Derryadd Windfarm
Peat Stability Risk Assessment

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Project Title:	Derryadd Windfarm
Report Title:	Peat Stability Risk Assessment
Document reference:	16011_02_01

Client:	Tobin Consulting Engineers
Ultimate Client:	Bord na Móna Powergen Ltd.

Document Control

Revision	Date	Authored:	Checked:	Approved:
00	12/11/2018	LB	PQ	PQ
Revision	**Date**	**Authored:**	**Checked:**	**Approved:**
01	17/01/2019	LB	PQ	PQ
Revision	**Date**	**Authored:**	**Checked:**	**Approved:**
Revision	**Date**	**Authored:**	**Checked:**	**Approved:**

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1 NON-TECHNICAL SUMMARY

Gavin Doherty Geosolutions (GDG) was engaged by Tobin Consulting Engineers (Tobin) on behalf of Bord na Móna Powergen Ltd. (BNM) to undertake a peat stability assessment of the proposed Derryadd windfarm site. 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 findings of the peat assessment, which involved reviewing over 35 locations, showed that the site has an acceptable "*Low"* hazard ranking and is suitable for the proposed wind farm development. The findings include possible mitigation measures for construction work in peat lands to ensure that all works adhere to an acceptable standard of safety.

The proposed wind farm comprises of 24 wind turbines, a substation, borrow pits, access tracks and other ancillary infrastructure. The windfarm will be located primarily on three bogs within the Mountdillon Group of peat production bogs, namely Derryaroge, Derryadd, and Lough Bannow cutaway bogs and a very small portion of a fourth cutaway bog, Derryshanoge. The topography of the site is relatively flat. A number of glacial depositions known as drumlins are identified across the site resulting in local variations in topography.

The development is underlain by raised bog cutaway/cutover soils. The bogs are currently under peat production by Bord na Móna. There are two areas of Basic Poorly Drained Mineral Soils with Peaty Topsoil, as defined by the Geological Survey of Ireland, noted within the site extents. Peat subsoil is encountered throughout the site. There are also some bodies of till derived from limestones in the development areas which relate to presence of drumlins. Lacustrine Marls are also found within the study area and site boundary.

The evaluation of the peat stability at the Derryadd wind farm site was carried out in accordance with Natural Scotland Scottish Executive (2017) guidelines, *Peat Landslide Hazard and Risk Assessments, Best Practice Guide for Proposed Electricity Generation Developments – Second edition*. The stability assessment of both the peat and soft soil material at various locations onsite is described in this report. The findings of the assessment indicate a "*medium*" hazard ranking of instability related to the requirement for deep excavations on the Derryadd wind farm site. Mitigation measures can be put in place during the construction of the scheme to reduce the likelihood of an excavation collapsing. Following mitigation, the risk ranking of the Derryadd wind farm development is considered to be "*low*". It is concluded that the site is suitable for the proposed wind farm development.

A peat management plan (PMP) has been prepared for the development which is included in as an Appendix to Chapter 7 of the project Environmental Impact Assessment Report (EIAR). Recommendations made in this report and in the PMP should be taken into consideration during the design and construction stage of the wind farm development. Best practice guidance regarding the management of peat stability must be inherent in the construction phase of the project.

2 INTRODUCTION

Gavin & Doherty Geosolutions Limited (GDG) has been appointed by Tobin Consulting Engineers (TOBIN) on behalf of Bord na Móna Powergen Ltd. (BNM) to carry out the peat stability risk assessment of the proposed Derryadd 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 Derryadd Windfarm 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 24 wind turbine development will be located primarily on three bogs within the Mountdillon Group of peat production bogs, namely Derryaroge, Derryadd, and Lough Bannow cutaway bogs and a very small portion of a fourth cutaway bog, Derryshanoge. These are located in south County Longford as shown in Figure 7.1 of the EIAR. The planning application boundary has a total area of approximately 1900 hectares, and are located in an area surrounded by the towns and villages of Lanesborough, Derraghan, Keenagh, and Killashee. The surrounding landscape is a mixture of forestry, agricultural land and cutaway peatland, and is predominately flat. The Royal Canal and Lough Ree are located to the east and west respectively, and the River Shannon passes the northern boundary of the proposed development site.

