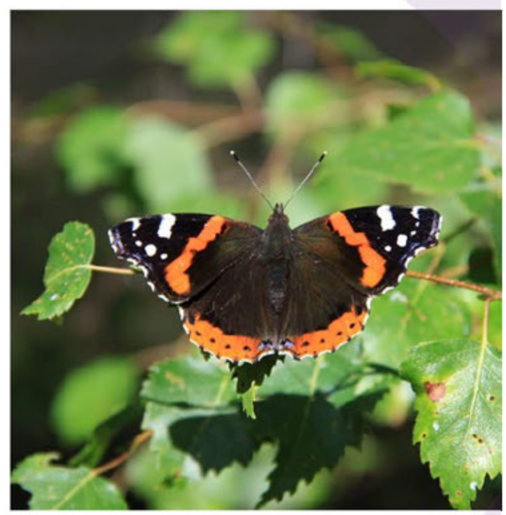
Infinergy

Limekiln Wind Farm
Section 36C Variation Application

Peat Landslide Risk Assessment



Wood Group UK Limited – June 2021

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Management systems

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Executive Summary

The purpose of this report is to present desk-based information and to review previous investigations to provide a comparison of the potential peat landslide risks at the Consented Development and the Revised Consented Development. A preliminary peat landslide risk assessment has been conducted in accordance with the Scottish Government best practice using the sources of available information and data identified in sub-Section 1.6 and Section 9.

In June 2019, Limekiln Wind Farm gained Section 36 consent from Scottish Ministers. The Applicant is now applying to the Scottish Government for consent under Section 36C of the Electricity Act 1989 for a Revised Consented Development comprising a 21no. turbine wind farm on the site of the Consented Development. The revisions include an increase in blade tip height, larger foundations and alterations to the access track layout, the removal of one borrow pit, relocation and enlargement on the temporary construction compound and increased consent period from 30 to 40 years.

Soil mapping of the Development Site indicates that the Revised Consented Development layout passes through a blanket of peat as well as pockets of peaty podzols and peaty gley soils. The NatureScot Carbon and Peatland 2016 map (SNH, 2016) indicates that these soils are Class 1 and 2 soils that are defined as carbon-rich and deep peat.

Geological mapping indicates that the Development Site is predominantly underlain by deposits of the Thormaid and Reay Till Members, Hummocky Deposits, peat and areas of thin or absent deposits with localised Alluvium along the main watercourses. The underlying bedrock is shown to comprise a mix of igneous and sedimentary bedrocks dominated by granite in the west and conglomerates and sandstone with subordinate siltstone and conglomerates in the east. In addition, sub-crops of limestone, psammite and semipelite are also identified.

An Ordnance Survey Digital Terrain Model (DTM) was obtained, which indicates that the Development Site lies at an elevation of between approximately 23m and 180m above Ordnance Datum (AOD) and contains slope angles ranging from almost level up to 35 degrees. The topography of the Development Site generally comprises a low generally flat-topped ridge running northwest to southeast through the centre of the Revised Consented Development. There are promontories at Creag Leathan and Creag Beag in the north of the Development Site but the remainder of the site is generally slightly undulating with a number of smaller promontories. The steepest slopes were identified around the north and north-eastern slopes of the main promontories in the north and north east of the site. The remainder of the Development Site contains sloping ground with angles ranging between 0 and 5 degrees, which change to between 5 and 8 degrees along the ridge through the centre of the Development Site.

A series of peat depth survey campaigns and a ground investigation have been undertaken at the Development Site since November 2011. The latest survey was undertaken on the Revised Consented Development layout in April 2021. In total 5,363 peat depth measurements have been taken across the Development Site and layouts of the Consented and Revised Consented Development. The peat depth ranged between 0.00m and 4.90m and the calculated mean of all peat depths ≥0.5m was revealed to be about 1.17m deep.

An assessment of the peat landslide risk has been undertaken in general accordance with the Scottish Government best practice guide by considering the likelihood and the consequences of such failure. The likelihood assessment has been undertaken through the identification and assessment of seven contributory hazard factors supported by a semi-quantitative assessment, using the infinite slope model. The hazards posed by each contributory factor have been individually scored based on their specific relevance on a scale 1 to 5.

An assessment of the peat landslide consequences considers the potential short and long-term effects on key receptors within a potential zone of influence of the site. These have been assessed for key physical and environmental receptors including human health, infrastructure, cultural, ecological and hydrological receptors, and the consequences of the impacts on each have been scored on a scale of 1 to 5.

The results of the peat landslide risk assessment indicate that the Development Site is considered to have a Negligible to Low Risk of peat landslide failure with one localised area of Moderate Risk, identified to the north of turbine T32. The area of Moderate Risk is associated with the infinite analysis, which indicated Factor of Safety values in the loaded scenario of less than 1.4 in this area.

When comparing the potential peat landslide risks at the Consented Development and Revised Consented Development, the potential risks are considered to be in general agreement (i.e. Low) as the access track layouts pass through similar lengths of Negligible and Low Risk areas. However, it is recognised that the Consented Development proposed to widen existing tracks rather than construct new access tracks. In addition, it is noted that an area of Moderate Risk has been identified along the access track between turbines 26 and 32, which will require further investigation and assessment prior to construction.

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Contents

1. Introduction

1.1 Background

Wood Group UK Limited (Wood) have been commissioned by Limekiln Wind Limited to prepare a Peat Landslide Risk Assessment (PLRA) in support of the Section 36C Variation Application for the proposed Limekiln Wind Farm, south of Reay, Caithness.

The 'Development Site' is located approximately 1.5km south of Reay at approximate central National Grid Reference (NGR) NC 98270 60620, as illustrated in **Figure 1.0** in **Appendix A**.

In June 2019, Limekiln Wind Farm gained Section 36 consent and deemed planning permission from Scottish Ministers. The 'Consented Development' comprises 21 no. wind turbines and associated infrastructure. The Applicant has applied to the Scottish Government for consent under Section 36C of the Electricity Act 1989 for the construction and operation of a Revised Consented Development comprising a 21 nos. turbine wind farm on the site of the Consented Development. The revisions to the layout comprise an increase in blade tip height, larger foundations and alterations to the access track layouts.

1.2 Scope and Purpose

The purpose of this report is to present desk-based information and to review previous investigations of the Development Site to provide a comparison of the potential peat landslide risks at the Consented Development with the Revised Consented Development. A preliminary peat landslide risk assessment has been conducted in accordance with the Scottish Government best practice guide, using quantitative and semi-quantitative approaches supported by field observations and published literature.

The preliminary peat landslide risk assessment supports the impact assessments conducted in the Environmental Impact Assessment and has been prepared from the information sources identified and described in sub-Section 1.6.

The peat landslide risk assessment comprises the following scope of work:

- A review of desk-based information including geological, soil, hydrological and hydrogeological data;
- A description of the findings and results of site reconnaissance including Phase 1 and 2 peat surveys;
- Identification of salient geomorphological features related to processes of peat erosion, drainage and mass movement;
- Identification and assessment of potential peat landslide hazards;
- Preliminary quantitative slope stability assessment by infinite slope analysis using geotechnical parameters derived from literature sources; and,
- Peat landslide risk assessment using the principles set out in the best practice guide.

1.3 Proposed Development

In June 2019, Limekiln Wind Farm (the "Consented Development") was granted consent under Section 36 of the Electricity Act 1989 and Section 57 of the Town and Country Planning (Scotland) Act 1997 by the Scottish

Ministers. The consent was for a wind farm with up to 21 no. wind turbines of varying tip heights and associated infrastructure. The Applicant is seeking to amend the consent to:

- Increase the height of all turbines to 149.9m (but keep them in their consented locations);
- Reroute the access tracks;
- Remove one borrow pit;
- Increase the period of consent from 30 to 40 years;
- Relocate the construction compound and increase its size from (100m x 100m) to (150 x 100m);
- Relocate five water crossings and insert two more;
- Increase the size of the crane hardstandings from 40 m x 22 m to 40 m x 35 m; and
- Removal of permanent anemometer mast.

Following the granting of consent for the Consented Development in June 2019, the Applicant has carried out the following enabling construction work:

- Forming of a temporary construction compound at the Development Site entrance;
- Creation of the consented access track from the A836 to Borrow Pit Search Area B;
- Construction of the substation compound platform; and
- Excavation of Borrow Pit B to meet the rock requirements of the Consented Development enabling works.

As the above works have already been consented and completed, these elements of the wind farm have not been assessed.

A summary of the variations to the Consented Development proposed in the Revised Consented Development are summarised in **Table 1.1** below. Note that **Table 1.1** only summarises the variations and not the entire development. The main access route leading in from the north to the borrow pit is not included.

Table 1.1 Summary of Consented Development and Revised Consented Development

Component	Consented Description	Revised Consented Description
Wind Turbines	Number: up to 21 turbines Base diameter: 18m	Number: as consented Base diameter: increased to 25m
Crane Pads	Number: up to 21 Dimensions: 22m x 40m	Number: as consented Dimensions: increased to 35m x 40m
Blade Laydown Hardstanding	Not included in Consented Development but included in the Peat Management Plan (PMP) submitted to discharge conditions for Consented Development.	Number: 21 Dimensions: 55m x 14.5m
Control Building and Substation Compound	Location: NC 9742 62702 Dimensions: 130 x 60m	Location: NC 97642 62702 Dimensions: 130 x 60m
Temporary Construction Compound	Location: NC 97995 63016 Dimensions: 100 x 100m	Location: NC 98192 62103 Dimensions: increased to 150 x 100m

Component	Consented Description	Revised Consented Description
Access Tracks (including turning heads)	Length: 15.7km Width: 5.5m	Length: decreased 12.1km Width: increased to 6.0m
Borrow Pits	Total number: 2 Footprint (assumed): 27,165.5m^2	Total number: 1 Footprint (assumed): 21,575.3m^2
Cable Trenches	Depth: 1.0m Width: 0.5m Length: 18.8km	Depth: 1.0m Width: increased to 1.2m Length: 12.1km

Collectively, the proposed variations to the Consented Development are referred to as the 'Revised Consented Development', which is shown on **Figure 2.0** in **Appendix A**.

