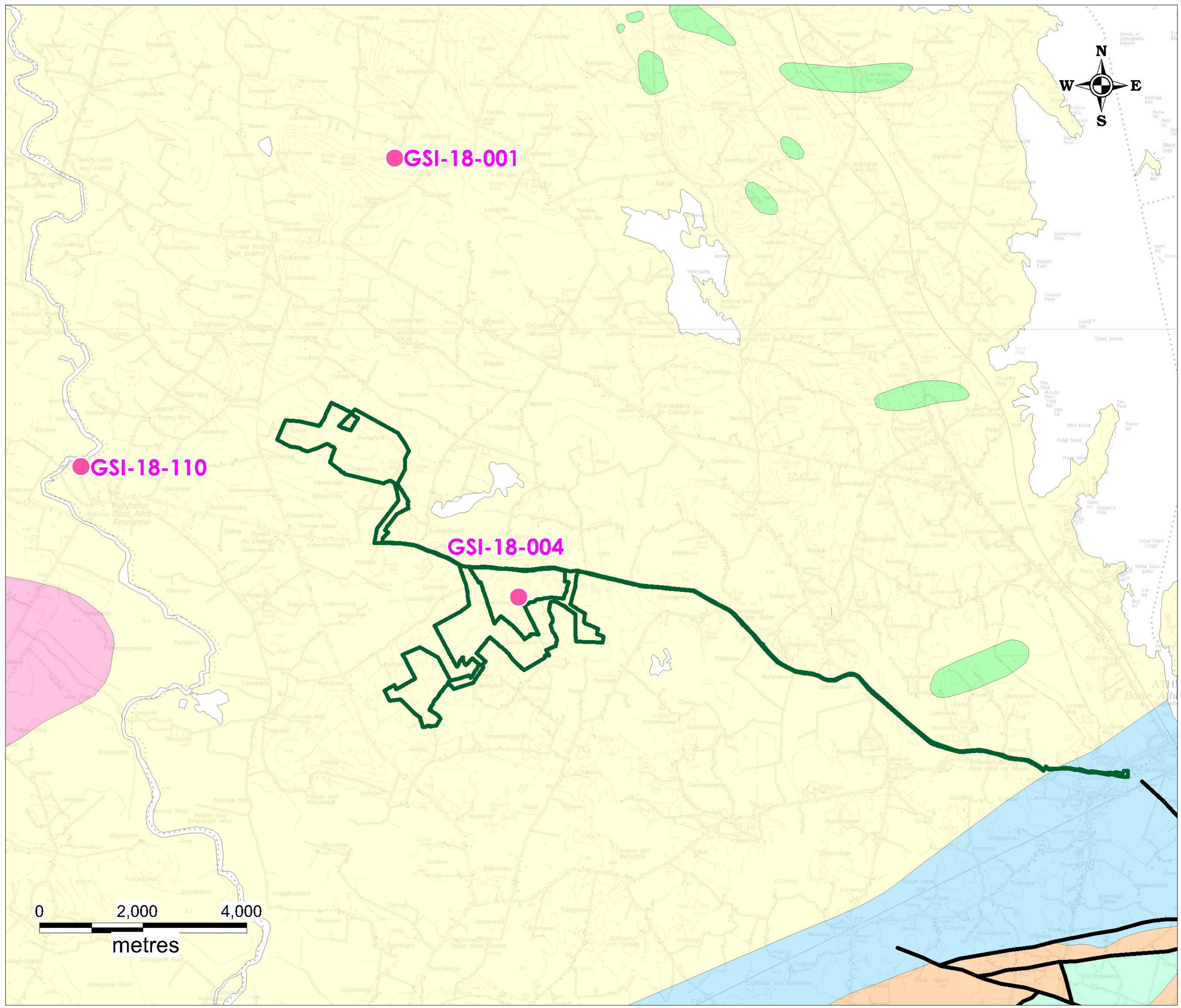
Initial rotary core boreholes were completed at 3 no. locations in 2015 at RC-T4-PH1, RC-T5-PH1 and at RC-SS-PH1 (the proposed substation location at that time). Bedrock was recorded in 2 of the 3 no. rotary core boreholes. Bedrock was met in RC-T4-PH1 at 12.3m and is described as very strong, thinly bedded bioclastic sparry fine to coarse grained Limestone. Bedrock was encountered in RC-T5-PH1 at 20.1m and is described as weathered Limestone with some clays from 20.1m - 22.8m and as very strong, thinly bedded Limestone from 22.8m - 30m.

Site investigation boreholes were then drilled at 3 no. locations across the norther cluster by Peterson Drilling for HES in 2020. Medium grey weak weathered Limestone was logged at borehole NT1 between 1.8m - 2.0m, followed by strong, grey Limestone with occasional weathered zones from 2.0m - 48.5m. At borehole NT3, strong, dark grey Limestone with occasional minor weathering was logged from 16.25m – 33.4m. The borehole log from NT7 describes strong grey Limestone with occasional minor fracturing from 6.3-10.9m, underlying moderately strong to strong Limestone with 2 no. identified clay infill layers, which are ~ 2-3m deep from 10.9m - 30.5m.

16 no. boreholes were drilled by IGSL, on behalf of MWP, with bedrock encountered in 6 of these 16 no. boreholes. The bedrock was met at varying depths between 1.7 – 9.6mbgl. The bedrock is described as strong to very strong, dark blueish grey, fine to medium grained Limestone. Where apertures are found in the rock, they are described as tight to locally open and locally clay/gravel filled.

---

[2] *The Geological Heritage of Roscommon, 2012; Parkes, R., Meehan, R., Preteseille, S*



Legend

- EIAR Site Boundary
- Borehole GSI 2018
- Mapped Faults
- Ballysteen Formation
- Lucan Formation
- Mudbank limestone
- Navan Beds
- Visean Limestones (undifferentiated
- Waulsortian Limestones

HYDRO ENVIRONMENTAL SERVICES
22 Lower Main St
Dungarvan
Co. Waterford
Ireland
tel: +353 (0)5844122
fax: +353 (0)5844244
email: info@hydroenvironmental.ie
web: www.hydroenvironmental.ie

Title: Local Bedrock Geology Map

Client: Energia Renewables ROI Ltd

Job: Seven Hills WF, Co. Roscommon

Project No: P1500-0

Figure No: 8-10

Sheet Size: A4

Drawing No: P1500-0-0422-A4-810-0A

Date: 20/04/2022

Scale: 1:100,000

Drawn By: GD | Checked By: MG

No karst features were noted during the drilling of the 16 no. boreholes. Geological cross sections of the Northern Cluster (Cross-Section A-A' and Cross-Section B-B') area based on the site investigation data are included in Appendix 8-5.

In total 285.7m of borehole drilling has been completed within the Northern Cluster (110.95m during the 2020 HES supervised drilling, 198.9m during the 2020 IGSL drilling and 84.8m during the previous site investigation work completed in 2015). Bedrock is identified at an average depth of 7.41mbgl and no significant karst conduit features have been logged throughout the 285.7m of drilling. In total, 157.8m of the drilling was in overburden (55.2%) with 59.09% of the boreholes encountering an overburden thickness in excess of 4m. The borehole drilling depths and the geographical spread of the borehole locations across the Northern Cluster provides confidence in stating that the Limestone bedrock is overlain by a variable thickness of overburden and bedrock is recorded as strong, dark grey bioclastic Limestone with discreet weathered zones and intermittent clay infilled fractures. Groundwater inflows were virtually absent during drilling, which are discussed further in Chapter 9 of this EIAR.

8.3.4.2 Southern Cluster

The underlying bedrock at the Southern Cluster is also mapped by the GSI as Visean Limestones (Undifferentiated) as described above. The GSI 1:100,000 bedrock map does not record the presence of bedrock outcrop near the Southern Cluster turbine locations. There are no mapped faults in the area. The closest mapped fault is a large northwest to southeast orientated fault, located approximately 5km southwest of the Southern Cluster.

