Technical Appendix 8.6: Peat Landslide Hazard Risk Assessment

Technical Appendix 8.6: Peat Landslide and Hazard Risk Assessment

8.6.1 Introduction

8.6.1.1 The objectives of the PLHRA are to:

- Undertake a desk-based review of published information including geological, hydrogeological and topographical information, to inform the baseline for the PLHRA;
- Undertake site visits to identify evidence of, and potential for, active, incipient or relict peat instability, including identification of the location of features as required;
- Reporting on evidence of any active, incipient or relict peat instability, and the potential risk of future instability, describing the likely causes and contributory factors;
- Identify potential controls to be imposed during the construction phase to minimise the risk of any peat instability at the Site; and
- Identify requirements for further work or specific construction methodologies to suit the ground conditions to mitigate against any increased risk of potential peat instability.

8.6.1.2 The scope of the PLHRA is as follows:

- Characterise the peatland geomorphology to determine whether there have been prior occurrences of instability, and whether contributory factors that might lead to instability in future are present across the Site;
- Determine the likelihood of a future peat landslide under natural conditions and in association with construction activities associated with the Proposed Development;
- Identify potential receptors that might be affected by peat landslides, should they occur, and quantify the associated risks; and
- Provide appropriate mitigation and control measures to reduce the risks to acceptable levels such that the Proposed Development is constructed safely with minimal risks to the environment.
- The contents of this PLHRA have been prepared in accordance with the Scottish Government's Best Practice Guidance[1], noting that the guidance '*should not be taken as prescriptive or used as a substitute for the developer's [consultant's] preferred methodology'*.

8.6.1.3 A series of Figures are included with this Technical Appendix in **Annex 8.6.1**.

8.6.2 Methodology

8.6.2.1 A desk study and several field surveys were undertaken to gather baseline conditions of the Site and allow a PLHRA to be completed. The desk study included an overview of the following elements to inform the baseline design:

- Bedrock and superficial geology from BGS Mapping[2];
- Peatland and peat characteristic information from the Scottish Natural Heritage (NatureScot) carbon rich soils, deep peat and priority habitat[3];
- Habitat survey information from **Chapter 6: Ecology (EIAR Volume 2)**;
- Hydrogeological and Hydrology information from **Chapter 8: Hydrology, Hydrogeology and Geology and Soils (EIAR Volume 2)**;
- Topographical information taken from published Digital Terrain Model (DTM) LIDAR data;
- Media articles, historic maps and local landowner accounts of historic land movements; and
- Meteorological rainfall data[4].

8.6.2.2 The results of the desk study are discussed **Section 8.6.3** of this report.

Field Survey

8.6.2.3 Peat depth surveys were undertaken across the Site, with the surveys designed based on best practice guidance for surveying developments on peatland[5].

8.6.2.4 A Stage 1 peat survey was undertaken during June 2024 by Ramboll UK Limited (RUK). The Stage 1 survey is a preliminary, low-density survey and was carried out on a 100 m grid across the Site within areas of likely peatland. The probing was carried out using collapsible avalanche probes, allowing for probing in excess of 6 m. However, such depths were not reached. Areas of the Site which were considered to be outwith the area to be considered for development were excluded from the survey area.

8.6.2.5 A Stage 2 peat survey was undertaken by RUK in April 2025. The survey comprised probing at refined locations to target proposed turbine locations, access tracks and potential borrow pit locations. Survey details as follows:

- Turbine locations: Peat probing was carried out at 10 m intervals along cardinal points from the central point of each turbine location to a distance of 50 m; and
- Access tracks: 50 m intervals along the track and at points every 10 m perpendicular to the centreline on either side of the proposed track.

8.6.2.6 During this survey, peat cores were taken and a number of field tests and observations were undertaken to identify:

- Depth of acrotelm;
- Degree of humification (using Hodgson, 1974[6]), to establish amorphous, intermediate, fibrous and content;
- Degree of humification using the Von Post, (Hobbs, 1986[7]) classification;
- Fine fibre content, based on scale of F0 (none) to F3 (very high);
- Coarse fibre content, based on scale of R0 (none) to R3 (very high);
- Water content, based on scale of B1 (dry) to B5 (very wet); and
- Substrate underlying the peat where this was possible.

8.6.2.7 A second Stage 2 peat survey was undertaken by RUK in August 2025. This survey comprised probing along the Eastern access track in line with the guidance detailed above for access tracks.

Limitations and Assumptions

8.6.2.8 Surveying has been undertaken based on the Proposed Development design and associated infrastructure locations available at the time of the survey to inform the assessment of the layout submitted for consent. The data collected to inform this PLHRA is considered sufficient to support a robust assessment of the peat landslide hazards and risks. Should the infrastructure design change

[1] Scottish Government (2017). Peat Landslide Hazard and Risk Assessments, Best Practice Guide for Proposed Electricity.
[2] Available at: GeoIndex (onshore) - British Geological Survey
[3] Available at: https://opendata.nature.scot/maps/171df29c8c5b45a9b93438a3bc5700c6
[4] Met Office Weather Data Dumfries: https://www.metoffice.gov.uk/research/climate/maps-and-data/location-specific-long-term-averages/gcv3nm521
[5] Scottish Government, Scottish Natural Heritage, SEPA. (2017). Peatland Survey. Guidance on Developments on Peatland. Available at: https://www.gov.scot/publications/peatland-survey-guidance/
[6] Hodgson, J.M (1974) Soil Survey Field Handbook.
[7] Hobbs N.B. (1986). Mire morphology and the properties and behaviour of some British and Foreign peats. Quarterly Journal of Engineering Geology, 19, pp7-80.

outside the incorporated limits of deviation, then further surveying and subsequent amendments to the PLHRA reporting may have to be undertaken.

8.6.3 Desk Study and Site Information

8.6.3.1 The Site location and setting are described in **Chapter 2: Description of Proposed Development (EIAR Volume 2).**

Topography

8.6.3.2 The Site topography is generally undulating, a moderately steep landscape is sculpted around four main hill peaks (Comb Law, Watchman's Brae, Rodger Law and Ewe Gair). Ground elevation varies significantly from 380 metres Above Ordnance Datum (mAOD) in the east to 68 mAOD at the summit of Rodger Law which is located in the west of the Site. Comb Law is located towards the north of the Site with its summit at 645 mAOD. Watchman's Brae is in the east of the Site with its summit at 594 mAOD. Ewe Gair is located in the south of the Site Boundary with its summit at 559 mAOD. Topography and elevation are shown on **Figure 8.6.1**.

8.6.3.3 Slope angles at the Site, as shown on **Figure 8.6.2**, are summarised below:

- Turbine 1 moderately steep (10 to 15°);
- Turbine 2 moderately steep (10 to 15°);
- Turbine 3 moderately steep (10 to 15°);
- Turbine 4 steep (15 to 20°);
- Turbine 5 moderately steep (10 to 15°);
- Turbine 6 generally moderate (5.1 to 10º);
- Turbine 7 generally moderate (5.1 to 10º);
- Turbine 8 generally shallow (2.1 to 5°);
- Turbine 9 generally moderate (5.1 to 10º);
- Turbine 10 generally moderate (5.1 to 10º);
- Turbine 11 generally moderate (5.1 to 10º);
- Turbine 12 moderately steep (10 to 15°); and,
- Turbine 13 generally moderate (5.1 to 10º).

8.6.3.4 Borrow Pit 01 (BP01), located in the north, is located on generally moderate (5.1 to 10°) to locally steep (15 to 20°) ground associated with the northern slopes of Hem Hill.

8.6.3.5 Borrow Pit 02 (BP02), located in the south, is located on shallow (2.1 to 5°) to locally steep (15 to 20°) ground associated with the southern slopes of Rodger Law.

8.6.3.6 The BESS is located on generally moderate (5.1 to 10°) to moderately steep (10.1 to 15°) ground.

8.6.3.7 The construction compound is located on shallow (2.1 to 5°) to generally moderate (5.1 to 10°) ground.

8.6.3.8 The substation is located on generally moderate (5.1 to 10°) ground.

8.6.3.9 The hardstand permanent, temporary and clearance are located on very shallow (<2.0°) to locally steep (15 to 20°) ground.

