8. LAND, SOILS AND GEOLOGY

8.1 Introduction

8.1.1 Background and Objectives

Hydro-Environmental Services (HES) was engaged by MKO to carry out an assessment of the potential, direct, indirect and cumulative significant effects of the proposed 7 no. turbine Curraglass Renewable Energy Development (Proposed Development), which is located approximately 5.6km northeast of Kealkill and 5.5km southwest of the village of Ballingeary, Co. Cork.

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

8.1.2 Statement of Authority

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

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

This chapter of the EIAR was prepared by Michael Gill and David Broderick.

Michael Gill (BA, BAI, Dip Geol., MSc, MIEI) is an Environmental Engineer and Hydrogeologist with over 18 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms and renewable projects in Ireland. In addition, he has substantial experience in surface water drainage design and SUDs design and surface water/groundwater interactions. For example, Michael has worked on the EIS for Oweninny WF, Cloncreen WF, and Yellow River WF, and over 100 other wind farm related projects across the country.

David Broderick is a hydrogeologist with over 13 years' experience in both the public and private sectors. Having spent two years working in the Geological Survey of Ireland working mainly on groundwater and source protection studies David moved into the private sector. David has a strong background in groundwater resource assessment and hydrogeological/hydrological investigations in relation to developments such as quarries and wind farms. David has completed numerous geology and water sections for input into EIARs for a range of commercial developments. David has worked on the EIS/EIARs for Slievecallan WF, Cahermurphy (Phase I) WF, and Oweninny WF, and over 60 other wind farm related projects across the country.

8.1.3 Relevant Legislation

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

- S.I. No. 349 of 1989: European Communities (Environmental Impact Assessment) Regulations, and subsequent Amendments (S.I. No. 84 of 1995, S.I. No. 352 of 1998,

S.I. No. 93 of 1999, S.I. No. 450 of 2000 and S.I. No. 538 of 2001), S.I. No. 30 of 2000, the Planning and Development Act, and S.I. 600 of 2001 Planning and Development Regulations and subsequent Amendments. These instruments implement EU Directive 85/373/EEC and subsequent amendments, on the assessment of the effects of certain public and private projects on the environment;
- Directives 2011/92/EU and 2014/52/EU on the assessment of the effects of certain public and private projects on the environment, including Circular Letter PL 1/2017: Implementation of Directive 2014/52/EU on the effects of certain public and private projects on the environment (EIA Directive);
- Planning and Development Act, 2000, as amended;
- S.I. No 296 of 2018: S.I. No. 296 of 2018: European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2018 which transposes the provisions of Directive 2014/52/EU into Irish law; and,
- The Heritage Act 1995, as amended.

8.1.4 Relevant Guidance

The land, soils and geology chapter of this EIAR was prepared having regard, where relevant, 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 (2015): *Draft - Advice Notes on Current Practice (in the preparation of Environmental Impact Statements*;
- Environmental Protection Agency (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 on 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 the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements;*
- National Roads Authority (2005): *Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;*
- *Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment* (DoHPLG, 2018); and,
- *Guidance on the preparation of the EIA Report* (Directive 2011/92/EU as amended by 2014/52/EU), (European Union, 2017).

8.2 Assessment Methodology

8.2.1 Desk Study

A desk study of the site and the surrounding area was completed in advance of undertaking the walkover survey and site investigation. This involved collecting all relevant geological data for the site and surrounding area. This included consultation with the following data sources:

- EIS and site investigation reports for the previously operational Curraglass Wind Farm;
- Environmental Protection Agency database (www.epa.ie);
- Geological Survey of Ireland - Groundwater and Geology Databases (www.gsi.ie);
- Geological Survey of Ireland – Geological Heritage site mapping (www.gsi.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 15 (Geology of Cork-Kerry). Geological Survey of Ireland (GSI, 2003);
- 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

A walkover survey, including geological mapping and investigations, was undertaken by HES in January 2020.

Geotechnical ground investigations and a peat stability assessment were undertaken by Gavin and Doherty Geosolutions Ltd (GDG) in January /February 2020. MKO have also completed peat depth probing at the site. The combined geological dataset collated by HES, MKO and GDG has been used in the preparation of this EIAR Chapter.

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

- A total of 230 no. peat probe depths/investigations points were carried out by GDG, HES and MKO to determine the depth and geomorphology of the peat at the proposed site;
- A geotechnical and peat stability assessment report by GDG (June 2020);
- A peat management plan has been prepared by GDG (June 2020);
- A total of 20 no. gouge core sample points were undertaken by HES across the site to investigate peat and mineral soil lithology;
- Logging of subsoil exposures across the site where mineral soils and peat profiles are exposed; and,
- Mineral subsoils and peat were logged according to BS: 5930 and Von Post Scale respectively.

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

8.2.3 Impact Assessment Methodology

Using information from the desk study and data from the site investigations, an assessment of the importance of the soil and geological environment within the study area and proposed site is assessed using the criteria set out in

Table 8-1 (NRA, 2008).

Table 8-1 Estimation of Importance of Soil and Geology Criteria (NRA, 2008).

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

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

The guideline criteria (EPA, 2017) for the assessment of likely significant effects require that likely effects are described with respect to their extent, magnitude, type (i.e. negative, positive or neutral) probability, duration, frequency, reversibility, and transfrontier nature (if applicable). The descriptors used in this environmental impact assessment report are those set out in the EPA (2017) Glossary of effects as shown in Chapter 1 of this EIAR. In addition, the two impact characteristics proximity and probability are described for each impact and these are defined in Table 8-2.

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

Table 8-3.

Table 8-2: Additional Impact Characteristics.

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

Table 8-3: 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 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 site is located immediately west of the R584 at the Pass of Keimaneigh which is situated approximately 5.6km northeast of Kealkill and 5.5km southwest of the village of Ballingeary. The Proposed Development site is a forested site and former wind farm site. Access to the site is from the Pass of Keimaneigh which runs along the northeastern boundary of the site. There is a network of existing access roads within the site from the previous wind farm development (Curraglass Wind Farm Energy Development). The topography is mountainous in setting with various peaks of the Shehy Mountains located to the east and west.