Initial rotary core boreholes were completed within the Southern Cluster in April 2015. 3 no boreholes (as described in Section 8.3.3.2) were drilled across the Southern Cluster. The borehole logs indicate bedrock was only met at one location. Probable weathered Limestone bedrock is logged at RC-T8-PH2 between 17.1-17.2m, followed by orange-brown clays from 17.2-20.0m. Very strong, thinly bedded Limestone was then logged between 20-24.8m.

Site investigation boreholes were then drilled at 3 no. locations in the Southern Cluster by HES in 2020. Medium strong grey Limestone is logged between 2-13m at ST2, with occasional weathering occurring in the top ~4m. Weak to strong grey Limestone is logged between 13-22m, which includes 1.7m of clay infill. Strong grey Limestone is then logged from 22-40m. Strong grey limestone was encountered at 3.75m in borehole ST4 and continued to the base of the hole at 34.25m, with a small section of weathered Limestone between 4.1-4.2m. Similar bedrock was identified at borehole ST8, with strong grey Limestone between 1.8-11.1m, a moderately weak, weathered section between 11.1-11.4m followed by predominantly strong grey Limestone to the base of the borehole at 36.7m.

26 no. boreholes were drilled at the Southern Cluster by IGSL, on behalf of MWP, with bedrock encountered in 19 of these 26 no. boreholes. The bedrock was met at varying depths between 1.3 – 8.7mbgl. The bedrock is described as strong to very strong, dark blueish grey, fine to medium grained Limestone. Where apertures are found in the rock, they are described as tight to locally open and locally clay/gravel filled. No karst features were noted during the drilling of the 26 no. boreholes at the Southern Cluster. Geological cross sections of the Southern cluster (Cross-Section C-C', Cross-Section D-D' and Cross-Section E-E') area based on the site investigation are included in Appendix 8-5.

In total 394.6m of borehole drilling has been completed within the Southern Cluster (112.4m during the 2020 HES supervised drilling, 113.1 during the 2020 IGSL drilling and 60.2m during the previous site investigation work completed in 2015). Bedrock is identified at an average depth of 7.32mbgl and no obvious karst features have been logged throughout the total depth of drilling. The bedrock at the Southern Cluster does appear to have more weathered sections of rock and clay infill at depth, however none of these zones appear to be characteristic of a karst system and none of these zones produced any substantial groundwater yields. In total, 234.45m of the drilling was in overburden (59.4%) with 68.75% of the boreholes encountering an overburden thickness in excess of 4m. The borehole drilling depths and the geographical spread of the borehole locations across the Southern Cluster provides confidence in stating that the Limestone bedrock is overlain by a substantial thickness of overburden and the bedrock is typically a strong, dark grey bioclastic Limestone with weathered zones and intermittent clay infilled fractures, similar to the Northern Cluster.

An example of the Limestone bedrock is shown in Site photos 8-9 of Appendix 8-1.

8.3.4.3 Grid Connection Route

The bedrock geology mapped along the Grid Connection route consists of Undifferentiated Visean Limestones between Dysert and Bellanamullia, with Waulsortian Limestone mapped between Bellanamullia and the Monksland substation. There is 1 no. fault mapped within the Waulsortian Limestone near Monksland which trends northwest-southeast. There are no other geological features mapped along the Grid Connection route. No bedrock was encountered during the intrusive site investigation carried out by IGSL between May-July 2021.

8.3.5 Geological Resource Importance

There are several Limestone mineral localities mapped in the vicinity of the Proposed Development site. There is one quarry, Cam Quarry, mapped along the R363, with a further bedrock quarry located ~4km southeast of Turbine 20. Site investigation from the Northern and Southern Cluster, along with visits to Cam quarry, suggest the bedrock is medium to thickly bedded, with little evidence of weathering/clay infills within the quarry. Data from 9 no. borehole geological logs at Cam quarry, provided by Roadstone Ltd, indicate an average of 8.8m of overburden above light grey Limestone bedrock. The Limestone bedrock is of moderate resource importance.

The Southern Cluster area is mapped as having low to moderate crushed rock potential and there are no areas with granular aggregate potential mapped near either Proposed Development cluster.

The Northern Cluster area is mapped as having moderate to very high crushed rock aggregate potential.

The GSI online Aggregate Potential Mapping Database shows that the Proposed Development site is located within an area mapped as being typically Moderate to Low in terms of crushed rock aggregate potential and with no potential for granular aggregate potential (i.e. potential for gravel reserves). Again, this agrees with the site investigation data as outlined in Section 8.3.3 and 8.3.4. The areas around the Castlesampson eskers are mapped as having very high aggregate potential, although this is a relatively small area.

Crushed rock aggregate potential along the grid route is mapped as low-moderate, with some areas of high potential located near Cam Hill and the townland of Bellanamullia.

Granular aggregate potential along the grid route is mapped as high between Brideswell and the Monksland townland.

8.3.6 Geological Heritage and Designated Sites

8.3.6.1 Wind Farm site

There are no recorded Geological Heritage sites, mineral deposit sites or mining sites (current or historic) near the Northern Cluster of the Wind Farm site.

The Killeglan Karst Landscape (RO015) is designated as a geological heritage site. The Southern Cluster overlaps with this geological heritage site. A total of 4 no turbines (T9, T10, T12 and T16) are mapped within this geological heritage site. The Killeglan Karst Landscape is described within the County Geological Heritage Site Report as "an extensive area of bouldery terrain in southern Roscommon, the area comprises a number of low, quasi-linear and hummocky ridges which is unique in Ireland." It is worth noting that despite being mapped within the extent of the Killeglan Karst Landscape, it was noted during site investigation works that T12 is located in reclaimed farmland and no longer contains the boulder terrain for which the Killeglan Karst Landscape has been designated.

The Castlesampson Esker (RO010) is designated as a geological heritage site. The Southern Cluster overlaps with this designated site, however no turbines are located within the designated site. The esker runs from between the townlands of Esker and Castlesampson and stretches northwest over ~6km towards Boleyduff/Cloonacaltry. The northern tip of the esker is situated ~350m south of T17 at its closest point. From the County Geological Site Report[3] for the Castlesampson Esker;

> *"The Castlesampson esker is an excellent example of a complex, multi-crested esker which is comprised of numerous beads. The esker system comprises ten individual segments, which stretch for a distance of just over six kilometres. The most complex portion of the longest bead (3.5km) has at least four crests."*

The proposed Wind Farm site is not located within any designated European site. The nearest SAC is the Killeglan Grassland SAC which is located ~0.75km southwest of the proposed Southern Cluster turbine locations. Nearby designated sites are listed in Table 8-5.

A Geological heritage sites map is included as Figure 8-11. A designated sites map is included as Figure 8-12.