8.6.3.10 Access track sections (refer to reference numbers shown on **Figure 8.6.10)** are detailed below:

- Generally moderate (5.1 to 10º) = Sections 1, 12, 28, 34, 3;
- Moderately steep (10 to 15°) = Sections 2, 3, 4, 5, 6, 7, 8, 10, 11, 13, 14, 15, 18, 22, 25, 26, 29, 30, 31, 32, 33, 36, 38, 39;
- Steep (15 to 20°) = Sections 9, 16, 17, 20, 23, 24, 27, 37; and
- Very Steep (>20°) = Sections 19 and 21.

Geology

8.6.3.11 The 1:50,000 scale geological mapping available from the British Geological Survey (BGS)[2] shows most of the Site is underlain by Silurian-aged Mindork Formation, metasandstone and metamudstone. The BGS Lexicon[8] describes the formation as a thick-bedded to massive, medium to coarse grained greywacke. Towards the east of the Site, by Rodger Law, the bedrock is mapped as Silurian-aged Gala Unit 4 Wacke, of the Gala Group. Gala Unit 4 is described by the BGS Lexicon as graded beds that may include wacke sandstone, siltstone and mudstone in variable proportions, interpreted as turbidites. Conglomeratic beds are a feature of this unit. Siltstone interbeds yielded fauna of the cyphus to triangulatus Biozones. A Devonian-aged Ballencleuch Law Granite Intrusion is mapped oriented southwest-northeast west of Rodger Law partially separating the aforementioned bedrock geologies. The BGS Lexicon notes Ballencleuch Law Granite intrudes wackes of the Gala Group. The western border of the Site, in the north where the Western Access track enters the Site from the A702, is mapped as Ordovician-aged Shinnel Formation wacke, described as a wacke sandstone and siltstone turbidite succession. Bedrock geology is shown on **Figure 8.6.3.1**.

8.6.3.12 BGS mapping[2] shows superficial geology is absent across most of the Site. Deposits of Devensian-aged Till – Diamicton are mapped bordering the Site to the west, north and east, with a local deposit in the centre of the Site. Quaternary-aged Alluvium is mapped overlying the Till in areas. Local areas of peat are mapped across the Site, with the largest area mapped towards the southwest of the Site, at the western toe of Rodger Law. Superficial Geology is shown on **Figure 8.6.3.2**.

8.6.3.13 BGS mapping[2] shows three fault lines, running approximately parallel in a southwest to northeast direction. A reverse/thrust fault borders the western edge of the Site (hanging wall towards west), a fault of unknown displacement is mapped towards Watchman's Brae, and a reverse/thrust fault is mapped bordering the Site to the east (hanging wall east). Each fault represents a boundary between the rock formations discussed above. The fault of unknown displacement is intercepted by the granite intrusion, but mapping shows the fault to continue further south of the intrusion.

Hydrogeology and Hydrology

8.6.3.14 The BGS 1:625,000 scale hydrogeology mapping[9] defines the rocks as follow:

- *Mindork Formation & Gala Unit 4 (Gala Group)* = low productivity aquifer (Highly indurated greywackes with limited groundwater in near surface weathered zone and secondary fractures).
- *Ballencleuch Law Granite Intrusion* = Low productivity aquifer (small amounts of groundwater in near surface weathered zone and secondary fractures; rare springs).
- *Shinnel Formation* = Low productivity aquifer (Highly indurated rocks with limited groundwater in near surface weathered zone and secondary fractures).

8.6.3.15 The average annual rainfall for the nearest weather station (Met Office weather station at Dumfries[4]) is 1181.08 mm, based on the most recent dataset (1991 to 2020).

[8] British Geological Survey, BGS Lexicon of Named Rock Units. Available at: SEARCH Rock Name Database | Lexicon of Named Rock Units | British Geological Survey (BGS)

[9] British Geological Survey, 1:625,000 scale digital hydrogeological data. Available at: http://www.bgs.ac.uk/products/hydrogeology/maps.html

Surface Water Features

8.6.3.16 The south of the Site (approximately 50% of the total Site area) is within the catchment of Daer Water, upstream of Daer Reservoir. The central area of the Site (approximately 30% of the total Site area) drains to Kirkhope Cleuch which in turn flows to Daer Reservoir with the west of the central catchment draining directly to Daer Reservoir. The north of the Site (approximately 15% of the total Site area) drains via Meikle and Calf Burn to Daer Water downstream of the reservoir. A very small area (<5% of the total Site area) drains in a north westerly direction to Potrail Water.

Groundwater Dependent Terrestrial Ecosystems (GWDTE)

8.6.3.17 NVC habitat surveys (**Technical Appendix 6.2a, EIAR Volume 4**) confirmed that areas of the Site are classified as potentially GWDTE, with some areas with high potential. A further hydrological assessment demonstrated that while potentially groundwater dependent vegetation communities are present, most of these are considered to have a low likelihood of groundwater dependency being fed by surface water. However, one area, downslope of the track between Turbine 6 and 7 is assessed to be of Moderate groundwater dependency; given the distance from the proposed infrastructure and the limited productivity of the underlying aquifer, the risk of impact to groundwater supplies is assessed to be low (refer to **Technical Appendix 8.3, EIAR Volume 4**).

Private Water Supplies

8.6.3.18 Three PWS are located within 250 m of the Site. Two are situated in the southeast of the Site and the third is located in the northeast outside and upslope of the Site Boundary.

8.6.3.19 These have been discounted from detailed assessment due to their distance from the proposed infrastructure and the fact that they are not in hydrological connectivity to the Proposed Development.

Land Use

8.6.3.20 The Site predominantly comprises open moorland and semi-improved grassland, with areas of forestry within the area for the access tracks to the main area of the Site. The Western Access to the Site goes through a woodland (Watermeetings Forest) along part of the Southern Upland Way (SUW). The area within the Site is hilly, with peaks in the region of 600 to 688 m elevation. Adjacent to the Site Boundary to the northeast and northwest there are larger areas of forestry, and a reservoir (Daer Reservoir) is located to the east. Daer Water and other streams pass through the Site, and these are hydrologically connected to the Daer Reservoir. A public road runs from north to south, to the east of the Site Boundary. A high-pressure gas pipeline runs through the Site in the very northern section. Shiel Dod SSSI is immediately south of the Site Boundary. A Scheduled Monument is located within the north of the Site close to where the Eastern Access track enters the main area of the Site.

Geomorphology

8.6.3.21 Digital aerial photography and Digital Terrain Model (DTM) LIDAR data was used to interpret and map geomorphological features within the developable areas of the Site. This interpretation and the resulting geomorphological map, as shown in **Figure 8.6.4** were subsequently verified during Site walkover surveys undertaken by an experienced hydrologist in October 2024 and peatland geomorphologists June 2024, April 2025, and August 2025.

8.6.3.22 The geomorphological features recorded are shown on **Figure 8.6.4**. The presence, characteristics and distribution of peatland geomorphological features have been defined to understand the hydrological function of the peatland, with reference to the balance of erosion and peat accumulation (or condition), and the sensitivity of peatland to potential land-use changes.

8.6.3.23 Some evidence of peat instability was identified during the surveys, with features including hags, groughs, and other peat erosion noted. Several localised areas of peat flushes were recorded across the Site which displayed basal erosion of peat due to surface water runoff. No major instability features, evidence of incipient instability or past landslides were noted.