1.4 Previous Assessments

In June 2013 Amec (now Wood) undertook a Peatslide Hazard and Risk Assessment on the Limekiln Wind Farm Development Site. The scope of the assessment was to provide information on the likely distribution and thicknesses of peat across the Development Site, and to also to provide a preliminary assessment of the peat landslide risk.

Peat depth surveys comprising a preliminary survey (where accessible) followed by a targeted survey were undertaken in November 2011 and May 2013, respectively. The targeted survey covered the full Development Site as well as the revised turbine locations, existing and proposed access tracks, borrow pits, control building and temporary construction compound in the Consented Development layout.

In addition to peat depths, in-situ Hand Shear Vane (HSV) tests were also performed in locations where there was an adequate thickness of peat greater than 0.5m bgl. Three tests were performed in each location for both the peak and residual shear strength, which revealed peat strengths in the range of 10kPa to 30kPa and residual strengths generally from 3kPa to 10kPa.

The peat landslide risk was estimated using the Peatslide Hazard Rating System (PHRS) (Nicol, 2006). This method comprises ten categories with criteria scores applied to each hazard corresponding to logical stages of associated increasing risk. The scores for each hazard category are derived from an exponential scale, which provides a rapid increase in score to distinguish the increasing severity of the hazard factor. The scores for each type of hazard can range from 0 (lowest hazard) to 100 (highest hazard). The PHRS scores for each criterion are applied to each survey location and combined to provide a total PHRS score to identify areas of low, moderate or high peat landslide risk. In general, localities with higher scores represent slopes with the highest risk of a peat landslide.

The PHRS method categorises score of less than 200 as low risk while those with a rating of more than 400 are identified as high risk. The findings of the PHRS assessment reveals that each location had a PHRS score less than 200 (low risk). A PHRS score of 88 was calculated as the average for the entire Development Site.

1.5 Assessment Methodology

The preliminary peat landslide risk assessment has been conducted in general accordance with Scottish Government best practice guidance document *Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments* (2nd edition, 2017)("best practice guide"). The preliminary assessment methodology uses a qualitative assessment of the hazards supported by field observations and a deterministic approach supported by field observations and published literature.

The preliminary risk assessment is based on the following approach:

- Desk based review of site information;
- Phase 1 peat depth survey (conducted by Atmos Consulting);
- Phase 2 peat depth survey and site reconnaissance (conducted by Natural Power);
- Identification of the hazards and consequences;
- Preliminary slope stability analysis based on literature sources; and,
- Risk assessment.

The preliminary risk assessment uses the results of the qualitative and deterministic approaches to allocate levels of peat landslide risk spatially across the Application Site in accordance with the risk level in the best practice guidance.

1.6 Sources of Information

The following sources of information have been used in conjunction with available information listed in Section 9 in this PLRA:

- Appendix 5.B: Peat Slide Hazard & Risk Assessment, Limekiln Wind Farm Resubmission, Environmental Statement, May 2016 (herein referred to as "the 2016 PHRA");
- Appendix 5.A: Preliminary Ground Investigation Factual Report, Limekiln Wind Farm Resubmission Environmental Statement, June 2016 (herein referred to as "the 2016 ES");
- Limekiln Wind Farm Resubmission, Environmental Statement, May 2016 (herein referred to as "the 2016 ES");
- Limekiln Wind Farm, Phase 1 Factual Ground Investigation Factual Report, reference 1228952, Natural Power, July 2020.
- Limekiln Wind Farm, Phase 2 Factual Ground Investigation Factual Report, reference 1233164, Natural Power, August 2020.
- Natural Power peat survey data, April 2021.

The Scottish Government guidance document "*Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments*" (2017) ("the best practice guide") has also been taken into account in the development of this PLRA.

1.7 Assumptions and Limitations

The following assumptions and limitations apply to the contents of this peat landslide risk assessment:

- This report provides a review of the available factual information about the geological setting of the Development Site based on the sources of information listed in Section 9. The sources obtained are not necessarily exhaustive and further information on the Development Site may be available from other sources.
- This assessment has been prepared and written in the context of the Revised Consented Development layout, guidance, and literature sources available at the time of writing. New information, improved practices and changes in guidance or significant alterations to the

Revised Consented Development layout may necessitate a re-interpretation of the assessment in whole or in part after its original submission.

- It should be recognised that the peat surveys and interpolations based on those surveys provide information characterising the variation of peat depths and that different conditions may be present between survey locations.
- This assessment contains peat depth data obtained by a third party and provided to Wood for the assessments herein. Wood has assumed that the data is true and correct at the time of use and cannot provide any warranty or accept any liability for its accuracy. Wood have not verified any of the peat depth measurements not undertaken by Wood.

2. Peat Instability

Peat is an organic material formed by the accumulation of plant matter at various stages of decomposition, formed over many thousands of years. The characteristics of peat vary widely depending on, but not limited to, the nature of plant material that the peat is derived from, the degree of decomposition and the type of peat bog. A peat landslide represents the most extreme and rapid process by which peat bogs are degraded and that pose a risk to the Revised Consented Development and neighbouring environmental and human receptors.

In Scotland, the Scottish Government defines peat and deep peat as follows (Scottish Government, 2017):

- **Peaty soils**: soils with an organic horizon <0.5m thick;
- **Peat**: soils with an organic surface horizon greater than 0.5m in thickness and an organic matter content exceeding 60%; and
- **Deep peat**: a peat as defined above, with a depth greater than 1.0m.

There are two distinct types of peat, termed acrotelmic and catotelmic peat. The interface between the two layers is controlled by the position of the water-table. The upper layer of the peat (the acrotelm) is typically fibrous and comprises the living and partially decomposed peat forming plant matter. The thickness of the acrotelm is typically controlled by seasonal variations in the water-table that creates cycles of aerobic and anaerobic conditions near the surface. The catotelm is situated below the minimum average depth of the water-table (Evans and Warburton, 2010). This results in permanent anaerobic decompositions of the plant matter and the formation of less fibrous amorphous peat.

The term 'peat landslide' is a broad term referring to two major groups of peat slope mass movement (or failure), 'bog bursts' and 'peat slides'. Dykes and Warburton (2007) developed a classification scheme for mass movements of peat to define the terminology used to describe the types of peat slope failure. The following forms of peat mass movements have been defined by Dykes and Warburton (2007):

- Bog bursts – failure of raised bogs by breakout of liquid catotelmic peat;
- Bog flows – failure of a blanket bog by breakout of catotelmic peat;
- Bog slide – translational sliding of intact peat along a failure surface within the peat;
- Peat slide – translational sliding of intact peat along a failure surface at the peat-substrate interface;
- Peaty-debris slides - translational failure of a slope covered with blanket peat where the failure occurs beneath the peat-substrate interface; and
- Peat flows – failure of any other peat bog type (e.g. fen peat).

Dykes and Warburton (2007) and Evans and Warburton (2010) indicate that bog bursts and flows are characteristic of deep peat with depths typically in the range of 1.5m to 5m situated on shallow slopes in the range of 2 to 5 degrees. Peat slides and bog slides have typically been reported on steeper slopes in the range of 5 to 15 degrees but in shallower thicknesses of peat in the range of 1m to 3m in thickness. However, as described in Evans and Warburton (2010) a limited number of bursts and slides have been reported outside of these ranges.

A peat landslide is the result of the combination of preparatory factors and trigger factors that either reduce the shear strength of the peat or increase the shear stress on the peat covered slope (Evans and Warburton, 2010). These factors directly or indirectly relate to changes in the hydrology of the peat that can occur rapidly or over a long period of time, and that include natural and anthropogenic (man-made) factors such as (Scottish Government, 2017):

- Increases in the mass situated on the slope (e.g. peat accumulation, seasonal water-table variations and the mass of planted trees);
- Reduction in shear strength through changes in the peat or substrate (e.g. drying and desiccation cracking);
- Loss of surface vegetation (e.g. burning);
- Increased buoyancy through impeded drainage, pooling, pipe networks and rapid rewetting of desiccation cracks; and,
- Commercial afforestation of peat resulting in lowering of the water-table and deep desiccation cracking.

In addition, Evans and Warburton (2010) indicate there are a number of pre-conditions that predispose a slope to failure that relate to the hydrological processes within the peat. These include:

- Impedance of drainage below the peat caused by impermeable clays or iron pans in the substrate;
- A convex slope or break in slope that can concentrate flows;
- Proximity to drainage features such as flushes, peat pipes and streams; and,
- Connectivity between the surface drainage and an impervious peat-substrate interface.

Where the combination of preparatory and pre-failure conditions occur, a peat landslide may be triggered on susceptible slopes by a number of possible trigger factors. The trigger factors can be natural or anthropogenic and are typically related to those that rapidly cause changes in the pore-water pressure, reduce shear strength or rapidly increase the mass on the slope. These factors include:

- Intense rainfall or snow melt and rapid migration to the peat-substrate interface;
- Ground accelerations due to earthquakes, vibrations from vehicles and blasting;
- Incision of the peat slope by streams and rivers, peat turve cutting and excavations during construction causing a rapid reduction in support at the toe of the slope;
- Rapid loading of the peat by landslide debris sliding onto susceptible peat slopes;
- Loading of the peat by heavy plant, digging and tipping; and,
- Alteration of natural drainage routes resulting in focussed drainage on susceptible slopes.

3. Site Setting

3.1 Site Description

The Development Site is located 1.5km to the south of the Village of Reay and 3km south/south west of the Dounreay Nuclear Power Station, in Caithness, Highland. The Development Site extends to approximately 1,140 hectares and largely comprises of a commercial coniferous woodland plantation. The Development Site is bound to the north by undulating moorland and semi-improved agricultural land with Reay village and dispersed settlements beyond. To the east lies further coniferous woodland while the land to the west and south is largely open moorland. The hill known as Beinn Ratha lies approximately 1.2 km to the west of the Development Site boundary.

3.2 Published Geology

Pedology

The 1:25,000 Soil Map of Scotland (The James Hutton Institute, 2020) indicates that Revised Consented Development layout passes through blanket peat as well as pockets of peaty podzols and peaty gley soils. The 1:25,000 Soil Map of Scotland is presented as **Figure 3.0 in Appendix A**.

