8 LAND, SOILS AND GEOLOGY

8.1 Introduction

8.1.1 Background and Objectives

Hydro-Environmental Services (HES) was engaged by McCarthy Keville O'Sullivan (MKO) to carry out an assessment of the potential impacts of a proposed 19 no. turbine wind farm and its grid connection cable route (the Proposed Development) at Meenbog and adjacent townlands, Co. Donegal on the land-soil and geological environment.

This report provides a baseline assessment of the environmental setting of the site of the Proposed Development (including the proposed wind farm site and grid connection route) in terms of soils and geology and discusses the potential impacts that the construction and operation of the Proposed Development will have. Where required, appropriate mitigation measures to limit any identified significant impacts to soils and geology are recommended.

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.

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 with over 15 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms in Ireland. In addition, he has substantial experience in surface water drainage design and SUDs design, and surface water/groundwater interactions.

David Broderick (BSc, H.Dip Env Eng, MSc) is a hydrogeologist with over 12 years' experience in both the public and private sectors. 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 EIAs for a range of commercial developments.

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. 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; S.I No. 538 of 2001); S.I. No. 30 of 2000 the Planning and Development Act, 2000;, and S.I 600 of 2001 Planning and Development Regulations and subsequent amendments, on the assessment of the effects of certain public and private projects on the environment; and,

- S.I. No. 4 of 1995: The Heritage Act 1995.

8.1.4 Relevant Guidance

The soils and geology section of this EIAR is carried out in accordance with the 'EIA Directive' as amended by Directive 2014/52/EU and having regard where relevant to guidance contained in the following documents:

- Environmental Protection Agency (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) (where relevant);
- Environmental Protection Agency (September 2015): Draft – Revised Guidelines on the Information to be Contained in Environmental Impact Statements (where relevant);
- Environmental Protection Agency (2003): Advice Notes on Current Practice (in the Preparation on Environmental Impact Statements) (where relevant);
- Environmental Protection Agency (2002): Guidelines on the Information to be Contained in Environmental Impact Statements (where relevant) ;
- Institute of Geologists Ireland (2013): Guidelines for Preparation of Soils, Geology & Hydrogeology Chapters in Environmental Impact Statements; and,
- National Roads Authority (2005): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes.

8.2 Schedule of Works

8.2.1 Desk Study

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

- Environmental Protection Agency database (www.epa.ie);
- Geological Survey of Ireland - National Draft Bedrock Aquifer map;
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 3 (Geology of South Donegal). Geological Survey of Ireland (GSI, 1999);
- 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 Mapping and Site Investigations

Extensive geological mapping, gouge coring and peat depth probing was undertaken initially by HES during October 2014, MKO during 2014, with additional site investigations also undertaken between 26th and 28th July 2017. Geotechnical investigations and a peat stability assessment were undertaken by AGEC Ltd between 29th September and 3rd October 2014 and between 20th and 24th and 28th and 29th March 2017.

The objectives of the intrusive site investigations, which accumulated over 350 hours of site work (man hours), included mapping the distribution and depth of blanket peat at the site along with assessing the mineral subsoil / bedrock interface beneath the peat at key development locations (*i.e.* proposed turbine, substation, compound and borrow pit locations. The surveying of several existing borrow pits at the site (not forming part of the development) confirmed the findings of the investigations and allowed the development of an accurate geological conceptual model of the site. The duration of time spent on site, and the accumulation of data from several site visits demonstrates that this work was not rushed or inadequate, and is in fact robust and comprehensive.

In summary, site investigations to assess the soil and geology section of the EIAR included the following:

- A total of over 500 no. peat probe depths were carried out by HES, MKO and AGEC Ltd to determine the depth and geomorphology of the blanket peat at the site and along the grid connection route;
- A geotechnical assessment of peat stability by AGEC Ltd (October, 2015);
- Gouge cores (+30 no.) and window sampling (1 no. location)[1] was undertaken to investigate peat and mineral subsoil lithology along with depth to bedrock;
- Logging of bedrock outcrops and peat/subsoil exposures; and,
- Mineral subsoils and peat were logged according to BS: 5930 and Von Post Scale respectively.

The Peat Stability Assessment report prepared by AGEC Ltd is included as Appendix 8.1 of this EIAR.

8.2.3 Scoping and Consultation

The scope for this assessment has been informed by consultation with statutory consultees, bodies with environmental responsibility and other interested parties. Certain issues and concerns highlighted by 3rd parties relating to the previous application for a wind farm lodged in 2015 (under ABP Ref: PA0040) have also been addressed in the context of this application.

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 soil and geological environment within the study area is assessed using the criteria set out in Table 8.1 (NRA, 2005).

[1] It was intended to complete 8 no. window sample drill holes on the site of the Proposed Development site, but in general peat overlies bedrock, weathered bedrock or very thin subsoils, and as such window sampling drilling to recover subsoil samples from below the peat was not needed, as none existed. This is explained further below.

Table 8.1. Estimation of Importance of Soil and Geology Criteria (NRA, 2005).

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

The statutory criteria (EPA, 2002, 2003, 2015 and 2017) for the assessment of impacts require that likely impacts 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 EIAR are those set out in EPA (2017) Glossary of Impacts 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 impacts are related to examples of potential impacts 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 Geological/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	Very Significant/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 a 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	An effect which causes noticeable changes in the character of the environment without affecting its sensitivities.
Positive, Negative or Neutral	Not Significant	An effect which causes noticeable changes in the character of the environment but without significant consequences.
Neutral	Imperceptible	No impacts, or impacts which are beneath levels of perception, within normal bounds of variation, or within the bounds of measurement or forecasting error.

8.3 Existing Environment

8.3.1 Site Description and Topography

The site of the Proposed Development is located approximately 8km to the southwest of the towns of Ballybofey and Stranorlar, Co. Donegal.

The total study area is approximately 990ha (9.9km^2) in area. The eastern and southern boundaries of the development study area are defined by the Northern Ireland border. The closest town in Northern Ireland is Castlederg which is located approximately 15km to the southeast of the site.

The site of the Proposed Development site is dominated by commercial forestry plantations that have been planted over blanket bog. The elevation of the site ranges

between approximately 180 and 310mOD (metres above Ordnance Datum) with the majority of the site sloping in a northwesterly direction towards the Bunaowen River which flows through the site. The southern section of the site slopes to the southeast towards the Northern Ireland border.

The site is generally bordered on all sides by forestry plantations with the eastern and southern boundaries also being defined by the Northern Ireland border. Land use is almost exclusively commercial forestry in the areas proposed for development with the exception of 2 turbines (T16 and T19) which are both located on open peatland.