The site topography is characterised by a central north/south trending ridge line which slopes to the east and west. The highest point of the ridge is an approximately 350m OD which slopes steadily to approximately 150m OD within the confines of the site. The majority of the Proposed Development infrastructure is located on the western slopes of the central trending ridge line. The majority of the site is

under forestry cover except on the eastern slopes of the central ridge which is dominated by shallow pockets of blanket bog and rocky outcrops.

8.3.2 Peat/Soils and Subsoils

The published soil and subsoil map (www.epa.ie) for the area shows that the site is dominated by shallow peaty soils over shallow bedrock (the subsoils mapping shows subsoils are largely absent with bedrock close to surface). Pockets of blanket peat are mapped along the summit of the central ridgeline and on the lower western slopes of the site in the area of the proposed infrastructure.

A map of the local subsoil cover is attached as Figure 8-1.

Measured peat depths in the area of the Proposed Development are typically shallow (<1m) with an overall average of 0.4m. The average peat depths at the proposed turbine locations varied between 0m (T1) to 0.87m (T5). Peats depths along the proposed new access roads were <0.5m.

In order to investigate the mineral subsoil lithology below the peat (or be it the peat and bedrock interface), a series of gouge core samples were taken at the turbine locations and also across the site at various proposed infrastructure locations. Shown on Table 8-4 below is a summary of the mineral subsoil lithology at the Proposed Development locations. The locations of the gouge core investigation points and all peat depth data are shown on Figure 8-2.

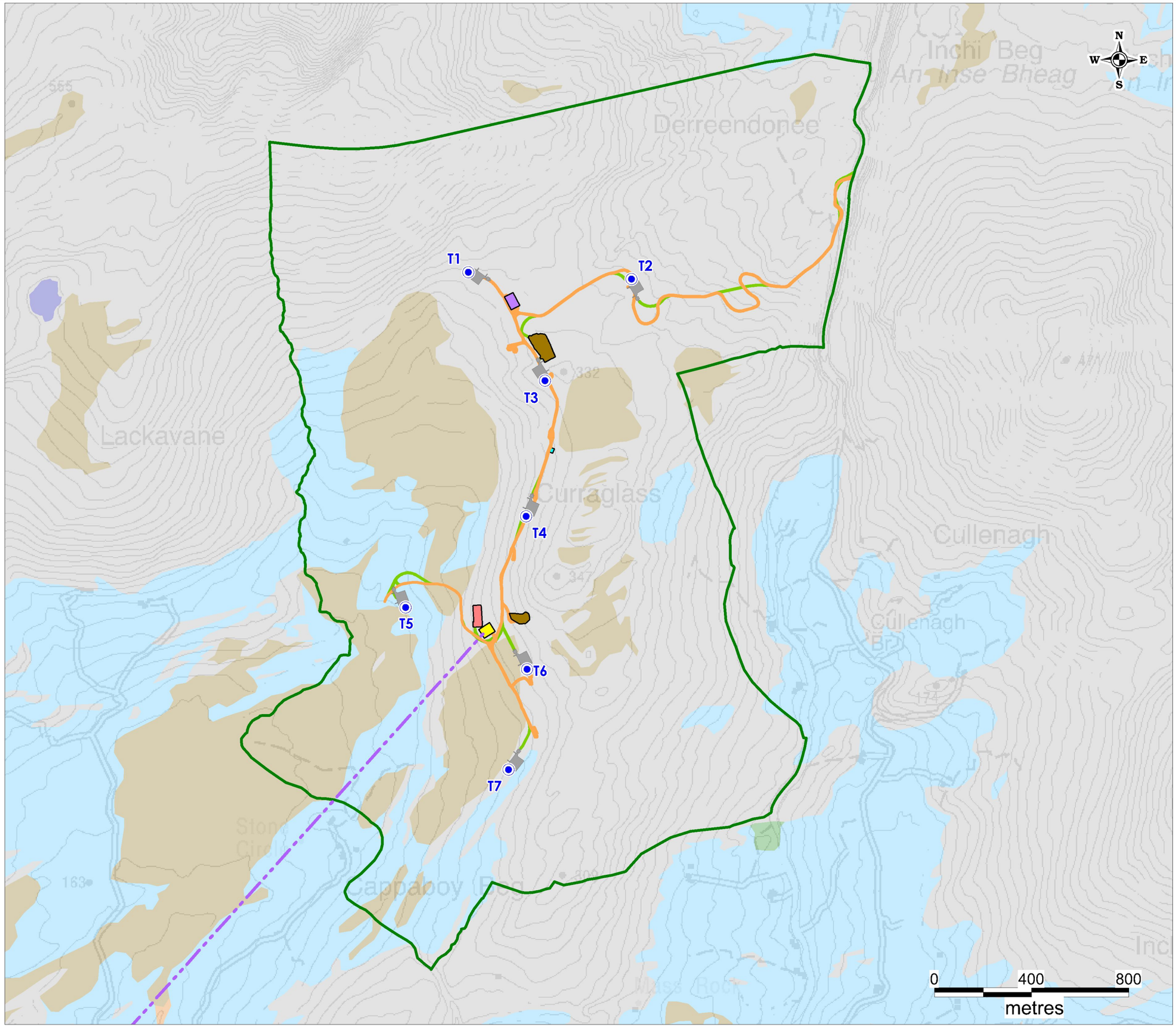
Gouge core sampling undertaken at the Proposed Development locations typically encountered well-drained, black/brown, firm pseudo-fibrous or fibrous peat. At most locations the peat was amorphous.

The mineral subsoil underlying the peat at the proposed turbine locations typically comprised firm SILT/CLAY which was gravelly in places. Based on subsoil exposures across the site, maximum mineral subsoil depths are unlikely to exceed 1m with most likely to be less than 0.5m.

A summary of average peat depths and subsoils geology for the 7 no. proposed turbines and other key infrastructure locations are included within Table 8-4.

