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 a remedial environmental impact assessment report (rEIAR) of the impacts of the constructed 9 turbine wind farm development at Cleanrath North and adjacent townlands (i.e. the Cleanrath wind farm development), Co. Cork on the land, soil and geological environment.

This chapter provides a baseline assessment of the environmental setting of the built development (as described fully in Chapter 4 of this rEIAR), in terms of land, soils and geology and discusses any significant effects that occurred during the construction and operational phases of the development. Likely effects associated with the decommissioning phase are also assessed.

Where required, appropriate remedial mitigation measures that were employed or that may need to be employed are described. The residual effects of the Cleanrath wind farm development are then presented.

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 rEIAR 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 Meenbog WF, Sheehymore WF, and Carrigarierk WF, and over 100 other wind farm related projects across the country. Michael also worked on the planning application for Cleanrath WF and attended the site several times during the construction of the wind farm in 2018 and 2019 to complete hydrological drainage audits and hydrological monitoring.

David Broderick (BSc, H. Dip Env Eng., MSc) is a hydrogeologist with over 12 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 also worked on the original planning application for Cleanrath WF, and also Meenbog WF, Sheehymore WF, and Carrigarierk WF.

8.1.3 Relevant Legislation

The rEIAR 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:

- Planning and Development Acts 2000 to 2019 and the Planning and Development Regulations 2001 to 2019;
- 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 rEIAR 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 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 Cleanrath wind farm development and the surrounding area was completed in advance of construction of the Cleanrath wind farm development and this data was reviewed and updated in the preparation of this rEIAR.

This involved collecting all relevant geological data for the Cleanrath wind farm development and surrounding area. This included consultation with the following data sources:

- Environmental Protection Agency database (www.epa.ie);

- Geological Survey of Ireland - Groundwater and Geology Databases (www.gsi.ie);
- Geological Survey of Ireland – Geological Heritage site mapping (www.gsi.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 21 (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 Pre-Construction Monitoring and Site Investigation Data

For the 2015 planning application and original EIS, site walkovers and geological mapping were undertaken by HES during December 2015. Geotechnical investigations and a peat stability assessment were undertaken by AGEC[1] Ltd between 9th and 11th December 2015. In summary, the following site investigations were undertaken during the EIS/pre-planning phase of the development:

- A total of over 225 no. peat probe depths were carried out by AGEC Ltd to determine the depth and geomorphology of the peat at the Cleanrath wind farm development;
- A geotechnical assessment of peat stability by AGEC (December, 2015);
- Logging of bedrock outcrops and 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 is included as Appendix 8-1 of this rEIAR.

8.2.3 Construction and Operational Phase Monitoring/Audit Data

In preparation of this rEIAR, walkover surveys and detailed geological mapping of the built development site were undertaken by HES during May 2020. A topographic survey of the built development footprint was undertaken by MKO on 27th February 2020.

In addition, quantum/volume data and monitoring/audit data recorded during the construction phase and operational phase was also complied and reviewed to address the land, soil and geology section of the rEIAR. This data includes the following:

Construction Phase Audits/Monitoring

- Ionic Consulting Ltd construction phase records (quantity, volumes etc)
- MKO construction phase site audits
- HES construction phase site audits

Operational Phase Audits/Monitoring

- MKO operational phase site audits
- HES operational phase site audits

8.2.4 Impact Assessment Methodology

Using information from the desk study, data from the pre-planning site investigations and audit/monitoring data from the construction and operational phase, an assessment of the importance of

[1] *Please note AGEC Ltd was acquired by Fehily Timoney & Company in 2019.*

the soil and geological environment within the study area and Cleanrath wind farm development 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 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 rEIAR are those set out in the EPA (2017) Glossary of effects as shown in Chapter 1 of this rEIAR. 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 a proposed project, as a direct result of a 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.

Impact Characteristics		Potential Hydrological Impacts
Quality	Significance	
		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 Cleanrath wind farm development is located approximately 13km to the southwest of Macroom, Co. Cork. The total site study area is approximately 525ha.

The DoEHLG Wind Energy Development Guidelines (2006) and the DoHPLG Draft Revised Wind Energy Development Guidelines (2019) provide advice to Planning Authorities on planning for wind energy developments through the Development Plan process and in determining applications for planning permission. These guidelines offer six landscape character types that represent most situations where wind turbines may be proposed with 'mountain moorland' landscape character type considered the most applicable descriptor of the Cleanrath wind farm development site.

Access to the Cleanrath wind farm development is from local road at Gortanaddan and Cloontycarthy townlands which is located 1.5km east of Reananerree village. The 9 turbines and associated infrastructure are positioned around a distinct conical shaped hill feature (referred to as Derrineanig on the OSI mapping) which is located approximately 3.5km to the southwest of the Cleanrath wind farm development entrance. Turbines T6, T7, T9 and T10 are located on the steadily sloping western side of Derrineanig Hill (peak at 300m OD) where the ground elevation at the turbine locations varies between approximately 220m and 260m OD. Turbines T1, T3, T4, T5 and T8 are located on the more moderately sloping eastern side of Derrineanig Hill where the ground elevation at the turbine locations varies between approximately 190 and 220m OD. The total development footprint area is approximately 10ha.

Bedrock is at the surface over much of the Cleanrath wind farm development, particularly on the western slopes of the site, with pockets of soils or peat that are confined to small local dips/valleys between ridged outcrops of bedrock. Landuse locally comprises rough pasture or forestry where a soil and subsoil has formed. For the majority of the Cleanrath wind farm development where rock outcrops this precludes any use other than patchy grazing.

The grid connection route, which is approximately c15km in length, connects the Cleanrath wind farm development to the Coomataggart 110 kV Substation, in County Kerry. A loop along the grid route was connected to Derragh wind farm substation which exists approximately 3km to the west of Cleanrath. The grid connection cable route is along existing public roads for much of the route.

8.3.2 Peat/Soils and Subsoils

The published soils map (www.epa.ie) for the area shows peaty podzols (AminSRPT) are the dominant soil type at the Cleanrath wind farm development especially on the more elevated western section of the site. These soils are typically very thin and generally are present in areas where bedrock is close or at the surface (i.e. mineral subsoils are absent). Outcropping bedrock is widespread, particularly across the western section of the Cleanrath wind farm development. Towards the lower lying central and eastern section of the site (i.e. between turbines T3, T4 and T15, small areas of blanket peat are mapped. On the far eastern section of the Cleanrath wind farm development, shallow well-draining (AminSW) and deep well draining soils (AminSW) become more dominant.