Table 8-5: Designated sites near the Northern and Southern Clusters of the Seven Hills Wind Farm

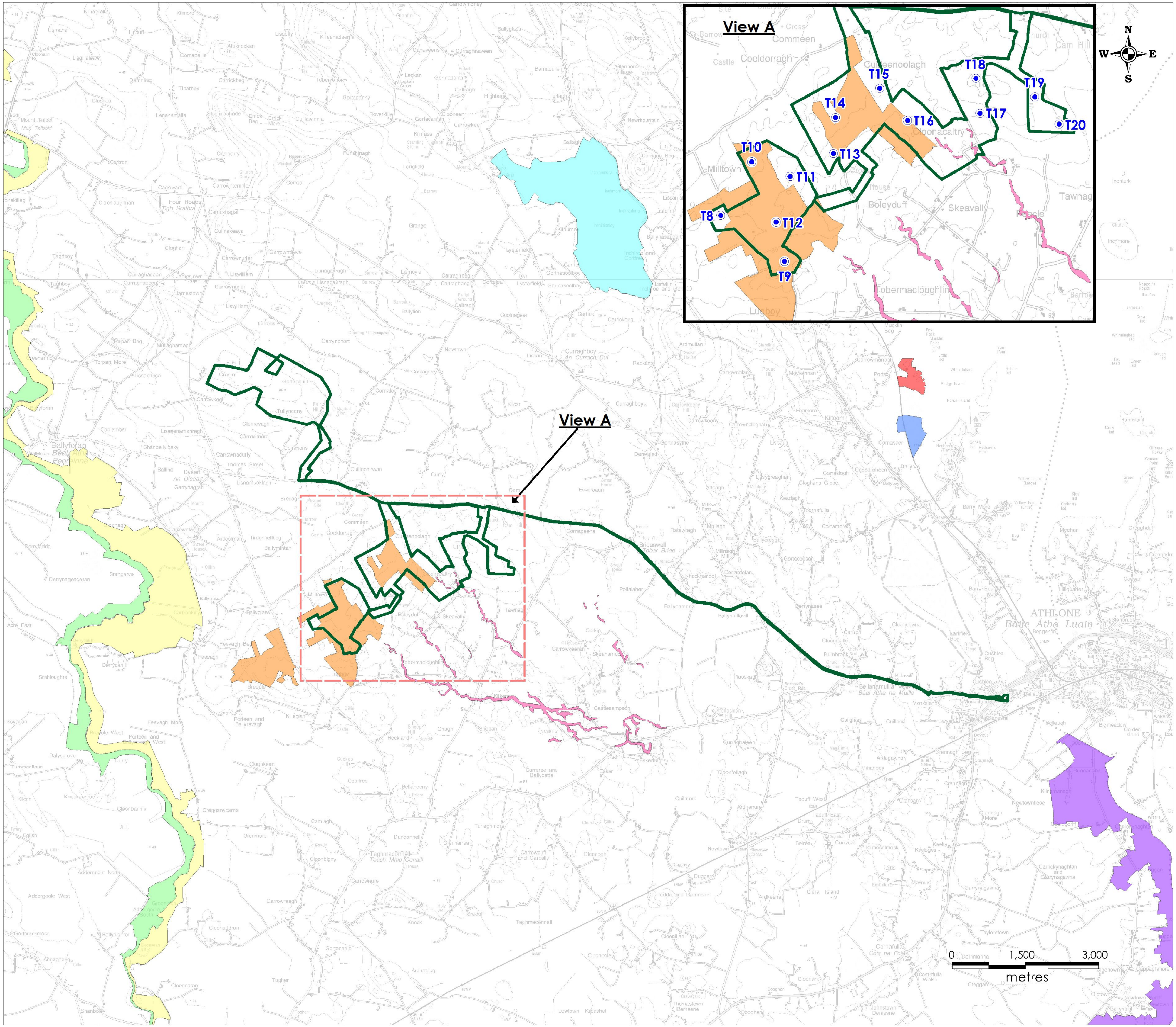
Site	Designations	Distance from Clusters/Turbines
Lough Croan	SAC pNHA SPA	1.0km northeast of Northern Cluster
Ballynamona Bog and Corkip Lough	SAC	0.9km southeast of Southern Cluster
Killeglan Grassland	SAC	0.75km southwest of Southern Cluster
Feacle Turlough	NHA	0.8km south of the Southern Cluster
Lough Funshinagh	SAC pNHA	5.9km northeast of the Northern Cluster
Castlesampson Esker	SAC	3.9km southeast of the Southern Cluster
Four Roads (Turlough)	SAC SPA	2.8km northwest of the Northern Cluster

[3] *Geological Survey of Ireland: Roscommon County Geological Site Report – Castlesampson Esker*

	pNHA	
Lisduff turlough	SAC	7km northeast of the Northern Cluster
Lough Ree	SAC	11km east of the Wind Farm site (Northern & Southern Clusters)
	SPA	
	pNHA	
River Shannon Callows	SAC	12km east of the Southern Cluster
	SPA	
River Suck Callows	SPA	2.4km west of the Southern Cluster
	NHA	

8.3.6.2 Grid Connection Route

There are 3 no. designated sites within 2km of the proposed Grid Connection route. The Ballynamona Bog and Corkip Lough SAC is located ~350m south of the R363. The SAC is situated topographically upgradient of the road. The Lough Ree SAC is situated ~700m north of the R362, while the River Shannon Callows SAC is situated ~850m south of the R362.



Legend

EIAR Site Boundary

Proposed Turbine Layout

Geological Heritage Sites

River Shannon Callows (RO027)

Suck River Callows (RO029)

Carrowmurragh Mushroom Rocks (RO007)

Killeglan Karst Landscape (RO015)

Castlesampson Esker (RO010)

Lough Funshinagh (RO018)

Suck River Callows (GY127)

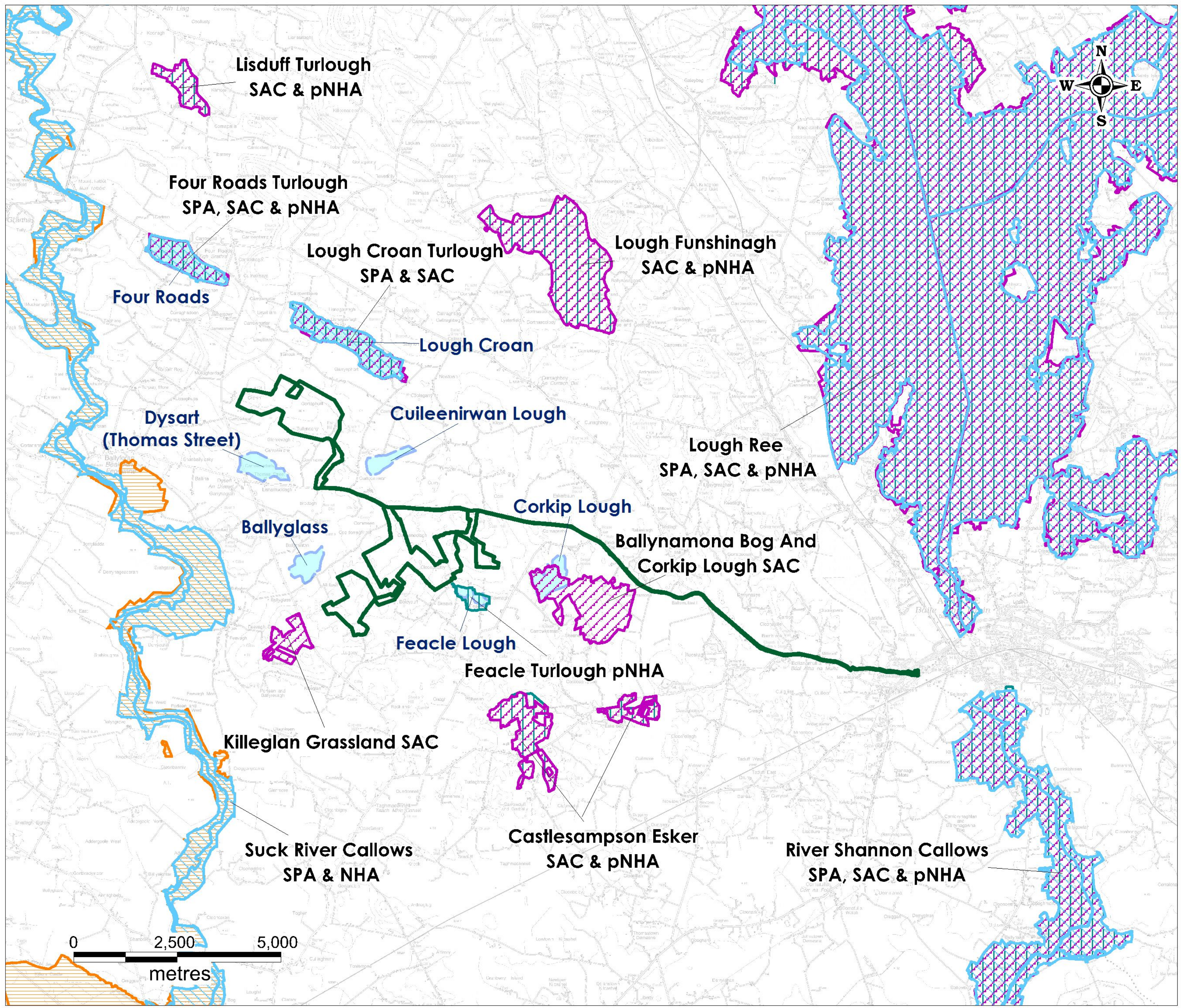
Moyvannon Mushroom Rocks (RO023)