Table 8-4: Summary of Peat Depths and Mineral Subsoil Lithology at Proposed Development Locations

Infrastructure Location	Average Peat Depth (m)	Summary of Underlying Mineral Subsoil Lithology
T1	0	Rock close to surface (outcrops locally)
T2	0.26	Subsoils absent, bedrock met below peat
T3	0.24	Rock close to surface (outcrops locally)
T4	0.1	Firm, gravelly SILT/CLAY
T5	0.87	Firm SILT/CLAY
T6	0.3	Firm, gravelly SILT/CLAY
T7	0.4	Subsoils absent, bedrock met below peat
Substation	0.45	Firm, gravelly SILT/CLAY
Compound	0.3	Firm, SILT/CLAY
Borrow Pit 1	0.5	Firm, gravelly SILT/CLAY
Borrow Pit 2	0.3	Firm, gravelly SILT/CLAY
Met Mast	0.7	Firm, gravelly SILT/CLAY



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Existing Overhead Line to Ballylickey
- Current Substation Location
- Proposed Substation
- Proposed Temporary Construction Compound
- Proposed Borrow Pits
- Proposed Met Mast Location
- Proposed Hardstanding
- New Proposed Road
- Existing Roads - Upgrade Proposed
- Blanket Peat
- Gravels derived from Devonian sandstones
- Bedrock outcrop or subcrop
- Till derived from Devonian sandstones
- 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: MKO

Job: Curraglass WF, Co. Cork

Title: Local Subsoils Map

Figure No: 8-1

Drawing No: P1483-0-0620-A3-8-1-0A

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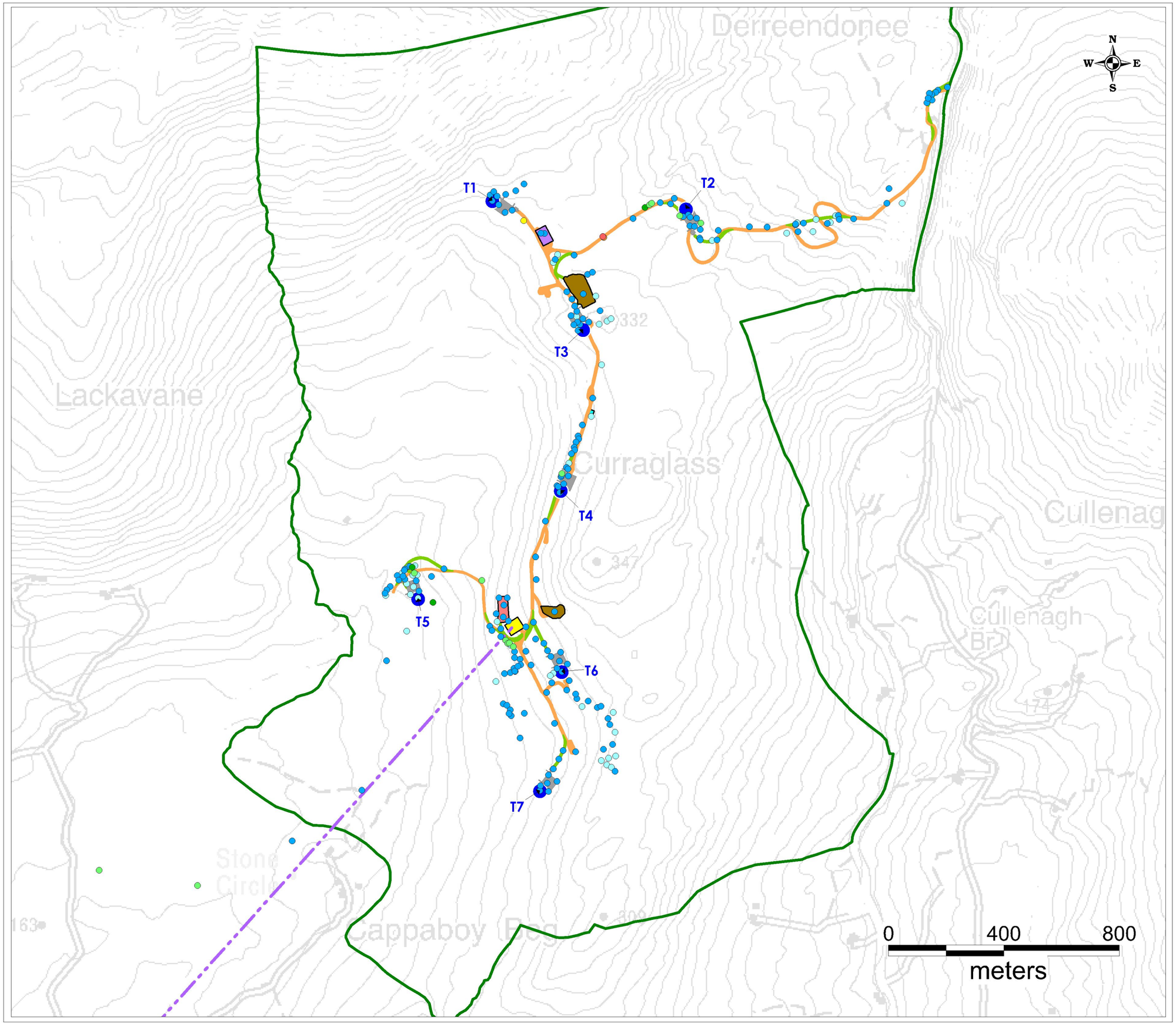

Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Existing Overhead Line to Ballylickey
- Current Substation Location
- Proposed Substation
- Proposed Temporary Construction Compound
- Proposed Borrow Pits
- Proposed Met Mast Location
- Proposed Hardstanding
- New Proposed Road
- Existing Roads - Upgrade Proposed

Peat Depth Legend

- 0 - 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- 1.5 - 2.0m
- 2.0 - 2.5m
- 3.0 - 3.5m
- 5.0 - 5.5m

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: MKO	
Job: Curraglass WF, Co. Cork	
Title: Summary Peat Depth Map	
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Sheet Size: A3	Project No: P1483-0
Scale: 1:12,500	Drawn By: GD
Date: 24/06/2020	Checked By: MG

8.3.3 Bedrock Geology

Based on the GSI bedrock mapping the bedrock units underlying the Proposed Development site comprises Devonian Old Red Sandstones (DORS). This bedrock type was visible at the numerous outcrops.