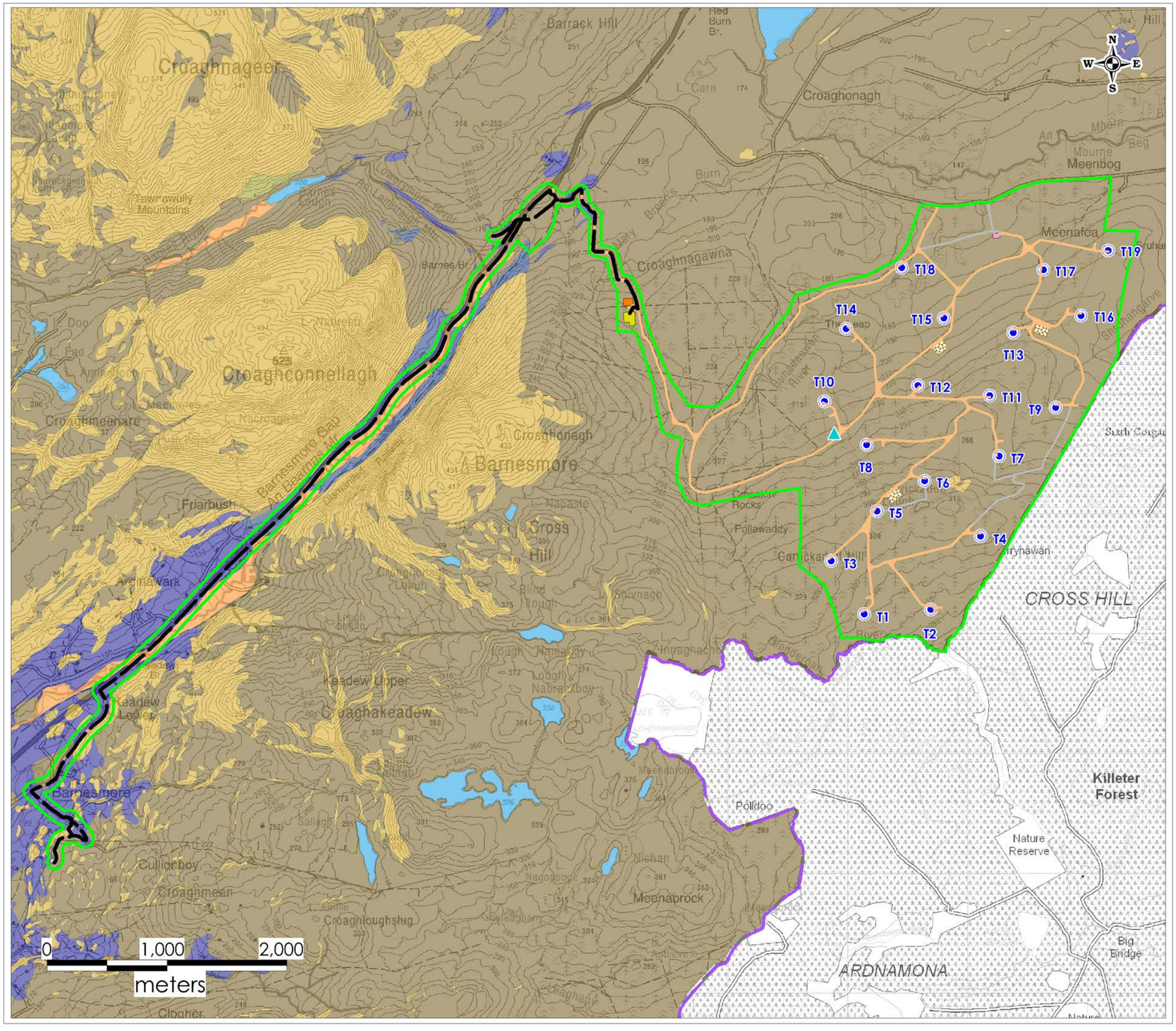
There is a network of existing forestry roads providing access in and around the site. The site is covered by peat with relatively few dispersed mineral subsoil/bedrock exposures present at the site. There are a small number of existing borrow pits where the subsoil and bedrock profile can be observed but these do not form part of this application.

The grid connection route will connect the proposed Meenbog Windfarm substation to the permitted Clogher substation at Cullionbuoy which exists approximately 6.2km to the southwest of the site. The proposed grid connection route is described in detail in Section 4.3.7 of this EIAR.

8.3.2 Soils and Subsoils

The published subsoils map (**www.epa.ie**) for the area shows that blanket peat is almost exclusively mapped at the site of the Proposed Development. The local subsoils map is shown as Figure 8.1.

A total of ~500 no. peat probes were undertaken by HES, AGEC Ltd and MKO within the proposed development footprint area (summary peat depth maps are shown as Figures 8.2, 8.3 and 8.4). Peat depths recorded during the peat probing investigation ranged from 0 to 5.8m with an average of 1.7m. The peat depth range distribution plot for the site (Plate 8.1) shows that the majority of peat depths (~73%) were between 0.5 and 2m. A summary of the peat depths is shown on Figure 8.2.



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Point
- Grid Connection Cable Route
- Northern Ireland Border
- Access Road
- Amenity Track
- Proposed Construction Compound
- Proposed Substation
- Proposed Borrow Pit
- Proposed Construction Compound / Amenity Area