The NatureScot Carbon and Peatland 2016 map (SNH, 2016) is presented as **Figure 4.0** in **Appendix A**. The map indicates that the Revised Consented Development passes through areas of Class 1 and 2 soils that are defined as carbon-rich and deep peat. The Revised Consented Development also passes through a small area of Class 5 (no peatland habitat recorded) adjacent to the borrow pit.

Superficial Geology

British Geological Survey (BGS) mapping indicates that the Development Site is predominantly underlain by Glacial Till of the Reay Burn and Thormaid Members, peat and areas that are of thin or absent deposits. Localised deposits of Alluvium are recorded in the north of the Development Site, near the proposed construction compound, in an area of the access track between proposed turbine 25 and 26. Hummocky Glacial Deposits are identified in the south of the Development Site.

In the central east, centre and south of the Development Site large areas of peat are identified in the location of the Revised Consented Development.

The BGS digital geology map of superficial deposits is presented as **Figure 5.0** in **Appendix A**.

Solid Geology

BGS mapping indicates that the Development Site is predominantly underlain by a late Silurian felsic igneous intrusion known as the Strath Halladale Granite. In addition, Devonian Conglomorate, known as the Tobaireach Conglomorate is also present in the northeast of the Development Site, underlying the Milton Moss area, and in the far south of the Development Site. The far east of the Development Site is underlain by the Rubha Sandstone Member comprising sandstone with subordinate conglomerate and siltstone. The far north of the Development Site is shown to be underlain by the Portskerra Formation comprising metamorphic bedrocks including migmatitic psammite and semipelite. A small outcrop of Reay Diorite is also present in the northwest of the Development Site

The Bridge of Forss Fault intersects the far south of the Development Site named striking generally northeast to southwest. In addition, the Development Site also has four additional geological faults in its central and northern part striking in various directions.

The BGS digital geology map of solid geology is presented as **Figure 6.0** in **Appendix A**.

3.3 Topography

The Ordnance Survey (OS) Terrain 5 Digital Terrain model (DTM) indicates that the Development Site lies at an elevation of between approximately 23m and 180m above Ordnance Datum (AOD). The topography of the Development Site generally comprises a low generally flat-topped ridge running northwest to southeast from Cnocan Dubh nan Eun south-eastward through the centre of the Revised Consented Development. In addition, there is a slight promontory at Creag Leathan and Creag Beag that rise to 128m AOD. The remainder of the Development Site is generally slightly undulating with a number of smaller promontories at Claperon and Torran Dubh.

The OS Terrain 5 DTM has been used to generate a slope angle raster in ESRI ArcGIS. This analysis indicates that the Development Site contains slope angles ranging from almost level up to 35 degrees. The steepest slopes within the Development Site are generally found around the north and north-eastern slopes of the Creag Leathan, around Creag Bheag and around Claperon. The remainder of the Development Site contains sloping ground with angles ranging between 0 and 5 degrees, which change to between 5 and 8 degrees along the ridge through the centre of the Development Site.

The slope angle analysis based on the OS Terrain 5 DTM is presented as **Figure 7.0** in **Appendix A**.

3.4 Hydrology

Reay Burn and Sandside Burn drain the western side of the Development Site in a northward direction towards the Atlantic Ocean and discharge through the Sandside Bay SSSI at Sandside Bay (NC 966 652). The east of the Development Site is bounded by the Achvarasdal Burn which becomes the Burn of Isauld approximately 1.5 km north of the Development Site, also discharges to the Atlantic Ocean at Sandside Bay. The Development Site contains a number of minor tributaries to these burns including the Meur Gadach, Meur an Fhuaraub Ghil, Meu an Fhraoich that drain the southeast of the Development Site. An unnamed watercourse and the Allt Cnoc an Fhraoich drain the far north and south of the Development Site respectively.

In addition to the watercourses, the Development Site contains the Lochan nan Eun located close to its centre. It is situated on the ridge within an area of particularly wet, boggy ground, to the south of a large rock outcrop.

The Scotland's Environment website reveals that SEPA have classified the Sandside Burn and Achvarasdal Burn as both having a 'Good' overall status.

The Development Site is not within a Drinking Water Protected Area for surface water.

The locations of the surface water features are presented in **Figure 14.0** in **Appendix A**.

3.5 Hydrogeology

The Scotland's Environment Aquifer Classification map indicates that the Development Site is predominantly underlain by an aquifer of low productivity, where flow is virtually all through fractures. In the far northeast and east of the Development Site, in the Milton Moss area, the underlying aquifer is classified as moderately productive with flow virtually all through fractures.

The Development Site is underlain by the Dounreay and Northern Highland groundwater aquifer, which are both classified as 'Good.'

The Development Site is within a Drinking Water Protected Area for groundwater.

3.6 Water Supply Abstractions

The 2016 ES revealed that SEPA had no records of any abstraction licences within a 3km radius of the Development Site. However, The Highland Council (THC) has records of one Private Water Supply (PWS) at Loanscorribest (NC 985 640), which is located ~0.2 km north of the Development Site boundary.

3.7 Designated Sites

The Scotland's Environment website indicates that there are no designated sites within the Development Site boundary. However, the Development Site is bound to the south and southeast by the following designated sites:

- Caithness and Sutherland Peatlands Ramsar site;
- East Halladale Site of Special Scientific Interest;
- Caithness and Sutherland Peatlands Special Area of Conservation; and
- Caithness and Sutherland Peatlands Special Protection Area.

In addition to the above; Reay Burn, Sandside Burn and Achvarasdal Burn flow through the Sandside Bay SSSI approximately 1.7km north of the Development Site boundary.

An NVC survey was undertaken in the 2016 ES and identified a number of Groundwater Dependant Terrestrial Ecosystems within the Development Site as shown in **Figure 14.0** in **Appendix A**. An assessment of the GWDTE's found that they are generally present along the forest rides, stream valleys and on the side cast peat alongside the existing forest access tracks.

3.8 Aerial Photography

Historical Imagery

An online search of the National Collection of Aerial Photography (NCAP) has been undertaken to identify any indications of historical peat landslides. Although the available photography is in black and white and at a small scale, it is possible to make out the Development Site prior to the planting of the commercial forestry plantation. While there are possible flush features identifiable in the imagery, there are no obvious indication of relic peat slides within the available imagery (though at the available scale they would be hard to identify if revegetated).

Contemporary Imagery

Google Earth aerial imagery (© 2021 Google, imagery date 2021) has been reviewed to identify any indications of relic failures and hydrological features such as flushes and erosion. However, the Development Site has a dense cover of commercial forestry plantation which has obscured the ground with tree cover and shadows. As such, the only areas of the ground that are visible are along fire breaks and clearings.

The aerial imagery shows possible gully erosion and flushing features along the banks of the Meur a Chrochain Ghill and Meur an Fhraoich in the far southeast of the Development Site. Flush features are also possibly present approximately 120m southeast of T30 and 300m north of T22.

The geomorphological features identified are presented in **Figure 10.0** in **Appendix A.**

3.9 Landslide Inventory

A search of the BGS National Landslides Database on the BGS GeoIndex indicates that there have been no recorded landslides within or in the vicinity of the Development Site (i.e. within 2km).

4. Field Surveys

4.1 Previous Investigations

A number of peat surveys have been undertaken within the Development Site since 2011. A summary of the scope of peat depth surveys undertaken is provided in **Table 4.1** below.

Table 4.1 Summary of Previous Peat Surveys within the Development Site

Author & Date	Purpose	Scope & Detail
AMEC (now Wood) November 2011	Preliminary assessment for consenting	• The aim of the survey was to provide a preliminary indication of the likely distribution of peat across the Development Site. However, due to dense forestry a targeted survey was undertaken primarily at turbine locations and along fire breaks and rides where access allowed. • A total of 124 no. peat depth measurements were taken using a peat utility probe and a Russian peat sampler where the peat depth was >1.0m. • The Russian peat core samples were subject to classification in accordance with the modified von Post classification scheme (Hobbs, 1986). • The results of the survey (including coordinates) are presented in Appendix 5.A Preliminary Ground Investigation Factual Report, Limekiln Wind Farm Resubmission, in the 2012 Environmental Statement.
AMEC (now Wood) May 2013	Detailed assessment for consenting	• The aim of the survey was to provide a detailed peat depth data across the Development Site as well as at the locations of turbine, existing and new access tracks, borrow pits, substation and construction compound. • A total of 129 no. peat depth measurements were taken using a peat utility probe and a Russian peat sampler where the peat depth was >1.0m.
Tony Gee and Partners LLP June 2020	Detailed assessment for Phase 1 of construction – access and enabling works	• A high resolution (closely spaced) peat depth survey was undertaken at all wind farm infrastructure to inform the enabling works (the main access, borrow pit, construction compound and control building) and discharge of conditions for the Consented Development. • The survey was undertaken alongside the initial tree felling operations to clear routes for the ground investigation. • An intrusive ground investigation was also undertaken concurrently with the peat probing, targeting the wind farm infrastructure. • The proposed access track route and the entire micro-siting buffer zone was probed where tree felling allowed. • The scope of peat survey comprised: ○ Access Tracks – transects every ~50m perpendicular to the track comprising a minimum of 5 no. probes every 20m from centre line.