HYDRO ENVIRONMENTAL SERVICES

22 Lower Main St
Dungarvan
Co.Waterford
Ireland

tel: +353 (0)58 44122
fax: +353 (0)58 44244
email: info@hydroenvironmental.ie
web: www.hydroenvironmental.ie

Client: Energia Renewables ROI Ltd	
Job: Seven Hills WF, Co. Roscommon	
Title: Geological Heritage Sites Map	
Figure No: 8-11	
Drawing No: P1500-0-0422-A3-811-0A	
Sheet Size: A3	Project No: P1500-0
Scale: 1:75,000	Drawn By: GD
Date: 20/04/2022	Checked By: MG



HYDRO ENVIRONMENTAL SERVICES
22 Lower Main St
Dungarvan
Co. Waterford
Ireland
tel: +353 (0)5844122
fax: +353 (0)5844244
email: info@hydroenvironmental.ie
web: www.hydroenvironmental.ie

Title: Designated Sites Map

Client: Energia Renewables ROI Ltd

Job: Seven Hills WF, Co. Roscommon

Project No: P1500-0

Figure No: 8-12

Sheet Size: A4

Drawing No: P1500-0-0422-A4-812-0A

Date: 20/04/2022

Scale: 1:60,000

Drawn By: GD | Checked By: MG

8.3.7 Soil Contamination

8.3.7.1 Wind Farm site

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

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

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

8.3.7.2 Grid Connection Route

There are no known areas of soil contamination present along the proposed Grid Connection route.

There are 2 no. Industrial Emissions (IE) licensed areas situated adjacent to the R362 in the townland of Monksland. These licences are associated with Arran Chemical Company Ltd (IE License: P0110-03) and Alkermes Pharma Ireland Ltd (IE Licence: P0100-02).

8.3.8 Geohazards

8.3.8.1 Slope Stability

The presence of dense glacial subsoil deposits, with low slope angles across the Northern and Southern Clusters means that slope stability is not an issue within the proposed Wind Farm site. No areas of peat or soft subsoils were identified and SPT values (subsoil strength measurements) conducted during the rotary core borehole drilling and the 30 no. dynamic probes conducted across the Wind Farm site confirm this assessment.

The design of turbine foundations as defined in Section 8.4.1 accounts for ground stability, and uses field measurement of subsoil and bedrock strength to confirm the foundation types required for each turbine base.

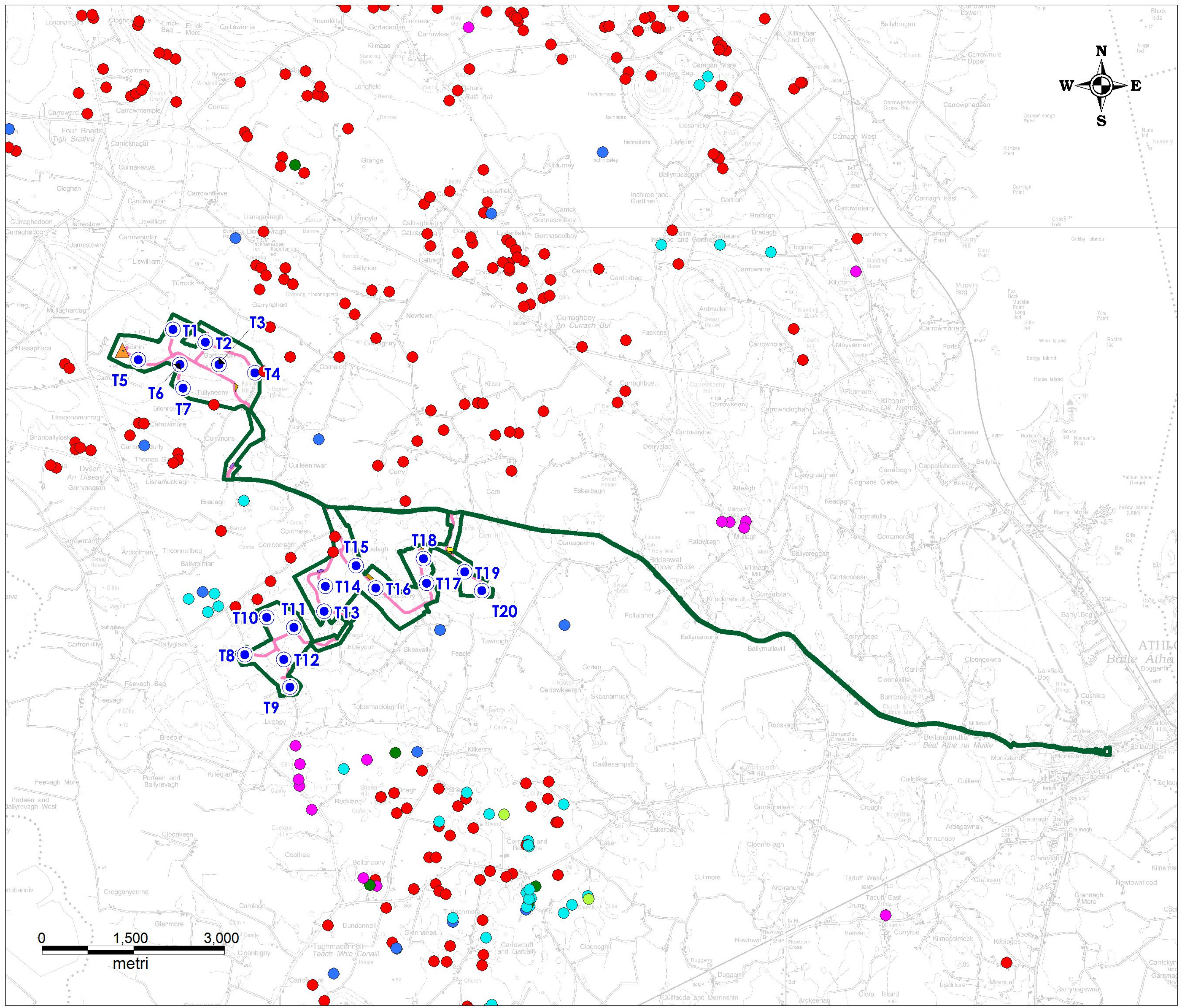
8.3.8.2 Karst

Karst features are mapped by the GSI and available through the GSI online viewer. There are a large number of karst features mapped near the Wind Farm site, the majority ~95% are dolines or enclosed depressions which are visible as depressions within the surrounding agricultural fields which may be 1-3m deep and typically ~100-200m^2, although their areal extent varies.