A map of the local subsoil cover is attached as Figure 8-1 (www.gsi.ie). This shows that subsoils are absent over much of the Cleanrath wind farm development which is consistent with site observations both at pre-construction and during construction phases. With the exception of some localised blanket peat and sandstone tills in the central and eastern sections of the Cleanrath wind farm development, subsoils were found to be largely absent.

The ground surface topography of the Cleanrath wind farm development, particularly on the upper slopes of Derrineanig Hill (i.e. west of site) is characterised by rocky outcrop ridgelines which have a westerly / south-westerly orientation. Soil/peat coverage is generally restricted to the small local dips/valleys between these rocky ridgelines.

Across the Cleanrath wind farm development in general, intact peat depths recorded during site investigation peat probing survey typically vary from 0 to 0.6m with some localised maximum peat depths of up to 3.4m. These recorded peat depth are consistent with site observations of cut/fill locations made during the construction phase and operational phase surveys.

Bedrock exposures are frequent across the Cleanrath wind farm development and where superficial deposits are visible at road excavation/cut locations, they can typically be described as peaty topsoil/ brown firm fibrous Peat overlying sandy gravelly Clay with cobbles and boulders and/or overlying weathered bedrock.

The intact soil peat depths surrounding (i.e. outside the development footprint) the 9 no. turbine locations varies from 0 to 0.7m with an average depth of ~0.2m.

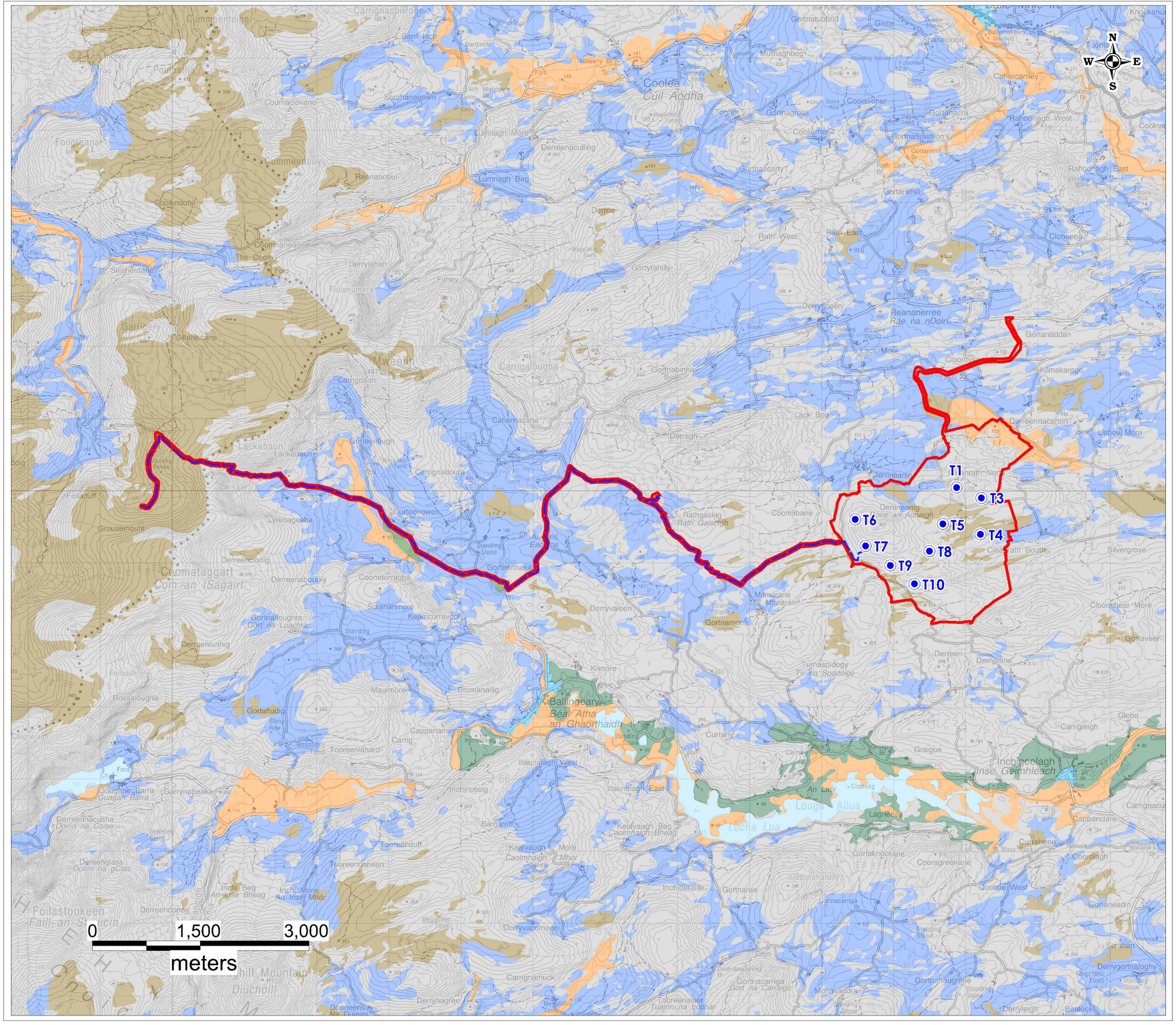
With respect to the installed access roads, adjacent intact soil peat depths are typically less than ~0.3m with localised peat depths of up to 3.4m.

The deepest peat is generally present on the east of the Cleanrath wind farm development where the topography is typically flatter. There are also some localised pockets of deep peat adjacent to the access roads in the southern area of the Cleanrath wind farm development (i.e. between turbines T9 and T10) which is also relatively low lying in places. A peat depth map is shown as Figure 8-2.

8.3.3 Bedrock Geology

The bedrock geology (www.gsi.ie) of the area shows that the Cleanrath wind farm development is underlain by Devonian Old Red Sandstones (ORS). The ORS comprises different combinations of sandstone, mudstone and siltstones which are regularly cross-bedded in areas.