Below the site the Devonian Old Red Sandstones are mapped to comprise mainly of green-grey sandstone and purple siltstone. There are no mapped bedrock faults in the area of the Proposed Development site.

A bedrock geology map of the area is attached as Figure 8-3.

8.3.4 Geological Resource Importance

The bedrock underlying the site could be classified as "Medium" importance. The bedrock could be used on a "sub-economic" local scale for construction purposes. The bedrock has not been used in the past at the site for this purpose.

The glacial subsoils could be classified as "Low" importance. The glacial subsoils could be used on a "sub-economic" local scale for construction purposes. There is no evidence that it was used in the past.

The overlying peat deposits at the site could be classified as "Low" importance as the peat is not designated in this area and is significantly degraded in most places due to the forestry.

Refer to

Table 8-1 for definition of these criteria.

8.3.5 Designated Sites

Within the Republic of Ireland designated sites include National Heritage Areas (NHAs), Proposed National Heritage Areas (pNHAs), candidate Special Areas of Conservation (SAC) and Special Protection Areas (SPAs).

The proposed site is not located within or adjacent to any designated site. Designated sites within the same surface water catchments as the Proposed Development site are listed below:

- Conigar Bog NHA (Site Code: 002386) is located approximately 5m to the west of the EIAR Site Boundary;
- Lough Allua pNHA (Site Code: 001065) is located approximately 6.5km to the northeast of the EIAR Site Boundary;
- Gouganebarra Lake pNHA (Site Code: 001057) is located approximately 1.5km to the north of the EIAR Site Boundary;
- Derryclogher (Knockboy) Bog SAC (Site Code: 001873) is located approximately 4km to the west of the EIAR Site Boundary; and,
- The Gearagh SAC (Site Code: 000108) is located approximately 19.4km to the northeast of the EIAR Site Boundary.

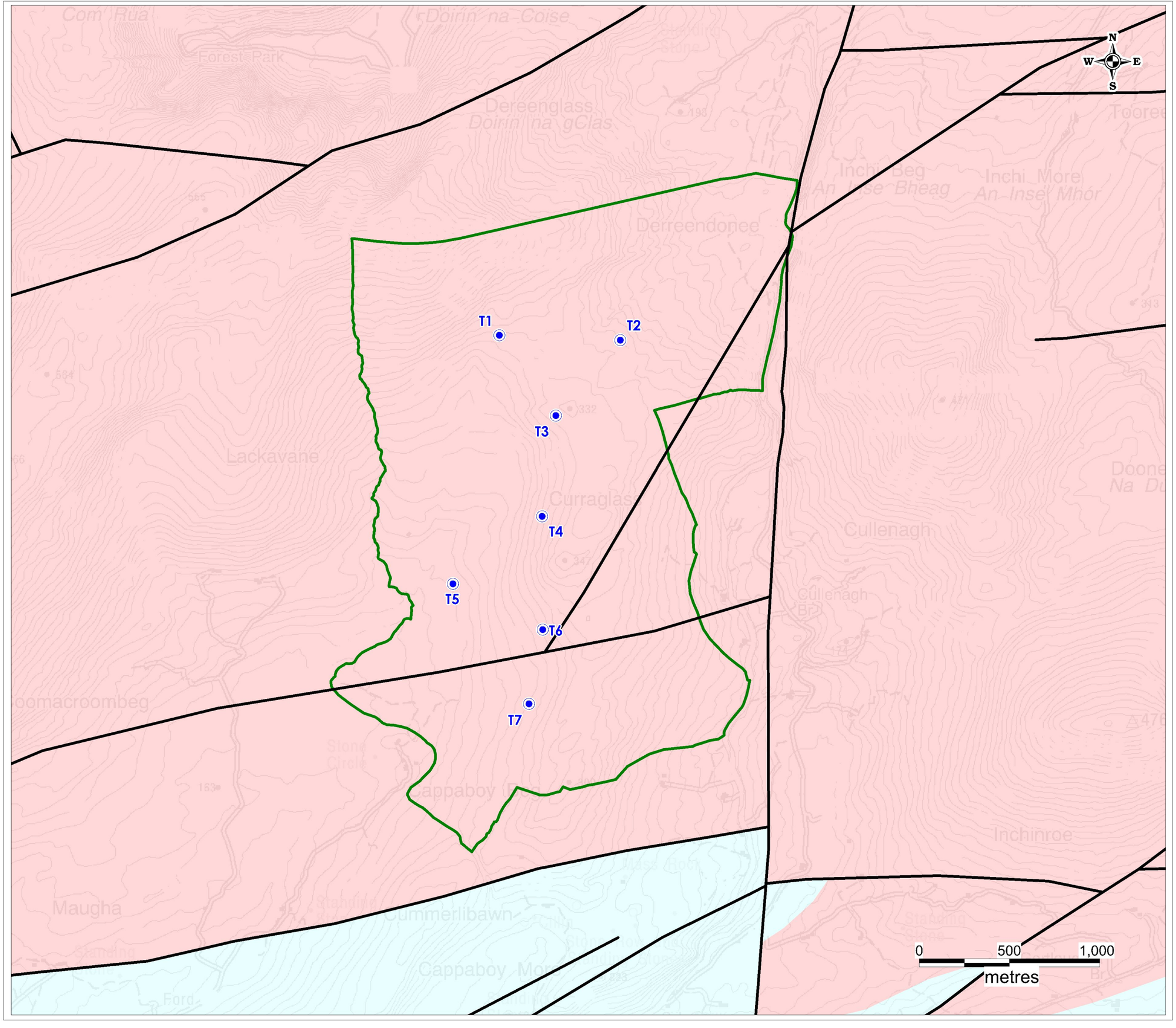
Potential hydrological pathways (surface water connections) and potential hydrogeological pathways (groundwater connections) to designated sites are assessed in the Water Chapter (Chapter 9).