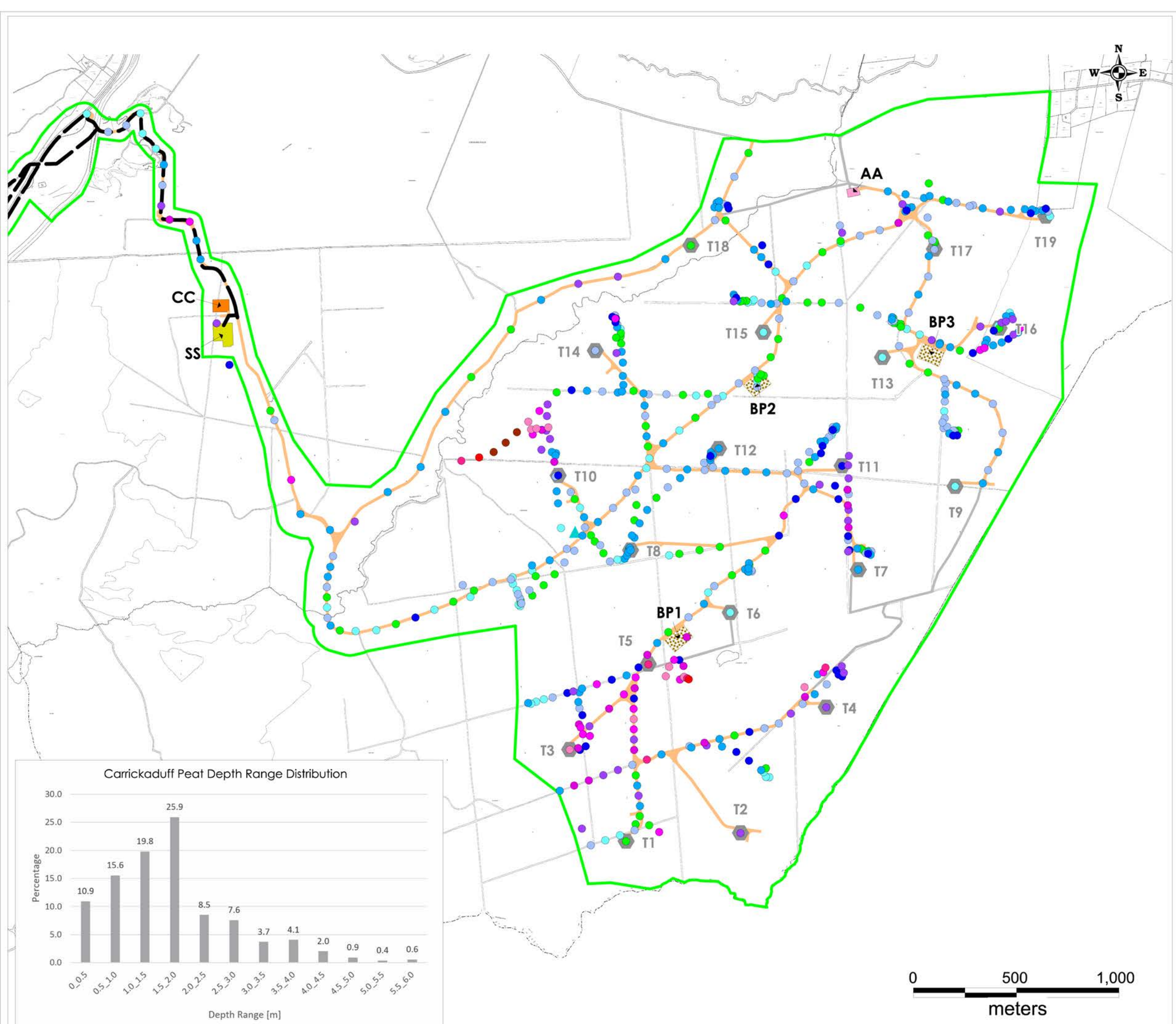
- Undifferentiated Alluvium
- Blanket Peat
- Bedrock at Surface
- Metamorphic Till
- Water

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: McCarthy Keville O'Sullivan	
Job: Meenbog WF, Co. Donegal	
Title: Subsoil Geology Map	
Figure No: 8.1	
Drawing No: P1249-2-1217-A3-801-00A	
Sheet Size: A3	Project No: P1249-2
Scale: 1:42,500	Drawn By: GD
Date: 12/12/2017	Checked By: MG



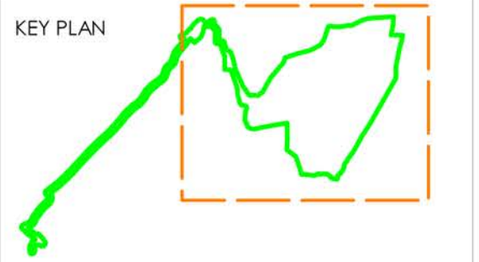
Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Proposed Met Mast
- Grid Connection Cable Route
- Access Road
- Amenity track
- Proposed Borrow Pit (BP)
- Proposed Construction Compound (CC)
- Proposed Substation (SS)
- Proposed Construction Compound / Amenity Area (AA)

Peat Depth legend

- 0 - 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- 1.5 - 2.0m
- 2.0 - 2.5m
- 2.5 - 3.0m
- 3.0 - 3.5m
- 3.5 - 4.0m
- 4.0 - 4.5m
- 4.5 - 5.0m
- 5.0 - 5.5m
- 5.5 - 6.0m
- 6.0 - 6.5m

KEY PLAN



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: McCarthy Keville O'Sullivan

Job: Meenbog WF, Co. Donegal

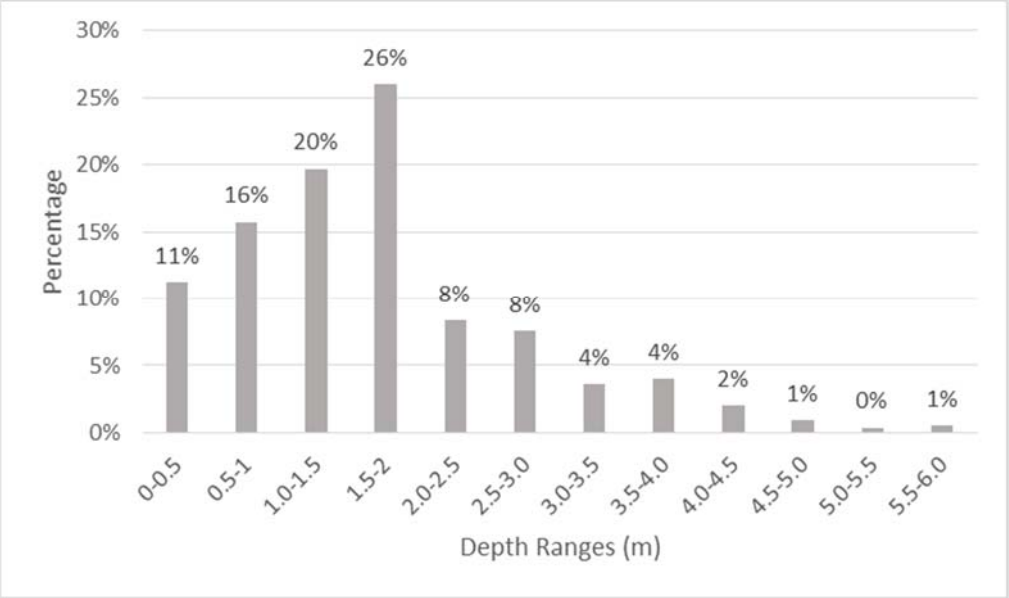
Title: Peat Depth Map

Figure No: 8.2

Drawing No: P1249-2-1217-A3-802-00A

Sheet Size: A3	Project No: P1249-2
Scale: 1:25,000	Drawn By: gd
Date: 12/12/2017	Checked By: MG

Plate: 7.1 Peat Depth Range Distribution Plot



The peat depths recorded at 17 of the 19 no. turbine locations varied from 0 to 2.7m with an average depth of 1.3m. At the remaining 2 no. turbines T3 and T5 maximum peat depths of between 4.5 and 4.7m were recorded. The turbines where deeper peat deposits are present have shallow slope angles typically 1 degree. The average peat depth at each turbine location is shown in Table 7.4 below.