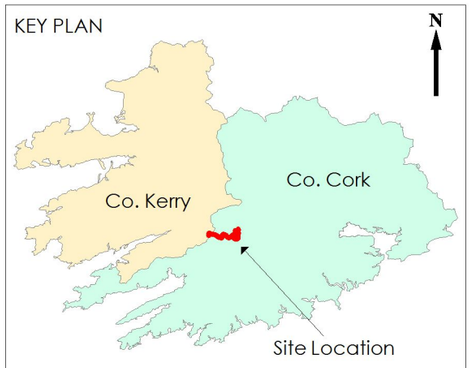
Bedrock outcrops are numerous across the site. In general, the structural geology in the vicinity of the Cleanrath wind farm development is characterised by rocky ridgelines which have a general southwest / northeast orientation. Many of the installed access roads intercept these rocky ridgelines. A significant amount of bedrock was generated for wind farm construction purposes where access road cuts were required along these ridgelines. This is discussed further in the impact section (Section 8.5).



Legend

- Study Area
- As Constructed Turbine Locations
- Grid Connection Cable Route
- Alluvium
- Blanket Peat
- Sandstone Sand and Gravels Devonian
- Bedrock at Surface
- Sandstone Till Devonian
- Water

KEY PLAN



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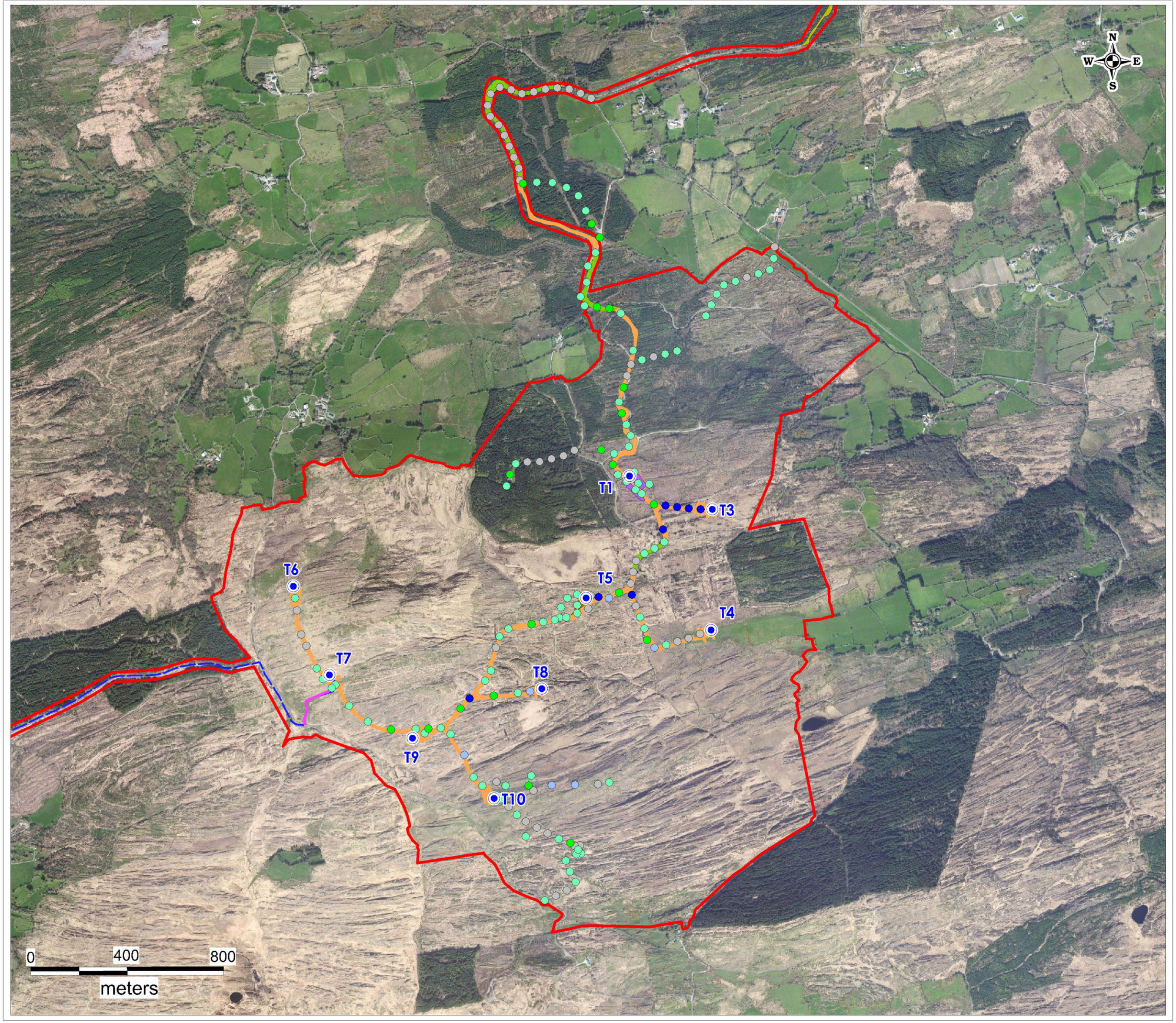
Client: MKO	
Job: Cleanrath WF, Co. Cork	
Title: Local Subsoils Map	
Figure No: 8-1	
Drawing No: P1272-5-0720-A3-8-1-0A	
Sheet Size: A3	Project No: P1272-5
Scale: 1:50,000	Drawn By: GD
Date: 17/07/2020	Checked By: MG



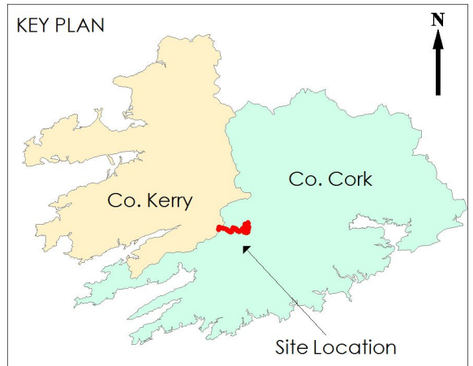
Legend

- Study Area
- As Constructed Turbine Locations
- Grid Connection Cable Route
- Borrow Pit Area
- Area used as aTemporary Construction Compound
- Turbine Delivery Accomodation Areas
- Newly Constructed Roads
- Exisitng Roads Upgraded
- Operational Access/Inspection Road with underground cabling permitted under PL ref. 18/04458

Peat Depth legend

- 0m
- 0 - 0.2m
- 0.2 - 0.5m
- 0.5 - 1m
- 0.75 - 1.0m
- 1.0 - 3.5m

KEY PLAN



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Client: MKO	
Job: Cleanrath WF, Co. Cork	
Title: Peat Depth Map	
Figure No: 8-2	
Drawing No: P1272-5-0720-A3-8-2-00A	
Sheet Size: A3	Project No: P1272-5
Scale: 1:15,000	Drawn By: GD
Date: 17/07/2020	Checked By: MG

GSI mapped faults within the bedrock of this region are numerous and are generally present in a southwest / northeast trend or a general north / south trend. Several southwest / northeast trending faults and a north / south trending fault are mapped to intersect the Cleanrath wind farm development.