Author & Date	Purpose	Scope & Detail
		○ Construction compound – grid of probes spaced at 25m centres across the entire footprint. ○ Control building – grid of probes at 20m centres across the entire footprint. ○ Borrow Pit B – transects every 20m along existing rides or felled corridors within the borrow pit footprint where possible (the number of probes depended on the cleared area).
Tony Gee and Partners LLP July & August 2020	Detailed assessment for Phase 2 of construction – access and turbine construction	• A high resolution (closely spaced) peat depth survey was undertaken at all remaining wind farm infrastructure to inform the construction of remaining access routes and discharge of conditions for the Consented Development. • The survey was undertaken alongside the tree felling operations to clear routes for the ground investigation. • The scope of peat survey comprised: ○ Access Tracks – transects every ~50m perpendicular to the track comprising a minimum of 5 no. probes every 20-50m from centre line. ○ Crane pads and turbines – grid of probes spaced at approximate 25m centres across the entire footprint where possible. ○ Borrow Pit A – transects every 20m along existing rides or felled corridors within the borrow pit footprint where possible (the number of probes depended on the cleared area).
Natural Power April 2021	Detailed assessment of the Revised Consented Development	• A detailed peat depth survey was developed by Natural Power in general accordance with guidance published by the Scottish Government et al (2017)[1]. • The survey targeted on the varied elements of the Revised Consented Development layout including the turbine location and access tracks. The unaltered elements of the Consented Development were not probed. • The scope of the survey comprised: ○ Access Track – the access tracks south of Borrow Pit B were surveyed at 50m intervals with a probe also placed ~15m perpendicular to either side of the access track. ○ Turbines – a crosshair of probes orientated to grid north-south were undertaken at 10m intervals from the location of the turbine up to 100m.

[1] Scottish Government, Scottish Natural Heritage, SEPA (2017) Peatland Survey. Guidance on Developments on Peatland, on-line version only

Ground Investigation

An intrusive ground investigation has been undertaken on the Consented Development by Natural Power over two phases under the supervision of engineers appointed by the Applicant. The ground investigation is summarised as follows:

- 54 no. boreholes (29 no. rotary percussive boreholes with follow on rotary core drilling, 25 no. windowless boreholes);
- 192 no. machine excavated trial pits and 3 no. hand dug trial pits;
- 5 no. pavement cores;
- In-situ testing (dynamic cone penetrometer testing; standard penetration testing, hand shear vane tests in peat in trial pits);
- Geotechnical Sampling;
- Groundwater and ground gas monitoring;
- Geotechnical and geochemical laboratory testing.

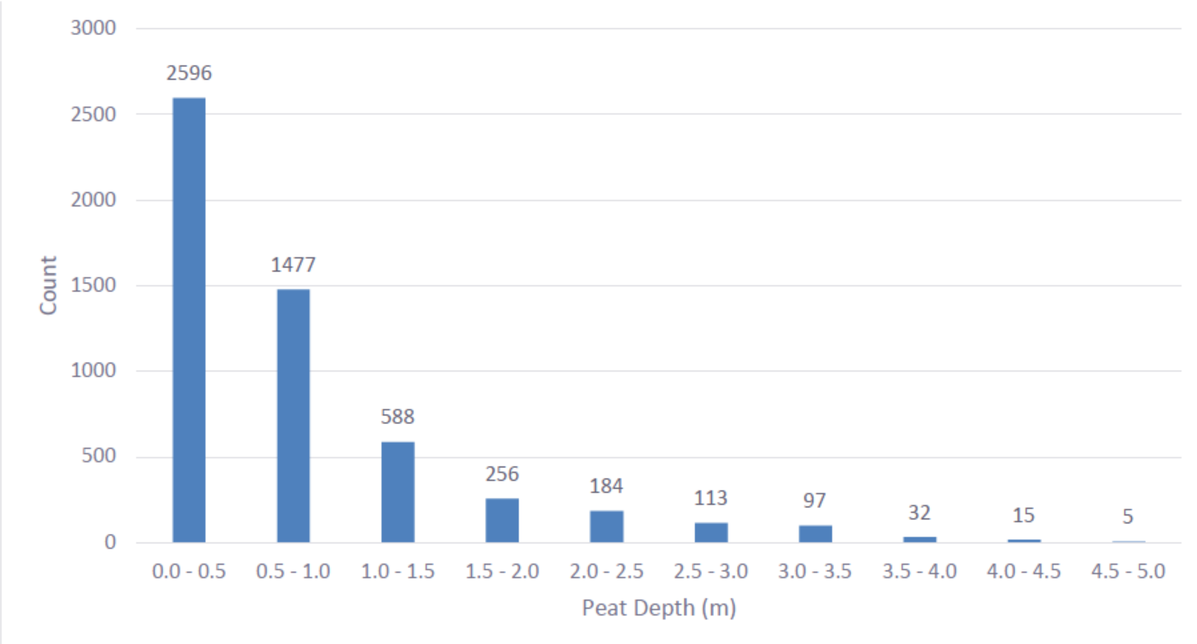
The results of the ground investigation are presented in the following factual ground investigation reports:

- Limekiln Wind Farm, Phase 1 Factual Ground Investigation Factual Report, reference 1228952, Natural Power, July 2020.
- Limekiln Wind Farm, Phase 2 Factual Ground Investigation Factual Report, reference 1233164, Natural Power, August 2020.

4.2 Peat Depths

The peat depth surveys summarised above comprised a total 5,363 peat depth measurements taken across the Development Site and layouts of the Consented Development and Revised Consented Development. The peat survey results and the ground investigation data reveal that peat depths range between 0.00m and 4.90m. A total of 2,767 (~51%) recorded peat depths ≥0.5m and the calculated mean of all peat depths ≥0.5m is 1.17m. **Figure 4.1** below summarises the distribution of peat depth measurements for the Development Site.

Figure 4.1 – Summary of all peat depth data



A summary of the peat depths recorded at the Consented Development and Revised Consented Development is provided in **Table 4.2** below.

Table 4.2 Summary of peat depths

	Consented Development	Revised Consented Development
Number of measurements	2,620	1,780
Minimum	0.00m	0.00m
Maximum	4.00m	4.60m
Mean	0.72m	0.81m

Notes
These values relate to the probing locations south of BP-B only.

A composite plan of all peat depth data is presented in **Figures 8.0 to 8.11** in **Appendix A**

The peat depth data obtained during the surveys has been used to generate an interpolated peat depth map for the Development Site. This has been achieved by using ESRI ArcGIS and the Natural Neighbour interpolation method. This method was chosen given its relative simplicity compared to other interpolation methods. It also avoids exaggeration of minimal and maximal values and results in a modelled surface that passes through the sample point value. The method also does not produce a pronounced "bulls-eye" effect on the modelled surface. However, unlike other methods it is not possible to barrier the interpolation meaning that cell values are modelled across the longest extents of the sample points resulting in interpolations over large distances where the sampling points are irregularly distributed.

Figure 9.0 in **Appendix A** shows the interpolated peat depths across the Consented Development and Revised Consented Development.

The interpolated peat depth map indicates that approximately one third of the Development Site contains peat depths <0.5m. In the west of the Development Site between T26 and T43 the proposed access passes through a large area of peat with thicknesses in excess of 2.0m, ranging up to approximately 4.5m. In addition, further pockets of peat with thicknesses >2.0m are identified throughout the site in or near the location of turbines 25, 30, 54, 55 and 57.

4.3 Peat Characteristics

A total of 74 peat cores were logged according to the von Post scale of humification during the peat depth surveys undertaken in 2011 and 2013. The coring revealed typical one or two layer profiles, with generally low moisture content values (typically B2). The humification values were typically less than H5 with H values up to H7 rarely recorded. The investigation also attempted to estimate the thickness of the acrotelmic layer, which revealed thicknesses varying from approximately 0.3m to 0.5m. However, as noted in the Peat Management Technical Note prepared by Wood, that the commercial forestry plantation has resulted in the peat being densely planted and with trees along deeply ploughed furrows. As a consequence of the planting, the increased drainage and evapotranspiration of the surface peat has resulted in the peat being reasonably dry. It was noted that the characteristics of the surface peat have been altered to such a degree that there was no clear distinction between acrotelmic and catotelmic peat. The peat was described as exhibiting 'haplotelmic' peat conditions in which the acrotelm has been degraded through drainage, compaction and oxidative wastage.

The intrusive ground investigation by Natural Power encountered fibrous to pseudofibrous (H3-H6) peat, with localised areas of amorphous peat (H7-H9). As identified by previous surveys, the distinction between the acrotelmic and catotelmic peat was difficult to distinguish. The distinction was especially difficult in areas where trees had been felled, and brash had to be removed prior to trial pitting. However, where identifiable, the acrotelmic layer generally varied in thickness from 0.1m-0.7m.

4.4 Peat Substrate

A review of the borehole and trial pit logs presented in the Natural Power Phase 1 and 2 ground investigation factual reports (April 2021) detailed in Section 4.1 reveal that the underlying substrate beneath the peat predominantly comprised granular deposits. A limited number of locations also encountered bedrock (weathered and intact). Clay deposits were found to be rare at the exploratory locations.

4.5 Laboratory & In-situ Testing

A total of 81 hand shear vane tests were performed in the trial pits during the ground investigation undertaken by Natural Power during the Phase 2 ground investigation of the Consented Development. The testing was performed at depths ranging from 0.3m to 3.8m in varying peat conditions. The results indicate that the peat shear strength ranges from 0.6kPa to 26.9kPa and that there is an apparent distinction in the peat shear strengths in shallow peat <1.0m and deep peat >1.0m. No laboratory strength testing of the peat was undertaken.

4.6 Geomorphology

The only feature noted in the 2016 PHRA was a possible relic peat landslide feature approximately 250m south of turbine 54 at the head of the Meur Gadach. The feature was noted to consist of a possible landslide with a backscar measuring approximately 15m long and 20m across. A peat probe undertaken in the proximity of this feature indicated a peat depth of 0.40m and the slope angle was recorded at approximately 5˚. However, the features are positioned at the head of a watercourse and in reviewing the picture of the feature presented in the 2016 PHRA it is considered that this feature is more likely to be a flush.

The 2016 PHRA did not identify any other relic peat landslides, flushes, peat pipes, erosion, tension or compression features within the Development Site.

The geomorphological features identified are presented in **Figure 10.0** in **Appendix A.**

5. Peat Landslide Hazard Assessment

5.1 Background

The following assessment of peat stability has been undertaken in general accordance with the Scottish Government best practice guide. This method considers the likelihood (i.e. the Hazards) associated with a particular area of peat multiplied by the consequences of a failure to derive the potential risk. This is expressed as:

Risk = Likelihood x Consequence

The assessment of the peat landslide likelihood has been undertaken through the identification and assessment of contributory hazard factors. In addition, a semi-quantitative assessment of the hazard has been conducted using the infinite slope model. This has been conducted using site specific peat depth and slope angle data derived from the DTM as well as generic literature values for the geotechnical properties of the peat.