There are ~30 depressions mapped in the low-lands surrounding the Northern Cluster of the Wind Farm site. Many of these depressions are located within the mapped turloughs and make up the basin topography which fills in the winter months to form the turloughs. The closest mapped depression to the Wind Farm site infrastructure is mapped ~0.15km southeast of proposed T4 and forms the Gortaphuill Turlough basin. There are no karst features mapped above 70 m OD. There are no karst springs or swallow holes mapped near the Northern Cluster of the Wind Farm site.

There are ~10 karst features (dolines and turloughs) mapped near the Southern Cluster of the Wind farm. They are all situated along the northern side of the cluster and again are mostly on the lower ground. The closest mapped depression is situated ~0.45km northwest of T15. South (3-4km) of the Southern Cluster of the Wind Farm site there are a number of enclosed depressions mapped as well as several swallow holes and springs. Mapped karst features near the Wind Farm site are show on Figure 8-13.

No significant areas of karst were identified during site investigations (trial pit and boreholes). Weathered Limestone bedrock and clay infilled fractures were identified, however these are typical across all Limestone bedrock in Ireland. None of the encountered fractures were particularly water bearing, with very limited inflows to the deeper boreholes following drilling. In the case of the 6 no. boreholes drilled by HES, it took 1-2 weeks before water was detected at the base of the boreholes.



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Proposed Substation
- Proposed Met Mast
- Proposed Temporary Construction Compound
- Proposed Spoil Storage Areas
- Proposed Access Roads
- Proposed Hardstand

Karst Features

- Borehole
- Cave
- Dry Valley
- Eclosed Depression
- Spring
- Superficial Solution Features
- Swallow Hole
- Turlough

HYDRO ENVIRONMENTAL SERVICES
22 Lower Main St
Dungarvan
Co. Waterford
Ireland
tel: +353 (0)5844122
fax: +353 (0)5844244
email: info@hydroenvironmental.ie
web: www.hydroenvironmental.ie

Title: Karst Feature Map

Client: Energia Renewables ROI Ltd

Job: Seven Hills WF, Co. Roscommon

Project No: P1500-0

Figure No: 8-13

Sheet Size: A4

Drawing No: P1500-0-0422-A4-813-0A

Date: 20/04/2022

Scale: 1:85,000

Drawn By: GD | Checked By: MG

8.4 Characteristics of the Proposed Development

8.4.1 Engineering Design

The Proposed Development consists of 20 no. wind turbines and associated infrastructure including hardstands, met mast, access roads and substation, as well as temporary construction compounds. The Proposed Development also includes the underground grid connection route which will be hosted in the carriageway of the local road network from the Wind Farm site to the Athlone 110 kV substation in Monksland. The engineering design for the Proposed Development is described in detail in Chapter 4.

The engineering design of the Proposed Development is underpinned by comprehensive site investigation datasets. The Wind Farm layout optimisation and the design process was iterative, and involved inputs from engineering, hydrogeological, and ecological experts, and through this iterative process areas of poorer ground conditions have been avoided. Owing to the good geotechnical conditions within the proposed Wind Farm site works can be construction on the existing surface without the need to strip large volumes of subsoil.

Table 8-6 provides a summary of proposed turbine foundation designs (i.e., design response at each turbine base (ground bearing foundation, and excavate to rock)). The depth to bedrock and the composition of subsoils at each turbine, and the foundation type for each turbine are defined based on the comprehensive site investigation data.

Ground bearing foundation will be utilised at all turbines within the Proposed Development site. Ground bearing foundations are suitable at this site due to the coherent and stable nature of the subsoil glacial tills. Where bedrock is located close to the surface the ground bearing foundation will be within the limestone bedrock.

Table 8-6: 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
T9	Ground-Bearing Gravity	3.0	Gravel/Cobbles	0
T10	Ground-Bearing Gravity	3.0	Rock	0
T11	Ground-Bearing Gravity	3.0	Rock	0

ID	Foundation Type	Formation Level (mbgl)	Formation Material (based on SI data)	Stone Upfill Depth (m)
T12	Ground-Bearing Gravity	5.0	Cobbles	2.0
T13	Ground-Bearing Gravity	0	Gravel	0
T14	Ground-Bearing Gravity	0	Gravel/Cobbles	0
T15	Ground-Bearing Gravity	3.0	Clay/Cobbles	0
T16	Ground-Bearing Gravity	0	Cobbles	0
T17	Ground-Bearing Gravity	0	Gravel/Sand	0
T18	Ground-Bearing Gravity	0	Gravel	0
T19	Ground-Bearing Gravity	0	Clay/Gravel	0
T20	Ground-Bearing Gravity	0	Clay	0

Access roads will be create using cut and fill methods. Material volumes for cut and fill are outlined below.

Drainage management at the proposed development is defined in Section 4.6. Drainage proposals will reflect the prevailing hydrology/hydrogeology of the site. Natural water flow pathways will be maintained, and drainage water will be collected, treated and recharged to ground as close to origin as possible. There are no discharges to stream/drains within the wind farm site, all drainage water will be treated and discharged to ground (recharge to ground is what happens in the baseline scenario).

The Grid Connection will comprise a single circuit connection with 3 no. 160mm diameter HDPE power cable ducts and 2 no. 125mm diameter HDPE communication ducts installed in an excavated trench, typically 600mm wide by 1,220mm deep.

5 no. existing crossings will be crossed along the R363 Regional Road to cater for the proposed collector cable and external Grid Connection towards the existing Athlone 110 kV substation. The locations of the watercourse crossings are shown on Figure 4-15 of Chapter 4 and in the layout drawings in Appendix 4-1 of this EIAR. Watercourse crossing will be completed using these methods:

- Crossing Using Standard Trefoil Formation
- Flatbed Formation over Bridges/Culverts
- Directional Drilling

These methods are described in detail in Section 4.8.7 of Chapter 4.

8.4.2 Material Quantities/Volumes

During the Proposed Development works spoil will be generated during excavations for roads, hardstands, wind turbine foundations, drainage swales, trenches etc. Minimisation of the production of this spoil will 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 a limited amount of spoil material will be stored around each turbine and hardstand. The remainder of the excavated spoil will be transported directly from the excavation for disposal within the proposed deposition areas as detailed in the Spoil Management Plan. This helps reduce the need for transportation of spoil across large areas and results in a reduced risk of dirty water generation.

A Spoil Management Plan (MWP, 2021) is attached in Appendix 4-7. For the construction phase the activities that are considered likely to generate spoil are as follows:

- Construction of new excavated roads;
- Excavation and reinstatement areas for spoil; and,
- Excavations for turbine bases, crane hardstands, substation and the temporary site construction compounds.

Estimated volumes of subsoil and bedrock to be excavated and proposed storage area volumes are shown in Table 8-7 and Table 8-8 respectively. Any bedrock excavated during cut and fill works will be used for filling along the development footprint. Spoil will be reused or stored locally to its point of generation and sufficient storage areas are provided for material that cannot be reused or stored adjacent to turbines and hardstands. The breakdown of surplus spoil material in the Northern Cluster and the Southern Cluster is 17,300m^3 and 49,600m^3 respectively. Permanent spoil deposition areas have been carefully selected within each cluster. The proposed storage areas can accommodate these volumes without the need to transport spoil from the Northern Cluster to the Southern Cluster and vice versa.