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

8.3.4 Geological Resource Importance

The ORS at the Cleanrath wind farm development could be classified as "Low" importance. The bedrock could be used on a "sub-economic" local scale for commercial construction purposes. The bedrock has not been used in the past at the Cleanrath wind farm development for this purpose other than for the construction of the Cleanrath wind farm development.

The peat and soils at the Cleanrath wind farm development could be classified as "Low" importance as the peat or soils are not designated in this area and is significantly degraded in most places at the site as a result of forestry related drainage. Refer to Table 8-1 for definition of these criteria.

8.3.5 Geological Heritage Sites

The Subject Development is not located within any designated site. Designated sites downstream of the development are dealt with in Water Chapter (Chapter 9).

Ballingeary Esker, which is a Geological Heritage site (ID:1563), is located along the grid connection route approximately 5km west of the windfarm site. The route of the grid connection at this location is along public roads and therefore has no interaction with the grid connection.

A map of local geological heritage sites is shown as Figure 8-4.

8.3.6 Peat Stability Assessment

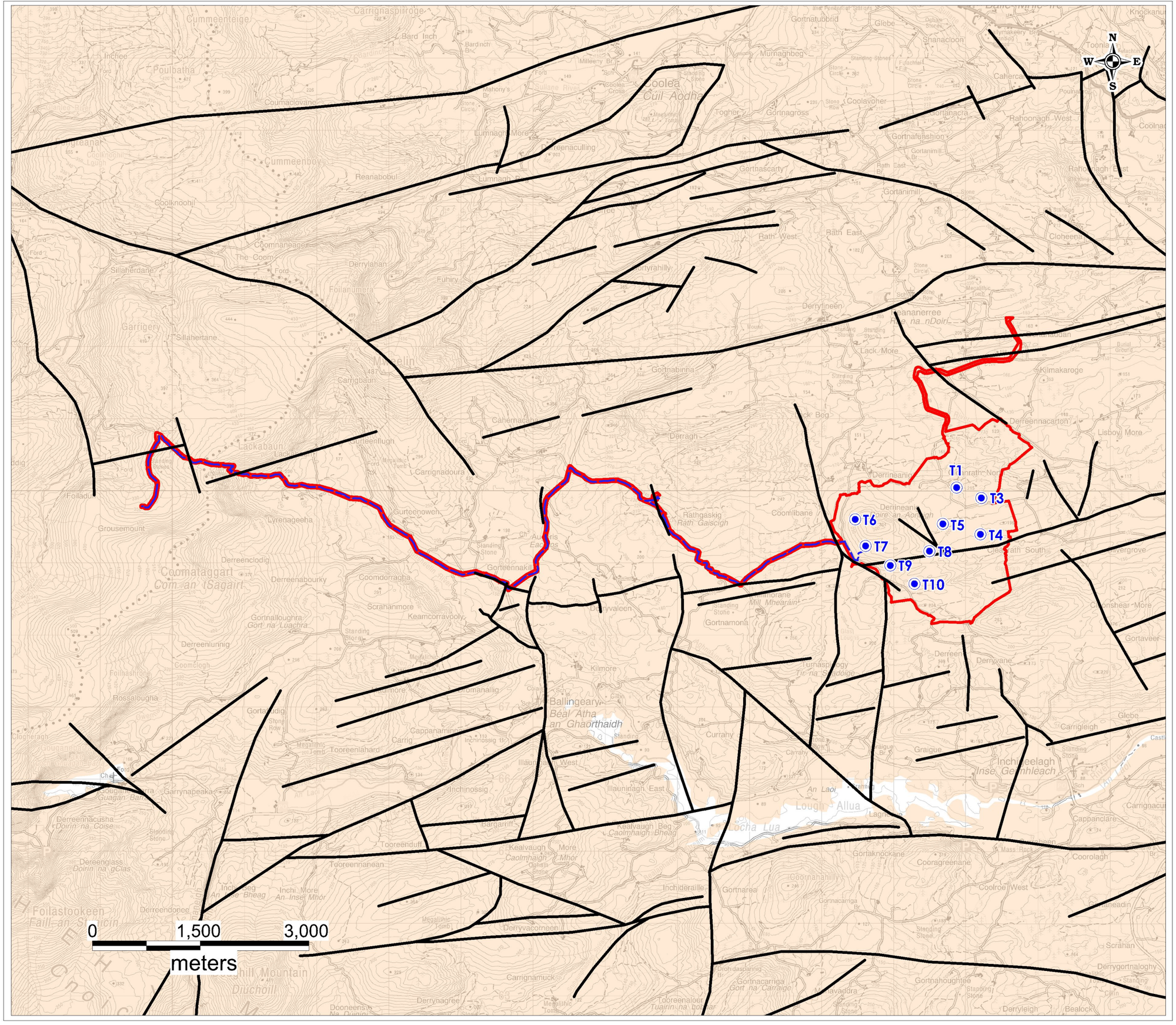
This section summarises the report on assessment of peat stability undertaken by AGEC (December, 2015) for the turbines and related infrastructure. The peat stability assessment report is included for reference as Appendix 8-1 of this rEIAR.

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

The findings, which involved analysis at 171 no. deterministic assessment locations, showed that the Cleanrath wind farm development has an acceptable margin of safety and was deemed to be suitable for the Cleanrath wind farm development that was subsequently successfully constructed. The findings included recommendations and control measures that were implemented for construction work in peat areas to ensure that all works adhered to an acceptable standard of safety.

The analysis showed peat shear strengths in the range 8 to 39kPa, with an average value of 20kPa. The lower bound strengths were recorded locally in the deeper peat deposits in the flatter areas of the Cleanrath wind farm development. Typically the peat strengths recorded are representative of shallow well drained peat as is present on the Cleanrath wind farm development site.

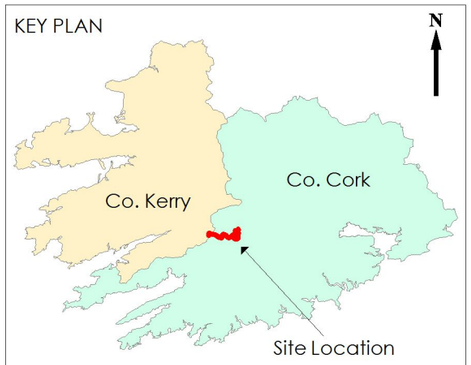
The minimum required Factor of Safety (FoS) is 1.3 based on BS6031:1981: Code of Practice for Earthworks (BSI, 2009). The assigned probability of instability associated with a given FoS value is described in Table 8-4 below.