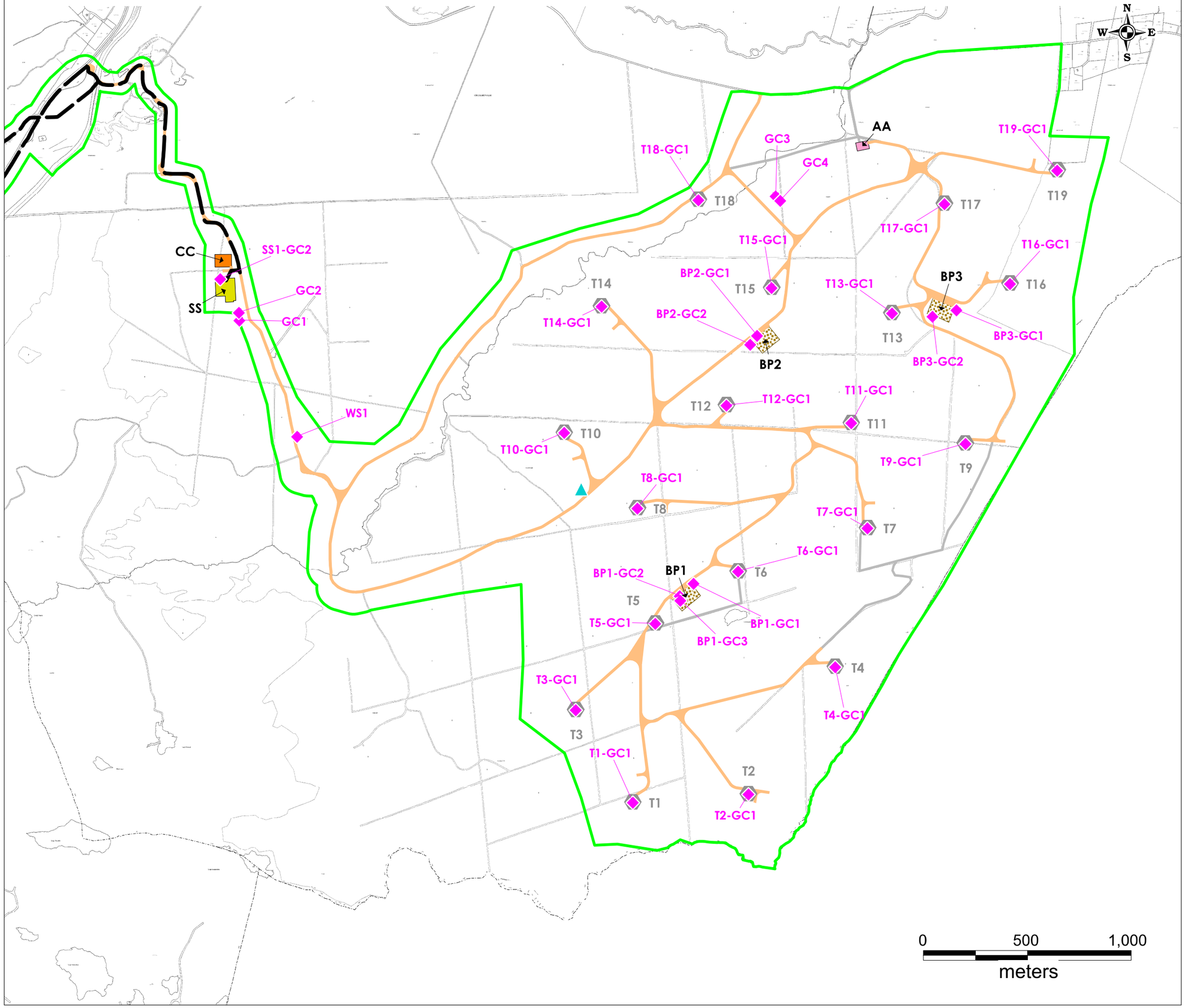
With respect to the existing access tracks, peat depths are typically less than 2.0m with localised depths of up to 3.5m recorded. Up to 15km of existing access tracks are present across the site and have been in operation for a number of years. Peats depths along the off road section of the grid connection are on average approximately 1 – 1.25m.

No evidence of past failures or any significant signs of peat instability were noted on the site of the Proposed Development.

The gouge cores and window sampling undertaken at the site of the Proposed Development (refer to Figure 8.3 for locations) show conclusively that the peat is underlain by very thin mineral subsoil or directly on weathered or massive bedrock (refer to Table 8.4 below for summary results). This is consistent with the observations made at several existing borrow pits and road cuttings which are also shown on Figure 8.3. Gouge core logs are shown in Appendix 8.2.

Based on the observations and the site investigations, the mineral subsoils are present in localized thin pockets with depths typically less than 0.5m over bedrock. The weathered bedrock horizon (if present) at the peat/mineral subsoil is very thin (0.2 – 0.3m) and the underlying bedrock (discussed further below) is typical massive and very competent.

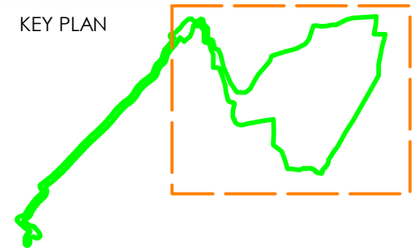
As stated above, 30 no. gouge cores were undertaken within the footprint of the Proposed Development and competent rock was encountered at ~20 no. of these locations (66%). The other ~10 no. locations encountered relatively thin pockets of mineral soil over bedrock. The observations at the existing borrow pits is very consistent with these findings.



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Proposed Met Mast
- Grid Connection Cable Route
- Access Road
- Amenity track
- Proposed Borrow Pit (BP)
- Proposed Construction Compound (CC)
- Proposed Substation (SS)
- Proposed Construction Compound / Amenity Area (AA)
- Gouge Core Locations

KEY PLAN



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: McCarthy Keville O'Sullivan	
Job: Meenbog WF, Co. Donegal	
Title: Site Investigation Map	
Figure No: 8.3	
Drawing No: P1249-2-1217-A3-803-00A	
Sheet Size: A3	Project No: P1249-2
Scale: 1:25,000	Drawn By: GD
Date: 12/12/2017	Checked By: MG

