Castlebanny Wind Farm

Peat Stability Risk Assessment

PRODUCED BY
Ciaran Reilly BE PhD CEng MIEI

DATE 12th January 2021
DOCUMENT P20_021_RP001
REVISION P04 S4

Report prepared for:
TOBIN Consulting Engineers,
Block 10-4,
Blanchardstown Corporate Park,
Dublin 15,
Ireland.

Report prepared by:
Ciaran Reilly & Associates
Consulting Geotechnical Engineers,
Maynooth,
Co. Kildare,
Ireland.

Table of contents

1. Non-Technical Summary

Ciaran Reilly & Associates has been appointed by TOBIN Consulting Engineers (TOBIN) on behalf of Coillte to carry out a peat stability risk assessment of the proposed Castlebanny Wind Farm development. In accordance with planning guidelines compiled by the Department of the Environment, Heritage and Local Government (DoEHLG) (2016), where peat is present on a proposed wind farm development, a peat stability assessment is required.

The proposed wind farm comprises of 21 wind turbines, a substation, access roads, and other ancillary infrastructure. The proposed site and the surrounding landscape is hilly and undulating and predominantly in use as a mixture of forestry and agricultural land.

The evaluation of the peat stability at the proposed Castlebanny Wind Farm site was carried out in accordance with the Energy Consents Unit Scottish Government (2017) guidelines, *Peat Landslide Hazard and Risk Assessments, Best Practice Guide for Proposed Electricity Generation Developments – Second edition* and described in this report. The findings of the assessment indicate a "negligible" risk of peat instability, subject to normal design and construction mitigations and controls.

Extensive deposits of soft clay and silt were noted in trial pit logs. Soft clay and silt soils pose their own risks to the development; however, it is considered that these risks can also be managed effectively through normal design and construction mitigations and controls.

Recommendations made in this report should be taken into consideration during the detailed design and construction stage of the wind farm development. Best practice guidance regarding the management of earthworks stability must be inherent in the construction phase of the project.

2. Introduction

Ciaran Reilly & Associates has been appointed by TOBIN Consulting Engineers (TOBIN) on behalf of Coillte to carry out a peat stability risk assessment of the proposed Castlebanny Wind Farm development. In accordance with planning guidelines compiled by the Department of the Environment, Heritage and Local Government (DoEHLG) (2016), where peat is present on a proposed wind farm development, a peat stability assessment is required as part of the environmental impact assessment.

This report sets out the methodology used to assess the peat stability risk, the activities undertaken and the results of the peat stability assessment. This report should be read along with Chapter 7 of the Castlebanny Wind Farm Environmental Impact Assessment Report (EIAR) and its appendices. Where reference is made throughout this report to figures, these refer to the figures contained in the Appendices to Chapter 7 of the EIAR.

2.1. Description of the Development

The proposed 21 wind turbine development is situated near Mullinavat, Co. Kilkenny on a large site, approximately 7km in length and 3km in width. The site is approximately 4,000 acres in total. The site is predominantly in forestry usage, with a minority of the site area in use as agricultural grassland. Access to the site is off the R704 regional road. The proposed development is described in detail in Chapter 2 of the EIAR and the site location and layout are shown in Figure 2-1 of the EIAR.

The surrounding landscape is hilly and undulating and the surrounding lands are predominantly in use as a mixture of forestry and agricultural land. Ballymartin Wind Farm is located to the south of the R704 road, less than 500m from the proposed entrance to the Castlebanny Wind Farm, and the M9 motorway is 2.6km to the west of the nearest turbine. The Arrigle River flows in a valley approximately 1.6km east of the nearest turbine and the grid connection will cross the river to connect to the overhead line network at Ballyvool.

2.2. Peat Failures

Peat landslides represent one end of a spectrum of natural processes of peat degradation. They have potential to cause fatalities, injury and damage to infrastructure and farmland. They also have the potential to cause significant damage to peatland habitats, affecting biodiversity and depleting the peatland carbon store.

In accordance with planning guidelines compiled by the DoEHLG (2016), where peat is present on a proposed wind farm development, a peat stability assessment is required. The IWEA best practice guidelines (2012) recommend that a peat stability assessment process be carried out for windfarms *in areas of*

peat slippage risk or other sensitive soils and in accordance with the Energy Consents Unit Scottish Government (2017) guidelines.