The proposed Derryadd Wind Farm is described in detail in Chapter 2 of the EIAR. The location and layout of the proposed wind farm is shown in Figure 7.1.

2.2 Experience

Specialist geotechnical consultancy, GDG, has been involved in all aspects of geotechnical design of wind farms, from conception through to commissioning. The GDG engineers are intimately familiar with the nature of the proposed works for the Derryadd Wind Farm, having worked on wind farms at Mount Lucas and Bruckana set in similar ground conditions.

This section has been prepared by Paul Quigley and Laura Burke of GDG. Paul Quigley is a Chartered Engineer with 20 years' experience in civil engineering and is a UK Registered Ground Engineering Adviser. He holds a bachelor in Civil Engineering from NUI Galway. His experience includes working in the planning, environmental impact and constraints study phases of large Irish infrastructure projects. Paul has worked on a number of windfarm projects both at planning and construction phase including Kilmeedy, Cappawhite and Castlepook windfarms and the Slagbooly windfarm peat stability assessment.

Laura is a Chartered Engineer with seven years' post graduate experience in civil engineering, three of which are within the onshore renewable energy sector. She obtained her Bachelor's degree in Civil Engineering from NUI Galway and a Masters in engineering geology from Imperial College London. She has worked on a number of windfarm projects in Ireland and the UK in the pre-construction, tender design and construction phases. These include Teevurcher, Meenwaun and Oweninny windfarm in Ireland and Dorenell and Quixwood Moor windfarm in Scotland.

2.3 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 environmental impacts causing 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 Natural Scotland Scottish Executive (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.

2.4 Methodology

The evaluation of the peat stability at the Derryadd wind farm site was carried out in accordance with Natural Scotland Scottish Executive (2017) Peat Landslide Hazard and Risk Assessments, Best Practice Guide for Proposed Electricity Generation Developments – Second edition. It should be noted that the investigations indicate that the soils encountered under the peat are very soft and potentially unstable. The assessment described below accounts for potential instability of both the peat and soft soil material at various locations onsite.

The geotechnical and 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 GDG, Tobin and Irish Drilling Limited (IDL); and
- Peat stability assessment using a qualitative approach.

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

3 SITE 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;
- Examination of peat mapping provided by Bord na Móna; 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 Appendix 7.1 of the main EIAR. The ground investigation information is included in Appendix 7.2 of the main EIAR.

As part of the study, GDG reviewed the following public information sources:

- Published geological, soil, groundwater, surface water, from the Geological Survey of Ireland (GSI);
- Irish Geological heritage site map from the GSI (www.gsi.ie);
- EPA online Envision Map Viewer (www.epa.ie);
- Aerial Photography from ESRI (ArcGIS).

3.2 Field work

Site surveys relating to the soil and geological environment and ground investigations were undertaken from October 2016 to March 2018. These surveys included:

- A site walkover by GDG to review the ground conditions and assess the topography, geomorphology and requirements for further investigations was carried out on the 28th October 2016 and the 1st December 2016;
- No. 200 Peat probes by Irish Drilling Limited (IDL, 2017) and Tobin at proposed turbine locations, along access tracks and at potential borrow pits, April 2017 - March 2018;
- No. 91 trial pits by GDG and Tobin (2017a, 2017b, 2018) at proposed turbine locations, potential substation locations, along access tracks and at potential borrow pits, October 2016 – March 2018;
- Hand shear vane tests on the material encountered in the trial pits, October 2016 – March 2018;

- No. 5 Rotary core drillings by Irish Drilling Limited (IDL, 2017) to assess interconnectivity of the wind farm site with nearby turloughs, June 2017; (this information informed the subsequent and separate borrow pit assessment)
- Logging of the soil layers and sampling of each stratum encountered; and
- Laboratory analyses of the samples collected during the above investigations.

The logs and records of the investigations can be found in Appendices 7.9.2.1 to 7.9.2.9 to Chapter 7 of the EIAR.

4 DETAILED SITE ASSESSMENT

4.1 Site Topography and Geomorphology

The topography of the site is relatively flat with elevations ranging from 37mAOD to 59mAOD. A number of glacial depositions known as drumlins are identified across the site resulting in local variations in topography. They can be seen in the form of a low oval mound with one steep blunt end, known as the stoss, and another shallow sloping end, known as the lee end.