8.6.4 Field Survey

8.6.4.1 Results from the peat surveys are detailed within **Technical Appendix 8.4 (EIAR Volume 4)**.

Peat Depth and Character

8.6.4.2 Most of the Site has either no peat present or has a shallow depth of peat present (peat was absent at approximately 49% of locations and 36% of locations found <0.5 m in depth). These areas of shallow peat <0.5 m in depth can be considered as organo-mineral soils. These are further summarised as follows:

- 1321 no. samples (48.8%) located on land with no peat/absent;
- 965 no. samples (35.6%) located on land with less than or equal to 0.5 m depth of peat;
- 294 no. samples (10.8%) located on land with between 0.51 m and 1.0 m depth of peat;
- 62 no. samples (2.3%) located on land with between 1.01 m and 1.5 m depth of peat;
- 44 no. samples (1.7%) located on land with between 1.51 m to 2.0 m depth of peat;
- 17 no. samples (0.7%) located on land with between 2.01 m to 2.5 m depth of peat;
- 3 no. samples (0.1%) located on land with between 2.51 m to 3 m depth of peat; and
- 0 no. samples (0.0%) located on land with >3.01 m.

8.6.4.3 The maximum depth of peat recorded at the Site during the Stage 1 survey was 3.0 m, located in the southwest of the Site, between Turbine 7 and 8. The maximum depth of peat taken from samples dispersed across the Site during the Stage 2 peat probe survey was 2.0 m. The mean peat depth recorded was 0.27 m. The peat depth results are shown on **Figure 8.6.5** of this report

8.6.4.4 Overall, the peat sampled across the Site was relatively shallow. Peat was found to be generally dry and in a state of moderate decomposition.

8.6.4.5 The majority of the Site has either no peat present or has a shallow depth of peat present (approximately 85% of peat probes were ≤0.5 m in depth). These areas of shallow peat can be considered as organo-mineral soils or peaty soils as described in ECUBPG[1] and therefore not considered in this assessment for the following reasons:

- Peaty soils in isolation do not pose a significant threat to watercourse and habitat environments.
- In isolation, their soil properties differ to that of peat, and due to their limited depth, a potential slide would be minor and limited in volume.

8.6.4.6 However, peaty soils are considered where they occur within areas of adjacent peat instability as their presence may contribute to the peat slide likelihood.

8.6.5 Peat Instability

Types of Peat Instability

8.6.5.1 Peat instability can be defined as either ‘minor instability’ or ‘major instability’ and observed by both field observations and through desk top review of aerial/satellite imagery of the Site:

- Minor instability can be defined as localised and small scale features that are not generally precursors to major failure and including gully sidewall collapses, pipe ceiling collapses, minor slumping along diffuse drainage pathways (e.g., along flushes). Indicators of minor instability include presence of tension cracks, compression ridges, or bulges; and

- Major instability can be defined by peat landslides.

8.6.5.2 For the purposes of this assessment, landslide classification is simplified and split into three main types:

- multiple peat slides with displaced slabs and exposed substrate;
- bog burst with peat retained within the failed area; and
- multiple peat soil slides with displacement of thin soils exposing substrate.

8.6.5.3 The term 'peat slide' is used to refer to large-scale landslides and occur 'top-down' from the point of initiation on a slope in thinner peats (between 0.5 and 1.5 m) and on moderate slope angles (typically 5-15°).

8.6.5.4 The term 'bog burst' is used to refer to very large-scale failures where peat is typically deeper (greater than 1.0 m and up to 10 m) and more amorphous than sites experiencing peat slides, with shallower slope angles (typically 2-5°).

8.6.5.5 'Peaty soil slide' is used to refer to small-scale slab-like slides in organic soils generally <0.5 m thick.

Factors Contributing to Peat Instability

8.6.5.6 Peat landslides are caused by a combination of preconditioning factors and triggering factors. The combined factors are discussed in greater detail in the Landslide Susceptibility Approach section of this report. Triggering factors have an immediate or rapid effect on the stability of a peat accumulation whereas preconditioning factors can influence peat stability over a much longer period. Only some of these factors can be addressed by site characterisation.

8.6.5.7 Preconditioning factors may influence peat stability over long periods of time (years to hundreds of years), and include:

- impeded drainage caused by a peat layer overlying an impervious clay or mineral base (hydrological discontinuity);
- a convex slope or a slope with a break of slope at its head (concentration of subsurface flow);
- proximity to local drainage, either from flushes, pipes or streams (supply of water);
- connectivity between surface drainage and the peat/impervious interface (mechanism for generation of excess pore pressures);
- artificially cut transverse drainage ditches, or grips (elevating pore water pressures in the basal peat mineral matrix between cuts, and causing fragmentation of the peat mass);
- increase in mass of the peat slope through peat formation, increases in water content or afforestation;
- reduction in shear strength of peat or substrate from changes in physical structure caused by progressive creep and vertical fracturing (tension cracking or desiccation cracking), chemical or physical weathering or clay dispersal in the substrate;
- loss of surface vegetation and associated tensile strength (e.g., by burning or pollution induced vegetation change);
- increase in buoyancy of the peat slope through formation of sub-surface pools or water-filled pipe networks or wetting up of desiccated areas; and
- afforestation of peat areas, reducing water held in the peat body, and increasing potential for formation of desiccation cracks which are exploited by rainfall on forest harvesting.

8.6.5.8 Triggering factors are typically of short duration (minutes to hours) and any individual trigger event can be considered as a result of cumulative events:

- intense rainfall or snowmelt causing high pore pressures along pre-existing or potential rupture surfaces (e.g., between the peat and substrate);
- rapid ground accelerations (e.g., from earthquakes or blasting); unloading of the peat mass by fluvial incision or by artificial excavations (e.g., cutting);
- focusing of drainage in a susceptible part of a slope by alterations to natural drainage patterns (e.g., by pipe blocking or drainage diversion); and
- loading by plant, spoil or infrastructure.

8.6.5.9 External environmental triggers such as rainfall and snowmelt cannot be mitigated, though they can be managed (e.g., by limiting construction activities during periods of intense rain).

8.6.5.10 Unloading of the peat mass by excavation, loading of the peat by plant and focusing of drainage can be managed and mitigated by careful design, site specific stability analyses, informed working practices and monitoring.

Approaches to Assessing Peat Instability

8.6.5.11 This report considers a qualitative contributory factor-based approach and conventional stability analysis (through limit equilibrium or Factor of Safety (FoS) analysis).

8.6.5.12 The advantage of the former is that many observed relationships between reported peat landslides and ground conditions can be considered together where a FoS is limited to consideration of a limited number of geotechnical parameters. The disadvantage is that the outputs of such an approach are better at illustrating relative variability in landslide susceptibility across a site rather than absolute likelihood.

8.6.5.13 The advantage of the FoS approach is that clear thresholds between stability and instability can be defined and modelled numerically. However, in reality, there is considerable uncertainty in input parameters and it is a generally held view that the geomechanical basis for stability analysis in peat is limited given the nature of peat as organic material, rather than mineral soil.

8.6.5.14 To reflect these limitations, both approaches are adopted and outputs from each approach integrated in the assessment of landslide likelihood.

Assessment of Peat Landslide Likelihood

Introduction

8.6.5.15 This section provides details on the landslide susceptibility and limit equilibrium approaches to the assessment of peat landslide likelihood used in this report. The assessment of likelihood is a key step in the calculation of risk, where risk is expressed as follows:

Risk = Probability of a Peat Landslide x Adverse Consequences

8.6.5.16 The probability of a peat landslide is expressed in this Technical Appendix as peat landslide likelihood and is considered below.

Limit Equilibrium Approach

8.6.5.17 Stability analysis has been undertaken using the infinite slope model to determine the FoS for a series of 25 m x 25 m cells within the developable area. The limit equilibrium approach has been applied within areas where the peat thickness is over 0.5 m. The limit equilibrium approach is the most frequently cited approach for the quantitative assessment of the stability of peat slopes. The approach assumes that failure occurs by shallow translational land sliding, which is the mechanism usually interpreted for peat slides. Due to the relative length of the slope and depth to the failure surface, end effects are considered negligible and the safety of the slope against sliding may be determined from analysis of a 'slice' of the material within the slope.