The assessment of peat slide hazards involves the allocation of hazard rating values for the various contributory and pre-condition factors which influence the probability of a peat landslide occurring. However, current guidance does not define the hazards that should be assessed nor the ratings that should be applied. In addition, there is no published guide specifically relating to this issue. As such, it is left to the judgement of the assessor to develop their own approach to the assessment of the hazards for each site. The likelihood of peat instability occurring has therefore been determined from a review of the following contributing and pre-condition hazard factors as detailed in the sections below:

- Slope angle;
- Peat depth;
- Natural Drainage;
- Artificial Drainage;
- Pre-failure Indicators;
- Forestry;
- Geology.

The hazards posed by each contributory factor have been individually scored based on their specific relevance to peat instability using both site observations and desk top studies. The hazard assessment relates the importance of the hazard to a scale of 1 to 5 as summarised in **Table 5.1** below.

Table 5.1 Hazard Scoring

Scale	Description
5	Extremely Serious
4	Serious
3	Substantial
2	Significant
1	Insignificant

A hazard ranking has then been calculated by the summation of each contributing factor thus allowing for the determination of the likelihood of instability in Section 6. The scores for each hazard factor are presented in the following sections and summarised in **Figure 11.0** in **Appendix A**.

5.2 Hazard Assessment

The following sections provide discussion on the contributory hazard factors and the method for assessing and scoring the hazards.

Slope Angle

The OS Terrain 5m DTM has been used to assess the slope angles across the Development Site.

Hazard scores have been based on information contained within published literature relating to historical failures in the UK and Ireland over a number of slope gradients. Evans and Warburton (2010) summarise the frequency of peat slides across various slope angle ranges. Their summary indicates that peat slides are more frequent on slopes between 5 and 20° (predominantly between 5 and ~15°). Therefore, these angles have each been assigned higher scores. The further away the angle is from these ranges, the lower the risk score as a result of the lower potential energy stored on lower slopes, the decreasing frequency of failures outside these ranges and the lower thicknesses of peat typically found on steeper slopes >20°.

Table 5.2 Slope Angle Hazard Scoring

Slope Range (degrees)	Score	Rationale
>20	1	Peat slides are considered unlikely due to the slope angle restricting the potential for significant depths of peat to form.
15-20	4	There are many peat slides recorded in this range of slope angles.
8-15	5	The majority of peat slides described in the literature occur within this range of slope angles.
5-8	3	Although some peat slides have been recorded they are less frequent than on steeper slopes.
<5	1	Few peat slides are recorded in the literature below 5 degrees.

Peat Depth

The thickness of peat is a key contributory factor in both the likelihood and mechanism of peat instability. Evans and Warburton (2010) have summarised the frequency of peat slides over a range of maximum peat depths. This summary indicates that peat slides are most frequent where the peat is between 1.0m and 2.0m thick. However, peat slides have been reported outside of this range and have been recorded up to a depth of 4.5m, though the frequency of peat slides decreases significantly at depths >1.5m. Their reasoning for this is that increased peat depth is commonly associated with greater variance in the humification of the peat profile.

Where the peat depth is less than 0.5m, instability is not typically associated with the peat but rather the underlying mineral substrate. However, whilst reduced, a risk may still remain and as such this is reflected in the scoring system. It should also be noted that no peat instability will occur where no peat or organic soil is recorded and landslides in these areas will be associated with deeper seated failures of the Glacial Till (not assessed here).

Table 5.3 Peat Depth Hazard Scoring

Peat Depth Range (m)	Score	Rationale
>3.5	2	The number of peat slides recorded in peat depths >3.5m are limited in number.
2.0 – 3.5	3	While at a lower frequency comparatively to depths between 1.0m and 2.0m some peat slides have been reported up to 3.5m.
1.0 – 2.0	5	Evans and Warburton (2010) indicate that most reported peat slides (~60 no.) occurred in this range of peat depths.
0.5 – 1.0	3	A limited number of peat slides have been reported at these depths.
<0.5	1	Failures are classified as a peaty debris slide with failure typically in the substrate material. The number of reported slides with peat depths <0.5m are comparatively few in number.

Natural Drainage

Peat hydrology and hydrogeology is complex and differing hydrogeological conditions within the acrotelm and catotelm are demonstrated in a number of studies (Warburton *et al*, 2004). In general, surface water flows are concentrated through the upper more fibrous acrotelm with flow depths up to 0.2m bgl reported. Catotelmic hydrogeology appears to be dominated by vertical seepage and concentration of flows along peat pipes.

The presence of peat pipes concentrates sub-surface flows through conduits within, or at the base of the peat profile. The peat pipes are a ubiquitous feature of upland peat and have been found to be a contributory factor in a number of peat slides reported in the literature. These features supply rainwater to the slide site or substrate (Warburton *et al*, 2003 and Nichol, 2009) and are therefore considered one of the greatest hazards.

The presence of surface drainage features such as flushes and bog pools may give rise to increased vertical migration of surface water through the catotelm leading to increased basal moistening or liquefaction of basal peat (Evans & Warburton, 2010) resulting in decreased shear strength. In addition, increasing moisture content and waterlogging of the peat will also increase the loading on the slope and basal/substrate pore water pressures. Mills (2003) attributes the presence of drainage features such as flushes discharging to the top of the slide as being a contributory factor in several reported peat slides.

The scores summarised in **Table 5.4** reflect the importance of the drainage feature in supplying rainfall directly to the failure site.

Table 5.4 Natural Drainage Hazard Scoring

Peat Depth Range (m)	Score	Rationale
Peat Pipes	5	A significant drainage pathway, often associated with peat instability. Surface water and rainfall can be rapidly transmitted to the peat / substrate interface in a storm event.
Flushes	4	Flushes have been found to be a contributory factor in peat slides and bog bursts under specific circumstances (i.e. blocking drainage lines or draining onto a slope). Flushes allow the storage and transmission of rainfall and increase the mass of the peat.
Bog Pool Complex	3	Bog pools are likely to transmit and store large quantities of water at or close to the peat substrate interface resulting in basal moistening and increased buoyancy.
Hummock and hollow complexes	2	Shallow pooling of water is unlikely to result in the rapid transmission of rainwater from the surface to the peat substrate interface but will result in increased loading.
Gullies and no obvious surface features	1	Surface pathways for slope drainage are well established, subsurface drainage is unlikely; peat landslides not usually recorded in gullied areas.

Artificial Drainage

It has been demonstrated that the presence of drainage ditches across a slope may have contributed to peat landslides in studies by authors such as Carling (1986), Dykes and Kirk (2006), Warburton *et al* (2004) and Holden, 2004. However, as there are no artificially cut drainage ditch (discounting ploughed furrows assessed as part of the forestry category) a score of 1 has been applied to the whole Development Site.

The scores summarised in **Table 5.5** reflect the three possible scenarios that may direct rainfall to a potential failure site.

Table 5.5 Artificial Drainage Hazard Scoring

Feature	Score	Rationale
Peat grips and ditches aligned across slope	5	Peat grips and ditches aligned across the slope have been demonstrated to be a contributory factor in peat slope failures.
Peat grips and ditches aligned down slope	3	Peat grips and ditches aligned down the slope are unlikely to intersect peat pipes and will transfer rainfall rapidly downslope.
No Artificial Drainage	1	No influence on peat slope stability.

Pre-failure Indicators

Relic failures and pre-failure indicators on a slope provide a strong indication that a slope is pre-disposed to a failure. The hazard rankings for pre-failure indicators are summarised in **Table 5.6**. As there were no pre-failure indications identified within the Development Site a hazard score of 1 has been applied to the whole Development Site.

Table 5.6 Pre-failure Indicators Hazard Scoring

Feature	Score	Rationale
Relic failures	5	Relic peat slides or bog bursts on a slope may indicate that slopes with similar conditions may be pre-disposed to failure.
Incipient failure features (tension and compression features)	4	Tension and compression features indicate that a failure is potentially imminent or ongoing and that the slope is strongly pre-disposed to failure.
Peat creep	3	Soil creep generally occurring in shallower peat and lower slope angles may indicate a slope's pre-disposition of rapid failure.
No failure indicators	1	No influence on slope stability.

Forestry

A report on the Derrybrien peat landslide by Lindsay and Bragg (2004) indicated that the alignments of the ploughed furrows within the commercial forestry may have contributed to the failure. The mechanism by which the ploughed furrows potentially contributed was through the drying of the peat by evapotranspiration and interception of rainfall. The drying was noted to have resulted in deep desiccation cracking along furrows essentially leading to the peat being divided into long ribbons with weaknesses between caused by fissuring of the peat. In addition, the loading of the peat by trees may influence peat stability.

Table 5.7 Natural Drainage Hazard Scoring

Feature	Score	Rationale
Deforested, ploughed furrow perpendicular to the slope	5	The removal of the canopy allows rainfall to resaturate the peat and any desiccation cracking present may allow rainwater to seep to the peat substrate interface. The ploughed furrows aligned perpendicular to the slope may present lines of weakness in the peat.
Deforested, ploughed furrow down the slope	4	The removal of the canopy allows rainfall to resaturate the peat and any desiccation cracking present may allow rainwater to seep to the peat substrate interface. However, ploughed furrows aligned down the slope presents a larger surface to resist failure.
Forested, ploughed furrow perpendicular to the slope	3	The tree canopy will restrict rainfall reaching and penetrating to the substrate interface but ploughed furrows aligned perpendicular to the slope may present lines of weakness in the peat.
Forested, ploughed furrow down the slope	2	The tree canopy will restrict rainfall reaching and penetrating to the substrate interface. Ploughed furrows aligned down the slope present a larger surface to resist failure.
Not Forested	1	

Geology

In a number of peat slides described in the literature, the substrate characteristics of the slopes have been considered a possible contributory factor. The presence of particular substrate features such as an iron pan within the soil profile below the peat was reported at three peat slides by Acreman (1991, p. 175). In other studies, Glacial Till deposits were reported at peat slides described by Crisp *et al* (1964), Tomlinson and Gardiner (1982) and Carling (1986). A basalt derived regolith and 'rubble' was noted in the study by Wilson and Hegarty (1993). Nichol (2009) noted patches of smooth rockhead at the head of a peat slide within the Scottish Highlands.