The shape of the drumlins can be seen on the geological plans (GSI, 2018) (EPA, 2018) on Figures 7.2, 7.3, 7.8 and 7.9 of the EIAR in the form of tear drop shaped geological zones (BminPDPT on Figure 7.2 and 7.3, and Till derived from Limestones on Figure 7.8 and 7.9). The drumlins generally follow a NNW-SSE alignment. Localised, man made changes in topography in the form of shallow excavations are also present due to the peat production activities.

4.2 Local Bedrock Geology

At Derryaroge, Derryadd and the small portion of Derryshanoge within the application boundary, the underlying bedrock is predominantly Visean Limestone (Undifferentiated) (GSI, 2018). Figure 7.5 shows the local bedrock geology.

Lough Bannow Bog, is characterised by eight formations, namely:

- Visean Limestone (Undifferentiated);
- Argillaceous Limestones;
- Ballysteen Formation;
- Meath Formation;
- Moathill Formation;
- Rinn Point Limestone Formation;
- Waulsortian Limestones; and
- Lucan Formation

The underlying bedrock for each proposed turbine location is presented in Table 4-1. This table shows three types of bedrock formation underlying the proposed turbine locations.

Faults are shown on the geological mapping in Figure 7.4 and Figure 7.5 running through Lough Bannow close to Turbines T18, T21 and T24. No bedrock outcrops are indicated within the site extents in the geological mapping.

Table 4-1: Underlyign bedrock formation for turbine, borrow pit and substation locations

Locations	Bedrock Formation
Turbine	
1 to 17	Visean Limestone (Undifferentiated)
18 to 23	Moathill Formation
24	Ballysteen Formation
Borrow Pit Location	
17-1 to 17-5	Visean Limestone (Undifferentiated)
Substation	
Option A	Visean Limestone (Undifferentiated)
Option B	Waulsortian Limestones

The GSI (2018) database contains records of ground investigations carried out within and nearby to the development area. These consist of boreholes located in and around the Lough Bannow bog. Logs of all but two of the boreholes are available from the database which indicate the boreholes were drilled for mining exploration purposes. They generally confirm the bedrock lithologies shown on the GSI geological maps.

4.3 Local Soils

The EPA (2018) databases indicate that the proposed project is generally underlain by a *raised bog cutaway/cutover*. The peat which is shown to underlie all of the bogs within the development boundary, is Quaternary in age. It was formed as an extensive envelope of the landscape in the area since deglaciation approximately 7,000 – 10,000 years ago. The bogs are currently under peat production by Bord na Móna. There are two areas of *Basic Poorly Drained Mineral Soils with Peaty Topsoil* noted within the site extents; north of Turbine T3 and next to Turbine T22. Figure 7.3 of the EIAR presents the local soils.

4.4 Local Subsoils

Peat is encountered throughout the site (EPA, 2018). There are also some bodies of till derived from limestones in the development areas. The bodies of till are related to the drumlins discussed previously in Section 4.1. Figure 7.9 shows the local subsoils. Lacustrine Marls are also mapped within the study area and site boundary. Marl lacustrine sediment is common in post glacial lake-bed sediments, often found underlying peat bogs such as those at the proposed development site.

The GSI (2018) database contains records of ground investigations carried out within and nearby to the development area. They do not contain detail information on subsoils but provide depths to bedrock. The findings of these ground investigations are summarised in Table 4-2. The GSI ground investigations carried out on and nearby the site are shown in Figures 7.8 and 7.9.

Table 4-2: GSI boreholes and depth to bedrock Lough Bannow

ID Borehole	Depth to bedrock (m)
DLF-16-581	3.0
01-581-03	7.0
DLF-02-185	9.1
01-1802-01	9.5
DLF-17-581	10.4
DLF-29	10.4
LF-20	12.2
DLF-28-581	12.8
DLF-3-185	15.8
DLF-4-581	16.5
DLF-18-667	18.0

4.5 Previous failures

A review of the landslide information on the GSI Irish Landslides Database indicated that the nearest recorded landslides occurred approximately 9 km north-east of the development area (ID GSI_LS16-0043 and 044). Both events are described as peatslides and happened in February 2016 (+/- 6 months). They are characterised by an area of raised peat that had undergone some slippage. The slip appears to be relatively large and other possible slippages have occurred on the same raised bog previously (GSI, 2018). Figure 7.10 shows the Regional Landslide Susceptibility, and Figure 7.11 shows the Local Landslide Susceptibility. The site is designated as "*Low*" 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.