8.3.6 Geological Heritage Sites

There are no recorded mineral deposit sites or mining sites (current or historic) within the Proposed Development area. The nearest Geological Heritage site to the Proposed Development site is the Pass of Keimaneigh (IGH7) which is referred to as a glacial spillway. The Pass of Keimaneigh is located adjacent to the north-eastern extent of the EIAR site boundary. The Proposed Development will have no potential to impact on the Pass of Keimaneigh.

The next nearest Geological Heritage site is Ballingeary Esker (IGH7) which is located approximately 6km to the northeast of the site.

The locations of these County Geological Heritage sites are shown on Figure 8-4 relative to the proposed site layout.



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Mapped Faults
- Dinantian Mudstones and Sandstones (Cork Group)
- Devonian Old Red Sandstones

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: MKO	
Job: Curraglass WF, Co. Cork	
Title: Local Bedrock Geology Map	
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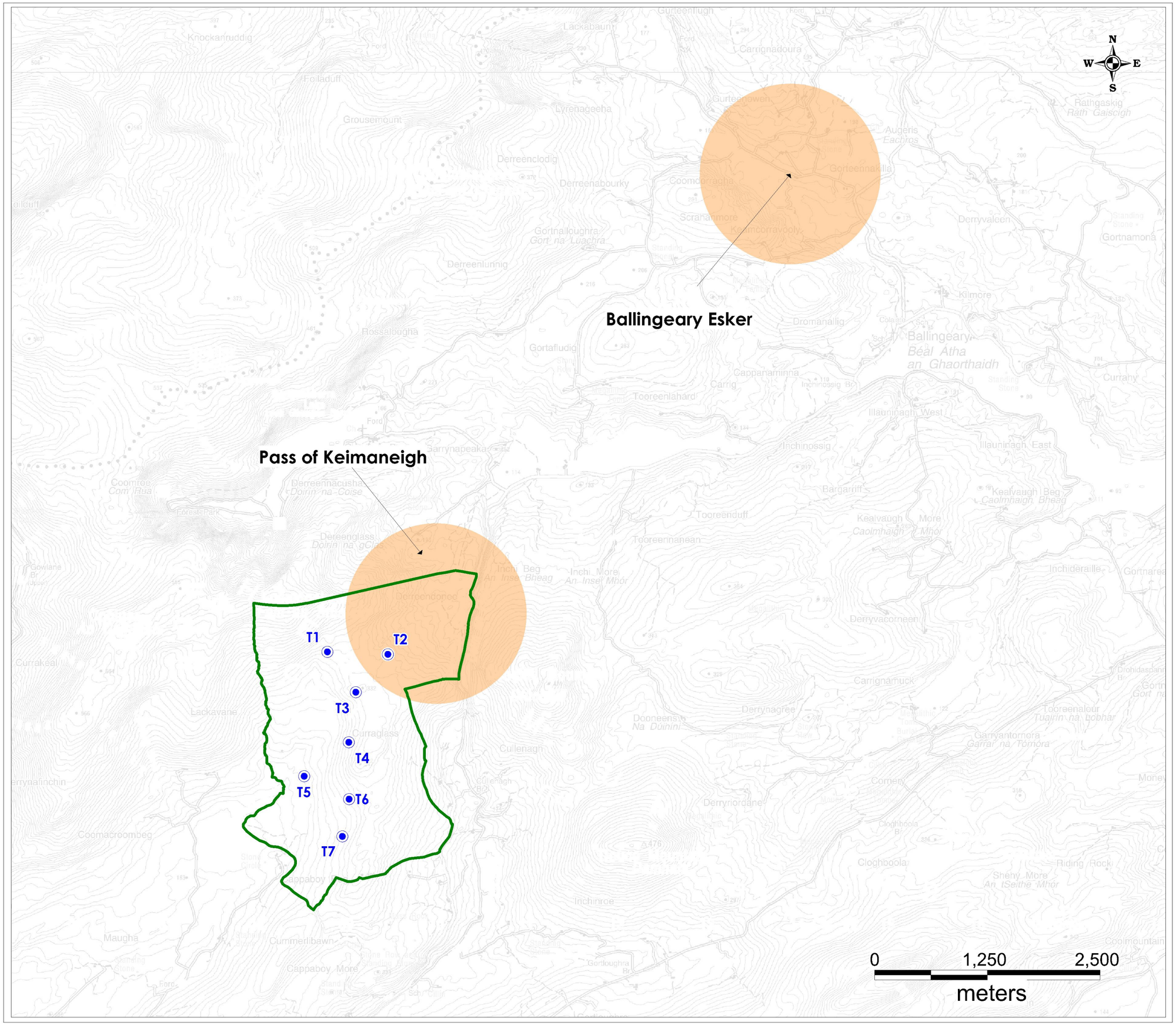

Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Geological Heritage Sites

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: MKO	
Job: Curraglass WF, Co. Cork	
Title: Geological Heritage Sites	
Figure No: 8-4	
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Sheet Size: A3	Project No: P1483-0
Scale: 1:40,000	Drawn By: GD
Date: 24/06/2020	Checked By: MG

8.3.7 Peat Stability Assessment

A Geotechnical and Peat Stability Assessment Report (GDG, 2020) is attached in Appendix 8-1. Summary data and conclusions from that report are provided below.

8.3.7.1 Factor of Safety Determination

The factor of safety is a measure of the stability of a slope. For any slope, the degree of stability depends on the balance between the landslide driving forces (weight of the slope) and its inherent shear strength.

Therefore, the factor of safety provides a direct measure of the degree of stability of a slope by the ratio of the shear resistance along a potential surface of failure and the landslide driving forces acting on such surface. Multiple potential surfaces of failure are possible, but the FoS assigned to a slope is that of the surface of failure with the lowest value of FoS.