Table 8.4: Summary Peat Depths and Mineral Subsoil Lithology

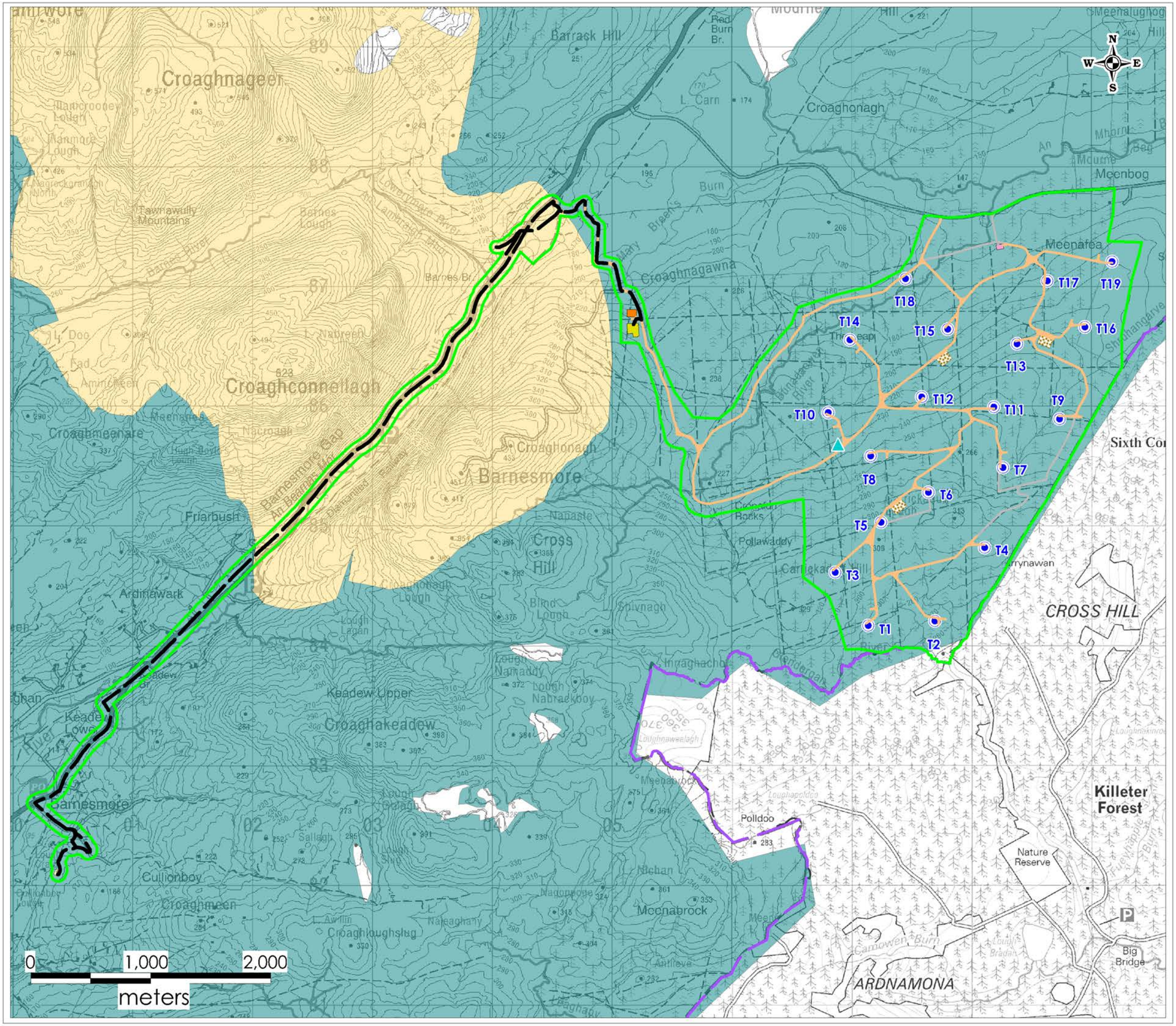
Location	Average peat Depth (m)	Summary of Mineral Subsoil Lithology
T1	0.3	Thin layer of greyish brown sandy SILT/CLAY (0.1m) over solid rock (bedrock presumed)
T2	2.5	Greyish brown sandy SILT/CLAY
T3	3.5	Greyish brown sandy SILT/CLAY
T4	2.6	Refusal on solid rock (bedrock presumed)
T5	4.3	Refusal on solid rock (bedrock presumed)
T6	0.1	Refusal on solid rock (bedrock presumed)
T7	1.4	Thin layer of dark brown sandy SILT/CLAY (0.1m) over solid rock (bedrock presumed)
T8	1.8	Refusal on solid rock (bedrock presumed)
T9	0.4	Soft, light brown, sandy SILT confirmed to 0.3m below base of peat
T10	2.0	Refusal on solid rock (bedrock presumed)
T11	1.8	Refusal on solid rock (bedrock presumed)
T12	1.4	Weathered rock or very gravelly mineral
T13	0.2	Refusal on solid rock (bedrock presumed)
T14	0.9	Firm, light brown sandy SILT/CLAY
T15	0.2	Refusal on solid rock (bedrock presumed)
T16	0.8	Refusal on solid rock (bedrock presumed)
T17	1.1	Firm to stiff, grey SILT
T18	0.3	Firm, grey SILT/CLAY
T19	0.1	Refusal on solid rock (bedrock presumed)
BP1	1.1	Mineral soil with cobbles (no sample recovered)
BP2	1.67	Refusal on firm brown sandy SILT
BP3	0.9	Refusal on solid rock (bedrock presumed)
Construction Compounds	1.74	Soft, grey sandy SILT/CLAY (0.45m) with refusal on rock (bedrock presumed)
Substation	2.2	Hard gravelly mineral soil (no sample)-
Met Mast	1.1	Refusal on solid rock (bedrock presumed)

8.3.3 Bedrock Geology

Based on the GSI bedrock map the bedrock units underlying the site of the Proposed Development comprises Precambrian quartzites, gneisses and schists with granites and intrusive rocks mapped along the grid connection route outside of the windfarm area.

As mentioned above bedrock is exposed at a number of existing borrow pit and road cuttings across the site, and these exposures generally confirm the mapped geology as outlined above. The bedrock was typically noted to be massive and very competent with a thin upper weathered zone at some locations.

A bedrock geology map of the area is attached as Figure 8.4.



Legend

- EIAR Site Boundary
- Proposed Turbine Layout
- Proposed Met Mast
- Grid Connection Cable Route
- Northern Ireland Border
- Access Road
- Amenity Track
- Proposed Substation
- Proposed Construction Compound
- Proposed Borrow Pit
- Proposed Construction Compound / Amenity Area
- Granites & Intrusive Rocks
- Precambrian Quartzites, Gneisses & Shists

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: McCarthy Keville O'Sullivan	
Job: Meenbog WF, Co. Donegal	
Title: Bedrock (Unit) Geology Map	
Figure No: 8.4	
Drawing No: P1249-2-1217-A3-804-00A	
Sheet Size: A3	Project No: P1249-2
Scale: 1:42,500	Drawn By: GD
Date: 12/12/2017	Checked By: MG

8.3.4 Geological Resource Importance

The Precambrian bedrock at the site of the Proposed Development 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 peat deposits at the site of the Proposed Development could be classified as "Low" importance as the peat is not designated in this area and is significantly degraded in most places at the site as a result of forestry related drainage and rill ploughing. Refer to Table 8.1 for definition of these criteria.