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.

4.6 Ground Investigation

A number of phases of ground investigation (GI) of the development area were carried out and are detailed in Table 4-3.

Table 4-3: Ground Investigation Summary

Date	Investigation method	Location	Logged by	Report Available in
October 2016 – January 2017	Trial pitting	Turbine locations	GDG	Appendix 7.9.2.1
April 2017		Substation	Tobin	Appendix 7.9.2.2
December 2017		Borrow pits	Tobin	Appendix 7.9.2.3
March 2018		Turbine locations and haul roads	Tobin	Appendix 7.9.2.4
June 2017	Rotary Coring	Borrow pits	IDL	Appendix 7.9.2.5
April 2017	Peat probing	Turbine locations, borrow pits and haul roads	IDL	Appendix 7.9.2.6
March 2018			Tobin	Appendix 7.9.2.7
December 2017 – April 2018	Laboratory Testing	Turbine locations	Testconsult, NMTL, IDL & GSTL	Appendix 7.9.2.8

These investigations confirmed the general geology indicated in the geological mapping. The GI indicated that the site is generally covered in peat which overlies soft to very soft silty clay or loose sand and gravels with numerous cobbles. Locations of the ground investigations are shown on Figures 7.12, 7.13, and 7.14, and details of each investigation location are presented in the Appendix 7.9.2 to chapter 7 of the EIAR.

4.6.1 Trial Pit Summary

A summary of the ground conditions encountered during the ground investigation carried out as part of this report is given in Table 4-4.

Table 4-4: Trial Pit Summary

Turbine	Ground profile	Comments
Turbine 1 TP18-1 (Appendix 7.9.2.4 of EIAR)	0.00 – 0.10m: Black fibrous PEAT 0.10 – 2.00m: Sandy gravelly CLAY 2.00 – 2.90m: Very silty, slightly sandy GRAVEL with gravel, cobbles and boulders	Concluded at 2.9m due to abundance of large boulders.
Turbine 2 TP18-2 (Appendix 7.9.2.4 of EIAR)	0.00 – 0.10m: Black fibrous PEAT 0.10 – 0.50m: Slightly sandy, gravelly CLAY 0.50 – 2.70m: Slightly sandy silty CLAY with gravels, cobbles and boulders	Concluded at 2.70m due to abundance of large boulders/ bedrock .
Turbine 3 TP18-3 (Appendix 7.9.2.4 of EIAR)	0.00 – 0.30m: Black fibrous PEAT 0.30 – 0.80m: Silty SAND 0.80 – 2.2m: Sandy, gravelly SILT with sand lenses	Concluded at 2.20m due to abundance of large boulders/ bedrock.
Turbine 4 TP18-4 (Appendix 7.9.2.4 of EIAR)	0.00 – 1.6m: Black/ brown fibrous PEAT 1.60 – 3.0m: Very sandy, gravelly SILT/CLAY	Minor water inflow at base.
Turbine 5 TP18-5 (Appendix 7.9.2.4 of EIAR)	0.00 – 0.10m: Black fibrous PEAT 0.10 – 1.30m: Very sandy, gravelly SILT with occasional sand lenses	Concluded at 1.30m due to bedrock.