Legend

- Study Area
- As Constructed Turbine Locations
- Grid Connection Cable Route
- Mapped Fault
- Devonian Old Red Sandstones

KEY PLAN



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Client: MKO	
Job: Cleanrath WF, Co. Cork	
Title: Local Bedrock Geology Map	
Figure No: 8-3	
Drawing No: P1272-5-0720-A3-8-3-0A	
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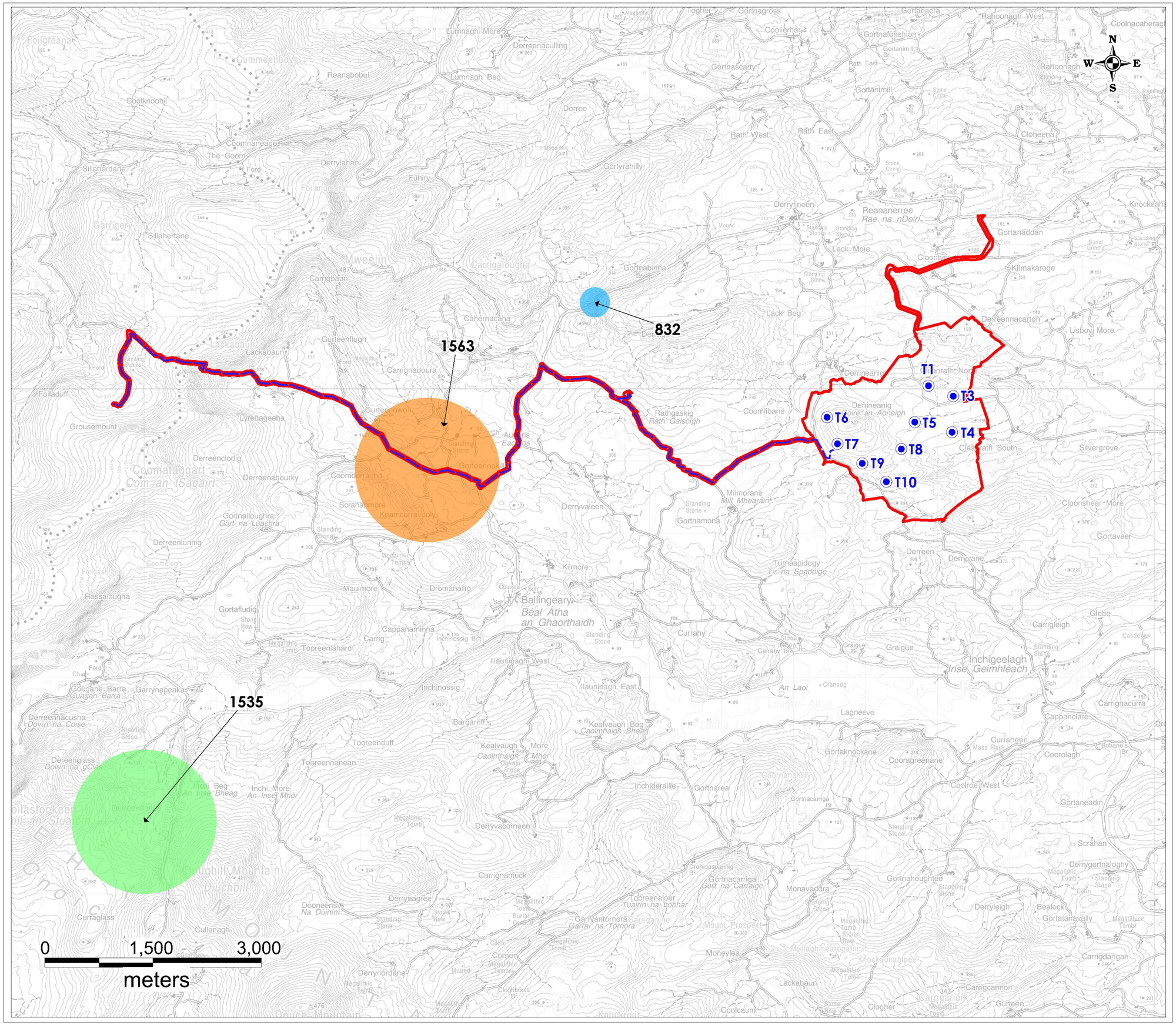

Legend

- Study Area
- As Constructed Turbine Locations
- Grid Connection Cable Route

Geological Heritage Sites

- Ballingeary Esker (ID: 1563)
- Pass of Keimaneigh (ID: 1535)
- Gortnabinna (ID: 832)

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Client: MKO	
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Title: Geological Heritage Sites Map	
Figure No: 8-4	
Drawing No: P1272-5-0720-A3-8-1-0A	
Sheet Size: A3	Project No: P1272-5
Scale: 1:50,000	Drawn By: GD
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Table 8-4: Probability 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

8.3.6.1 Peat Stability Assessment Results

8.3.6.1.1 *Undrained Analysis*

The results of the undrained analysis for the peat are presented in Table 8.5.

Table 8-5: Factor of Safety Results (undrained condition)

Turbine (new no. in brackets)	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T1	120871	70057	86.01	14.34
T3	121213	69913	114.80	10.44
T4	121200	69411	19.13	7.18
T5	120682	69553	172.03	15.64
T6	119466	69620	25.56	2.32
T7	119610	69250	114.8	10.44
T8	120493	69178	86.22	7.84
T9	119952	68981	16.40	6.75
T10	120288	68725	28.70	8.20
Construction Compound[2]	120871	70057	114.80	10.44

8.3.6.1.2 *Drained Analysis*

The results of the drained analysis for the peat are presented in Table 8-6.

[2] *Please refer to Section 4.3.8 of Chapter 4 for details of the Construction Compound*

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

Turbine (new no. in brackets)	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T1	120871	70057	57.34	20.68
T3	121213	69913	76.53	15.05
T4	121200	69411	12.76	10.34
T5	120682	69553	114.68	22.57
T6	119466	69620	17.04	3.25
T7	119610	69250	76.53	15.05
T8	120493	69178	57.48	11.29
T9	119952	68981	10.93	9.74
T10	120288	68725	19.13	11.82
Construction Compound[3]	120871	70057	76.53	15.05

The risk rating for each infrastructure element at the Cleanrath wind farm development was designated to be acceptable tolerable following some mitigation/control measures that were implemented during the construction phase.