Excavations works on windfarm construction sites can induce slope failures due to the low basal strength in peat, even in relatively flat sites. These peat failures induced by excavations can extend significantly beyond the excavations, likely due to seepage forces caused by intentional or accidental drainage of the peat.

The potential for peat failure at this site is examined with respect to wind farm construction and associated activity.

2.3. Methodology

The evaluation of the peat stability at the proposed Castlebanny Wind Farm site was carried out in accordance with the Energy Consents Unit Scottish Government (2017) Peat Landslide Hazard and Risk Assessments, Best Practice Guide for Proposed Electricity Generation Developments – Second edition.

The peat stability assessment at the site included the following activities:

- Desk study;
- Site reconnaissance including peat depth measurements;
- Review of ground investigation carried out at the site by Ground investigations Ireland (GII); and
- Completion of peat stability assessment.

The risk assessment approach is discussed in detail in Section 5.

3. Ground Investigation

3.1. Desk study

A desk study was undertaken in order to collate and review background information in advance of the site survey. The desk study involved the following:

- Examination of the Geological Survey of Ireland (GSI) datasets pertaining to geological, landslide and the GSI borehole database;
- Examination of Environmental Protection Agency (EPA) data including soil and subsoils; and
- Preparation of site maps and suitable field sheets for the site survey.

The desk study information obtained is referenced below. Following the desktop study and the site survey, geological maps were generated in GIS and are included in Chapter 8 (Land, Soils and Geology) of the main EIAR. The ground investigation information is included in Appendix 8-1 of the main EIAR.

Publicly available sources of mapping, aerial photography and satellite imagery were consulted to establish the expected ground conditions, topography, and condition of the site in the past. The following sources was referred to:

- Ordnance Survey historical mapping;
- Geological Survey of Ireland mapping; and
- Publicly available satellite photography (Google Maps & Bing Maps).

3.2. Field work

Site surveys relating to the soil and geological environment and ground investigations were undertaken from February 2020 to August 2020. These surveys included:

- A site walkover by GII to review the ground conditions and assess the topography, geomorphology and requirements for site investigations;
- 41 nr trial pits, 4 nr rotary cores, and 3 nr groundwater monitoring wells by GII in January and February 2020 at proposed turbine locations, potential substation locations, proposed borrow pits, and along access tracks.
- Site walkover and soft ground probing by Ciaran Reilly & Associates, 21st August 2020.

The logs and records of the investigations can be found in Appendix 8-1 to the main EIAR.

4. Detailed Site Assessment

4.1. Site Topography and Geomorphology

The topography of the site can be described as gently sloping, rising from c.130 mAOD in the east and c. 120 mAOD in the west to a high point of 250 mAOD in the north and 265 mAOD in the south. The site consists largely of resistant Devonian sandstone forming the higher ground with the eastern boundary tapering to lower elevations. Geological Survey Ireland mapping indicates glacial landforms orientated north-south across the site, subglacial streamlined bedrock further supported by glacial striae at St. Mullin's Cave, Co. Kilkenny. The nearby Arrigle River is a mapped meltwater channel. Two commissioned wind farms are located south/ southeast of the site, Ballymartin and Rahora Windfarms respectively.

4.2. Local Bedrock Geology

Geological Survey Ireland bedrock mapping, shown in Figure 1, indicates that the proposed wind farm access road from the R704 to the south of the site is underlain by the Maulin Formation of dark blue-grey slate, phyllite and schist and the Brownsford Formation of dark grey semi-pelitic, psammitic schist.

The mapping shows that the majority of the site is underlain by the Carrigmaclea Formation of red and brown conglomerate and sandstone, with Turbine 16 potentially being underlain by undifferentiated Granite and Turbine 12 and Turbine 14 being underlain by Diorite. An unconformity between the Carrigmaclea Formation and the other formations to the west, shear zones, and a fold which have been mapped by the GSI are also shown in Figure 1.