Turbine	Ground profile	Comments
Turbine 6 TP18-6 (Appendix 7.9.2.4 of EIAR)	0.00 – 0.80m: Black fibrous PEAT 0.80 – 1.20m: Shelly marl and organic CLAY 1.20 – 2.90m: Slightly sandy laminated SILTS and CLAYS	Concluded at 2.90m due to abundance of subsidence of adjacent ground and collapse of trial pit.
Turbine 7 TP18-7 (Appendix 7.9.2.4 of EIAR)	0.00 – 0.10m: Black/ brown fibrous PEAT 0.10 – 1.50m: Slightly gravelly SAND	Concluded at 1.50m due to large water inflow and collapse of trial pit.
Turbine 8 TP18-8 (Appendix 7.9.2.4 of EIAR)	0.00 – 1.70m: Red/ brown fibrous PEAT 1.70 – 3.30m: Laminated sandy SILT and silty SAND	
Turbine 9 TP18-9 (Appendix 7.9.2.4 of EIAR)	0.00 – 1.60m: Brown/ black fibrous PEAT 1.60 – 3.00 m: Very sandy, gravelly SILT/ CLAY with occasional limestone cobbles and boulders	Concluded at 3.00m due to water ingress.
Turbine 10 TP18-10 (Appendix 7.9.2.4 of EIAR)	0.00 – 0.30m: Black fibrous PEAT 0.30 – 2.30m: Slightly sandy gravelly SILT	Concluded at 2.30m due to abundance of large boulders.
Turbine 11 TP18-11 (Appendix 7.9.2.4 of EIAR)	0.00 – 0.40m: Black/ brown fibrous PEAT 0.40 – 1.30m: Gravelly SILT	Concluded at 1.30m due to bedrock.
Turbine 12 TP18-12 (Appendix 7.9.2.4 of EIAR)	0.00 – 2.00m: Red/ brown fibrous PEAT 2.00 – 2.60m: Laminated sandy SILT 2.60 – 3.20m: Gravelly SILT/ CLAY	
Turbine 13 TP18-13 (Appendix 7.9.2.4 of EIAR)	0.00 – 0.70m: Brown/ black fibrous PEAT 0.70 – 3.00m: Very sandy, gravelly SILT/ CLAY with occasional limestone cobbles and boulders	Trial pit Concluded at 3m due to water ingress.
Turbine 14 TP18-14 (Appendix 7.9.2.4 of EIAR)	0.00 – 0.60m: Brown fibrous PEAT	Peat probe at 2.1m; possible gravel/ gravelly till or bedrock.
Turbine 15 TP18-15 (Appendix 7.9.2.4 of EIAR)	0.00 – 1.00m: Black/ brown fibrous PEAT 1.00 – 2.60m: Slightly sandy SILT/ CLAY 2.60 – 3.00m: Very silty, sandy GRAVEL with large sub-angular to sub-rounded boulders and cobbles	Concluded at 3.00m due to boulders.
Turbine 16 TP18-16 (Appendix 7.9.2.4 of EIAR)	0.00– 2.10m: Red/ brown fibrous PEAT 2.10 – 3.70m: Sandy, gravelly SILT/ CLAY	Minor inflows present.
Turbine 17 TP18-17 (Appendix 7.9.2.4 of EIAR)	0.00 – 1.60m: Brown/ black fibrous PEAT 1.60 – 2.70m: Sandy, gravelly SILT/CLAY with occasional cobbles and boulders	Terminated at 2.70m due to boulders.
Turbine 18 TP 101 (Appendix 7.9.2.1 of EIAR)	0.00 – 0.90m: Black PEAT with very little discernible fibres and roots 0.90 – 3.10m: Light grey soft slightly sandy gravelly CLAY with significant amount of cobbles and boulders and occasional minor lenses of yellow fine to medium sand.	Significant amount of water trickling from the interface of peat and gravelly clay. Trial Pit walls crumbling / slightly unstable after that.
Turbine 19 TP 06 (Appendix 7.9.2.1 of EIAR)	0.00 – 1.10m: Black to brown fibrous PEAT 1.10 – 2.00m: Slightly clayey SILT with abundant gravels and cobbles 2.00 – 2.50m: Slightly clayey SILT with abundant gravels, cobbles and boulders	Terminated at 2.50m due to obstruction.