The Natural Power ground investigation indicates that the peat is typically underlain by granular deposits ranging from sand to weathered bedrock recovered as boulders. The ground investigation identified only two locations where the principle soil type was described as clay located near turbines T30 and T33. However, the locations surrounding the positions with a clay substrate were surrounded by a granular substrate.

Given that the ground investigation identified granular deposits and weathered rockhead recovered as granular material with only two small pockets of clay substrate the entire Development Site has been given a score of 1.

Table 5.8 Geology Hazard Scoring

Feature	Score	Rationale
Glacial Till and Alluvium	5	Deposits comprising mainly clay are likely to provide a discrete interface where reduced drainage and the formation of iron pans may increase the likelihood of a failure.
Impermeable bedrock	3	Impermeable bedrock, particularly those with smooth planar surfaces will provide reduced resistance to a slide.
Permeable bedrock and granular deposits.	1	Significant peat depths are unlikely to form on permeable bedrocks and few slides are associated with granular substrate materials.

5.3 Peat slide Stability Assessment

A semi-quantitative peat slope stability assessment has been undertaken in accordance with the methodology detailed within Scottish Government best practice guide (2017). The 'Infinite Slope' method of analysis, after Skempton and DeLory (1957), is the most well established and commonly applied method for the preliminary assessment of peat slope stability. An assessment of the slope stability has been performed for the undrained and drained cases, using *in-situ* testing results obtained during the Natural Power ground investigation and literature values, respectively.

Drained Case

The factor of safety of a given slope for the drained case scenario assuming a steady seepage is calculated by comparing the sum of the resisting forces with those of the destabilising/acting forces, given by the following equation:

$$\mathbf{F} = \frac{Shear\ Resistance}{Shear\ Forces} = \frac{c' + (\gamma - m.\gamma w).z.cos^2\beta.tan\phi'}{\gamma.z.sin\beta.cos\beta}$$

Where:

F = Factor of Safety
c' = Effective cohesion

γ = Bulk unit weight of saturated peat
γ_w = Unit weight of water
m = Height of water table as a fraction of the peat depth
z = Peat depth in the direction of normal stress
β = Angle of the slope to the horizontal
ϕ' = Effective angle of internal friction

As an onerous number of samples would be required to sufficiently characterise the geotechnical parameters of the peat, testing was not undertaken for the preliminary assessment. As such, the geotechnical parameters for this assessment have been obtained from a review of literature sources. A summary of literature values used to inform the stability analysis are presented in **Table 5.9** below.

Table 5.9 Geotechnical parameters of peat derived from literature review

Reference	Effective cohesion c′ (kPa)	Effective angle of friction φ′ (°)	Unit weight ɣ (kN/m3)	Comments
Hanrahan et al (1967)	5.5 – 6.1	36.6 – 43.5	-	Remoulded H_4 *Sphagnum* peat
Hollingshead and Raymond (1972)	4.0	34	-	-
Landva and La Rochelle (1983)	2.4 – 4.7	27.1 - 35.4	-	*Sphagnum* peat (H3, mainly fibrous)
Carling (1986)	6.52	0	10	-
Rowe and Mylleville (1996)	2.5	28	10.2	Fibrous peat
Kirk (2001)	2.7 – 8.2	26.1 – 30.4		Ombrotrophic blanket peat
Warburton et al (2003)	5.0	23	9.68	Basal peat
Warburton et al (2003)	8.74	21.6	9.68	Fibrous peat
Dykes and Kirk (2006)	3.2	30.4	9.61	Acrotelm
Dykes and Kirk (2006)	4.0	28.8	9.71	Catotelm
O'Kelly and Zhang (2014)	0	28.9 - 30.3	-	Pseudo-fibrous peat
Estimated Design Value	**5.0**	**23**	**10**	**-**

The design values given in **Table 5.9** have been adopted on a site wide basis. The water table level is assumed to be at ground level (m = 1) to provide a conservative assessment based on flooded conditions (i.e. worst case heavy rainfall).

The Factor of Safety (FoS) **F** values for the Development Site have been calculated using ESRI ArcGIS Spatial Analyst Raster Calculator to derive the **F** value from the interpolated peat depth map, DTM and the design values given in **Table 5.9**. In addition, a loaded analysis has been conducted by adding a load of 10 kPa equivalent to the load implied by a 1m high stockpile of peat (for example side cast during road construction) to the shearing forces.

The Factor of Safety results are summarised in **Figure 12.0** in **Appendix A**.

The best practice guidance suggests that F values of <1.0 should indicate slopes that have or may in future experience failure under the modelled conditions and as such are considered areas of increased risk. However, Boylan *et al* (2008) argue that given the uncertainties in relation to the strength of peat and factors that cause peat landslides a cautious approach should be adopted. Their study indicates that a relatively high **F** value should be used to identify slopes with the potential for instability and as such an **F** value of 1.4 has been used in this assessment.

The results of the infinite slope analysis for the unloaded scenario reveal that under the modelled conditions the entire Revised Consented Development layout is within areas with an **F** value >1.4. There are only two very small areas at significant distances from the Revised Consented Development with **F** values <1.4. These are located approximately 460m south of T60 and 710m northwest of the control building compound along the edges of the Meur an Fhraoich and Reay Burn, respectively. The results are noted to be consistent with the conditions on site where no relic or incipient failure features were identified.

The loaded analysis reveals that five areas of the Development Site with **F** values <1.4. However, with the exception of one area, all of them are located more than 150m or upslope of the Revised Consented Development layout. In the centre of the Development Site, in the location of some of the deepest peat within the Development Site is an area with **F** values <1.4 located along the access track between T26 and T32. This area is also shown to contain a limited number of calculated cells with **F** values <1.0 located either side of the track approximately 200m north of T32.

Although the preliminary stability assessment indicates that areas of the Proposed Development may be susceptible to failure, there is considerable uncertainty in the geotechnical parameters of peat identified in the literature (Boylan *et al*, 2008) and no site-specific assessment has been undertaken. As such, a pessimistic approach and relatively high factor of safety has been used in the stability assessment. Therefore, the factor of safety values calculated herein should only be considered as indicative of the potential peat slope stability. A detailed assessment of the peat slope stability should be undertaken using site specific design parameters taken from a ground investigation, particularly where slope angles exceed approximately 3° and peat depths exceed 1.0m.

Undrained Case

Where the slope is assumed to fail translationally in an undrained manner, the factor of safety of a given slope is calculated using the formula given in Skempton & Delory (1957) shown below:

$$\mathrm{F} = \frac{Shear\ Resistance}{Shear\ Forces} = \frac{Cu}{\gamma.z.sin\beta.cos\beta}$$

Where:

F	=	Factor of Safety
Cu	=	Shear strength
γ	=	Bulk unit weight of saturated peat
z	=	Peat depth in the direction of normal stress
β	=	Angle of the slope to the horizontal

In total 81 hand shear vane tests were undertaken in the trial pits during the Natural Power ground investigation of the Consented Development layout. The testing was performed at a range of depths from 0.3m to 3.8m below ground level. The shear strengths results ranged between 0.6 kPa and 26.9kPa with the lowest results typically within the deepest peat. A review of the results reveals that there is an apparent distinction between the shear strengths of shallow peat <1.0m and deeper peat >1.0m. The tests indicate that in areas of peat <1.0m deep the average shear strength is 11kPa and in areas of peat >1.0m the average shear strength is 5kPa. The infinite slope analysis has been undertaken based on peat shear strength of 5kPa for deep peat >1.0m and 11kPa for shallow peat <1.0m. The bulk unit weight of the peat has been derived from the literature sources and estimated design value presented in **Table 5.9** above. The factor of safety values have been calculated for the loaded and unloaded scenario as per the drained case.

While *in-situ* hand shear vane testing is commonly used to establish the undrained strength of peat, the interpretation of hand vane results is complicated by the presence of fibres and the ease of deformation of the peat during the test (Boylan *et al*, 2008). In addition, it is possible that some drainage around the vane is unavoidable during the test and as such, hand shear vane testing and its interpretation should be used with caution and an understanding of the limitations of the test method when applied to peat. However, hand shear vane testing does provide a useful indication of the strength of the peat and is particularly useful in identifying soft layers within the peat (which is demonstrated above).

The Factor of Safety results are summarised in **Figure 12.0** in **Appendix A**.

As per the drained case, **F** values of less than 1.4 has been used in this case to indicate slopes that have or may in future experience failure under the modelled conditions and as such are considered areas of increased risk.

The results of the undrained case analysis for the unloaded scenario reveal that under the modelled conditions the entire Revised Consented Development layout is within areas with an **F** value >1.4 indicating stable conditions. The loaded analysis reveals that there is an area of susceptibility to the north of T32 as identified in the drained case analysis.

6. Peat slide Risk Assessment

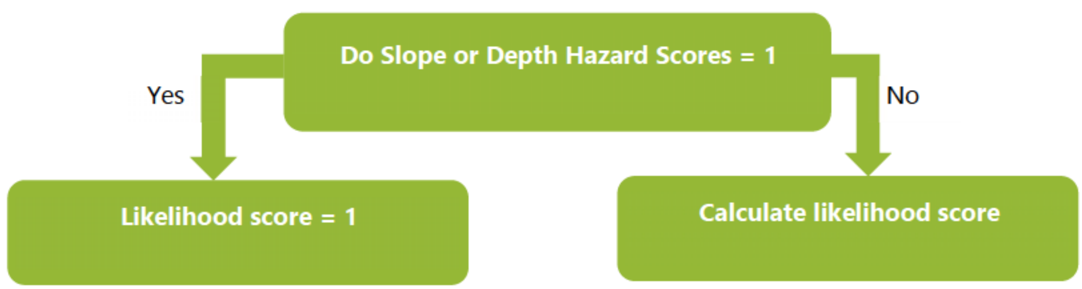
The approach for assessing the risk of a peat slide occurrence considers the combination of hazards factors (or likelihood assessed above) associated with a particular area of peat multiplied by the consequences of a failure. The assessment of the perceived hazards in combination with the potential consequences (or exposure) represents the assessment of peat landslide risk. This provides a means of identifying areas of the Development Site where there is a potential risk of a slide occurring such that preventative measures may be prioritised at an early stage of the Proposed Development.