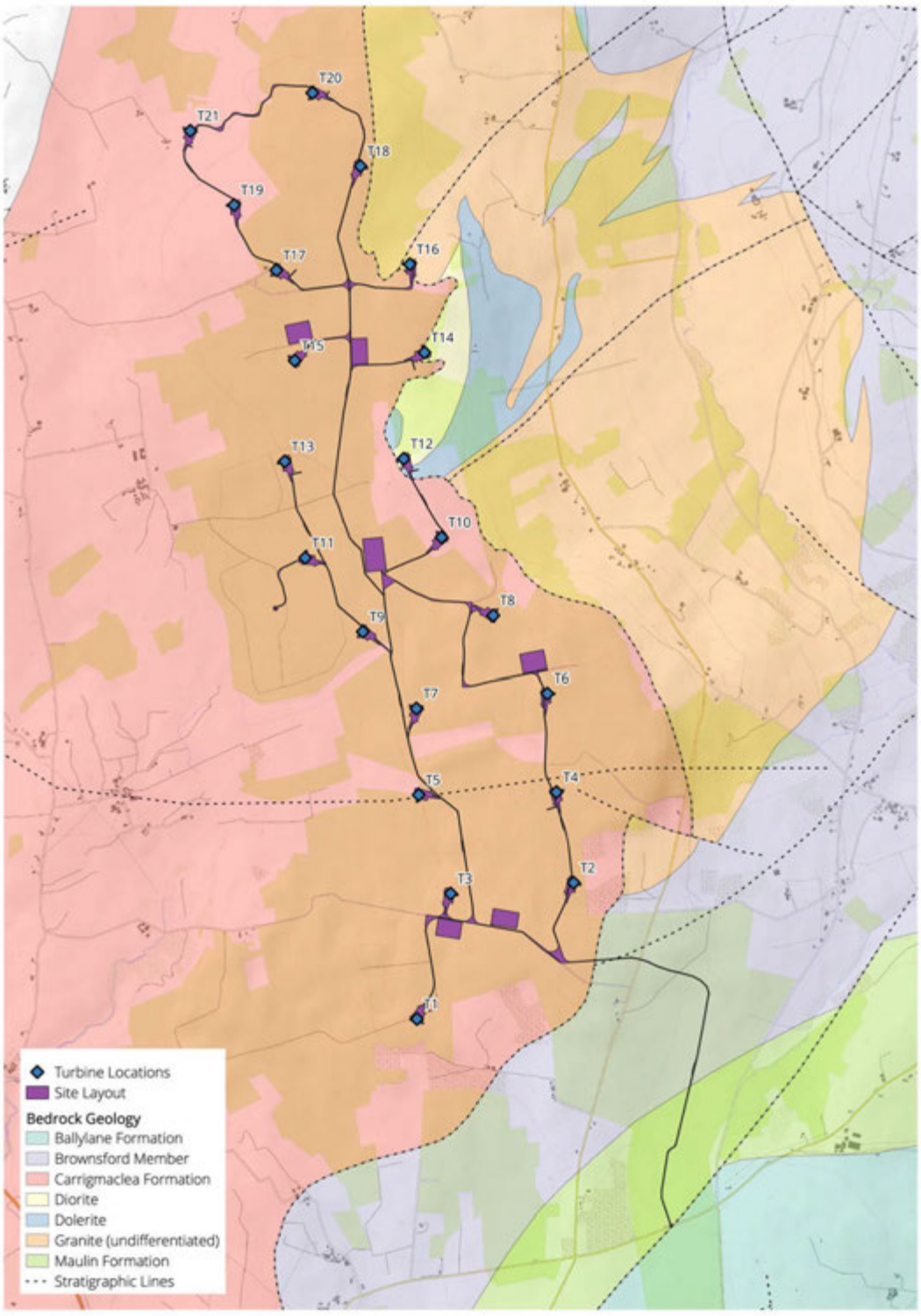

Figure 1 - Bedrock (Source: GSI 1:100,000 bedrock mapping)

4.3. Local soils and subsoils

The nearest historical borehole contained in the GSI database of verified borehole logs is greater than 12 km from the wind farm development area and is not considered here. GSI quaternary mapping, indicating the likely subsoil conditions over the top one metre of the soil column, is shown in Figure 2. This mapping indicates that the site is predominantly underlain by "till derived from Devonian sandstones" with areas of "bedrock outcrop or subcrop". No peat, alluvium, or lacustrine sediments are mapped within the wind farm development area.