8.3.5 Geological Heritage and Designated Sites

There are no recorded Geological Heritage sites, mineral deposit sites or mining sites (current or historic) within the site of the Proposed Development. The Proposed Development is not located within any designated site, however the Barnesmore Gap (IGH 7) is a geological heritage site, and is designated for its glacial/quaternary deposits which includes lateral moraines. The majority of the grid connection route, assessed as part of this EIAR, runs along the N15 National Primary Route in the Barnesmore Gap.

8.3.6 Soil Contamination

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

According to the EPA online mapping (http://gis.epa.ie/Envision), there are no licenced 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 Economic Geology

The GSI Online Minerals Database accessed via the Public Data Viewer shows a single crushed rock quarry north of Ballybofey, with a small number of non-metalic mineral localities in the general study area.

The GSI online Aggregate Potential Mapping Database shows that the proposed wind farm site is not located within an area mapped as being of Very High or High granular aggregate potential (i.e. potential for gravel reserves).

3 no. borrow pits are proposed as part of the Proposed Development and this is discussed in Sections 8.4 and 8.5.2.1.

8.3.8 Peat Stability Assessment

This section summarises the report on assessment of peat stability undertaken by AGEC Ltd (October, 2017) for the proposed 19 no. turbines and related infrastructure. The peat stability assessment report is included as Appendix 8.1 of this EIAR.

The purpose of the peat stability assessment was to determine the stability *i.e.* Factor of Safety (FoS), of the peat slopes where construction is proposed during the Proposed Development. This involved geotechnical assessments of each of the infrastructure locations and included peat depth measurements and shear strength testing.

The findings, which involved analysis of over 540 locations, showed that the site the Proposed Development. has an acceptable margin of safety and is suitable for the proposed wind farm development. The findings include recommendations and control measures for construction work in peatlands to ensure that all works adhere to an acceptable standard of safety.

The hand vane results showed peat shear strengths in the range 5 to 50kPa, with an average value of 16kPa. The lower bound strengths recorded would be typical of deep weak saturated peat and were recorded in the deeper peat deposits on site. Peat strength at sites of known peat failures (assuming undrained loading failure) are generally very low, being approximately 2.5kPa. No such low shear strengths were recorded at this proposed wind farm application site.

The minimum required Factor of Safety (FoS) is 1.3 based on BS6031:1981: Code of Practise for Earthworks (BSI, 2009). The assigned probability of instability associated with a given FoS value is described in Table 8.4 below.

Table 8.4. Probability of instability Scale for Factor of Safety.

Scale	Factor of Safety	Probability
1	1.30 or greater	Negligible/None
2	1.29 to 1.20	Unlikely
3	1.19 to 1.11	Likely
4	1.01 to 1.10	Probable
5	<1.0	Very Likely

8.3.8.1 Peat Stability Assessment Results

Undrained Analysis

The results of the undrained analysis for the peat are presented in Table 8.5 (for the turbine locations).

Table 8.5 Factor of Safety Results (undrained condition)

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T1	207133	384174	28.65	14.33
T2	207689	384214	10.61	7.74
T3	206859	384619	6.37	5.21
T4	208106	384826	10.61	7.74
T5	207241	385035	6.1	5.03
T6	207639	385286	10	1.67
T7	208261	385494	3.39	2.13
T8	207155	385589	2.88	1.92
T9	208732	385899	6.47	2.16
T10	206803	385952	5.73	4.1
T11	208183	385999	4.56	3.09
T12	207583	386083	2.83	1.78

T13	208379	386526	47.79	11.03
T14	206983	386559	22.04	12.46
T15	207800	386648	71.68	11.95
T16	208946	386668	9.57	4.78
T17	208631	387052	3.21	1.92
T18	207448	387070	9.57	4.78
T19	209173	387212	31.89	7.36
Substation	205184	386668	2.76	2.00
Met Mast	206339	385419	4.11	2.40

Drained Analysis

The results of the drained analysis for the peat are presented in Table 7.6 (for the turbine locations).

Table 7.6 Factor of Safety Results (drained condition)

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T1	207133	384174	22.92	24.82
T2	207689	384214	8.49	13.42
T3	206859	384619	5.09	9.03
T4	208106	384826	8.49	13.42
T5	207241	385035	4.88	8.71
T6	207639	385286	8	2.78
T7	208261	385494	2.71	3.68
T8	207155	385589	2.3	3.31
T9	208732	385899	5.18	3.69
T10	206803	385952	4.59	7.09
T11	208183	385999	3.64	5.34
T12	207583	386083	2.26	3.07
T13	208379	386526	38.23	19.09
T14	206983	386559	17.63	21.58
T15	207800	386648	57.34	20.68
T16	208946	386668	7.65	8.28
T17	208631	387052	2.57	3.31
T18	207448	387070	7.65	8.28
T19	209173	387212	25.51	12.73
Substation	205184	386668	2.21	3.45
Met Mast	206339	375419	3.29	4.14

The results of the risk assessment for potential peat failure at the main infrastructure elements is presented in Appendix 8.1.

The risk rating for each infrastructure element at the site of the Proposed Development is designated trivial and tolerable following some mitigation/control measures being implemented. Sections of access roads to the nearest infrastructure element should be subject to the same mitigation/control measures that apply to the nearest infrastructure element.

8.3.9 Forestry Replanting Sites

The base line environment of proposed forestry replanting sites, in relation to land, soils and geology, are outlined in Appendix 4.3 of this EIAR.

8.4 Characteristics of the Proposed Development

The Proposed Development will typically involve removal of peat and thin underlying subsoils (where present) for additional access road, hardstanding emplacement and the grid connection trench. The excavation of mineral subsoil will be minimal.

Bedrock for construction will be sourced from 3 no. proposed borrow pits. It is proposed that these borrow pits will be re-instated using peat/ spoil excavated on-site.

Estimated volumes of overburden (peat and spoil) and bedrock to be removed are shown in Table 8.7 and Table 8.8 respectively. Not all of the peat excavated will be sent to the borrow pits, a portion will be used for reinstatement and landscaping works around the site. The volume of spoil to be excavated for the grid connection route has been calculated separately as shown in Table 8.7. The grid cable (when on-road) will lie within the same excavation/footprint as the proposed access road, existing roads for upgrade or private roads. Peat and spoil from the grid connection works will be transported back to the wind farm site to be placed in the borrow pits. The excavated tar from the grid connection works along public roads will be transported to an authorised waste recovery facility. Settlement ponds [within the wind farm] where constructed will be volume neutral, *i.e.* all material excavated will be used to form side bunds and landscaping around the ponds. There will be no excess material from settlement pond construction. The material will also be reinstated during decommissioning where appropriate.