6.1 Peat Landslide Likelihood

Hazard scores have been mapped across the Development Site as detailed in Section 5. This has been achieved using GIS to create ranked polygons for each category based on desk-based information and site observations. The polygons have been converted to raster layers using the hazard ranking score and summed to provide a peat landslide likelihood score.

The above method does not take account of conditions where a peat slide is unlikely given the slope angle and peat depth conditions. As such, in order to account for this, the key contributory factors of slope angle and peat depth have been used to weight the hazard assessment as shown in **Figure 6.1** below.

Figure 6.1 Peat landslide likelihood weighting



The above method therefore applies to areas where it is considered that a peat landslide is unlikely due to the absence of peat depths and slope conditions that are considered conducive to peat landslide failure.

Based on this system the hazard scores in this assessment range from 1 (negligible likelihood) to a maximum of 35 (almost certain likelihood). **Table 6.1** outlines the hazard score ranges and how these scores relate to the likelihood score taken forwards in the assessment of peat landslide risk. The scoring system also takes into account the infinite slope analysis described in Section 5.3 to adjust the likelihood scores in areas where the likelihood of failure is increased based on the preliminary geotechnical assessment of peat slope stability.

Table 6.1 Peat landslide likelihood scores

Hazard Score	F Value	Likelihood	Likelihood Score
1-7	>1.4	Negligible	**1**
8-14		Unlikely	**2**
15-21	>1.0 < 1.4	Likely	**3**
22-28		Probable	**4**
29-35	<1.0	Almost Certain	**5**

The results of the likelihood assessment are presented in **Figure 13.0** in **Appendix A**.

The results of the likelihood assessment indicate that very few areas are considered to have Likely or above probability of a peat landslide. The nearest areas to the Revised Consented Development with a likelihood score of 5 are located either side of the access track approximately 200m north of T32 that are associated with the likelihood identified by the loaded infinite slope analysis. In general, the likelihood of a peat landslide for the remainder of the Development Site is negligible to unlikely.

6.2 Consequence

A key step in the peat landslide risk assessment is to identify the potential effects that a peat slide may have on key receptors. The assessment of peat landslide consequences is a qualitative assessment of the effects on key physical and environmental receptors such as:

- Loss of human life;
- Public infrastructure (road, rail, utilities and public water supplies);
- Property (homes);
- Surface water (rivers and streams including protected ecology);
- Cultural and Heritage sites; and
- Ecology (rivers & terrestrial, including priority habitats).

In addition to considering the immediate impacts, the potential long-term impacts such as the cost and time taken for recovery of ecosystems and revegetation are also taken into account as part of the assessment of the consequences.

Predicting the magnitude of a failure and the run-out distance is very difficult as this depends on the nature of the peat source and the relative proportions of peat to water (Evans and Warburton, 2010). In addition, should a peat slide enter a watercourse, run-out distances and impacts may be observed many kilometres downstream of the source area as was the case at the Derrybrien failure in Co. Galway, Ireland in 2003 (Bragg & Lindsay 2005). In these cases, the impacts may be observed over a significant proportion of the catchment and are likely to remain observable in the relatively long term. However, in many instances minor slumping is localised and little or no impact to receptors is observable.

As estimated by the infinite slope analysis, the likelihood of a peat slide occurring under the natural unloaded conditions is considered to be negligible. As such, the construction of the proposed wind turbines and associated infrastructure are considered to be the only activities with the potential to significantly alter the peat slope stability (e.g. by cutting), not-withstanding climate change. Therefore, the risk assessment only considers the potential consequences on downslope receptors from the Revised Consented Development, if the source was at, or near, the proposed infrastructure.

In order to establish the exposure, information on the key receptors has been assessed in GIS and the likely consequences determined by the location of receptors relative to proposed infrastructure. The assessment considers that any receptor is at risk of an impact from an infrastructure location regardless of distance. However, the assessment does consider the presence of physical barriers such as water courses, valleys and breaks in slope which would abruptly redirect or halt a peat landslide. It should be noted that this is a conservative assessment of the risk.

Consequence scores have been considered for distances up to 500m from the Development Site boundary taking into account the local topography where a slide may run from an onsite location to an offsite receptor.

Tables 6.2 to 6.4 outline the consequence classifications. **Figure 14.0** in **Appendix A** shows the receptors that have been considered in the assessment and illustrates the worst case consequence scores based on the maximum consequence score from any one of the receptors. It is these values that have been taken forward to the Peat Landslide Risk Assessment.

While it is recognised that there are property and highways receptors near the Development Site boundary, neither are considered to be directly in line with the potential runout of a peat landslide originating from the Revised Consented Development. This is due to the distance to receptors which is more than 2km from the nearest element of the Revised Consented Development and the topography which rises or levels out between the Revised Consented Development and the receptors.

Table 6.2 Consequences for cultural and ecological receptors

Consequence (Score)	Cultural and Heritage Sites	Ecology (including GWDTE's)
5 - Very High	Potential for damage to Scheduled Monuments of national importance.	Destruction of designated sites. Impacts requiring significant cost and time to restore.
4 - High	-	-
3 - Moderate	Potential for damage to or loss of non-scheduled cultural and heritage sites.	Destruction of sensitive groundwater dependent eco-systems requiring high restoration costs.
2 - Low	-	-
1 – Very Low	No cultural or heritage sites within the potential runout zone.	Destruction of non-designated habitats and ecosystems (e.g. open moorland and farm land).

Table 6.3 Consequences for man-made receptors

Consequence (Score)	Public Infrastructure (road, railways, utilities public water supplies)	Property (residential properties, cattle and commercial forestry)
5 - Very High	Damage to infrastructure. Serious damage and potential for death. Long term delays, very high repair costs and serious social and economic impacts on the community.	Loss of life at a residential property.
4 - High	Blockage to either A roads. Short term delays, high repair costs and social and economic impacts on the community. High costs to provide temporary measures	-

Consequence (Score)	Public Infrastructure (road, railways, utilities public water supplies)	Property (residential properties, cattle and commercial forestry)
	to maintain supplies / services (e.g. tankered water supply).	
3 - Moderate	Damage or blockage of unclassified roads. Low repair costs, short term delays and low social and economic impacts on the community.	Damage to fields and pasture land. Loss of livestock. Loss of forestry and damage to plantations.
2 - Low	Damage or blockage of unclassified access tracks. Very low repair costs, short term delays and economic impacts on individuals (i.e. residents and landowners).	-
1 – Very Low	The significant impacts of peat slide or bog burst are unlikely to be observed at the receptor.	The significant impacts of peat slide are unlikely to be observed at the receptor.

Table 6.4 Consequences for hydrological receptors

Consequence (Score)	Surface Water	Private Water Supplies
5 - Very High	Potential for impacts on protected river or loch. Significant impacts including a large reduction of animal populations. Impacts requiring high costs to restock and / or restore. Very high socio-economic impacts (e.g. long term suspension of fishing).	Potential for impacts on water supplies. High cost impacts such a repair and/or replacement or other long term measures.
4 - High	Potential for impacts on a river or stream leading to a downstream protected river or loch. Impacts on protected receptors are likely to be less significant due to dilution of contaminants. Potential for high socio-economic impacts (e.g. reduction in fishing).	-
3 - Moderate	Potential for impacts on an unprotected river or loch. Impacts requiring lesser restoration works. Moderate to high socio-economic impacts (e.g. reduction in fishing on a river of lesser importance).	Potential for damage to residential private water supplies downstream of the site. Lower cost impacts.
2 - Low	Potential for impacts due to peat indirectly entering an unclassified and / or unprotected river or loch. Low socio-economic impacts (e.g. impacts on a river of little importance to fishing).	-
1 – Very Low	Peat entry into a surface water feature that is not protected and is not important for fishing.	Very low or no potential for impacts on water supplies.

6.3 Peat Landslide Risk Assessment

The overall risk of a peat slide event has been calculated as the product of the likelihood and consequence score. **Table 6.5** shows the associated risk ranking as derived from Table 5.3 in the best practice guidance and provides the indicative risk of a peat slide.

Table 6.5 Risk Ranking

		Consequences				
		Very Low	Low	Moderate	High	Very High
Likelihood		1	2	3	4	5
Negligible	1	1	2	3	4	5
Unlikely	2	2	4	6	8	10
Likely	3	3	6	9	12	15
Probable	4	4	8	12	16	24
Almost Certain	5	5	10	15	20	25

The suggested actions based on the peat landslide risk are summarised in **Table 6.6** below.

Table 6.6 Suggested actions based on Risk Ranking

Risk	Suggested Action
>20 - High	Avoid Proposed Development at these locations.
10 – 19 - Moderate	Proposed Development should not proceed unless hazard can be avoided or mitigated at these locations, without significant environmental impact, in order to reduce risk ranking to low or negligible.
5 to 9 - Low	Proposed Development may proceed pending further investigation to refine assessment and mitigate hazard through relocation or re-design at these locations.
1 to 4 - Negligible	Proposed Development should proceed with monitoring and mitigation of peat landslide hazards at these locations as appropriate.

The results of the peat landslide risk assessment are presented in **Figure 15.0** in **Appendix A**. The findings of the peat landslide risk assessment outlined above indicate that the Development Site is considered to have a Negligible to Low Risk of peat slide failure with one localised area of Moderate Risk identified to the north of turbine 32. The area of Moderate Risk is associated with infinite analysis which indicated Factor of Safety values less than 1.4 in this area.

When comparing the potential peat landslide risks at the Consented Development and Revised Consented Development the potential risks are considered to be in general agreement (i.e. Low), as the access track layouts pass through similar lengths of Negligible and Low Risk areas. However, it is recognised that the Consented Development proposed to widen existing tracks rather than construct new access tracks. In addition, it is noted that an area of Moderate Risk has been identified along the access track between turbines 26 and 32 which will require further investigation and assessment prior to construction.