- FoS < 1 indicates a slope is unstable and prone to fail.
- FoS = 1 indicates a slope is theoretically stable, but not safe.
- The acceptable safe range for FoS typically ranges from 1.3 to 1.4. The previous code of practice for earthworks BS 6031:1981 (BSI, 1981), provided advice on the design of earthworks slopes. It stated that for a first-time failure with a good standard of site investigation the design FoS should be greater than 1.3. This way the slope is stable and safe.

As a general guide, the FoS limits for peat slopes assumed in the peat stability assessment report are summarised in

Table 8-5 below.

Table 8-5: Probability Scale for Factor of Safety.

Factor of Safety Limits	Slope Stability
FoS <1	Unstable
1≤ FoS <1.3	Stable but not safe
FoS ≥ 1.3	Stable and safe

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

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

Two surcharging conditions are considered for the stability analysis:

- Condition 1 - No Surcharging load; and
- Condition 2 - Surcharging load of 10 kPa, equivalent to 1 m of stockpiled or side-cast peat.

As mentioned above, the Geotechnical and Peat Stability Assessment Report (GDG, 2020) is attached in Appendix 8-1.

Undrained Analysis

- Undrained analysis results are presented in

Table 8-6. As outlined above the undrained loading condition applies in the short-term during construction and until construction induced pore water pressures dissipate.

Table 8-6: Factor of Safety Results (undrained condition)

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T1	508763	563650	134.15	6.39
T2	509433	563623	33.45	6.9
T3	509077	563204	42.62	8.25
T4	509000	562646	29.07	2.64
T5	508505	562272	9.3	4.33
T6	509003	562019	11.44	2.64
T7	508927	561606	8.75	2.50

Drained Analysis

Drained analysis results are presented in

Table 8-7. As outlined above, the drained loading condition applies in the long-term. The condition examines the effect of in particular, the change in groundwater level as a result of rainfall on the existing stability of the natural peat slopes.

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

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T1	508763	563650	67.15	6.87
T2	509433	563623	16.83	7.46
T3	509077	563204	21.43	8.93
T4	509000	562646	14.56	2.74
T5	508505	562272	4.75	4.71
T6	509003	562019	5.76	2.78
T7	508927	561606	4.41	2.64

The FoS calculations for the rest of site i.e. the proposed substation and battery storage, temporary construction compound, existing and upgraded access roads, borrow pits and met mast has been carried out semi-automatically in GIS and can be seen in Figures K-1 to K-4 in the Geotechnical and Peat Stability Assessment Report (Appendix 8-1).

The FoS at each of the development infrastructure locations assessed is >1.3 (i.e. Stable and Safe). Outside of the development footprint a number of safety buffers within the overall site were mapped where

construction should be avoided and should not be used for material/spoil storage or side casting (refer to the Geotechnical and Peat Stability Assessment Report in Appendix 8-1 (GDG, 2020).

8.3.7.2 Risk Assessment

Risk is the potential or probability of adverse consequences, including economic losses, environmental or social harm or detriment. Risk is expressed as the product of a hazard (e.g. peat landslide) and its adverse consequences (Lee & Jones, 2004; Corominas et al., 2014) (Equation below). Some use approximate synonyms and refer to risk as the product of the likelihood and the impact, or the product of susceptibility and the exposure.

Risk = (Hazard) x (Adverse Consequences)

The hazard is calculated from a variety weighted factors including the FoS and thirteen secondary factors related with geomorphic observations, topography, hydrology, vegetation, peat workings, existing loads and slide history (refer Appendix M of Peat Stability Assessment Report).

Each hazard factor has been reclassified into one of four classes with rating values ranging from 0 to 3 (Appendix M of Peat Stability Assessment Report). A rating of 0 indicates that the hazard factor is not relevant, rating 1 indicates low correlation to instability hazard, rating 2 indicates medium and a rating of 3 indicates high correlation to instability hazard.

The impacts of peat landslides on the infrastructure and surrounding environment and existing assets may typically generate a variety of adverse consequences. In the peat stability assessment report, these consequences have been assessed qualitatively following the *Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments* (Scottish-Executive, 2017).

The nine consequence factors considered have been reclassified in the same fashion the hazard factors were reclassified (Appendix M of Peat Stability Assessment Report). A rating of 0 indicates that the consequence factor is not relevant and rating 3 indicates high consequences

Risk at each infrastructure location is calculated by multiplying the scores of the hazard and the scores of the consequences. The risk rating ranges between 0 and 1 and the following levels of risk rating have been distinguished as outlined in Table 8-8.

Table 8-8: Levels of Risk Rating

Risk Score	Risk Ranking	Engineering/Design Response
0.6 to 1	High	Avoid project development at these locations. Mitigation is generally not feasible.
0.4 to 0.6	Medium	Project should not proceed unless risk can be avoided or mitigated at these locations, without significant environmental impact, to reduce risk ranking to low or negligible.
0.2 to 0.4	Low	Project may proceed pending further investigation to refine assessment and mitigate hazard through relocation or re-design at these locations.
0 to 0.2	Negligible	Project should proceed with monitoring and mitigation of peat landslide hazards at these locations as appropriate

The sites for turbines T1, T2, T3, the met mast, the substation and battery storage, the temporary compound and the access roads to the turbines are located in sectors of negligible risk. Turbines T4, T5, T6 and T7 are located in sectors of low risk. It is noted that the resulting risk rating does not indicate a probability of losses due to landslides, it simply expresses a rating. This information is summarised in

Table 8-9.

Table 8-9: Levels of Risk Rating

Risk Ranking	Infrastructure Locations
Negligible	Turbines T1, T2, T3, T5, T7, the met mast, the substation and battery storage, the temporary compound and the access roads to the turbines are located in sectors of negligible risk.
Low	Turbines T4 andT6 are located in sectors of low risk. For these turbines with low rating, the project may proceed pending further investigation to refine assessment and mitigate hazard through relocation or re-design at these locations, prior to construction.

As outlined above, the findings of the peat assessment showed that the site has an acceptable margin of safety and is suitable for the Proposed Development.