Table 8-7: Estimated Spoil Management Volumes for the Wind Farm

Development Type	Approx. Volume (m^3) Northern Cluster	Approx. Volume (m^3) Southern Cluster
Approx. Total Volume (m^3) (Total Rock and Spoil as per Table 4-3 in Chapter 4)	**+126,500**	
Infrastructural Spoil Generation	**+ 40,700**	**+ 85,800**
Storage at hardstands and turbines	- 10,500	- 13,500
Reuse of material for ballast	- 7,000	- 13,000
Reuse of rock	- 3,900	- 4,200
Landscaping	- 2,000	- 5,500
Total Overburden to be managed	**17,300**	**49,600**

Table 8-8: Proposed Spoil Storage Area Volumes

Type of Overburden	Volume (m^3) (approx.)
Northern Site Spoil Storage Areas	17,300
Southern Site Spoil Storage Areas	49,600
Total Volume	**66,900**

8.5 Likely and Significant Effects on Land, Soils and Geology

8.5.1 Do Nothing Scenario

An alternative land-use option to the development of a renewable energy project at the Proposed Development site would be to leave the site as it is, with no changes made to existing land-use practices. Agriculture would continue at the site.

In implementing the 'Do-Nothing' alternative, however, the opportunity to capture a significant part of the country's renewable energy resource 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 existing agricultural operations can and will continue in conjunction with this proposed wind energy use of the site.

8.5.2 Construction Phase – Likely Significant Effects and Mitigation Measures

The likely impacts of the Proposed Development and mitigation measures that will be put in place to eliminate or reduce them are shown below. These are defined and assessed as per the explanation provided at Section 8.2.4 above.

Please note that the Grid Connection Route works are assessed in each impact section below along with the Proposed Development other than for Soil-Subsoil Excavation (Section 8.5.2.3). The Turbine Delivery Route is assessed separate from the proposed Development at 8.5.2.8.

8.5.2.1 Effects on Land and Landuse

The Proposed Development covers an area of approximately 588 hectares, in total, and it is divided into two clusters. The construction of the proposed Wind Farm site will result in the loss of approximately 29.8ha of agricultural land within the EIAR Site Boundary. The Wind Farm construction works (turbine foundations, substation foundations, hardstands and access roads) will result in local topographic changes with the removal of glaciofluvial and glacial overburden and some bedrock from the site. There will be no effects on land or landuse resulting from the electrical cabling within the Wind Farm site as all ground will be reinstated once works are complete. The loss of 29.8ha of agricultural land is not significant and will not materially affect land use within the Wind Farm site. Existing agricultural activities can readily co-exist and there will be no perceptible effect on these activities.

There will be no effects on land and landuse along the Grid Connection as all ground will be reinstated once the cabling works are complete.

There will be no effects on the lands adjoining the Proposed Development 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 Impact: Negative, slight, direct, likely probability, permanent impact on land and landuse.

Impact Assessment:

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

Given the hummocky nature of local topography resulting from the glacial deposits, any change in topography is likely to be minimal in the overall landscape.

Mitigation Measures:

No mitigation is proposed.

Residual Impact: Agricultural land used for grazing is the dominant land use in the area of the Proposed Development. Due to the relatively small footprint (29.8ha) of the Proposed Development on a local scale the residual effect is considered Negative, direct, slight, likely, permanent impact on land and landuse. The land and landuse along the Grid Connection will not change.

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 – Wind Farm

Excavation of soil, subsoil and bedrock will be required for site levelling and for the installation of infrastructure and foundations for the access roads and turbines. This will result in a permanent removal of soil/subsoil and bedrock at excavation locations. Estimated volumes of subsoil and bedrock to be removed are shown in Table 8-7 and Table 8-8 above.

Mechanism: Extraction/excavation.

Receptor: Soil, subsoil and bedrock (across which the development is proposed)

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

Impact Assessment:

The bedrock at the site is classified as “Medium to High” importance, partly due to the presence of the Geological Heritage Site across parts of the Southern Cluster (assessed below at Section 8.5.2.6 below). Excavation volumes of soils and subsoils/bedrock are relatively small in comparison to the scale of the Wind Farm (126,500m^3 of rock and spoil during construction, with reuse of c 59,600m^3). Some permitted wind farms have subsoil/spoil volumes of 200,000 to 400,000m^3. 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:

- Placement of turbines and associated infrastructure in areas with suitable ground conditions (based on detailed iterative site investigation data);
- Excavated soils/subsoils shall be excavated and stored separately to topsoil; this will prevent mixing of materials and facilitate reuse afterwards;
- All materials which require storage 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 disposal will take place within a minimal distance of each turbine to avoid excessive transport of materials within the site;
- Spoil will be deposited, in layers of 0.50m and will not exceed a total thickness of 1m and 2m as indicated on the drawings;
- Spoil will only be deposited on slopes of less than 5 degrees to the horizontal and greater than 10m from the top of a cutting; and,
- No turbines or related infrastructure will be constructed within 700m of any European designated sites such as SACs or SPAs.

Residual Effect Assessment: The cohesive and granular soil/subsoil at the site are classified as of "Low to Moderate" importance as they are present across the region. The impact is the disturbance and relocation of c 126,500m^3 of rock and spoil during construction, with reuse of c 59,600m^3. All work will be in accordance with the Spoil Management Plan attached at Appendix 4-7. The site layout design has been made using comprehensive site-specific site investigation dataset, which includes boreholes, trial pits, geophysical survey data, dynamic probe data and lab analysis of subsoil samples. The residual effect is – negative, slight, direct, likely probability, permanent effect on soils/subsoils and bedrock due to disturbance and relocation within the site.

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 Soil, Subsoil Excavation - Grid Connection Route

The majority of the Grid Connection route is located within the public road and measures approximately 12km in total. The construction of the Grid Connection route will involve the excavation of soils/subsoils from the Grid Connection route trench, ~0.6m (w) x 1.22m (d). The excavation of the Grid Connection route has the potential, although limited, to alter the permeability of the soils and subsoils (no bedrock was encountered in any of the grid connection route site investigations) within the trench and may, for a time, alter the landuse/landcover along the ~0.6m wide strip.

Pathway: Excavation/removal and reinstatement of soil subsoil within an area ~11,000m (l) x 0.6m(w) x 1.22m(d).

Receptor: Soil and subsoil composition and local permeability.

Pre-Mitigation Potential Impact:

Negative, insignificant, indirect, likely probability, medium term impact on soil and subsoil permeability.

Impact Assessment:

The proposed Grid Connection route trench excavation is limited in wide (~0.6m), but extends along the full length of the route. The trench excavation will be shallow (~1.22m), and it will be reinstated following placement of the ducting for the 110kV cable.

Proposed Mitigation Measures:

- Soils and subsoils excavated along the Grid Connection route will be temporarily stored in covered stockpiles along the edge of the road carriageway for reuse.
- Once the emplacement of the 110 kV cable has been completed, the trench will be backfilled and compacted in accordance with the required specification. The tarmacadam road surface will be replaced with the same design standard as the surrounding carriageway.

- For unsurfaced/grass sections, at least 100 mm topsoil or match existing level at the top to allow for seeding or replace turves as per the specification of the local authority or landowner.

Residual Effect Assessment: The residual effects are considered to be neutral, insignificant, indirect, likely impact on the soils/subsoils (permeability and composition) along the Grid Connection route.

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.

8.5.2.4 Contamination of Soil by Leakages and Spillages

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

Pathway: Soil, subsoil and underlying bedrock pore space.

Receptor: Soil, subsoil and bedrock.

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

Impact Assessment:

The bedrock at the site is classified as "Medium to High" importance, partly due to the presence of the Geological Heritage Site across parts of the Southern Cluster. Meanwhile, the soils and subsoil deposits at the Wind Farm site can be classified as "Low to Moderate" importance. The use and storage of hydrocarbons and small volumes of chemicals within the proposed Wind Farm site and along the Grid Connection has the potential to contaminate the soils, subsoils and bedrock across the Proposed Development.