7. Mitigation Measures

As discussed in Section 6, under the current conditions the likelihood of a peat landslide is considered to be Negligible to Low and the Factor of Safety values are typically in excess of 1.4 for both the loaded and unloaded conditions with the exception of one area near turbine 32. The construction of the Revised Consented Development and alterations of the slopes are considered a potential trigger (along with other contributory and trigger factors) that may increase a slope's susceptibility to peat instability. In general, the construction practices which should be avoided, include:

- Stockpiling and side casting of excavated materials on, or at the top of marginally stable peat covered slopes;
- Loading of susceptible peat by floating roads;
- Removal or breaking of acrotelmic peat beneath floating roads;
- Removal of support at the toe of peat covered slopes; and
- Poor drainage practices such as the draining of excavations, and placement of outfalls on to peat covered slopes or blocking of drainage channels.

Further discussion on specific mitigation measures is provided in the sub-sections below.

7.1 General Considerations

Prior to construction, a detailed ground investigation should be undertaken to assist in detailed design of the Revised Consented Development as well as any slope modification. It is assumed that this would form part of the planning conditions for the Section 36C application. This is also considered the best opportunity to confirm the peat landslide hazard assessments and to perform detailed assessment of the most susceptible slopes based on site specific parameters, observations and the proposed construction methods.

In addition to the above, detailed ground investigation of the Revised Consented Development should determine the slope stability of mineral superficial deposits and bedrock where placing infrastructure will require slope cuts and benching.

The ground investigation should aim to provide information on the geotechnical characteristics (e.g. shear strength and bulk density) of the peat and underlying mineral substrate. The results of the ground investigation should inform the development of a geotechnical risk register which should be reviewed and updated at each stage of the post-consent phase of the Revised Consented Development.

7.2 Turbine Locations

At turbine locations where there are shallow peat depths and negligible peat landslide risk normal best practice construction methods may be employed (e.g. Scottish Renewables, Scottish Natural Heritage, SEPA and Forestry Commission guidance).

Where turbines will be within areas of Low or Moderate peat landslide risk further detailed assessment should be considered alongside mitigation measures should further assessment confirm the slopes potential susceptibility to failure. In general, mitigation measures should aim to maintain current drainage routes or divert it to purpose-built drainage networks to reduce the impact on the peat hydrogeology, hydrology and avoid the surface loading of slopes. These mitigation measures may include the following:

- Avoidance of stockpiling and side casting on slopes considered to be Low to Moderately at risk of peat landslides or with peat depths >1.0m;
- Avoiding discharge of water from excavations onto peat, particularly to the head of peat covered slopes, flushes, furrows and grips. Wherever possible water should be directed to purpose-built, reinforced, drainage channels;
- The accumulation / ponding of water within excavations should be avoided and pumping out of excavations should be to purpose built drainage networks;
- Upslope of the turbine excavation / base and the crane pads, drainage ditches or culverts may be constructed to divert flows to a purpose-built drainage network in order to maintain flows and prevent upslope ponding; and
- Adequate drainage should be designed to cater for expected heavy rainfall events such that there is no possibility of water ponding upslope.

7.3 Tracks

Cut / Excavated Tracks

Cut tracks, where the foundation of the track will be on the underlying bedrock or superficial deposits, are proposed for areas with peat depths <1.0m. Where a cut track is required through areas of Low or Moderate risk of a peat slide, further detailed investigation will be required to confirm the peat landslide risk assessment. Where required, mitigation measures should aim to maintain or divert water away from slopes in order to avoid surface water ponding; and, where peat covered slopes will be undercut, measures must be included to ensure that the peat is supported. These measures may include the following:

- Adequate drainage should be designed to intercept surface water from flushes, peat exposures, peat grips and drainage ditches. This water should be redirected down slope along a purpose-built drainage network. This network should be capable of transferring flows during expected heavy or prolonged rainfall events;
- Where upslope ponding occurs, measures should be taken to drain the area to the purpose-built network;
- Drainage outfalls on to the peat or any flushes should be avoided. Where an outfall will drain to a surface water channel, measures should be installed to avoid erosion and headward gully formation.

In addition, to avoid water ponding upslope of the track, storage locations for excavated spoil, rock and peat should be carefully selected to avoid loading moderately stable slopes or slopes with peat depths >1.0m.

Floating Roads/Tracks

Floating tracks are proposed for areas with peat depths >1.0m. Best practice guidance on the design and construction of floating roads on peat is well documented (NatureScot and Forestry and Land Scotland) and the guidance and methods presented therein should be implemented during design and construction of floating tracks.

Where floating roads are required, the route should be subject to detailed ground investigation including an assessment of the bearing capacity of the peat in relation to the maximum loads it may experience, loading rates and slope stability. In addition, the route of the floating road should be walked to identify the location of possible surface and sub-surface peat drainage features crossing the proposed routes in order to target mitigation measures, which should aim to maintain these drainage routes, but avoid focussing them on to susceptible slopes. This may require non-intrusive methods of ground investigation to identify as many of the sub-surface features as possible.

In addition to the above, further mitigation measures that may be required include:

- Surface vegetation and acrotelmic peat should be left *in-situ* to provide additional strength and support;
- Floating road construction should be conducted at a rate which allows sufficient time for the peat to 'rebound' and regain strength. This may involve applying aggregates in a number of layers and monitoring of settlement;
- Construction of the floating roads should be conducted outward from the starting point so as to limit loadings directly onto peat by construction traffic;
- Measures to limit the weight of delivery vehicles may be required to reduce loading onto the peat during construction; and
- Targeted monitoring of slope stability and ground movement will be required throughout construction and a detailed monitoring programme should be developed for sensitive areas prior to construction.

The above mitigation measures will also be required at locations where a displacement crane pad is required.

7.4 Borrow Pits

The Revised Consented Development contains one borrow pit in an area of Negligible Risk. It is understood that the borrow pit has been consented and partially excavated to obtain rock for the construction of the main access track. It is assumed that appropriate further assessment and mitigation measures are already in place to minimise the risk of a peat landslide.

7.5 Side Casting & Stockpiling of Subsoils

A peat management plan detailing the measures for handling and storage of peat and the design and selection of peat and subsoil storage areas has been prepared separately to this peat landslide risk assessment. The recommendations of the peat management plan should be followed throughout the construction of the Revised Consented Development and storage areas should be confirmed through detailed ground investigation and confirmation of the peat landslide risks at the stockpiling areas.

Storage of excavated materials on slopes with peat depths >1.0m and areas with Low or Moderate peat landslide susceptibility should be avoided. Where storing of materials in these areas is unavoidable, a detailed assessment of their stability should be undertaken during the post consent ground investigation and mitigation measures similar to those for floating and cut tracks should be employed accordingly.

7.6 Other Proposed Development

The proposed temporary construction compound is all located within an area of Negligible Risk of peat landslides. As such, following ground investigation, construction may be undertaken using normal best practice methods and the mitigation measures discussed for cut access tracks.

8. Conclusions & Recommendations

8.1 Conclusions

A peat landslide risk assessment has been conducted in general accordance with the Scottish Government best practice guidance document Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (2nd edition, 2017). The preliminary methodology has used a qualitative assessment of the hazards supported by field observations and a deterministic approach supported by field observations and published literature.

A number of peat probing surveys and a ground investigation have included a total of 5,363 peat depth measurements which reveal that approximately 51% of the Development Site has peat depths >0.50m. In general, peat depths ranged between 0.00m and 4.90m with the deepest peat recorded in localised areas between turbines 26 and 43 and at or near the locations of turbines 25, 54, 55, 30 and 57.

An assessment of peat landslide likelihood has been undertaken to assess the likelihood of a peat landslide failure within the Development Site by combining the results of a hazard assessment and the results of the infinite slope analysis. The results of the infinite slope analysis reveal that under unloaded conditions the majority of the Revised Consented Development has an **F** value >1.4 with only two very small areas at significant distances from wind farm infrastructure that have **F** values <1.4. In the loaded scenario five areas of the Development Site have **F** values <1.4 with the most notable located on the access track between turbines 26 and 32. The results of the likelihood assessment indicate that there are very few areas considered to a Likely or higher likelihood of a peat landslide and that the site predominantly has a Negligible or Unlikely likelihood. The most notable area is approximately 200m north of turbine 32 that was identified as having a Likely likelihood based on the loaded infinite slope analysis.

A peat landslide risk assessment of the Revised Consented Development, using the method outlined in the best practice guide, indicates that receptors are considered to be at predominantly a Negligible to Low Risk of peat slide failure. There is one localised area of Moderate Risk identified to the north of turbine 32. In addition, comparison of the potential peat landslide risks at the Consented Development and Revised Consented Development indicates that the risks are comparable (i.e. Low), as the access track layouts pass through similar lengths of Negligible and Low Risk areas.

8.2 Recommendations

The following recommendation are provided based on the assessments conducted herein.

A post-consent detailed ground investigation is recommended to assist in detailed assessment of peat slope stability in the most sensitive areas of the Revised Consented Development. The ground investigation should also aim to establish the nature and geotechnical parameters of the peat and peat substrate interface. It is recommended that ground investigation information is used to check/verify the peat slope stability assessments.

It is also recommended that mitigation measures are employed as required, particularly where crossing peat pipes, flushes, peat grips and drainage ditches. The mitigation measures employed should aim to maintain the current drainage of the peat, avoid ponding of surface water upslope of the Revised Consented Development and redirect drainage to a purpose-built network. In addition, monitoring of slopes may be required where a detailed ground investigation of the proposed infrastructure confirms that sensitive slopes may be moderately susceptible to peat landslides.

In conjunction with the above, a geotechnical risk register should be developed and maintained by a Geotechnical Engineer throughout the life cycle of the Revised Consented Development. During construction, a Geotechnical Clerk of works should also be present on site to monitor sensitive slopes for movement and to manage any changes to the peat landslide risks.

9. Bibliography

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Appendix A
Figures