Sections of access roads to the nearest infrastructure element were subjected to the same mitigation/control measures that applied to the nearest infrastructure element. The control measures that were employed are in the AGEC Ltd peat stability assessment to manage all risks associated with peat instability.

There were no peat stability issues recorded during the construction works of the wind farm, and as such the conclusions of the peat stability assessment completed pre-construction have been borne out, i.e. that there was a low risk of any stability issues occurring as a result of the construction of the Cleanrath wind farm development.

8.4 Characteristics of the Development

8.4.1 Summary Development Description

The installed development comprises of the following elements:

- 9 wind turbines, having a maximum ground to blade tip height of up to 150m metres and all associated foundations and hard-standing areas;
- New access roads (4.8km) and upgrade of internal site access roads (1.3km) and the upgrade of an existing access junctions;
- All associated site drainage;

[3] *Please refer to Section 4.3.8 of Chapter 4 for details of the Construction Compound*

- 1 no borrow pit (BP1);
- 1 no. construction compound
- Underground electricity connection cabling;

8.4.2 Cut and Fill Volumes

The actual cut and fill volumes for the Cleanrath wind farm development are shown in Table 8-7 below. The total excavation volume was 61,065m^3 and this comprised of approximately 9,160m^3 of soft overburden/peat (i.e. unusable material) and 51,905m^3 of bedrock.

The total bedrock volume includes the material taken from the on-site borrow pit (BP1) and from the numerous cut locations across the footprint of the development.

The estimated volume of rock taken from the actual borrow pit alone is 4,763m^3 (only 1 no. of the 3 no. proposed borrow pits was used during the construction). The total rock excavation volume for the whole site (including the borrow pit) was 51,905m^3 .

Table 8-7: Cut and Fill Volumes for the Built Development

Location	Cut	Fill	Net
	m^3	m^3	m^3
Spine Road Volume (incl T5 and BP1)	16583.515	3112.088	-13471.427
T10 and Spur Road	7321.185	11307.198	3986.013
T8 and Spur Road	6253.285	2636.975	-3616.31
T4 and Spur Road	1111.493	2232.257	1120.763
T3 and Spur Road	450.249	5859.687	5409.438
T1 and Spur Road	1570.779	843.289	-727.49
T6, T7 and Spur Road	19480.704	10879.863	-8600.84
T9 and Spur Road	4349.885	311.012	-4038.874
Entrance Road to T1	0	7,350	7,350
Floating Road to T4	0	1,204	1,204
T4 Sub-Foundation	0	1,650	1,650
Totals (m^3)	**61,065**	**48,169**	**-12,896**
Soft overburden/peat component (m^3)	**9,160**	-	-
Rock component (m^3)	**51,905**	-	-

In addition to the extracted volume of 61,065 m^3 within the Cleanrath wind farm development, 11,448 m^3 of spoil was removed from the grid connection cable trench. 5,724m^3 of that spoil was exported off site to a permitted facility with the remainder reused as part of reinstatement and the improvement of infrastructure along the section of cable which was on existing private access tracks.

8.5 Significant Effects and Mitigation Measures

This section provides a brief overview of the potential impacts that were identified in the original planning application and then the actual observed impacts are discussed. Mitigation measures imposed during construction are outlined. There was no requirement for remedial mitigation measures as a result of the Cleanrath wind farm development during construction or operation.

8.5.1 Do Nothing Scenario

A do-nothing option to developing the Cleanrath wind farm development would have been to leave the site as it was prior to construction, with no changes made to the land-use practices of low-intensity agriculture, turf cutting and commercial forestry. This option would have no positive impact with regards to the production of renewable energy or the offsetting of greenhouse gas emissions. On the basis of the positive environmental effects arising from the Cleanrath wind farm development , the do–nothing scenario was not the chosen option. Instead, an application for planning permission was made and granted ultimately by An Bord Pleanála.

The Cleanrath wind farm development has been constructed, has been operational and is now operating in Sleep Mode with the site essentially in a shut-down mode with no export of electricity pending the outcome of the Substitute Consent process. In the event that Substitute Consent is obtained, the intention is to recommence and continue the full operation of the Cleanrath wind farm development until the end of 25 years from the formal commissioning of the turbines in July 2020 and implement the decommissioning plan for the Cleanrath wind farm development at the end of the operational period.

In the event that Substitute Consent is not granted and full operation of the development is not recommenced, it will remain in Sleep Mode which is, in effect, the "do nothing" option insofar as it represents the current situation as at the date of the application for Substitute Consent. There is the possibility that the decommissioning plan may need to be implemented early, should Substitute Consent not be granted and therefore this is also assessed in this rEIAR and below.

8.5.2 Construction Phase

The observed construction phase effects of the development and mitigation measures that were undertaken (where required) to reduce or eliminate those effects them are outlined below.

8.5.2.1 Peat, Subsoil and Bedrock Excavation

Excavation of peat, subsoil and bedrock was required for the construction of access roads, upgrade of existing access junctions and roads, foundations for turbine bases, crane hardstands, cable network, borrow pit and temporary construction compound.

This resulted in a permanent removal and relocation of in-situ peat, subsoil and bedrock at all excavation locations. The total volume of peat and bedrock excavated and relocated during the construction phase of the wind farm infrastructure was 9,160m^3 and 51,905m^3 respectively, the combined total volume being 61,065m^3. 11,448 m^3 of spoil was removed from the grid connection cable trench.

Please note that the bedrock at the site can be classified as of "Low" importance, and the peat deposits at the site could be classified as of "Low" importance as the peat is already degraded by forestry works and drainage. There is also abundant peat and bedrock deposits in the wider landscape.

Pathway: Extraction/excavation

Receptor: Peat, subsoil and bedrock

Pre-Mitigation Potential Impact: Negative, slight/moderate, direct, high probability, permanent impact on peat, subsoil and bedrock.

Mitigation Measure Implemented During the Construction Phase:

- Turbines and associated infrastructure were designed and placed in areas with shallow peat. This is borne out by the reduced peat volumes recorded during the construction phase than anticipated pre-construction volume calculations ;
- The existing forestry road network was used to reduce peat excavation and borrow pit excavation volumes;
- Floating roads were installed where it was geotechnically acceptable to do so, and this reduced peat excavation volumes;
- The peat and subsoil which was removed during the construction phase was localised to the turbine location and access roads; and,
- A minimal volume of peat and subsoil was removed to allow for infrastructural work to take place in comparison to the total volume present on the site.
- Material excavated during drainage works and settlement pond construction was used locally for pond creation and landscaping.