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 bowser with spill kits on the ready for accidental leakages or spillages;
- On site re-fuelling will be undertaken by suitably trained personnel only under a permit to refuel system;
- Fuels stored on site will be minimised. Storage areas located at the temporary compounds where required will be bunded appropriately for the fuel storage volume for the time period of the construction and fitted with a storm drainage system and an appropriate oil interceptor;
- The electrical substation will be bunded appropriately to the volume of oils likely to be stored, and to prevent leakage of any associated chemicals and to groundwater or surface water. The bunded area will be fitted with a storm drainage system and an appropriate oil interceptor;
- The plant used during construction will be regularly inspected for leaks and fitness for purpose;
- All waste tar material arising from the chipping and resurfacing of the public road portion of the temporary construction access road will be removed off-site and taken to licenced waste facility; and,

- An emergency plan for the construction phase to deal with accidental spillages is contained within the Construction and Environmental Management Plan (Appendix 4-9 of this EIAR). Spill kits will be available to deal with and accidental spillage in and outside the re-fuelling area.

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

8.5.2.5 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 Proposed Development and the surrounding environment.

A significant amount of Site Investigation data has been acquired across the Wind Farm site (Northern & Southern Clusters). These data provide confidence on the depth of subsoil and the subsoil type. Subsoils are logged as glacial deposits comprising SILY GRAVELS, SAND, sandy GRAVEL and GRAVELS, which would not be associated with ground instability or a risk of landslides.

The subsoils range in depth between 1.3-16m at the Northern Cluster and 1.3-30m across the Southern Cluster. 30 no. dynamic probes have been conducted across the Wind Farm site which confirm the absence of soft soils or peat across the proposed infrastructure development areas within the 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 involving multiple stages of ground investigations, followed by turbine and infrastructure design has been completed in order to avoid poor ground conditions.

Site investigation works have also been completed along the proposed Grid Connection route. Local geology along the Grid Connection route comprises made ground (tarmacadam) over variable glacial deposits (refer to Section 8.3.3.3). Peat deposits are recorded at one location (BH01) near Brideswell Village. No bedrock was recorded in any of the site investigation locations completed along the Grid Connection route. The Grid Connection route site investigation data are provided in Appendix 4-4 and Appendix 4-5.

Mechanism: Vehicle movement and excavations.

Receptor: Subsoils and weathered/karstified bedrock.

Pre-Mitigation Potential Impact: Negative, slight, direct, unlikely 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 Development is underpinned by comprehensive a site investigation dataset. The Wind Farm layout optimisation and design process was iterative, and through this iterative process areas of poorer ground conditions have been avoided.

The proposed Grid Connection is a 1.2m deep trench below an existing roadway, based on these characteristics there is negligible potential for ground instability along the proposed grid route.

Mitigation Measures:

The following measures which will be implemented during the construction phase of the Proposed Development 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 Development is underpinned by comprehensive a site investigation dataset. The Wind Farm layout optimisation and design process was iterative, and through this iterative process areas of poorer ground conditions have been avoided. The risk of ground failure during construction is very low. The residual effect is – No effects on subsoil/weathered bedrock and ground.

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.

8.5.2.6 Potential Impacts on Geological Heritage Sites

There are a number of geological heritage sites mapped locally to the proposed Wind Farm site. The Killeglan Karst Landscape Geological Heritage Site (which measures approximately 303ha) is mapped within the Southern Cluster of the Wind Farm site. Excavation and the emplacement of access roads and turbine hardstands will involve the removal of the limestone boulders in some places which constitute the bouldery terrain, however the majority of access roads will follow existing cleared paths through the land and the majority of turbine locations are on previously cleared lands. The Proposed Development will cause a loss of 3.9ha of the Killeglan Karst Landscape Geological Heritage Site.

The Castlesampson Esker Geological Heritage Site is located ~350m south of Turbine 17 at its closest point. This is the tail end of the esker where the glacial deposits thin out. This does not coincide with the Castlesampson Esker SAC, located ~3.9km southeast of the Wind Farm site.

Pathway: Excavation/removal of overburden and limestone boulders.

Receptor: Geological Heritage Sites -Killeglan Karst Landscape – bouldery terrain & Castlesampson Esker

Pre-Mitigation Potential Impact:

Killeglan Karst Landscape GHS - Negative, significant, direct, likely probability impact on Killeglan karst landscape by removal or relocation of limestone boulders and glacial deposits.

Castlesampson Esker GHS – Negative, slight, direct, likely probability impact on Castlesampson Esker by placement of access track material on a short section (~50m) of existing access track that already bisects the line of the esker.

Impact Assessment / Proposed Mitigation Measures:

Killeglan Karst Landscape

The design iterations of the proposed layout have taken into account the sensitivity of the Killeglan Karst Landscape and engaged in mitigation by avoidance wherever possible. Mitigation measures for the Killeglan Karst Landscape include:

- Using the paths of existing cleared tracks within the landscape for site access roads and emplacing the turbines on previously cleared lands where possible.
- During construction, all vehicle and construction plant operators will be advised of the location of the geological sites and instructed to avoid those areas.
- Exclusions zones will be marked out on the ground to ensure these areas are avoided.

When the above mitigation was taken into account, the Proposed Development only accounted for a loss of 3.9ha of the Killeglan Karst Landscape Geological Heritage Site.

The GSI have also recognised, within the Killeglan Karst Landscape County Geological Site Report[4] that;

"*Further research and investigation is required to document and understand the full scientific story. Since a windfarm has been granted planning permission in 2012*[5]*, it is hoped that scientific opportunity created by ground excavations for this will be used and not wasted.*"

Therefore, the site investigation works, and the construction works of the Proposed Development provide an opportunity to generate further understanding of the Killeglan Landscape and its glacial origins.

Castlesampson Esker

The northern end of the Castlesampson Esker is situated ~350m south of the nearest turbine location. There is 1 no. proposed access road which bisects two areas of esker deposit, south of T17. There is already a ~6m wide farm road in place which passes between these two deposits, therefore the access road will not lead to any additional widening of the track. Some fill material and local excavations may be required during construction, but as these are being placed on an existing farm track, there will be no effect on the adjacent in-situ esker deposits. The remainder of the Castlesampson Esker deposit will be avoided, with no excavation of the glacial deposits which constitute the esker.

Residual Effect Assessment: The Killeglan Karst landscape will likely be impacted by the Proposed Development, however by emplacing the access roads and hardstands in areas which have previously been cleared for agricultural practices, where possible, the disruption to the boulder terrain will be minimised. With the implementation of these avoidance measures the residual effects are considered to be - Negative, moderate, direct, likely effect on the County Geological Site with Positive impacts on the potential for scientific research at exposed sections.

The residual effects on the Castlesampson Esker are considered to be – Negative, slight, indirect, likely probability impact on Castlesampson Esker by placement of access track material on a short section (~50m) of existing access track that already bisects the line of the esker.

Significance of Effects For the reasons outlined above there will be - No significant effects on the Killeglan Karst Landscape; No significant effect on the Castlesampson Esker.

---

[4] *Geological Survey of Ireland: Roscommon County Geological Site Report - Killeglan Karst landscape*
[5] *Previously granted Wind Farm Application 2012*

8.5.2.7 Potential Impacts on Designated Sites

There are a number of designated sites (SAC's, SPA's NHA's and pNHA's) mapped locally to the Proposed Development site as detailed in Section 8.3.6. The closest SAC is the Killeglan Grassland SAC located ~0.75km southwest of the Southern Cluster of the development site. The Castlesampson Esker SAC is located ~3.9km southeast of the Southern Cluster. This SAC does not coincide with the mapped extents of the Castlesampson Esker geological heritage site.