8.6.5.18 The stability of a peat slope is assessed by calculating a Factor of Safety, F, which is the ratio of the sum of resisting forces (shear strength) and the sum of driving forces (shear stress):

$$\frac{c' + (\gamma - h\gamma_w)\, z\, cos^2\, \beta\, tan\, \phi')}{\gamma z\, sin\, \beta\, cos\, \beta}$$

In this formula:

- c is the effective cohesion (kPa);
- γ is the bulk unit weight of saturated peat (kN/m³);
- γw is the unit weight of water (kN/m³);
- z is the vertical peat depth (m),
- h is the height of the water table as a proportion of the peat depth;
- β is the angle of the substrate interface (°); and
- ϕ' is the angle of internal friction of the peat (°).

8.6.5.19 This form of the infinite slope equation uses effective stress parameters, and assumes that there are no excess pore pressures, i.e., that the soil is in its natural, unloaded condition.

8.6.5.20 The choice of water table height reflects the full saturation of the soils that would be expected under the most likely trigger conditions, i.e., heavy rain.

8.6.5.21 Where the driving forces exceed the shear strength (i.e., where the bottom half of the equation is larger than the top), F is <1, indicating instability. A FoS between 1 and 1.4 is normally taken in engineering terms to indicate marginal stability (providing an allowance for variability in soil strength, depth to failure). Slopes with a FoS greater than 1.4 are generally considered to be stable.

8.6.5.22 There are numerous uncertainties involved in applying geotechnical approaches to peat, not least because of its high water content, compressibility and organic composition. Peat comprises organic matter in various states of decomposition with both pore water and water within plant constituents, and the frictional particle-to-particle contacts that are modelled in standard geotechnical approaches are different in peats. There is also a tensile strength component to peat which is assumed to be dominant in the acrotelm, declining with increasing decomposition and depth. As a result, analysis utilising geotechnical approaches is often primarily of value in showing relative stability across a site given credible and representative input parameters rather than in providing an absolute estimate of stability. With this in mind, representative data inputs have been derived from published literature and used for drained analysis only.

Data Inputs

8.6.5.23 Stability analysis was undertaken using GIS software and a 25 m x 25 m grid was superimposed on areas of peat only, with key input parameters derived for each grid cell. A 25 m x 25 m cell size was chosen because it is sufficiently small to define a minimum credible landslide size and avoid 'smoothing' of important topographic irregularities. Given the cell size of the input DTM, which provides a key input parameter, any smaller cell size would be unlikely to provide significant benefits.

8.6.5.24 **Table 8.6.1** shows the input parameters and assumptions for the stability analyses undertaken. The shear strength parameters c' and ϕ' are usually derived in the laboratory using undisturbed samples of peat collected in the field and therefore site-specific values are often not available ahead of detailed site investigation for a development. Therefore, for this assessment, a literature search has been undertaken to identify a range of credible but conservative values for c' and ϕ' quoted in fibrous and humified peats. FoS analysis was undertaken with a conservative ϕ' of 22° and a value of 5 kPa for c'.

Table 8.6.1: Geotechnical Parameters for Drained Infinite Slope Analysis

Parameter	Values	Rationale	Source
Effective Cohesion (c')	5	Credible conservative cohesion values for humified peat based on literature review	5.5 - 6.1 - peat type not stated (Long, 2005).[10] 3, 4 - peat type not stated (Long, 2005)[10] 5 - basal peat (Warburton *et al*, 2003).[11] 8.74 - fibrous peat (Carling, 1986).[12] 4 - peat type not stated (Dykes and Kirk, 2001).[13] 7 – 12 - H8 peat (Huat *et al,* 2014).[14]
Bulk Unit Weight (γ)	10.5	Mid-range value for humified catotelmic peat taken from Laboratory testing	10.1 – catotelm peat (Mills, 2002).[15] 10.1 – Irish bog peat (Boylan *et al*, 2008).[16]
Effective Angle of Internal Friction (ϕ')	22	Credible conservative friction angle for humified peat based on literature review	40 – 65 - fibrous (Huat *et al*, 2014)[14] 50 – 60 - amorphous (Huat *et al*, 2014)[14] 36.6 - 43.5 - peat type not stated (Long, 2005)[10] 31 – 55 - Irish bog peat (Hebib, 2001).[17] 34 – 48 - fibrous sedge pear (Farrell & Hebib, 1998).[18] 32 – 58 - peat type not stated (Long, 2005)[10] 23 - basal peat (Warburton *et al*, 2003)[11] 21 - fibrous peat (Carling, 1986)[12]
Slope Angle from Horizontal (β)	Various	Mean slope angle per 25 m x 25 m grid cell	5 m DTM of site
Peat Depth (z)	Various	Mean peat depth per 25 m x 25 m grid cell	Interpolated peat depth model of site
Height of Water Table as a Proportion of Peat Depth (h)	1	Assumes peat mass is fully saturated (normal conditions during intense rainfall events or snowmelt, which are the most likely natural hydrological conditions at failure)	Assumed

Results

8.6.5.25 **Figure 8.6.6** shows the results for drained analysis of the peat areas at the Site. The results indicate that the Factors of Safety demonstrates stability across most of the site (FoS >1.4). This is consistent with the lack of observation of instability features during the Site walkover and on review of aerial imagery.

8.6.5.26 The following areas of Marginal Unstable ground (FoS = 1.0 – 1.4) are mapped:

- 40 m east of the track by Turbine 4;.
- 50 m north and east of the track between Turbines 7 and 8;

[10] Long M (2005) Review of peat strength, peat characterisation and constitutive modelling of peat with reference to landslides.
[11] Warburton *et al* (2003) Anatomy of a Pennine peat slide, Northern England. Earth Surface Processes and Landforms.
[12] Carling (1986) Peat slides in Teesdale and Weardale, Northern Pennines, July 1983: description and failure mechanisms.
[13] Dykes and Kirk (2001) Initiation of a multiple peat slide on Cuilcagh Mountain, Northern Ireland.
[14] Huat *et al* (2014) Geotechnics of organic soils and peat.
[15] Mills (2002) Peat slides: Morphology, Mechanisms and Recovery
[16] Boylan N, *et al* (2008) Peat slope failure in Ireland
[17] Hebib (2001) Experimental investigation of the stabilisation of Irish peat
[18] Farrell and Hebib (1998) The determination of the geotechnical parameters of organic soils

- 65 m west of the track by the construction compound;
- 125 m east of the track 200 m north of Turbine 7;
- 200 m east of the track by the northern borrow pit (BP01); and
- 450 m south of Turbine 4.

8.6.5.27 No areas of Marginal Unstable ground (FoS = 1.0 – 1.4) are located within the footprint of the Proposed Development. General good practice construction mitigation measures are advisable to mitigate risks based on the Limit Equilibrium analysis, discussed in **Section 8.6.8.**

Landslide Susceptibility Approach

8.6.5.28 The landslide susceptibility approach is based on the layering of contributory factors to produce unique 'slope facets' that define areas of similar susceptibility to failure. The number and size of slope facets will vary from one part of the site to another according to the complexity of ground conditions. As with the limit equilibrium approach, facets were only defined in areas of true peat.

8.6.5.29 Eight contributory factors are considered in the analysis:

- slope angle (S);
- peat depth (P);
- substrate geology (G);
- peat geomorphology (M);
- drainage (D);
- forestry (F);
- slope convexity (C); and
- land use (L).

8.6.5.30 For each factor, a series of numerical scores between 0 and 3 are assigned to factor 'classes', the significance of which is tabulated for each factor. The higher a score, the greater the contribution of that factor to instability for any particular slope facet. Scores of 0 imply neutral/negligible influence on instability.

8.6.5.31 Factor scores are summed for each slope facet to produce a peat landslide likelihood score (SPL), the theoretical maximum being 24 (8 factors, each with a maximum score of 3):

SPL = SS + SP + SG + SM + SD + SF + SC + SL

8.6.5.32 In practice, a maximum score is unlikely, as the chance of all contributory factors having their highest scores in one location is very small.

8.6.5.33 Figures to show the spatial distribution of each factor across the Site are shown in **Figures 8.6.7.1 to 8.6.7.8** of this report.

Slope Angle

8.6.5.34 **Table 8.6.2** shows the slope ranges, their significance and related scores for the slope angle contributory factor. Slope angles were derived from the 5 m DTM and scores assigned based on reported slope angles associated with peat landslides rather than a simplistic assumption that 'the steeper a slope, the more likely it is to fail'.