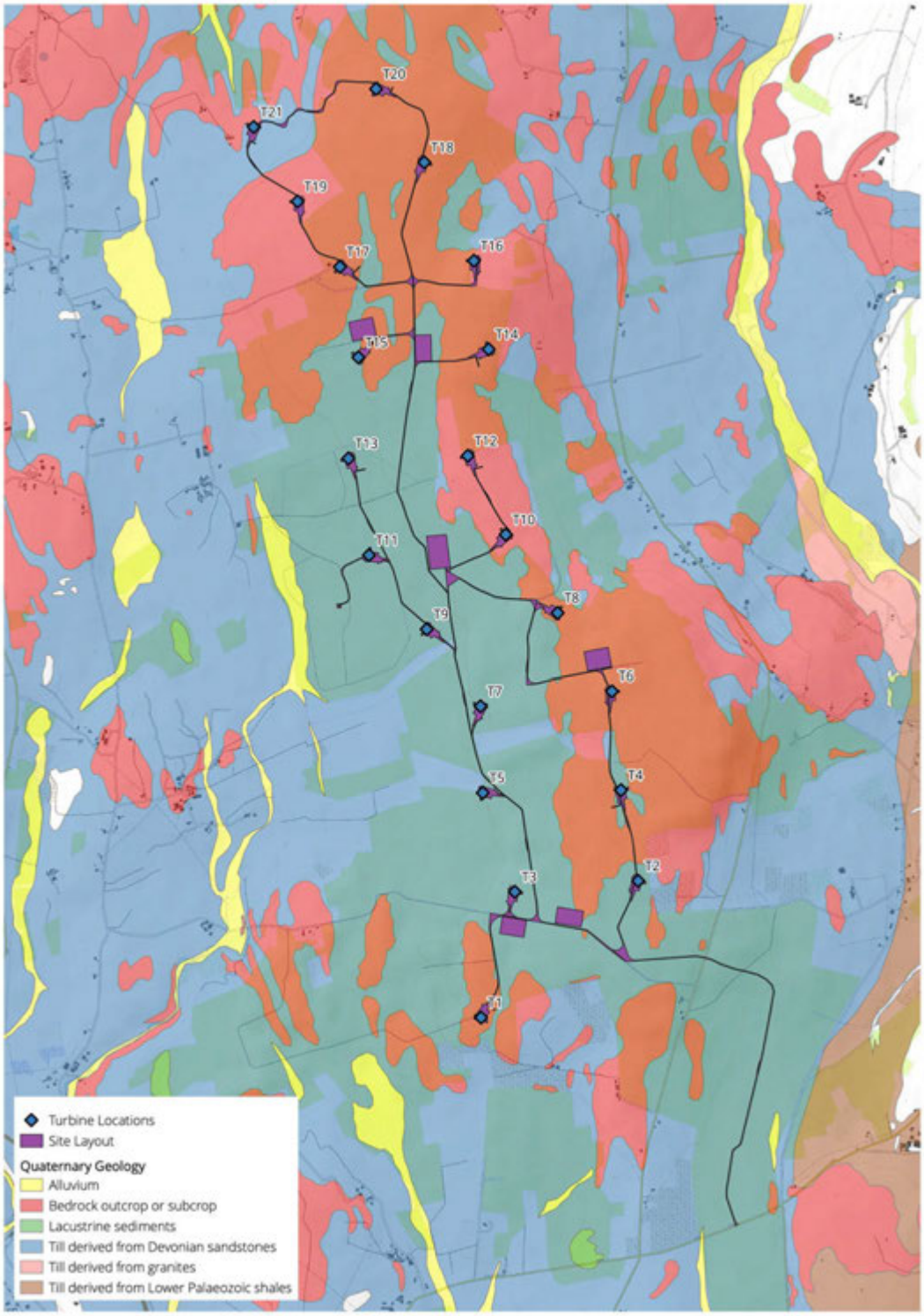

Figure 2 - Quaternary sediments (Source: GSI Quaternary mapping, 2016)

4.4. Previous failures

The mapping produced under the National Landslide Susceptibility Mapping project carried out between 2007 – 2016 (Geological Survey Ireland, 2018a) has been reviewed for the area. The review of the historical landslide event database indicated that the nearest recorded landslides occurred approximately at least

5.7km from the development area. The nearest recorded landslide events are presented in Table 1.

Table 1 - Landslide events (GSI database, 2018)

Event ID	Description	Geology	Distance from site (km)
GSI_LS16-0037	Landslide at road cutting slope on the north side of the road R700	Bedrock outcrop or subcrop	5.7
GSI_LS03-0049	Section of Dublin-Waterford rail line and embankment failed close to the N9 which runs parallel to the railway	Sandstone till (Devonian)	7.1
GSI_LS06-0289	Rock fall, no further details known	Lr-Mid Ordovician Slate	9.1

The National Landslide Susceptibility Mapping was prepared with the purpose of assessing landslide susceptibility to assist in the identification of areas that are likely to experience land sliding and develop a model for susceptibility mapping on a national level. The map was prepared at a scale of 1:50,000 and can be taken to have a resolution of 20m (Geological Survey Ireland, 2018b). The landslide susceptibility mapping for the area is shown in Figure 3.