Turbine	Ground profile	Comments
Turbine 20 TP 07 (Appendix 7.9.2.1 of EIAR)	0.00 – 1.10m: Black to brown fibrous PEAT 1.10 – 1.40m: Slightly silty CLAY with occasional gravels 1.40 – 2.00m: Silty SAND with numerous gravels and cobbles	Water strike at 2.00m Terminated at 2.00m due to obstruction.
Turbine 21 TP 08 (Appendix 7.9.2.1 of EIAR)	0.00 – 2.00m: Black to brown fibrous PEAT 2.00 – 2.70m: Slightly clayey, gravelly SILT 2.70 – 3.70m: Silty, gravelly SAND with numerous cobbles and boulders	
Turbine 22 TP 03 (Appendix 7.9.2.1 of EIAR)	0.00 – 3.50m: Black to brown fibrous PEAT 3.50 – 4.50m: Silty, gravelly SAND with abundant cobbles	
Turbine 23 TP 04 (Appendix 7.9.2.1 of EIAR)	0.00 – 0.05m: Plastic fibrous Black Organic PEAT 0.05 – 0.40m: Slightly clayey sandy, gravelly SILT with numerous cobbles 0.40 – 2.20m: Slightly sandy, gravelly SILT/ CLAY with numerous cobbles and occasional boulders	Terminated at 2.20m due to obstruction.
Turbine 24 TP 05 (Appendix 7.9.2.1 of EIAR)	0.00 – 1.30m: Black to brown fibrous PEAT 1.30 – 2.70m: Slightly clayey sandy SILT with abundant cobbles	Terminated at 2.70m due to obstruction.
Borrow Pit 17-1 TPBP1 - TPBP7 (Appendix 7.9.2.3 of EIAR)	0.00 – 0.70m: Black/ brown fibrous PEAT 0.70 – 1.00m: Organic SILTS and shelly MARL 1.00 – 2.25m: Sandy, gravelly CLAY	Concluded at 2.25 due to presence of large angular boulders.
Borrow Pit 17-2 TPBP8 – TPBP11 (Appendix 7.9.2.3 of EIAR)	0.00 – 0.20m: Black and brown organic PEAT 0.20 – 2.50m: Very silty, clayey GRAVEL with numerous cobbles and boulders	Concluded at 2.50m due to presence of large angular boulders.
Borrow Pit 17-3 TPBP22 – TPBP31 (Appendix 7.9.2.3 of EIAR)	0.00 – 0.44m: Black and brown organic PEAT 0.44 – 1.80m: Sandy, gravelly SILT/ CLAY	Water inflows at base of trial pit. Concluded at 1.80m due to abundance of large angular boulders and bedrock.
Borrow Pit 17-4N TPBP12, TPBP19 – TPBP21 (Appendix 7.9.2.3 of EIAR)	0.00 – 0.20m: Black organic PEAT 0.20 – 0.90m: Slightly sandy, gravelly CLAY	Concluded at 0.90m due to bedrock
Borrow Pit 17-4S TPBP13 – TPBP18 (Appendix 7.9.2.3 of EIAR)	0.00 – 0.25m: Black organic PEAT 2.50 – 2.40m: Slightly sandy, gravelly CLAY	Water inflows at base of trial pit. Concluded at 2.40m due to obstruction.
Borrow Pit 17-5 TPBP31 (Appendix 7.9.2.3 of EIAR)	0.00 – 0.20m: PEAT Noted as an area of bedrock subcrop during trial pitting	stone was hit at 0.2m
Substation 1 STP1, STP2, STP3, STP4 (Appendix 7.9.2.2 of EIAR)	0.00 – 1.50m: Brown to Black PEAT 1.50 – 3.15m: Slightly sandy SILT/CLAY 3.10 – 3.30m: Sandy, gravelly SILT/CLAY with Large cobbles of sandstone and limestone.	
Substation 3 STP5, STP6 (Appendix 7.9.2.2 of EIAR)	0.00 – 1.50m: Red/Brown fibrous PEAT 1.50 – 2.25m: Organic shelly MARL with occasional rootlets 2.30 – 4.50m: Thinly laminated slightly sandy SILT/CLAY	

5 PEAT AND SUBSOILS STABILITY ASSESSMENT

The guidelines set out four categories of risk; and recommends various mitigation / avoidance actions for each category. The categories of risk are:

1- Insignificant;
2- Significant;
3- Substantial; and
4- Serious.

The concept of risk analysis for a particular hazard presented in the guidelines referred to the publication entitled "Scottish Road Network Landslides Study" by Winter et al. (2005) and is presented as follows:

Hazard Ranking = Hazard x Exposure

Where:

- Hazard = The likelihood of the (peat or soft clay) landslide event occurring
- Exposure = The effect and consequences that the event may have

Table 5-1 presents the scale of the likelihood and Table 5-2 presents the classification of exposure ratings based on a percentage of total project cost/time. These classifications are taken from the report entitled Peat Landslide Hazard and Risk Assessments, Best Practice Guide for Proposed Electricity Generation Developments – Second edition, from NSSE, 2017.