Table 8.6.2: Slope Classes, Significance and Scores

Slope Range (°)	Significance	Score
>20.0	Failure typically occurs as peaty debris slides due to low thickness of peat	1
15.1-20.0	Failure typically occurs as peaty debris slides due to low thickness of peat	2
10.1-15.0	Failure typically occurs as peat slides, bog slides or peaty debris slides, a key slope range for reported population of peat failures	3
5.1-10.0	Failure typically occurs as peat slides, bog slides or peaty-debris slides, a key slope range for reported population of peat failures	3
2.1-5.0	Failure typically occurs as bog bursts, bog flows or peat flows; peat slides and peaty debris slides rare due to low slope angles	2
≤2.0	Failure is very rarely associated with flat ground, neutral influence on stability	0

8.6.5.35 **Figure 8.6.7.1** shows the distribution of slope angle scores across the Site. The results show the slope angles across most of the site are between 2.1° and 15°. With some localised steeper gradients around hill and watercourse formations.

Peat Depth (P)

8.6.5.36 **Table 8.6.3** shows the peat depths, their significance and related scores for the peat depth contributory factor. Peat depths were derived from the peat depth model shown on **Figure 8.6.7.2** and reflect the peat depth ranges most frequently associated with peat slides (Evans and Warburton, 2007).[19].

Table 8.6.3: Peat Depth Classes, Significance and Scores

Depth Range (m)	Significance	Score
>1.5	Sufficient thickness for any type of peat failure	2
1.0-1.5	Sufficient thickness for peat slide or bog slide	3
0.5-1.0	Sufficient thickness for peat or bog slide and peaty-debris slide but not for bog burst	3
<0.5	Organic soil rather than peat, failures would be peaty-debris slides	1
No Organic Soil	No organic soil and therefore failures cannot be interpreted as peat slides, neutral influence on stability	0

8.6.5.37 **Figure 8.6.7.2** shows the distribution of peat depth scores across the Site. The results indicate that the Site is predominantly covered by peat thicknesses <0.5 m. Areas near the northeast (east of Turbine 1 and 4), northwest (north of the construction compound, Substation and BESS) and southwest (between Turbine 7 and 8) show localised areas of peat accumulation of generally <2.01 m but in places up to 3.0 m.

Substrate Geology

8.6.5.38 **Table 8.6.4** shows substrate type, significance and related scores for the peat depth contributory factor. The shear surface or failure zone of peat failures typically overlies an impervious clay or mineral (bedrock) base giving rise to impeded drainage. This, in part, is responsible for the presence of peat, but also precludes free drainage of water from the base of the peat mass, particularly under extreme conditions (such as after heavy rainfall, or snowmelt).

8.6.5.39 Peat failures are frequently cited in association with glacial till deposits in which an iron pan is observed in the upper few centimetres. They have also been observed over glacial till without an

[19] Evans, M & Warburton, J 2007, Geomorphology of Upland Peat: Erosion, Form and Landscape Change.P104-135

obvious iron pan, or over impermeable bedrock. They are rarely cited over permeable bedrock, probably due to the reduced likelihood of peat formation.

Table 8.6.4: Substrate Geology Classes, Significance and Scores		
Substrate Geology	**Significance**	**Score**
Glacial Till With Iron Pan	Failures often associated with underlying till; particularly where impermeable iron pan provides polished shear surface	3
Glacial Till	Failures often associated with underlying till	2
Impermeable Bedrock	Failures sometimes associated with bedrock, particularly if smooth top surface	1
Permeable Bedrock	Failures rarely associated with permeable bedrock (peat is often thin or absent), neutral influence on stability	0

8.6.5.40 **Figure 8.6.7.3** shows the distribution of substrate geology scores across the Site. The results indicate that the Site is underlain mostly by granular deposits to the northeast (east of Turbine 1 and 4) and southwest (by Turbine 7 and 8) and impermeable bedrock across the rest of the Site. There are a few areas of localised Glacial Till noted in areas of peat >0.5 m depth, including in the northeast by Wintercleugh, a small deposit east of the northern borrow pit (BP01), a small deposit near Turbine 4 and the largest deposit of Till is noted between Turbine 7 and 8. The results are consistent with the solid geology observed during the survey within exposures and watercourses, and indicated on BGS geology mapping[2].·

Peat Geomorphology

8.6.5.41 **Table 8.6.5** shows the geomorphological features identified across the Site, their significance and related scores.

Table 8.6.5: Peat Geomorphology Classes, Significance and Scores		
Geomorphology	**Significance**	**Score**
Adjacent/upslope (<50 m) to existing instability (peat slide, peaty-debris slide, bank failure)	Failures often associated with underlying till; particularly where impermeable iron pan provides polished shear surface	3
Incipient instability (tension crack, compression ridge, bulging, quaking bog)	Failures are likely to occur where incipient failure morphology is observed	3
Undrained intact planar peat	Failures are most frequently recorded in intact peat, planar peat	2
Diffuse natural drainage/pool/flush	Failures are often associated with areas of diffuse subsurface drainage (such as flushes)	2
Pipe/Collapsed Pipe	Failures are often associated with areas of soil piping	2
Existing Peat Slide	Failures typically stabilise and do not reactivate after the initial event	1
Gullied/Dissected/Hagged/Eroded Peat/Bare Peat/Bare Ground	Failures are rarely recorded in peat fragmentated by erosion	1

8.6.5.42 **Figure 8.6.7.4** shows the distribution of geomorphology scores across the Site. The results indicate that the land east of Turbine 7 and north of Turbine 8 shows evidence of existing Peat Slide/Hag/Peat Cutting/Bare Ground. A peat flush is located >100 m away from the track between Turbine 7 and 8. There are no significant geomorphological features associated with historic peat slide failure.

Drainage (D)

8.6.5.43 **Table 8.6.6** shows artificial drainage feature classes, their significance and related scores. Transverse/oblique drainage lines may reduce peat stability by creating lines of weakness in the peat slope and encouraging the formation of peat pipes. Review of published literature indicates that a number of peat failures have been identified which have failed over moorland grips. The influence of changes in hydrology become more pronounced the more transverse the orientation of the drainage lines are relative to the overall slope.

Table 8.6.6: Drainage Feature Classes, Significance and Scores	
Significance	**Score**
Failures are sometimes reported in association with artificial drains oblique/transverse to slope	3
Failures are rarely associated with artificial drains parallel to slope	1
Neutral influence on stability	0

8.6.5.44 **Figure 8.6.7.5** shows the distribution of drainage feature scores across the Site. Artificial drainage was observed within commercial forestry to the north and in localised moorland areas to the north, southwest and southeast of the Site (e.g., open moorland habitat areas characterised by underlying peat). These drains were found to be aligned to the slope.

Forestry (F)

8.6.5.45 **Table 8.6.7** shows forestry classes, their significance and related scores.

Table 8.6.7: Forestry Classes, Significance and Scores		
Forestry Class	**Significance**	**Score**
Afforested area (with mature trees), ridge and furrows oblique to slope	Peat underlying forestry stands with rows aligned oblique to slope has inter ridge cracks which are conducive to slope instability	2
Afforested area (with mature trees), ridge and furrows aligned to slope	Peat underlying forestry stands with rows aligned with slope is conducive to slope instability, but less so than where rows are aligned oblique to slope	1
Deforested area (few or no trees), ridge and furrows oblique to slope	Peat underlying deforested stands has a higher water table and more neutral buoyancy, but retains inter ridge cracks (lines of weakness) conducive to instability; alignment of cracks oblique to slope is most conducive to instability	3
Deforested area (few or no trees), ridge and furrows aligned to slope	Peat underlying deforested stands has a higher water table and more neutral buoyancy, but retains inter ridge cracks (lines of weakness), however, orientation of these cracks is less critical when aligned to slope	2
Not Afforested	Neutral influence on stability	0

8.6.5.46 **Figure 8.6.7.6** shows the distribution of forestry feature scores. Most of the Site is not afforested. There is a small area of afforested land aligned to the slope in the northwest of the Site by Wintercleugh.