The majority of the site is designated as “Low”, “Low (inferred)”, or “Moderately Low” susceptibility. Turbine 16, Turbine 21, and the access road between Turbine 20 and Turbine 21 are in areas designated as “Moderately High” susceptibility. It should be noted that the GSI risk assessment only accounts for the current site topographic and hydrological conditions. The development of a wind farm can alter these parameters in the temporary and/or permanent case. There is an area which is mapped as being of “High” susceptibility, but it is 1.8km from the site.

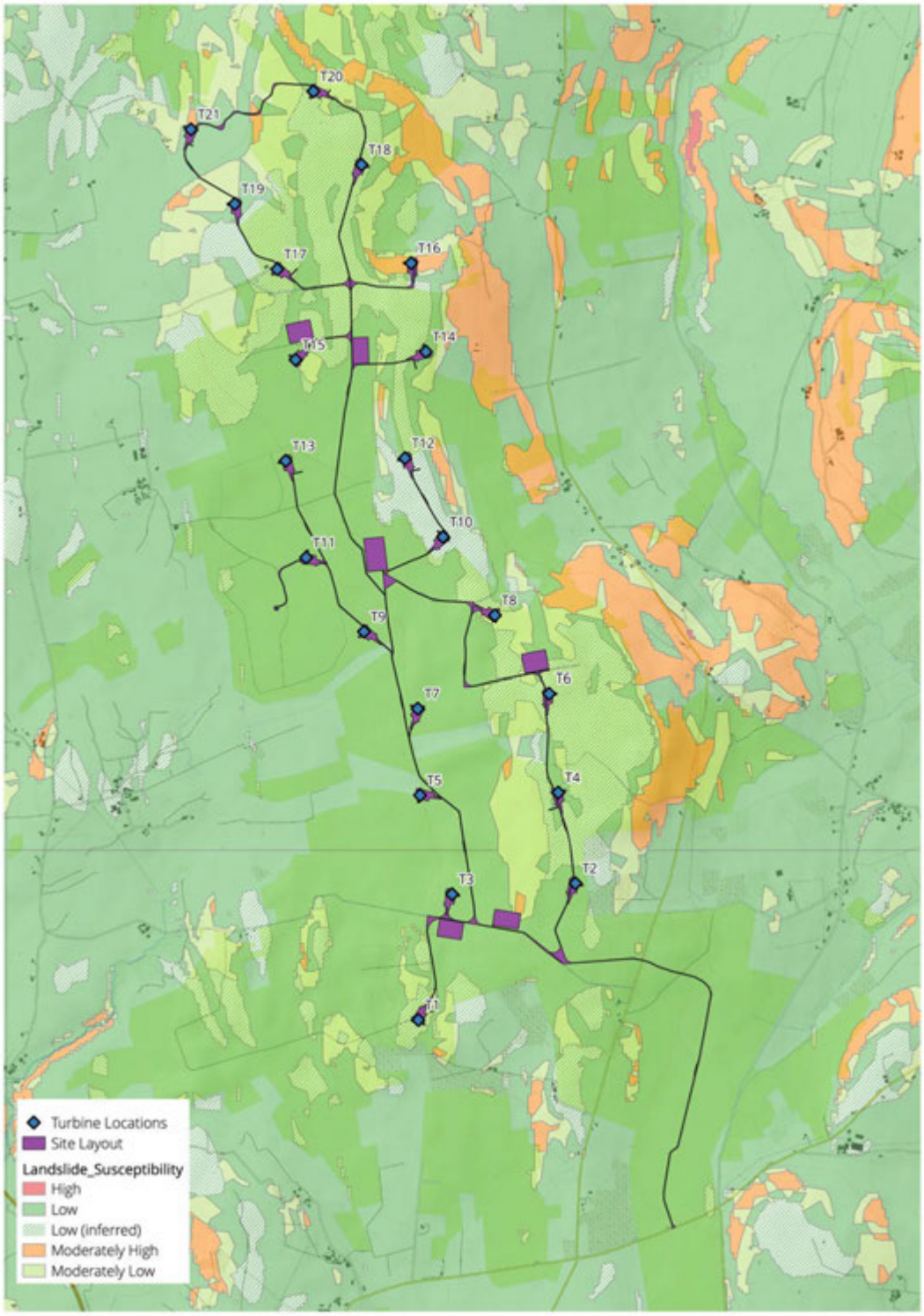

Figure 3 - Landslide susceptibility (Source: GSI National Landslide Susceptibility Mapping, 2018)