Impact Assessment:
Due to the "low" importance of the bedrock geology at the site, as well as the degraded nature of the peat, the magnitude of the effect of this extraction on the soils and geology at the Cleanrath wind farm development is low.

Residual Effects Assessment: The design measures incorporated into the project as described above, in particular the avoidance of deeper peat areas combined with the 'low' importance of the peat and bedrock deposits means that the residual effect is - Negative, slight, direct, high probability, permanent effect on peat/subsoils and bedrock due to disturbance and relocation within the site.

Significance of Effects: For the reasons outlined above, no significant effects on land, soils, subsoils or bedrock have occurred or will occur as a result of the Development.

8.5.2.2 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, subsoil and underlying bedrock pore space.

Receptor: Peat, subsoil and bedrock.

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

Mitigation Measure Implemented During the Construction Phase:

- Off-site refuelling of site vehicles was undertaken, where possible;
- On site re-fuelling was undertaken at the wind farm at designated refuelling areas using a fuel truck which came to site and in more remote areas of the site using a double skinned bowser with spill kits on the ready for accidental leakages or spillages.

Refuelling was undertaken, where possible, outside of the self-imposed buffer zones to local watercourses;
- On site re-fuelling was only undertaken by suitably trained personnel;
- Fuel stored on site during the construction phase was minimised;
- The plant used during the construction phase were inspected regularly for leaks and fitness for purpose;
- No major spills or environmental incidents were recorded during the construction phase; and,
- An emergency plan for the construction phase to deal with accidental spillages was contained within the Construction and Environmental Management Plan, but no emergency measures had to be implemented during the construction phase.

Impact Assessment:
There were no records/reports of soil contamination incidences during the construction phase or operational phase of the development. There were no soil contamination issues observed during any of the site inspections/audits completed by HES & MKO.

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, such as refuelling off site, were applied during the construction phase. The residual effect is assessed as - Negative, imperceptible, direct, short-term, low probability effect on peat and subsoils and bedrock.

Significance of Effects: For the reasons outlined above, no significant effects on land, soils, subsoils or bedrock have occurred or will occur as a result of the Development.

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

There usually is a high likelihood of erosion of peat and spoil during its excavation and during landscaping works during wind farm construction phase. 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.

Mitigation Measure Implemented During the Construction Phase:

- Peat removed from turbine locations and access roads was used for landscaping, or was cast aside alongside designated access roads, and was used to reinstate the borrow pit.
- All excavations were completed in line with a full Peat and Spoil Management Plan for construction phase; and,
- During tree felling brash mats were used to support vehicles on soft ground, reducing peat and mineral soils erosion and avoiding the formation of rutted areas.

Impact Assessment:
There were no records/reports of any significant incidences of peat or spoil erosion during the construction phase or operational phase of the development. No observations of peat or spoil erosion was observed during any of the site inspections/audits completed by HES and MKO.

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 were completed in accordance with a detailed Peat and Spoil Management Plan, and all excavated material was moved the least possible distance, and reseeding and planting was completed to bind landscaped peat and spoil together. No significant peat and spoil erosion were observed during the construction phase, or during the brief operational phase. As such the residual effected is assessed as - Negative, slight, direct, short-term, medium probability effect on peat and subsoils by erosion and wind action.

Significance of Effects: For the reasons outlined above, no significant effects on land, soils, subsoils or bedrock have occurred or will occur as a result of the Development.

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 wind farm 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 Cleanrath wind farm development could have resulted 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.

Pathway: Vehicle movement and excavations.

Receptor: Peat subsoils.

Pre-Mitigation Potential Impact: Direct, negative, significant, low probability impact on peat and subsoils.

Mitigation Measures/Controls Implemented During the Construction Phase:
Prior to construction a deterministic peat risk assessment for each infrastructure element at the Cleanrath wind farm development was determined to be trivial and tolerable following implementation of some mitigation/control measures.

The following general measures were implemented during the construction phase of the wind farm and these assisted in the management of peat stability risks for this site:

- An experienced and competent contractor was appointed;
- The construction works was supervised by experienced and qualified personnel;
- Sufficient time was allocated for the construction phase;
- No undercutting of slopes took place, and no excavations went unsupported;
- A robust and managed drainage system was maintained across the construction site;
- No loads or overburden was placed on marginal ground;
- The construction phase was monitored by an independent engineer;
- Agreed and approved construction method statements were followed; and,
- The Geotechnical Risk Register was reviewed and revised as required during the construction phase.

Please refer to Appendix 8-1 for turbine specific and road section mitigation measures.

Impact Assessment:
There were no records/reports of any significant incidences of peat instability during the construction phase or operational phase of the development. No observations of peat instability was observed during any of the site inspections/audits completed by HES and MKO, and none were reported by the site engineer or contractor.

Residual Effects Assessment: A detailed Geotechnical and Peat Stability Assessment was completed at development design stage. The findings of that assessment demonstrated that there was a low risk of peat failure (at the site) during the construction phase of the development. Controls measures outlined in the Geotechnical and Peat Stability Assessment were implemented during the construction phase. No observations of peat instability were observed during any of the site inspections/audits completed by HES and MKO, and none were reported by the site engineer or contractor. Based on these data the residual effect is - Negative, imperceptible, direct, low probability, permanent effect on peat and subsoils.

Significance of Effects: For the reasons outlined above, no significant effects on land, soils, subsoils or bedrock have occurred or will occur as a result of the Development.

8.5.3 Operational Phase

The effects set out below relate to the operational phase of the Cleanrath wind farm development should Substitute Consent be granted. This includes the previous period of short-term operation and the current period of Sleep Mode and also assesses the period when turbines are being commissioned.

No impacts on land, soils and geology were reported or observed during the operational phase of the development to date, and none will occur going forward.

8.5.3.1 Operational Phase Works

In conjunction with the above operational phase activities, and subject to substitute consent being granted, a peatland habitat restoration will be undertaken within a 4.3 Ha area of the Cleanrath wind farm development during the operational phase of the Cleanrath wind farm development. The restoration will comprise the management of an area of forestry that was felled during construction along with an additional hectare of immature forestry will be felled to establish suitable peatland habitat. The works will involve felling, chipping and removal of brash and restoring the peatland habitat to its original condition prior to planting which will include the blocking of drains with no further drainage to be installed around the area. During the initial restoration process, erosion of peat and subsoil is considered to a potential negative, short term effect, however, over the long term the restored peatland will provide a positive impact on the Cleanrath wind farm development in terms of the soils and geology.