Table 5-1 Qualitative assessment of peat landslide Hazard over the lifetime of the development (NSSE, 2017)

Scale	Likelihood	Probability of occurrence
5	Almost certain	> 1 in 3
4	Probable	1 in 10 – 1 in 3
3	Likely	1 in 10^2 – 1 in 10
2	Unlikely	1 in 10^7 – 1 in 10^2
1	Negligible	< 1 in 10^7

Table 5-2 Qualitative assessment of peat landslide Exposure over the lifetime of the development (NSSE, 2017)

Scale	Exposure	Effect as % of total project cost or time
5	Extremely high effect	> 100% of project
4	Very high effect	10% - 100%
3	High effect	4% - 10%
2	Low effect	1% - 4%
1	Very low effect	< 1% of project

Using Table 5-1 and Table 5-2 it is possible to assign a hazard ranking for each zone by multiplying the hazard by the exposure. This will result in a hazard ranking between 1 to 25 (Table 5-3). Following the result, mitigation measures can be targeted.

Table 5-3 Hazard Ranking and suggested actions (NSSE, 2017)

Hazard Ranking	Designation	Action suggested
17-25	High	Avoid project development.
10-16	Medium	Project should not proceed unless the hazard can be avoided or mitigated without significant environmental effect, in order to reduce hazard ranking to low or negligible.
5-9	Low	Project may proceed pending further investigation to refine assessment and mitigate hazard through relocation or re-design.
1-4	Negligible	Project should proceed with monitoring and mitigation of peat landslide hazards as appropriate.

The Derryadd Wind farm is located in a flat area and the GSI database indicates that the susceptibility of this site to a landslide is "*Low"* (GSI, 2018). It should be noted that the GSI 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. 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. For this reason, the stability assessment presented in this report looks at three stages of the development; pre-construction, during construction and post construction.

During the geotechnical investigation by trial pits, some of the walls of the trial pits were unstable and collapsed. The material encountered was generally described as soft to very soft. Given this, the likelihood of an excavation collapsing during construction is generally in the range "likely" to "almost certain" in the absence of mitigation. The potential impacts are addressed in Section 7.4.

The significance of a collapse in terms of cost and programme is likely to be in the range "very low effect" to "high effect" as the collapse is likely to be localised to each individual turbine as opposed to having an effect on the whole project. Given that the likelihood is "almost certain", the outcome of excavation collapse is ranked as "*Medium; Project should not proceed unless hazard can be avoided or mitigated without significant environmental effect, in order to reduce hazard ranking to low or negligible*."

Mitigation measures can 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 detailed slope stability assessment by a competent temporary works designer) or construction of a granular berm or temporary sheet pile wall to support the peat and soft clays during construction. This is addressed further in Section 7.5.

A peat management plan has been prepared for the development which is included as an Appendix to Chapter 7 of the project EIAR. Following mitigation, the risk ranking of the development is considered to be "*low*". It is concluded that the site is suitable for the proposed wind farm development.

The assessment process described above was applied to discreet locations at each of the proposed turbine locations, borrow pits, substation locations, internal roads, and is summarised in Table 5-4. Where internal roads are not located adjacent to the other infrastructure, they are assessed separately (e.g. between Turbine 9 and Substation option A).This assessment is based on information from geological maps from GSI and site investigation information presented in Table 4-4.

The risk assessment results are the same for most turbines as soft ground was encountered in all of these trial pits without confirmation of depth of a competent layer. The lower risk rating relates to a lesser depth of peat or very soft soils identified in these areas.