Slope Convexity (C)

8.6.5.47 **Table 8.6.8** shows profile convexity classes, significance and related scores. Convex and concave slopes (i.e., positions in a slope profile where slope gradient changes by a few degrees) can be associated with the initiation point of peat landslides. Convexities are often associated with thinning of peat; such that thicker peat upslope applies stresses to thinner 'retaining' peat downslope. Conversely, buckling and tearing of peat may trigger failure at concavities.

Table 8.6.8: Convexity Feature Classes, Significance and Scores		
Convexity Feature	**Significance**	**Score**
Convex Slope	Peat failures are often reported on or above convex slopes	3
Concave Slope	Peat failures are occasionally reported in association with concave slopes	1
Rectilinear Slope	Rectilinear slopes show no particular predisposition to failure, neutral influence on stability	0

8.6.5.48 **Figure 8.6.7.7** shows the distribution of convexity feature scores across the Site. Slopes are shown to be predominantly rectilinear in nature across the Site, with an area of more concave and convex slopes in the southwest between Turbine 7 and 8.

Land use (L)

8.6.5.49 **Table 8.6.9** shows land use classes, significance and related scores. A variety of land uses have been associated with peat failures which form the scoring and potential for failure.

Table 8.6.9: Land Use Feature Classes, Significance and Scores		
Land Use	**Significance**	**Score**
Cutting/ Turbary	Peat failures are often associated with peat cuttings/turbary	3
Adjacent Quarrying	Failures are occasionally reported adjacent to quarries (usually as bog bursts, bog flows or peat flows)	2
Burning	Failures are rarely associated with burning though this activity may create pathways for water to the base of peat	1
Other Land Use	Failures are rarely associated with other forms of land use	0

8.6.5.50 **Figure 8.6.7.8** shows the distribution of land use feature scores across the Site. Most of the Site is noted as 'Other Land Use' with a small area noted as 'Cutting' associated with Kirkhope Cleuch, this appears to be an area of historic cutting.

LIKELIHOOD SCORES

8.6.5.51 The eight contributory factor layers were combined in GIS software to produce likelihood scores for a peat landslide as shown on **Figure 8.6.8**. These likelihood scores were then converted into descriptive 'likelihood classes' from 'Very Low' to 'Very High' with a corresponding numerical range of 1 to 5, and are described in **Table 8.6.10** below.

Table 8.6.10: Likelihood Classes Derived from the Landslide Susceptibility Methodology			
Summed Contributory Factor Scores	**Typical Site Conditions Associated with Score**	**Qualitative Likelihood**	**Peat Landslide Likelihood Score**
≤6	Unmodified peat with no more than low weightings for peat depth, slope angle, underlying geology and peat morphology	Very Low	1
7-11	Unmodified or modified peat with no more than moderate or some high scores for peat depth, slope angle, underlying geology and peat morphology	Low	2
12-16	Unmodified or modified peat with high scores for peat depth and slope angle and/or high scores for at least three other contributory factors	Moderate	3
17-21	Modified peat with high scores for peat depth and slope angle and several other contributory factors	High	4
>21	Modified peat with high scores for most contributory factors (unusual except in areas with evidence of incipient instability)	Very High	5

8.6.5.52 **Table 8.6.10** describes the basis for the likelihood classes. Professional judgement was made that for a facet to have a moderate or higher likelihood of a peat landslide, a likelihood score would be required equivalent to both the worst case peat depth and slope angle scores (3 in each case, i.e., 3 x 2 classes) alongside three intermediate scores (of 2, i.e., 2 x 3 classes) for other contributory factors. This means that any likelihood score of 12 or greater would be equivalent to at least a moderate likelihood of a peat landslide. Given that the maximum score attainable is 24, this seems reasonable.

8.6.6 Peat Slide Risk Assessment and Mitigation

8.6.6.1 **Table 8.6.11** below defines the stability risk assessment based on the peat slide likelihood and the required mitigation actions for each Risk Level.

Table 8.6.11: Risk Assessment		
Peat Slide Likelihood	**Potential Stability Risk (Pre-Mitigation)**	**Mitigation Action**
Very Low	Very Low	No peat present>0.5 m and therefore no mitigation action required.
Low	Unlikely/Low	Development of a site-specific construction and management plan for peat areas
Moderate	Likely/Medium	As for Low condition plus may require mitigation to improve site conditions.
High	Probable High	Unacceptable level of risk, the area should be avoided. If unavoidable, detailed investigation and quantitative assessment required to determine stability with long term monitoring.
Very high	Almost Certain/Very high	Unacceptable level of risk, the area should be avoided

8.6.6.2 **Table 8.6.12** below shows the risk level (Likelihood) and required mitigation measures proposed for the turbines and proposed access tracks of the Proposed Development. Refer to **Figure 8.6.10** for location of access track as defined in **Table 8.6.12** below.

Table 8.6.12: Risk Level (Likelihood) and Mitigation				
Wind Farm Infrastructure				
Turbine/ Infrastructure	**Peat Depth m (Max)**	**Slope Angle Deg (Average)**	**Risk Level**	**Comment/Mitigation**
Turbine 1	0.71	10.45	Low	Peat >0.5m recorded. Average slope >10 degrees. Low Likelihood. (Refer Section 8.6.8)
Turbine 2	0.30	11.30	Very Low	No peat recorded >0.5 m depth. No mitigation required
Turbine 3	0.06	10.77	Very Low	No peat recorded >0.5 m depth. No mitigation required
Turbine 4	0.04	16.33	Very Low	No peat recorded 0.5 m depth. No mitigation required
Turbine 5	0.05	10.20	Very Low	No peat recorded >0.5 m depth. No mitigation required

Table 8.6.12: Risk Level (Likelihood) and Mitigation

Wind Farm Infrastructure

Turbine/ Infrastructure	Peat Depth m (Max)	Slope Angle Deg (Average)	Risk Level	Comment/Mitigation
Turbine 6	0.00	8.60	Very Low	No peat recorded >0.5 m depth. No mitigation required
Turbine 7	0.10	7.90	Very Low	No peat recorded >0.5 m depth. No mitigation required
Turbine 8	0.31	4.23	Very Low	No peat recorded >0.5 m depth. No mitigation required
Turbine 9	0.04	7.27	Very Low	No peat recorded >0.5 m depth. No mitigation required
Turbine 10	0.82	3.45	Very Low	Peat >0.5 m recorded. Average slope <5 degrees. Low Likelihood. (Refer Section 8.6.8)
Turbine 11	0.21	7.38	Very Low	No peat recorded >0.5 m depth. No mitigation required
Turbine 12	0.31	9.87	Very Low	No peat recorded >0.5 m depth. No mitigation required
Turbine 13	0.00	8.61	Very Low	No peat recorded >0.5 m depth. No mitigation required
Hardstand Permanent	1.50	8.50	Low	Peat >0.5 m recorded. Average slope >5 degrees. Low Likelihood. (Refer Section 8.6.8)
Hardstand Temporary	1.02	8.54	Low	Peat >0.5 m recorded. Average slope >5 degrees. Low Likelihood. (Refer Section 8.6.8)
Hardstanding Clearance	1.02	8.33	Low	Peat >0.5 m recorded. Average slope >5 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 1	0.19	2.16	Very Low	No peat recorded >0.5 m depth. No mitigation required
Access Track 2	1.06	3.61	Moderate	Peat >0.5 m recorded. Average slope <5 degrees. Maximum slope >10 degrees. Moderate Likelihood. (Refer Section 8.6.8)
Access Track 3	0.51	6.08	Low	Peat >0.5 m recorded, Slope >5 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 4	1.05	4.97	Low	Peat >0.5 m recorded, Average slope <5 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 5	1.52	6.95	Low	Peat >0.5 m recorded, Average slope >5 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 6	1.48	4.18	Moderate	Peat >0.5 m recorded. Average slope <5 degrees. Maximum slope >10 degrees. Moderate Likelihood. (Refer Section 8.6.8)
Access Track 7	0.44	6.41	Low	Peat <0.5 m recorded. Average slope >5 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 8	0.67	5.61	Low	Peat >0.5 m recorded. Average slope >5 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 9	0.84	5.95	Low	Peat >0.5 m recorded. Average slope >5 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 10	2.06	6.10	Moderate	Peat >0.5 m recorded. Average slope >5 degrees. Maximum slope >10 degrees. Moderate Likelihood. (Refer Section 8.6.8)
Construction Compound	0.76	5.87	Low	Peat >0.5 m recorded, Average slope >5 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 11	1.64	7.10	Low	Peat >0.5 m recorded. Average slope >5 degrees. Maximum slope >10 degrees. Low Likelihood. (Refer Section 8.6.8)