Further details are provided in the Peat and Spoil Management Plan (AGEC Ltd, October 2017) for the works which is included in Appendix 4.2

Table 8.7. Estimated Peat and Spoil Excavation Volumes

Development Component	Peat Volume (m3)	Spoil Volume (m3)
19 no. Turbines, Hardstands & Crane Pads	100,900	25,685
1 no. substation	31,350	6,275
Access Roads	42,150	10,950
1 no. Meteorological Mast	575	300
2 no. Construction Compounds	15,975	2,710
3 no. borrow pits	55,125	33,750
Grid connection*	1,000	5,075
Sub-Total Volumes	**247,075**	**84,745**
Total Volume	**331,820**	

***grid connection includes 2,280m³ of excavated tar.**

Table 8.8. Estimated Borrow Pit (Stone) Excavation Volumes.

Borrow Pit No.	Volume (m³)
BP1	102,605
BP2	102,605
BP3	102,600
Total	**307,810**

8.5 Potential Impacts of the Proposed Development

8.5.1 Do Nothing Scenario

Surface water drainage excavations carried out in areas of existing access road, peat cutting and coniferous plantations will continue to function and may be extended in the case of all three. Coniferous forestry will be felled as forestry compartments reach maturity. Re-planting of these areas with more coniferous trees is likely to occur. Plantations will be reploughed where necessary to facilitate afforestation. Localised peat cutting will also continue.

The impact on the soils and geology would remain largely unaltered as a result of the Do Nothing Scenario.

8.5.2 Likely impacts and Mitigation Measures – Construction Stage

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 relate to the construction stage. It should be noted that the main potential impacts on the soils and geology environment will occur during the construction stage.

Forestry replanting sites are assessed in Appendix 4.3

8.5.2.1 Peat, Subsoil Excavation and Bedrock Excavation

Excavation of peat, subsoil and bedrock will be required for site leveling, for the installation of foundations for the access roads and turbines etc and for the grid cable connection trench. This will result in a permanent removal of peat, subsoil and bedrock at most excavation locations. Some subsoil excavated along the grid cable connection will be reinstated back within the trench, and the remainder (1,000m^3 of peat and 5,075m^3 of spoil) will be transported back to the wind farm site for placement within the borrow pits. The excavated tar material (along public roads) will be transported to an authorised waste recovery facility. Estimated volumes of peat and bedrock to be relocated are shown in Tables 8.7 and 8.8 above.

Mechanism: Extraction/excavation.
Receptor: Peat, subsoil and bedrock.
Potential Impact: Negative, slight/moderate, direct, high probability, permanent impact on peat, subsoil and bedrock.

8.5.2.1.1 Mitigation Measures/Impact Assessment

- Placement of turbines and associated infrastructure in areas with shallower peat where possible;
- Use of the existing forestry road network to reduce peat excavation and borrow pit volumes;
- Use of floating roads (where geotechnically acceptable to do so) to reduce peat excavation volumes;
- No turbines or related infrastructure will be constructed in any designated sites such as NHAs or SACs;
- A minimal volume of peat and subsoil 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;
- Construction of settlement ponds will be volume neutral, and all excess material will be used locally to form pond bunds and surrounding landscaping.

8.5.2.1.2 Residual Impact

Negative, direct, slight, high probability, permanent impact on peat and bedrock.

8.5.2.1.3 Significance of Effects

No significant effects on soils, subsoils or bedrock are anticipated.

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

Pathway: Peat, subsoil and bedrock pore space.
Receptor: Peat, subsoil and bedrock.
Potential Impact: Negative, direct, slight, short term, medium probability impact on peat, soils and bedrock.

8.5.2.2.1 Proposed Mitigation Measures

- Minimal refuelling or maintenance of construction vehicles or plant will take place on site. Off-site refuelling will occur at a controlled fuelling station;
- On site re-fuelling will be undertaken using a double skinned bowser with spill kits on the ready for accidental leakages or spillages;
- Re-fuelling will be undertaken by suitably trained personnel only;
- Fuels stored on site will be minimised. Storage areas 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 plant used during construction will be regularly inspected for leaks and fitness for purpose; and,
- An emergency plan for the construction phase to deal with accidental spillages will be contained within the Construction and Environmental Management Plan (Appendix 4.4 of this EIAR). Spill kits will be available to deal with and accidental spillage in and outside the re-fuelling area.

8.5.2.2.2 Residual Impact

Negative, Imperceptible, direct, short term, low probability impact.

8.5.2.2.3 Significance of Effects

No significant effects on soils, subsoils or bedrock are anticipated.

8.5.2.3 Erosion of Exposed Subsoils and Peat During Tree Felling, Grid Connection works, Access Road and Turbine Base Construction Work

Mechanism: Vehicle movement, surface water and wind action.
Receptor: Peat, subsoil & weathered bedrock.
Potential Impact: Negative, direct, slight, high probability impact on peat, subsoils and bedrock.

8.5.2.3.1 Proposed Mitigation Measures

Peat removed from turbine locations and access roads will be used for landscaping, side-cast at appropriate locations and placed within the 3 no. proposed borrow pits. Where possible, the upper vegetative layer will be placed with the vegetation of the sod facing the right way up to encourage growth of plants and vegetation at the surface of the re-instated borrow pits. Re-seeding and spreading/planting of heather and moss cuttings will also be carried out in these areas. These measures will prevent erosion of the placed peat in the long term. A full Peat and Spoil Management Plan for the Proposed Development is shown as Appendix 4.2 of this EIAR.

During the works (including grid connection works), any excess temporary mounded or side-cast peat/soil will be covered by a polyethylene sheets or seeded at the earliest opportunity. This will prevent erosion of peat/soil. Silt fences will be installed around stockpiles to limit movement of entrained sediment in surface water runoff. The use of bunds around earthworks and mounds will prevent egress of water from the works.

In order to minimize erosion of mineral subsoils, stripping of peat will not take place during extremely wet periods (to prevent increased silt rich runoff). Temporary drainage systems will be required to limit runoff impacts during the construction phase.

During forestry works, brash mats will be used to support vehicles on soft ground, reducing peat and mineral soils erosion and avoiding the formation of rutted areas, in which surface water ponding can occur. Brash mat renewal will take place when they become heavily used and worn. Provision will be made for brash mats along all off-road routes, to protect the soil from compaction and rutting.