No evidence of historic peat failure was identified during the site walkover. During the geotechnical investigation by trial pits, some of the walls of the trial pits were unstable and collapsed, however this is not unexpected for steep-sided trial pits dug in superficial deposits.

4.5. Ground Investigation

A number of phases of ground investigation (GI) of the development area were carried out as outlined in §3.2. The details of each investigation location are presented in Appendix 8-1 of the main EIAR. These investigations confirmed the general geology indicated in the geological mapping.

The typical findings were 0.1 to 0.5m of TOPSOIL over typically soft to stiff (slightly) sandy (slightly) gravelly CLAY/SILT with occasional to many angular to subrounded cobbles and boulders over (slightly) clayey gravelly SAND or (slightly) clayey sandy GRAVEL over bedrock of SHALE, SILSTONE, or SANDSTONE. The superficial deposits encountered are interpreted as glacial deposits. The depth to bedrock ranged from 0.1m to greater than 4.3m below ground level.

Extensive deposits of soft CLAY and SILT were noted in trial pit logs. It is considered that risks due to soft CLAY and SILT can be managed effectively through normal design and construction mitigations and controls to secure the short- and long-term stability of the proposed earthworks including turbine and substation foundations and access roads.

There was very limited evidence of peat at the site. Of the 45 trial pits and boreholes, only one encountered "peaty" material: TPSS2-1 found "soft white/grey slightly sandy slight gravely SILT with occasional subrounded cobbles and peaty lenses" to 1.2m bgl. Other mentions of organic soil are all within TOPSOIL layers and all at depths shallower than 0.5m bgl, as shown in Table 2.

Table 2 – Organic soil found by GII investigations

Exploratory hole	Description	Depth (m bgl)
BPN1_1	Dark brown organic Clay TOPSOIL	0.4
BPN1_2	Dark brown organic Clay TOPSOI	0.4
BPS2	Dark brown organic slightly gravelly Clay TOPSOIL	0.5
TP02	Dark brown organic TOPSOIL	0.25
TP15	Dark brown organic Clay TOPSOIL	0.5
TP18	Dark brown organic Clay TOPSOIL	0.2
TP19A	Brown organic Clay TOPSOIL	0.2
TP19B	Brown organic Clay TOPSOIL	0.2
TP20	Dark brown organic Clay TOPSOIL	0.4

The walkover study carried out in August 2020 found limited evidence of peaty and organic topsoil within the site boundary, particularly to the north of the scheme. It is considered that some of this material identified as "peaty" may be recent decomposed forest floor material. The depth of this peaty or organic topsoil was less than 500mm in all cases encountered during the walkover and mostly less than 150mm. The areas where this peaty and organic topsoil was identified are shown in Figure 4, along with nearby areas of "moderately high" landslide susceptibility as identified by GSI.