Table 8.6.12: Risk Level (Likelihood) and Mitigation

Wind Farm Infrastructure

Turbine/ Infrastructure	Peat Depth m (Max)	Slope Angle Deg (Average)	Risk Level	Comment/Mitigation
BESS	1.00	9.37	Low	Peat >0.5 m recorded. Average slope >5 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 12	1.36	5.43	Low	Peat >0.5 m recorded, Average slope >5 degrees. Low Likelihood. (Refer Section 8.6.8)
Substation	0.93	7.65	Low	Peat >0.5 m recorded. Average slope >5 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 13	0.28	9.50	Very Low	No peat recorded >0.5 m depth. No mitigation required
Access Track 14	0.33	8.25	Very Low	No peat recorded >0.5 m depth. No mitigation required
Access Track 15	0.78	8.90	Low	Peat >0.5 m recorded, Average slope >5 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 16	0.39	11.30	Very Low	No peat recorded >0.5 m depth. No mitigation required
Borrow Pit North (BP01)	0.41	10.96	Very Low	No peat recorded >0.5 m depth. No mitigation required
Access Track 17	1.22	8.28	Low	Peat >0.5 m recorded, Average slope >5 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 18	1.12	9.01	Low	Peat >0.5 m recorded, Average slope >5 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 19	0.70	16.70	Low	Peat >0.5 m recorded, Average slope >10 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 20	0.50	13.38	Low	Peat >0.5 m recorded, Average slope >10 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 21	0.09	14.64	Very Low	No peat recorded >0.5 m depth. No mitigation required
Access Track 22	1.20	9.16	Low	Peat >0.5 m recorded, Average slope >5 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 23	0.76	11.87	Low	Peat >0.5 m recorded, Average slope >10 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 24	0.33	9.46	Very Low	No peat recorded >0.5 m depth. No mitigation required
Access Track 25	0.35	7.75	Very Low	No peat recorded >0.5 m depth. No mitigation required
Access Track 26	0.50	10.55	Low	Peat >0.5 m recorded, Average slope >10 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 27	1.06	9.57	Low	Peat >0.5 m recorded, Average slope >5 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 28	1.01	7.35	Low	Peat >0.5 m recorded, Average slope >5 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 29	2.34	4.11	Low	Peat >0.5 m recorded, Average slope <5 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 30	0.26	4.85	Very Low	No peat recorded >0.5 m depth. No mitigation required
Access Track 31	0.30	5.40	Very Low	No peat recorded >0.5 m depth. No mitigation required

Table 8.6.12: Risk Level (Likelihood) and Mitigation				
Wind Farm Infrastructure				
Turbine/ Infrastructure	**Peat Depth m (Max)**	**Slope Angle Deg (Average)**	**Risk Level**	**Comment/Mitigation**
Borrow Pit South (BP02)	0.18	7.76	Very Low	No peat recorded >0.5 m depth. No mitigation required
Access Track 32	0.27	7.58	Very Low	No peat recorded >0.5 m depth. No mitigation required
Access Track 33	0.30	8.80	Very Low	No peat recorded >0.5 m depth. No mitigation required
Access Track 34	1.02	3.93	Low	Peat >0.5 m recorded, Average slope <5 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 35	0.94	4.85	Low	Peat >0.5 m recorded, Average slope <5 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 36	0.98	8.71	Low	Peat >0.5 m recorded, Average slope >5 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 37	0.30	11.10	Very Low	No peat recorded >0.5 m depth. No mitigation required
Access Track 38	0.94	7.66	Low	Peat >0.5 m recorded, Average slope >5 degrees. Low Likelihood. (Refer Section 8.6.8)
Access Track 39	0.34	8.54	Very Low	No peat recorded >0.5 m depth. No mitigation required

8.6.6.3 From **Table 8.6.12**, all the proposed turbine, hardstanding, BESS, substation, construction compound and borrow pit locations are classified as Very Low or Low likelihood of peat slide. The majority of the track is classified as Very Low or Low likelihood of a peat slide; however three sections are classified as Moderate likelihood. **Section 8.6.8** details mitigation measures which should be considered for areas of Moderate likelihood of peat slide. The combined factor assessment scoring for peat slide likelihood is shown on Figure **8.6.8.**

Results

8.6.6.4 The results of the FoS assessment (**Figure 8.6.6**) and Peat Slide Likelihood Combined Factor Assessment (**Figure 8.6.8**) indicate that both assessments agree that most of the proposed construction infrastructure locations across the Site are considered to be of 'Low' or 'Very Low' likelihood of a peat landslide. Three sections of track (2, 6 and 10) are 'Moderate' likelihood of a peat landslide and the FoS assessment does not identify any areas of 'Marginal Unstable' ground (FoS 1.0 – 1.4) within at least 40 m of proposed infrastructure.

8.6.6.5 In order for there to be a 'High' or 'Medium' risk associated with Proposed Development, combined peat landslide likelihood must be 'Moderate' or higher at an infrastructure location, as defined by Scottish Government Guidance[1]

8.6.6.6 Where combined peat landslide likelihoods are assessed as 'Low' or 'Very Low', post-consent site investigations and application of good practice construction mitigation methods should be employed prior to and during construction as detailed in **Section 8.6.8** below.

8.6.6.7 Specific mitigation methods for areas assessed as 'Moderate' likelihood are also detailed in **Section 8.6.8**).

8.6.7 Consequence Evaluation

8.6.7.1 Based on the assessment of consequence of risk methodology, as defined by the Scottish Government Best Practice Guidance[1], four receptors (refer to **Figure 8.6.9**) have been identified at the Site, and are assessed for consequence in **Table 8.6.13**.

Table 8.6.13: Assessment of Consequence and Risk					
Receptor ID	**Receptor**	**Consequence**	**Score**	**Justification for Score**	**Consequence Scale**
1	Watercourse – Meikle Burn Wintercleugh National Grid Reference NS 96095 09998	Increased turbidity and acidification, fish kill, blockage of drainage, effects on private water supplies	4	Water Quality, Flood risk and Private water supplies have been considered within **Chapter 8 (EIAR Volume 2).**	High
2	Residential Property – National Grid Reference NS 96165 09646	Medium term loss of residency for local occupants. Significant cost to restore property and temporary accommodation. Possible injury, loss of life to occupants	5	Loss of life, though unlikely, is a severe consequence; financial implications of damage and repair to residents property are less significant	Extremely High
3	Unnamed Road – National Grid Reference NS 96174 09620	Medium term loss of access for transport link. Significant cost to restore highway infrastructure and public access.	4	Disruption to local highways routes. Although highways are bounded via cut off ditches and elevated verge, significant peat slide could temporarily disrupt traffic/access.	High
4	Non Riverine Habitat (Shiel Dodd SSSI)– National Grid Reference NS 95248 04806	Medium term loss of vegetation cover, disruption of peat hydrology, carbon release	4	Effects on peatland habitats, though the effects of peat landslides are generally short in duration.	High

8.6.7.2 There are three areas of moderate likelihood of peat slide identified directly at infrastructure (track) locations, Receptors have been included in **Table 8.6.14** below to confirm the evaluation for the level of risk associated with the Proposed Development.