8.5.2.3.2 Residual Impact

Negative, slight, direct, medium probability impact on peat, subsoils and weathered bedrock.

8.5.2.3.3 Significance of Effects

No significant effects on soils, subsoils or bedrock are anticipated.

8.5.2.4 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 Development and the surrounding environment. Peat failure excludes localised movement of peat that could occur below an access road, creep movement or erosion type events. The consequence of peat failure at the study area may result in:

- Death or injury to site personnel;
- Damage to machinery;
- Damage or loss of access tracks;
- Drainage disrupted;
- Site works damaged or unstable;
- Contamination of watercourses, water supplies by particulates;
- Degradation of the peat environment.

Mechanism: Vehicle movement and excavations.
Receptor: Peat subsoils.
Potential Impact: Direct, negative, significant, low probability impact on peat and subsoils.

The risk rating for each infrastructure element at the Propose Development is designated trivial and tolerable following some mitigation/control measures being implemented. Sections of access roads to the nearest infrastructure element will be subject to the same mitigation/control measures that apply to the nearest infrastructure element. A number of control measures are given in the AGEC Ltd peat stability assessment to manage all risks associated with peat instability.

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

- Appointment of experienced and competent contractors;
- Site supervision by experienced and qualified personnel;
- Allocation of sufficient time for the proposed development (having regard to the fact that decreasing the construction time has the potential to increase the risk of initiating a peat movement);
- Prevention of undercutting of slopes and unsupported excavations;
- Maintenance of a managed robust drainage system;
- Prevention of placement of loads/overburden on marginal ground;
- Setting up, maintenance and report findings from monitoring systems;
- Ensuring construction method statements are followed or where agreed modified/ developed; and,
- Revising and amending the Geotechnical Risk Register as construction progresses.

Please refer to Appendix 8.1 for proposed turbine specific and road section mitigation measures.

8.5.2.4.1 Residual Impacts

There are no residual impacts anticipated on the soils and geological environment.

8.5.2.4.2 Significance of Effects

No significant effects on soils, subsoils or bedrock are anticipated.

8.5.2.5 Assessment of Health Effects

Potential health effects arise mainly through the potential for soil and ground contamination. A wind farm is not a recognized source of pollution and so the potential for effects during the operational phase are negligible. Hydrocarbons will be used onsite during construction however the volumes will be small in the context of the scale of the Proposed 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 negligible.

8.5.2.6 Potential Cumulative Impacts

The majority of the windfarm site is located in the Bunadaowen River surface water catchment while the majority of the grid connection cabling route is located in the Lowerymore River surface water catchment, including the Drumnahough and Lenalea Wind Farms grid connection cable (Drumnahough cable). Therefore, in terms of soils and geology cumulative impacts arising from the Proposed Development i.e. the wind farm infrastructure and the grid connection route including the Drumnahough Cable Option, none are anticipated as the proposed grid connection route is predominately along the carriageway of existing forestry roads and public roads and is generally remote from the wind farm site development footprint. Some subsoil excavated along the grid cable connection will be reinstated back within the trench, and the remainder will be transported back to the wind farm site for placement within the borrow pits.

The current application seeks planning permission for underground cabling to link with the underground grid connection cabling from the Drumnahough substation currently proposed under Pl. Ref 17/505/43 & ABP Ref. PL05E.248796. This is the preferred method of connection to Clogher substation, however, an independent underground cabling connection from the proposed Meenbog wind farm to the Clogher substation is also assessed in this EIAR.

There are therefore two options for the grid connection cable, and both have spate potential cumulative impacts, as outlined in Table 8.9.

Should the Meenbog Wind Farm grid connection link into the cabling route from Drumnahough to Clogher, the cables would be placed in a single trench and the works would be completed at the same time. As the proposed grid connection along this section is predominately along the existing tracks and the N15 carriageway, and remote from the main wind farm works the potential for cumulative impacts are not significant.

A separate connection from Meenbog WF substation to Clogher substation (with 2 no. further minor route options closer to Clogher substation) has also been assessed. As the proposed grid connection along this section is predominately along the existing tracks and the N15 carriageway, and remote from the main wind farm works, and the works will be completed at a separate time than the Drumnahough cable, the potential for cumulative impacts are not significant.

The proposed amenity walkways (which are part of the wind farm project) will have negligible cumulative impact as they are relatively minor near surface works.

The proposed forestry replanting sites area remote from the proposed wind farm site (in counties Clare, Cork and Kerry), and in totally different and distant geological environments. There is no geological or hydrogeological connectivity between the replanting sites and the site of the Proposed Development, and therefore there can be no cumulative effects or interactions at any phase of the Proposed Development.

8.5.3 Likely Impacts and Mitigation Measures – Operational Stage

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

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

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. Please note the on-site borrow pit will have been restored following the construction stage and will not be available to source aggregate during the operational phase.

No cumulative impacts on the soils and geology environment are envisaged during the operational stage, as there will be no significant movement of soils/subsoils or peat, or construction works, during this period.

Forestry replanting sites are assessed in Appendix 4.3.

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/peat and subsoils and groundwater or surface water quality. The substation transformer and oil storage tanks will be in a concrete bunded capable of holding 110%

of the oil in the transformer and storage tanks. 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/peat/soils and subsoils, and groundwater and surface water quality.

8.5.4 Likely Impacts and Mitigation Measures – Decommissioning Stage

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, and the substation. 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 Decomissioning 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 bases will be rehabilitated by covering with local topsoil/peat in order to regenerate vegetation which will reduce runoff and sedimentation effects. Access tracks which are not required for farm use or forestry will also be left to vegetate naturally. 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 in Section 8.5.2.2.

The replanted forestry lands will not be decommissioned as they will continue as forestry.

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

8.5.5 Summary

Excavation of peat, subsoil and bedrock will be required for site leveling and for the installation of the grid cable connection, infrastructure and foundations for the access roads and turbines. This will result in a permanent removal of peat, subsoil and bedrock at most excavation locations. Volumes of peat/spoil and bedrock to be removed are estimated to be 331,820m^3 and 307,810m^3 respectively, and 2,280m^3 of excavated tar will also be removed from site to an authorised facility. Excavated peat will be utilized to re-instate the borrow pit locations (3 no.) and a portion will also be used for reinstatement and landscaping works around the site. The handling and management of peat will be done in accordance with the Peat & Spoil Management Plan (refer to Appendix 4.2). 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 the risk of peat failure is designated trivial and tolerable and that the site has an acceptable margin of safety. A number of control measures are given (*c.f.* Section 8.5.2.4) in the AGEC Ltd Peat Stability Assessment Report (see Appendix 8.1) assessment to manage all risks associated with peat instability.

No significant impacts on the soil and geology of the site of proposed development will occur.