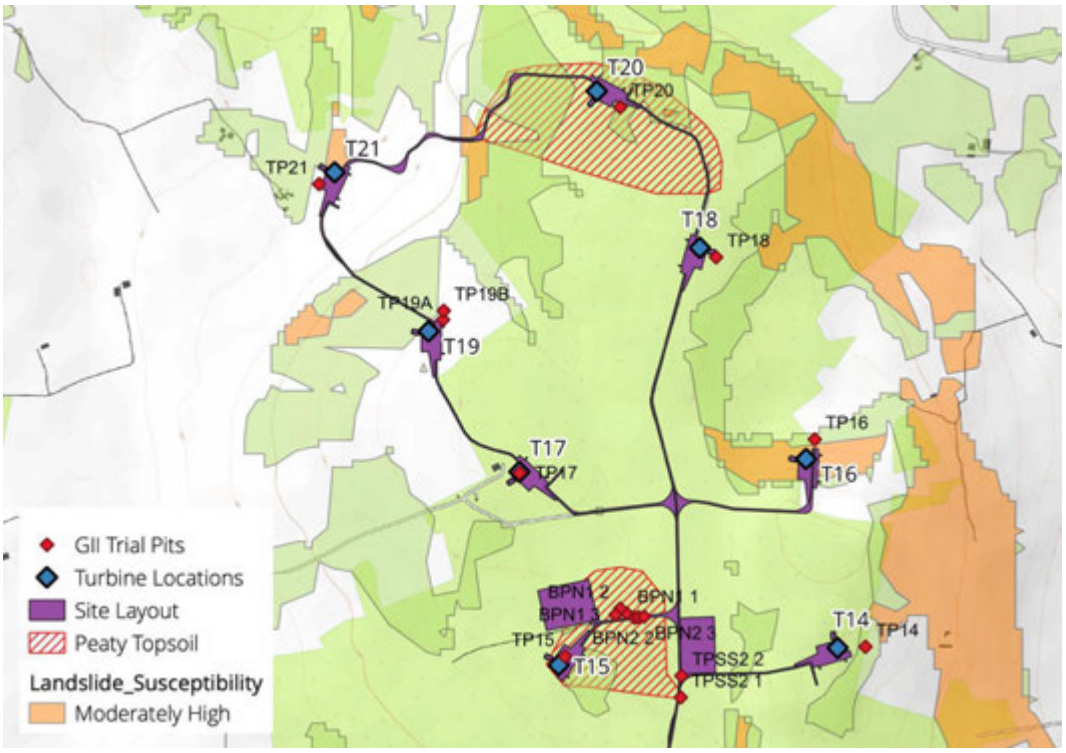

Figure 4 - Areas where peaty or organic topsoil identified during walkover survey and areas of "moderately high" landslide susceptibility (GSI, 2018a)

There is one area where "moderately high" landslide susceptibility was identified in conjunction with peaty topsoil, between Turbine 20 and Turbine 21, however the walkover study found less than 0.15m of peaty topsoil in this location and hence it is considered that the risk of peat instability is "negligible" at this location, subject to normal design and control measures during construction.

"Moderately high" landslide susceptibility was identified at the locations of Turbine 16 and Turbine 21. On review of trial pits TP16 and TP21 and based on the site walkover, no peat was found near Turbine 16 or Turbine 21. Hence, and on further study, the risk of peat instability is considered "negligible" at these locations subject to normal design and control measures during construction. The risk of instability in soft CLAY and SILT can be managed effectively through normal design and construction mitigations and controls to secure the short- and long-term stability of the proposed earthworks.

5. Peat Stability Assessment

Due to the very limited depths and extents of "peaty" materials identified on the site, it is not considered that qualitative or quantitative peat stability risk assessments are required to demonstrate that the risk of peat instability is "negligible" in accordance with the Energy Consents Unit Scottish Government (2017) Peat Landslide Hazard and Risk Assessments, Best Practice Guide for Proposed Electricity Generation Developments – Second edition.

Peaty materials were mostly identified within TOPSOIL and may be decomposed forest floor materials and as such will be stripped during the topsoil stripping operations over the construction footprint and should be stockpiled for reuse.

Normal detailed design and mitigation measures during construction should be applied, based on the findings of the ground investigation.

Excavations for turbine foundations are often several metres deep and represent a significant alteration to the local topography in the short term. This can have a significant effect on the stability of the material local to the turbine and mitigation measures will be put in place during the construction of the scheme to reduce the likelihood of an excavation collapsing. Possible mitigation measures include battering back of excavations to a safe angle (as determined through a slope stability assessment by a competent temporary works designer) or construction of a temporary sheet pile wall to support the soil during construction.

Further, access roads on sidelong ground may suffer from global stability-type failures. Possible mitigation measures include detailed analysis of expected loadings and careful detailed design to account for the expected loadings and the use of geogrids as base stabilisation and reinforcement.

6. Summary and Conclusions

Ciaran Reilly & Associates has been appointed by TOBIN Consulting Engineers (TOBIN) on behalf of Coillte to carry out a peat stability risk assessment of the proposed Castlebanny Wind Farm development.

One out of forty-six exploratory holes at the site noted ”peaty lenses” in the top metre of soil and peaty or organic topsoil was noted to depths of less than 0.5m in other trial pits and during site walkover surveys. In accordance with planning guidelines compiled by the Department of the Environment, Heritage and Local Government (DoEHLG) (2016), where peat is present on a proposed wind farm development, a peat stability assessment is required as part of the environmental impact assessment.