There will also ongoing maintenance to the turbines and the windfarm drainage, but these works will have no effect on land, soils and geology.

Pathway: Vehicle movement, surface water and wind action.

Receptor: Peat and subsoil.

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

Positive, significant, direct, long-term, likely effect on peat (following stabilisation and growth of acrotelm)

Proposed Mitigation Measure:

- Brash removed during the restoration process should be stored up slope of the cleared area, to provide a buffer to surface water flows which may have the potential to erode,

- During tree felling brash mats will be used to support vehicles on soft ground, reducing peat and mineral soils erosion and avoiding the formation of rutted areas.

Residual Effect Assessment: Peat soils and spoil can be eroded by vehicle movements, wind action and by water movement. To prevent this, excavation and removal works 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 operational phase.

As such the residual effected is assessed as - Positive, slight, direct, short-term, medium probability effect on peat and subsoils by erosion and wind action.

Significance of Effects: Significant positive effect.

8.5.4 Decommissioning Phase

The potential impacts associated with decommissioning of the Development will be similar to those observed during the construction phase, but of reduced magnitude.

During decommissioning, it may be possible to reverse or at least reduce some of the impacts observed during construction phase by rehabilitating construction areas such as turbine bases. This will be completed, where possible by covering with peatland vegetation/scraw or poorly humified peat, sourced within the Cleanrath wind farm development, to encourage vegetation growth and reduce run-off and sedimentation. The covering of the turbine foundations will be completed using material imported to site as the required quantity of material does not currently exist at the site. This will require 1,547m3 of inert soil to be imported to the site which will be sourced locally. The foundation areas will then be reseeded. The soil berm at the temporary junction accommodation works and the turbine delivery accommodation roadway will also need to be temporarily removed during decommissioning (Section 4.10) to provide access to and from the site with abnormal loads.

The Cleanrath wind farm development roadways will be kept and maintained following decommissioning of the wind farm infrastructure, as these will be utilised by ongoing forestry works and by local farmers.

The electrical cabling connecting the site infrastructure to the Derragh wind farm substation will be removed, while the ducting itself will remain in-situ, as this is considered to have less of a potential impact on the soils and geology than excavating and removing the ducting.

The turbines will be removed by disassembling them in a reverse order to their erection. This will be completed using similar model cranes as used in their construction. They will then be transported off-site along their original delivery route. The disassembly and removal of the turbines is not considered to have an impact on the land, soils and geology at the Cleanrath wind farm development.

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 phase activities will be similar to those applied successfully during construction phase where relevant. Some of the impacts will be avoided by leaving elements of the Development in place where appropriate. The turbine bases will be rehabilitated by covering with topsoil, sourced within the Cleanrath wind farm development and locally in order to regenerate vegetation which will reduce runoff and sedimentation effects. Mitigation measures to avoid

contamination by accidental fuel leakage and compaction of soil by on-site plant will be implemented as per the construction phase mitigation measures.

No significant impacts on the soils and geology environment are expected during the decommissioning phase of the Development.

A Decommissioning Plan has been prepared (Appendix 4-9) for an early decommission of the Cleanrath wind farm development

8.5.5 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. Regular maintenance of the wind turbines and site infrastructure will involve oil changes (*i.e* gearbox oil within the turbine), which involve the use of hydrocarbons. The oil changes will be performed in a controlled manner, within a bunded area and as such are not deemed to pose a risk to the soils and geology at the site.

Hydrocarbons were used onsite during the construction phase, however the volumes used were small in the context of the scale of the Development. In addition, they were handled and stored in accordance with best practice mitigation measures. There were no records/reports of soil contamination incidences during the construction phase or operational phase of the development. There were no soil contamination issues observed during any of the site inspections/audits completed by HES and MKO. As such, there are no impacts associated with soil or ground contamination and subsequent/associated health effects.

8.5.6 Cumulative Assessment

The geological impact assessment undertaken above in this chapter outlines that significant effects were not experienced during the construction of the Cleanrath wind farm development, and that impacts on the soils and geological environment were very localised nature of the construction works. Impacts on land soil and geology did not extend beyond the immediate vicinity of the Development Site. Therefore, no cumulative impacts between the Development, and other existing, permitted or proposed projects, listed in Section 2.5 of this rEIAR, on land soils and geology are identified. The Grousemount Wind Farm, which is located adjacent to the western end of the Cleanrath wind farm development grid connection. Construction on Grousemount Wind Farm was ongoing at the same time as the western section of the cable route of the Cleanrath wind farm development. However, the scale of the works on this section of the cable route were (~10km) relatively minor, shallow and localised in comparison to the Grousemount Wind Farm therefore, no significant cumulative effects occurred. Furthermore, this section of cable was laid within an existing track therefore no potential for impact on land soils and geology.

8.5.7 Conclusion

Excavation of peat, subsoil and bedrock was required for site levelling and for the installation of wind farm and grid connection infrastructure. Bedrock was sourced from the on-site borrow pit and from various outcrop cut locations within the site. This resulted in a permanent removal of peat, subsoil and bedrock at most excavation locations. However, the actual total excavations volumes were considerably less than the pre-construction estimates. No significant effects occurred on land, soils and geology with regard excavations.

There were no records/reports of soil contamination incidences during the construction phase or operational phase of the development. There were no soil contamination issues observed during any of the site inspections/audits completed by HES & MKO.

During the operational phase of the wind farm development, there were no observed impacts on the land, soils and geological environment. Subject to the substitute consent being granted, it is proposed to restore an area of 4.3 Ha within the Cleanrath wind farm development to a peatland habitat. This is considered to have a net positive impact on the soils and geology of the site.

During the decommissioning phase of the Cleanrath wind farm development, the majority of the site infrastructure will be removed from the Cleanrath wind farm development. The decommissioning phase will essentially involve the reverse procedures implemented during construction. No significant impacts on the land, soil and geological will occur. Due to the localised nature of the work effects within the planning boundary no cumulative effects occurred.

In summary, no significant impacts on land, soil and geological environmental occurred during the construction or operational phase of the wind farm. There was no requirement for remedial mitigation measures.

Effects during the decommissioning would be similar to the construction phase but of much less magnitude. No cumulative impacts on the geological environmental occurred nor were there are health effects reported.