8.4 Characteristics of the Proposed Development

The Proposed Development will typically involve removal of peat and subsoils for upgrade of existing and new access roads, internal access road networks, internal cable network, hardstanding emplacement, turbine foundations, substation and battery storage, including associated connection to the national grid, crane hardstands, construction compound, borrow pits and met mast installation. The construction grade granular fill and the higher quality surfacing granular fill will be sourced from 2 no. proposed on-site borrow pits. The Proposed Development also includes for junction upgrade works to the existing site entrance as well as temporary works along the turbine delivery route.

Excavated peat and subsoil will be utilised to restore the on-site borrow pits and will also be used for reinstatement and landscaping works as close to the extraction point as possible.

Estimated volumes of peat, subsoil and bedrock to be removed/relocated/reused are shown in Table 8-10 and 8-11 below, with further detail in the Peat and Spoil Management Plan (Appendix 4-4).

Table 8-10 Estimated Peat, Mineral Soil and Bedrock Excavation Volumes

Infrastructure Item	Excavated volume – Peat (m^3)	Excavated volume – Spoil (m^3)	Excavated volume – Rock (m^3)
Access Roads	13,000	8,500	33,800
Turbine foundations and crane hardstandings	8,000	5,400	21,300
Compound hardstanding	100	100	0
Substation	800	0	0
Met Mast hardstanding	200	50	150
Borrow Pit 1	2,200	0	62,000
Borrow Pit 2	1,200	0	7,600
Total	**25,500**	**14,050**	**124,850**

Peat generated during construction can be reused or reinstated across the Proposed Development. Peat may be reused for landscaping on edges of constructed infrastructure (including, road verges, turbine foundations) and shall be placed as soon as reasonably practical after construction as detailed. This shall act as part of the landscaping restoration and tie-in with surrounding topography, reducing visual impacts and restore the existing habitat. Two metres of excavated non-peat material is proposed to be placed in Borrow Pit 1 as part of reinstatement. Both borrow pits may be backfilled with peat up to 2m deep or deeper where site-specific detailed designs are produced. Potential peat reuse/reinstatement volumes have been estimated and are also presented in Table 8-11.

Table 8-11 Summary of preliminary reinstatement volumes

Infrastructure Item	Peat reinstatement volume (m^3)	Comments
Access Roads	11,200	Placement of arisings (3m wide and 1m depth) alongside existing and new founded roads, where topography allows
Turbine foundations and crane hardstandings	900	This is a conservative estimate of the volume of peat that will be required for landscaping purposes at each of the turbine locations.
Compound hardstanding	0	Volumes for landscaping at these infrastructures have been conservatively omitted from preliminary calculations
Substation hardstanding	0	
Met mast hardstanding	0	
Borrow Pit 1	12,300	Assumes 2m of peat reinstated along the base of borrow pit
Borrow Pit 2	4,000	Assumes 2m of peat reinstated along the base of borrow pit
Total	28,400	

The summary of preliminary earthwork volumes indicates that the capacity of the development to accommodate excavated material, namely that provided once Borrow Pit 1 and 2 are reinstated, is greater than the volume of peat excavated for the various infrastructures. Temporary storage of peat will likely be required during construction. It is recommended that suitably level areas, which do not have peat at surface, can be used for the temporary storage of peat. Please refer to the Peat and Spoil Management Plan (Appendix 4-4)

Likely Significant Effects and Associated Mitigation Measures

8.4.1 Do Nothing Scenario

If the Proposed Development were not to proceed, no changes would be made to the current land-use practice of forestry and the site would continue to be managed under the existing commercial forestry arrangements.

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

8.4.2 Construction Phase - Likely Significant Effects and Mitigation Measures

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

8.4.2.1 Peat, Subsoil and Bedrock Excavation

Excavation of peat, subsoil and bedrock will be required for construction of works for the installation of access roads foundations for turbine bases, crane hardstands, met mast, substation and battery storage, internal cable network and borrow pits. This will result in a permanent removal and relocation of in-situ peat, subsoil and bedrock at most excavation locations. Estimated volumes of peat, subsoils and bedrock to be relocated are summarised above. There is no loss of peat, subsoil or bedrock, it will just be relocated within the site. Bedrock will be sourced from infrastructure excavations and 2 no. on-site borrow pits.

Pathway: Extraction/excavation.

Receptor: Peat, subsoil and bedrock.

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

Proposed Mitigation Measures by Design:

- Placement of turbines and associated infrastructure in areas with shallower peat where possible;
- The peat, subsoil and bedrock which will be removed during the construction phase will be localised to the wind farm infrastructure turbine location, substation and battery storage, temporary compounds, access roads and borrow pits;
- The Proposed Development has been designed to avoid sensitive habitats within the application area;
- A minimal volume of peat, subsoil and bedrock will be removed to allow for infrastructural work to take place in comparison to the total volume present on the site due to optimisation of the layout by mitigation by design;
- Excavated peat will only be moved short distances from the point of excavation and will be used locally for landscaping; and,
- Construction of settlement ponds will be volume neutral, and all excess material will be used locally to form pond bunds and surrounding landscaping.

Residual Effect Assessment: The granular soil and peat at the site can be classified as of "Low" importance and the bedrock "Medium" Importance). The overall site area is extensive while the Proposed Development footprint is approximately 1.2% of the overall site area. The impact is the disturbance and relocation of c 163,600m^3 of soil, subsoil and bedrock during construction. The design measures incorporated into the project as described above in particular the avoidance of deeper peat

areas combined with the 'low to medium' importance of the deposits means and bedrock that the residual effect is considered - Negative, slight, direct, high probability, permanent effect on peat and subsoils due to disturbance and relocation within the site.

Significance of Effects: No significant effects on soils, subsoils or bedrock are anticipated.

8.4.2.2 Contamination of Soil by Leakages and Spillages and Alteration of Peat/Soil Geochemistry

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

Pathway: Peat and subsoil and underlying bedrock pore space.

Receptor: Peat and subsoil, bedrock.

Pre-Mitigation Potential Impact: Negative, slight, direct, short-term, medium probability effect on peat, subsoils and bedrock.