The evaluation of the peat stability at the Castlebanny Wind Farm site was carried out in accordance with the Energy Consents Unit Scottish Government (2017) Peat Landslide Hazard and Risk Assessments, Best Practice Guide for Proposed Electricity Generation Developments – Second edition.

Due to the very limited depths and extents of “peaty” materials identified on the site, it is considered that the risk of peat instability is “negligible”. Peaty materials were mostly identified within topsoil and may be decomposed forest floor materials and as such will be stripped during the topsoil stripping operations over the construction footprint and should be stockpiled for reuse.

Based on a broad assessment of landslide susceptibility the GSI National Landslide Susceptibility Mapping project designates the majority of the site as “Low”, “Low (inferred)”, or “Moderately Low” susceptibility. Turbine 16, Turbine 21, and the access road between Turbine 20 and Turbine 21 are in areas designated as “Moderately High” susceptibility and may require further mitigation measures during detailed design stage. Between Turbine 20 and Turbine 21, peaty topsoil coincides with an area of “moderately high” landslide susceptibility, however the depth of peaty topsoil is very shallow at 0.15m and hence the risk of peat instability is considered “negligible” at this location, subject to normal design and control measures during construction. No peat was found near Turbine 16 or Turbine 21 and so the risk of peat instability is also considered “negligible” subject to normal design and control measures during construction.

Extensive deposits of soft clay and silt were noted in trial pit logs. Soft clay and silt soils pose their own risks to the development. However, it is considered that these risks can be managed effectively through normal design and construction mitigations and controls to secure the short- and long-term stability of the proposed earthworks including turbine and substation foundations and access roads.

7. Geotechnical Risk Register

The Geotechnical Risk Register shown in Table 3 below.

Table 3 – Geotechnical risk assessment

Hazard	Risk	Consequence	Proposed mitigation
Greater extent and/or thickness of peaty soil or soft clay and silt.	Greater depth excavation and replacement or length of piles may be required for turbine or substation foundations. Greater risk of instability.	Cost increases, Delays, Environmental incidents, Injury or death.	Addition ground investigation consisting of rotary cored boreholes recommended at proposed turbine and substation locations during detailed design.
Strength and durability of bedrock.	Greater foundation sizes may be required for turbine or substation foundations.	Cost increases, Delays.	Addition ground investigation consisting of rotary cored boreholes recommended at proposed turbine and substation locations during detailed design.
Strength of peaty soils and soft clay and silt.	Greater risk of instability. Access road failure.	Cost increases, Delays.	Addition ground investigation consisting of additional boreholes and confirmatory plate bearing tests recommended along access roads during detailed design.
Compressibility of peaty soils and soft clay and silt.	Greater risk of instability. Access road failure. Turbine or substation failure.	Cost increases, Delays.	Additional ground investigation at substation sites and along access roads.
Difficulties in excavation of peaty or soft soil.	Risk to operatives and machinery	Injury or death, Cost, Delay.	Competent temporary works designer to be engaged for design of excavation works.
Flooding / surface water ingress.	Flooding of works	Injury or death, Cost, delays	Risk of flooding to be communicated to detailed design phase.
Groundwater level.	Elevated groundwater levels during adverse weather or at particular times of year.	Cost increases, Delay.	Ongoing ground water monitoring is advised through the detailed design stage.

8. References

Department of Housing, Planning and Local Government. 2006. *Review of Wind Energy Development Guidelines "Preferred Draft Approach".*

Environmental Protection Agency EPA Map Viewer *https://gis.epa.ie/EPAMaps/.*

Geological Survey of Ireland. 2020. *Online Mapping.* *https://www.gsi.ie/Mapping.htm*

Geological Survey Ireland. 2018a. *National Landslide Susceptibility Map.*

Geological Survey Ireland. 2018b. *Important disclaimer, guidance notes and conditions of use for landslide susceptibility maps.*

I.S. EN 1997-1:2005 + AC:2013 + NA+2015. *Eurocode 7: Geotechnical design - Part 1: General rules (Including Irish National Annex).* Dublin, National Standards Association of Ireland.

IWEA. 2012. *Best Practice Guidelines for the Irish Wind Energy Industry.*

Energy Consents Unit Scottish Government. 2017. *Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments – Second edition.*

Ordnance Survey Ireland. 2018. *GeoHive spatial data. www.geohive.ie.*