Table 5-4 Peat Stability Assessment Summary

Location	Pre-Construction			During Construction (No Mitigation)			During Construction (Mitigation in Place - Note 1)			Post Construction (See Note 2)		
	P	I	R	P	I	R	P	I	R	P	I	R
Turbine 1	2	3	6	3	3	9	2	3	6	2	3	6
Turbine 2	2	3	6	3	3	9	3	3	9	2	3	6
Turbine 3	2	3	6	3	3	9	3	3	9	2	3	6
Turbine 4	2	3	6	4	3	12	3	3	9	2	3	6
Turbine 5	2	3	6	3	3	9	3	3	9	2	3	6
Turbine 6	2	3	6	5	3	15	3	3	9	2	3	6
Turbine 7	2	3	6	3	3	9	3	3	9	2	3	6
Turbine 8	2	3	6	5	3	15	3	3	9	2	3	6
Turbine 9	2	3	6	4	3	12	3	3	9	2	3	6
Turbine 10	2	3	6	3	3	9	3	3	9	2	3	6
Turbine 11	2	3	6	3	3	9	3	3	9	2	3	6
Turbine 12	2	3	6	5	3	15	3	3	9	2	3	6
Turbine 13	2	3	6	3	3	9	3	3	9	2	3	6
Turbine 14	2	3	6	3	3	9	3	3	9	2	3	6
Turbine 15	2	3	6	5	3	15	2	3	6	2	3	6
Turbine 16	2	3	6	5	3	15	3	3	9	2	3	6
Turbine 17	2	3	6	4	3	12	3	3	9	2	3	6
Turbine 18	2	3	6	5	3	15	3	3	9	2	3	6
Turbine 19	2	3	6	4	3	12	3	3	9	2	3	6
Turbine 20	2	3	6	5	3	15	3	3	9	2	3	6
Turbine 21	2	3	6	5	3	15	3	3	9	2	3	6
Turbine 22	2	3	6	5	3	15	3	3	9	2	3	6
Turbine 23	2	3	6	3	3	9	3	3	9	2	3	6
Turbine 24	2	3	6	4	3	12	3	3	9	2	3	6
Borrow Pit 17-1	2	3	6	5	3	15	3	2	6	2	2	4
Borrow Pit 17-2	2	3	6	3	3	9	2	2	4	2	2	4
Borrow Pit 17-3	2	3	6	4	3	12	3	2	6	2	2	4
Borrow Pit 17-4N	2	3	6	5	3	15	3	2	6	2	2	4
Borrow Pit 17-4S	2	3	6	5	3	15	3	2	6	2	2	4
Borrow Pit 17-5	2	3	6	3	3	9	3	2	6	2	2	4
Substation A	2	3	6	5	3	15	3	3	9	2	3	6
Substation B	2	3	6	4	3	12	3	3	9	2	3	6
Road: T9 to Substation A	2	3	6	4	3	12	3	3	9	2	3	6
Road: T12 to T13	2	3	6	4	3	12	3	3	9	2	3	6
Road: Substation B to T18	2	3	6	4	3	12	3	3	9	2	3	6

P –Probability of slope instability based on Table 5-1

I – Impact of slope instability based on Table 5-2

R- Risk rating based on Table 5-3

Note 1 – Assessment based on mitigation measures such as granular berms or sheet piles, not cut slopes

Note 2 – Post construction assessment based on excavations being filled to existing ground level

SUMMARY AND CONCLUSIONS

Gavin & Doherty Geosolutions Limited (GDG) has been appointed by Tobin Consulting Engineers (TOBIN) on behalf of Bord na Móna Powergen Ltd. (BNM) to carry out the peat stability risk assessment of the proposed Derryadd Wind Farm development.

The evaluation of the peat stability at the Derryadd wind farm site was carried out in accordance with Natural Scotland Scottish Executive (2017) Peat Landslide Hazard and Risk Assessments, Best Practice Guide for Proposed Electricity Generation Developments – Second edition. The assessment described accounts for potential instability of both the peat and soft soil material at various locations onsite. The findings of the peat stability risk assessment indicate a "*medium*" hazard ranking of instability related to the requirement for deep excavations on the Derryadd wind farm site. The collapse is likely to be localised to each individual excavation as opposed to having an effect on the whole project Mitigation measures can 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 detailed slope stability assessment by a competent temporary works designer) or construction of a granular berm or temporary sheet pile wall to support the peat and soft clays during construction. Following mitigation, the hazard ranking of the development is considered to be "*low*". It is concluded that the site is suitable for the proposed wind farm development.

A peat management plan (PMP) has been prepared for the development which is included in as an Appendix to Chapter 7 of the project EIAR. Recommendations made in this report and in the PMP should be taken into consideration during the design and construction stage of the wind farm development. Best practice guidance regarding the management of peat stability must be inherent in the construction phase of the project.

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