Proposed Mitigation Measures:

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

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

Significance of Effects: No significant effects on peat, subsoils and bedrock are anticipated.

8.4.2.3 Erosion of Exposed Subsoils and Peat During Construction of Infrastructure

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

Pathway: Vehicle movement, surface water and wind action.

Receptor: Peat and subsoil.

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

Proposed Mitigation Measures:

- Peat removed from turbine locations and access roads will be used for landscaping close to the extraction area;
- Where possible, the upper vegetative layer (where still present) will be stored with the vegetation part of the sod facing the right way up to encourage growth of plants and vegetation at the surface of the stored peat within the peat storage areas;
- Re-seeding and spreading/planting will also be carried out in these areas; and,
- A full Peat and Spoil Management Plan for the development is shown as Appendix 4-4.

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

Significance of Effects: No significant effects on soils, subsoils or bedrock are anticipated.

8.4.2.4 Peat Instability and Failure

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

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

Pathway: Vehicle movement and excavations.

Receptor: Peat and subsoils.

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

Impact Assessment:

The findings of the peat stability assessment showed that the proposed Curraglass Renewable Energy Development site has an acceptable margin of safety, is suitable for the Proposed Development and is considered to be at low risk of peat failure. The findings include recommendations and control measures for construction work in peatlands to ensure that all works adhere to an acceptable standard of safety.

Proposed Mitigation Measures:

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

- Appointment of experienced and competent contractors;

- The site should be supervised by experienced and qualified personnel;
- Allocate sufficient time for the project (be aware that decreasing the construction time has the potential to increase the risk of initiating a localised peat movement);
- Prevent undercutting of slopes and unsupported excavations;
- Maintain a managed robust drainage system;
- Prevent placement of loads/overburden on marginal ground;
- Set up, maintain and report findings from monitoring systems (as outlined in the Geotechnical and Peat Stability Assessment);
- Ensure construction method statements are developed and agreed before commencement of construction and are followed by the contractor; and,
- Revise and amend the Construction Risk Register as construction progresses to ensure that risks are managed and controlled for the duration of construction.

Please refer to Appendix 4-4 for proposed turbine specific and road section design proposals.

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

Significance of Effects: No significant effects on soils and subsoils are anticipated.

8.4.2.5 Proposed Turbine Delivery Route Junction Works

The proposed turbine delivery route options are detailed in Chapter 4, Section 4.4. Only areas which may require groundworks or road widening were considered in terms of direct effects on Land, Soils and Geology.

The proposed turning area along the R584, will require removal of fencing and temporary placement of hardcore, so the area can be used during the delivery of large turbine components. Once the turbines have been delivered, this area will be returned to its original state. Furthermore, the existing site entrance will be upgraded to facilitate the delivery of the construction materials and oversized loads.

Pathway: Extraction/excavation of soil/subsoil.

Receptor: Soils and subsoils.

Pre-Mitigation Potential Impact: Negative, slight/moderate, direct, high probability, permanent effect on soil and subsoil.

Proposed Mitigation Measures:

Mitigation measures in respect of peat and subsoil excavation are outlined at Section 8.4.2.1.

Mitigation measures to prevent soil / subsoil contamination (leaks / spills) are dealt with in Section 8.4.2.2 above and measures dealing with soil erosion are dealt with in Section 8.4.2.3.

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

Significance of Effects: No significant effects on soils and subsoils are anticipated.

8.4.3 Operational Phase - Likely Significant Effects and Mitigation Measures

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

- Some construction vehicles or plant may be necessary for maintenance of turbines which could result in minor accidental leaks or spills of fuel/oil; 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.

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

Mitigation measures for soils and geology during the operational phase include the use of aggregate from authorised quarries for use in road and hardstand maintenance. Oil used in transformers (at the substation and within each turbine) and storage of oils in tanks at the substation could leak during the operational phase and impact on ground/peat and subsoils and groundwater or surface water quality. All transformers will be bunded with capacity capable of holding 110% of the stored oil volume. These mitigation measures are considered sufficient to eliminate potential risks to ground/peat/soils and subsoils, and groundwater and surface water quality.

The residual effects are considered as - Negative, direct, imperceptible, high probability, permanent effect on local peat and subsoils.

8.4.4 Decommissioning Phase - Likely Significant Effects and Mitigation Measures

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

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

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

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

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

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

The residual effects are considered as - Negative, direct, slight, high probability, permanent effect on local peat and subsoils.

8.4.5 Cumulative Effects

Due to the localised nature of the proposed construction works which will be kept within the Proposed Development site boundary, there is no potential for significant cumulative effects in-combination with other local developments on the land, soils and geology environment. The only way the Proposed Development can have in combination effects with other off-site projects and plans is via the drainage and off-site surface water network, and this hydrological pathway is assessed in Chapter 9. The construction of the grid connection works, turbine delivery route and junction upgrade works will only require relatively localised excavation works within the EIAR site boundary and therefore will not contribute to any significant cumulative effects.

8.4.6 Post Construction Monitoring

None required.

8.4.7 Conclusion

Excavation of peat, subsoil and bedrock will be required for site levelling and for the installation of wind farm infrastructure. This will result in a permanent removal of peat, subsoil and possibly bedrock at most excavation locations. Excavated peat will be utilized to re-instate the borrow pit locations (2 no.) and will also be used for reinstatement and landscaping works around the site. The handling and management of peat will be undertaken in accordance with the Peat and Spoil Management Plan as set out in Chapter 4 of this EIAR. Storage and handling of hydrocarbons/chemicals will be carried out using best practice methods.

Measures to prevent peat and subsoil erosion during excavation, reinstatement, and permanent placement in borrow pits will be undertaken to prevent water quality impacts.

A peat stability assessment undertaken for the site shows that there is a low risk of peat instability/failure at the Proposed Development site and along the proposed construction access road.

No significant impacts on the land, soil, and geology of the site of Proposed Development will occur during construction, operation, or during decommissioning phases.

This assessment also concludes that there will be no cumulative effects on land soil and geology environment as a result of the Proposed Development.