Other designated sites proximal to the Northern and Southern Clusters include:

- Lough Croan pNHA: 1.0km northwest of the Northern Cluster
- Feacle Turlough pNHA: 0.8km south of the Southern Cluster
- River Suck Callows NHA/SPA: 2.4km west of the Southern Cluster

Other local designated sites have been screened out for potential impacts on land soils and geology as they are located too far away from the Proposed Development for any direct impact on land soils and geology to occur. These screened out designated sites include:

- Ballynamona Bog and Corkip Lough SAC
- Lough Funshinagh SAC/pNHA
- Four Roads Turlough SAC/SPA
- River Suck Callows SPA/NHA
- River Shannon Callows SAC/SPA
- Lisduff Turlough SAC
- Lough Ree SAC/SPA/pNHA

Pathway: Excavation/removal of soils/subsoils and limestone boulders.

Receptor: Designated Sites

Pre-Mitigation Potential Impact:

Killeglan Grassland SAC - Neutral, insignificant, indirect, unlikely impact on Killeglan Grassland SAC. The grassland is located on the opposite side of the R357.

Castlesampson Esker SAC - Neutral, insignificant, indirect, unlikely impact on Castlesampson Esker SAC. The esker is located ~3.9km southeast of the Wind Farm site.

Lough Croan SAC/pNHA - Neutral, insignificant, indirect, unlikely impact on Lough Croan. There is no viable pathway between Lough Croan and the Northern Cluster where impacts on the land soils and geology could be affected.

Feacle Turlough pNHA - Neutral, insignificant, indirect, unlikely impact on land soils and geology at Feacle Lough.

River Suck Callows NHA/SPA – Neutral, insignificant, indirect, unlikely impact on the River Suck Callows. This SPA/NHA is located 2.3km west of the nearest turbine within the Southern Cluster. No realistic pathway has been identified between the land, soils and geology at the Proposed Development site and the River Suck Callows.

Impact Assessment / 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 Chapter 9 of this EIAR, 'Water', which deals with suspended sediment entrainment from the excavation works. As the designated sites are distal to the Wind Farm site, there can be no direct impacts on the land soils and geology of the designated sites. Indirect effects are considered and mitigated by:

- Avoiding physical damage to watercourses, and associated release of sediment;
- Avoiding excavations within close proximity to surface watercourses;
- 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 elements to achieve these mitigation measures are included in detail within Section 9.4.2.2, but briefly include:

- Use of buffer zones on watercourses and water features during the constraints stage of the design;
- Source controls such as interceptor drains, sandbags and the covering of stockpiles;
- Use of silt bags when temporary pumping from excavations is required, and use of silt fencing around stockpiles; and,
- Use of 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:

Designated Site	Residual Effects
Killeglan Grassland SAC	None
Castlesampson Esker	None
Ballynamona Bog and Corkip Lough SAC	None
Lough Funshinagh SAC/pNHA	None
Lough Croan SAC/pNHA	None
Feacle Turlough pNHA	None
Four Roads Turlough SAC/SPA	None
River Suck Callows SPA/NHA	None
Lisduff Turlough SAC	None
Lough Ree SAC/SPA/pNHA	None

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; Killeglan Grassland SAC, Castlesampson Esker SAC, Ballynamona Bog and Corkip Lough SAC, Lough Funshinagh SAC/pNHA, Lough Croan SAC/pNHA, Feacle Turlough pNHA, River Suck Callows SAC, River Shannon Callows SAC, Four Roads Turlough SAC/SPA, Lisduff Turlough SAC and Lough Ree SAC/SPA/pNHA.

8.5.2.8 Turbine Delivery Route

The proposed turbine delivery route is defined in Section 4.4. No road widening or junction accommodation works are required along the turbine delivery route. Some areas of oversail are required along third-party lands at bends on the R363 Regional Road. Some minor modifications to street furniture will also be required along the turbine delivery route such as temporary removal of some street signs, traffic lights, etc. These minor modifications can have local direct impacts on the land soils and geology at the particular point of works, however given the scale of typical roadworks, the wider implications and effects on the land and soils outside of the immediate works area are limited.

Pathway: minor temporary hard coring and reinstatement of soil, subsoil at street furniture locations

Receptor: Soil and subsoil and landuse

Pre-Mitigation Potential Impact:

Negative, insignificant, direct, very low probability, temporary impact on soil and subsoil landuse.

Impact Assessment:

Some minor modifications to street furniture will also be required along the turbine delivery route such as temporary removal of some street signs, traffic lights, etc. These minor modifications can have local direct impacts on the land soils and geology at the particular point of works, however given the small footprint and local scale of such works, the wider implications and effects on the land and soils outside of the immediate works area will be imperceptible.

Proposed Mitigation Measures:

None proposed.

Residual Effect Assessment: None.

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

8.5.3 Assessment of Health Effects

Potential health effects arise mainly through the potential for soil and ground contamination. The Proposed Development is not a recognized source of pollution 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 Development and will be handled and stored in accordance with best practice mitigation measures. The potential residual impacts associated with soil or ground contamination and subsequent health effects are imperceptible.

8.5.4 Operational Phase - Likely Significant Effects and Mitigation Measures

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

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

In relation to indirect impacts a small amount of granular material 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 substation and within each turbine) and storage of oils in tanks at the substation could leak during the operational phase and impact on ground/soil/subsoils and groundwater or surface water quality. The substation transformer will be 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 impacts associated with decommissioning of the Proposed Development will be similar to those associated with construction but of reduced magnitude (i.e. soil/subsoil/bedrock excavation; Contamination by Leakage/Spillages).

During decommissioning, it may be possible to reverse or at least reduce some of the potential impacts caused during construction by rehabilitating construction areas such as turbine bases, hard standing areas, and the substation. This will be done by covering with soils/subsoils and vegetation to encourage vegetation growth and reduce run-off and sedimentation. Other impacts such as possible soil compaction and contamination by fuel leaks will remain but will be of reduced magnitude. 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 (i.e., mitigation outlined at Sections 8.5.2.2 and 8.5.2.3). Some of the impacts will be avoided by leaving elements of the Proposed Development in place where appropriate. The turbine bases will also be left in-situ and the surrounding ground will be rehabilitated by covering with local topsoil/soil in order to regenerate vegetation. Mitigation measures to avoid contamination by accidental fuel leakage and compaction of soil by on-site plant will be implemented as per the construction phase mitigation measures.

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

8.5.6 Potential Cumulative Impacts

The geological impact assessment undertaken above in this chapter outlines that significant effects are unlikely due to the localized nature of the construction works. Impacts on land soil and geology will not extend beyond the immediate vicinity of the Proposed Development (Wind Farm site, Grid Connection and TDR) footprint. Therefore, no cumulative impacts between the Proposed Development, the proposed construction access road and other existing, permitted or proposed projects, listed in Section 2.6 of this EIAR, on land soils and geology are predicted.

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

8.5.7 Assessment Summary and Conclusion

The assessment is summarised as follows:

- The impact assessment is underpinned by an extensive site specific geological dataset;
- Site investigations completed at the site were iterative and multi-phased, with multiple site visits being completed in both summer and winter, and with HES completing a total of 318 hours of sitework;
- The comprehensive site investigations included a total of 152 no. site investigation points and 114 no. laboratory tests accompanied by 80 no. geophysical surveys;
- Subsoil lithology, permeability and variability across both Wind Farm site clusters has been investigated and is understood;
- The bedrock geology underlying both Wind Farm site clusters is now comprehensively understood with the recognition that karst features are not ubiquitous, and that the bedrock geology is characterised by competent limestone;
- No proposed WTG is located over a known or suspected karst anomaly. The iterative approach to design has ensured that turbine locations were moved or reconfigured to avoid potential subsurface anomalies identified from drilling and geophysical investigations;
- A clearly defined design (turbine locations, foundation levels and types, access road alignment etc) has been developed and has been subject to detailed and robust geological environmental assessment;
- The engineering proposals for the Wind Farm site layout are bespoke and complementary to the prevailing geological environment; and,
- The findings of the Land, Soils and Geological Section are unambiguous and are underpinned by a significant geological dataset that comprises best-in-class scientific information.