Table 8.6.14 Risk levels derived from Likelihood vs Consequence						
Receptor	**Qualitative Likelihood worst case (See Table 8.6.12)**	**Consequence Scale/ Score (See Table 8.6.13)**	**Risk Level**	**Minimum Distance to Receptor**	**Level of Mitigation Required**	**Risk Level (Post Mitigation)**
Watercourse	Moderate (3)	High (4)	Moderate	27 m southeast of Eastern Access track	Specific Mitigation detailed in **Section 8.6.8**	Low
Residential Property	Moderate (3)	Extremely High (5)	Moderate	382 m south of Eastern Access track	Specific Mitigation detailed in **Section 8.6.8**	Low

Table 8.6.14 Risk levels derived from Likelihood vs Consequence						
Receptor	**Qualitative Likelihood worst case (See Table 8.6.12)**	**Consequence Scale/ Score (See Table 8.6.13)**	**Risk Level**	**Minimum Distance to Receptor**	**Level of Mitigation Required**	**Risk Level (Post Mitigation)**
Unnamed Road	Moderate (3)	High (4)	Moderate	400 m south of Eastern Access track	Specific Mitigation detailed in **Section 8.6.8**	Low
Non Riverine Habitat	Low (2)	High (4)	Low	483 m southeast of access track from turbine 12 to 13	General Good Practice **Section 8.6.8**	Low

8.6.7.3 The risk levels identified above for each potential receptor are based on the worst case likelihood and closest proximity to the receptor. The risk level for these areas is considered to be Moderate for the Watercourse, Residential Property and Unnamed Road and Low for the Non-Riverine Habitat, based on:

- Proximity of potential for unstable ground from infrastructure location;
- Level and slope angle both up and down slope; and
- Run out distances to potential receptors (Refer to **Figure 8.6.9**).

8.6.7.4 Implementing specific mitigation measures would lower the post mitigation risk to low for the receptors identified as moderate risk, Section **8.6.8**.

8.6.7.5 Based on the combined Qualitative likelihood vs Consequence and the findings within the FoS assessment previously outlined, it is considered that the combined risk level of peat landslide in association with the construction of the Proposed Development is assessed as being Low risk once specific and general mitigation measures are implemented. This assessment of Risk level is based on Low likelihood or Moderate likelihood vs High or Extremely High consequence as outlined in Table 5.3 of ECU best practice guidance[1], as shown below:

Table 8.6.15: Indicative Risk Levels						
		Adverse Consequence				
Peat Landslide Probability or Likelihood	**Receptor**	**Extremely high**	**High**	**Moderate**	**Low**	**Very Low**
	Very High (Almost certain)	High	High	Moderate	Moderate	Low
	High (Probable)	High	Moderate	Moderate	Low	Negligible
	Moderate (Likely)	Moderate	Moderate	Low	Low	Negligible
	Low (Unlikely)	Low	Low	Low	Negligible	Negligible
	Very Low (Negligible)	Low	Negligible	Negligible	Negligible	Negligible

Table 8.6.15 Based on Table 5.3: Extract from Scottish Government (2017). Peat Landslide Hazard and Risk Assessments, Best Practice Guide for Proposed Electricity Generation Developments.

8.6.8 Mitigation Measures

Specific Mitigation Methods

8.6.8.1 Three sections of track (2, 6 and 10) have been identified as moderate risk based on the likelihood assessment. Micrositing of infrastructure following additional post-consent ground investigation and detailed design to reduce potential risk associated with construction in areas of moderate risk should be considered. Where micrositing is not practicable then excavation of the peat to remove the potential risk would be required.

8.6.8.2 General good practice should be applied across the Site to engender awareness of peat instability and enable early identification of potential displacements and opportunities for mitigation.

General Mitigation Measures

8.6.8.3 A comprehensive intrusive geotechnical assessment should be undertaken post-consent based on the combined ground investigation, to support the engineering design of turbine foundations, tracks and ancillary infrastructure for the Proposed Development.

8.6.8.4 Appropriate field and laboratory testing would also be undertaken as part of the comprehensive ground investigation to confirm the peat stability baseline across the Site to cover the areas affected by the tracks and ancillary infrastructure, and further design mitigation used as appropriate to reduce the likelihood of peat instability (where required).

8.6.8.5 A geotechnical risk register would be prepared detailing any ground risks identified during the ground investigation and providing mitigation measures as appropriate. The risk register should be considered a live document and updated throughout the phases of the Proposed Development. The monitoring requirements discussed in the following paragraphs would be undertaken by the Contractor.

8.6.8.6 During construction of the Proposed Development the following mitigation would be undertaken for excavations:

- A geotechnical risk register would be prepared for the Proposed Development following intrusive investigations post consent and location specific stability analyses;
- Site inspections and audits would be undertaken at scheduled intervals to identify any unusual or unexpected changes to ground conditions (which may be associated with construction or which may occur independently of construction);
- All construction activities and operational decisions that involve disturbance to peat deposits would be overseen by an appropriately qualified geotechnical engineer with experience of construction on peat sites;
- Awareness of peat instability and pre-failure indicators would be incorporated in site induction, tool box talks, and training to enable all site personnel to recognise ground disturbances and features indicative of incipient instability;
- Monitoring checklists would be prepared with respect to peat instability addressing all construction activities forming the Proposed Development;
- Use of appropriate supporting structures around peat excavations, where required, (e.g. for towers, crane pads and compounds) to prevent collapse and the development of tension cracks;
- Avoid cutting trenches or aligning excavations across slopes (which may act as incipient back scars for peat failures) unless appropriate mitigation has been put in place;

- Implement methods of working that minimise the cutting of the toes of slope, e.g. working up-to-downslope during excavation works;
- Monitor the ground upslope of excavation works for creep, heave, displacement, tension cracks, subsidence or changes in surface water content;
- Monitor cut faces for changes in water discharge, particularly at the peat-substrate contact; and
- Minimise the effects of construction on natural drainage by ensuring natural drainage pathways are maintained or diverted such that there is no significant alteration of the hydrological regime of the site; drainage plans should avoid creating drainage/infiltration areas or settlement ponds towards the tops of slopes (where they may act to both load the slope and elevate pore pressures).

8.6.8.7 During construction of the Proposed Development the following mitigation would be undertaken for excavated tracks:

- Maintain drainage pathways through tracks to avoid ponding of water upslope;
- Monitor the top line of excavated peat deposits for deformation post-excavation; and
- Monitor the effectiveness of cross-track drainage to ensure it water remains free-flowing and that no blockages have occurred.

8.6.8.8 During construction of the Proposed Development the following mitigation would be undertaken for floating tracks (as proposed between Turbine 7 and 8):

- Allow peat to undergo primary consolidation by adopting rates of road construction appropriate to weather conditions.
- Monitor the effects of secondary compression over the life of the development, where required, while the tracks are utilised (can be up to 40 years) to ensure running surfaces remain elevated above the ground surface and does not cause ponding.
- Identify 'stop' rules, i.e., weather dependent criteria for cessation of track construction based on local meteorological data.
- Run vehicles at 50% load capacity until the tracks have entered the second compression phase.
- Prior to construction, setting out the centreline of the proposed track to identify any ground instability concerns or particularly wet zones.

8.6.8.9 During construction of the Proposed Development the following mitigation would be undertaken for temporary storage of peat and restoration activities:

- Where practicable, ensure temporary stores of peat are located on non-peat soils to minimise potential for instability of the underlying soils;
- Avoid storing peat on slope gradients >3° and preferably store on ground with neutral slopes and natural downslope barriers to peat movement;
- Monitor effects of wetting/re-wetting stored peat on surrounding peat areas, and prevent water build up on the upslope side of peat mounds; and
- Maximise the interval between material deliveries over newly constructed tracks that are still observed to be within the primary consolidation phase.

8.6.8.10 During the operational phase of the Proposed Development monitoring of key infrastructure locations would continue through Site walkovers and inspections by the maintenance Contractor to look for signs of unexpected ground disturbance, including:

- Ponding on the upslope side of infrastructure sites and on the upslope side of access tracks;
- Subsidence and lateral displacement of tracks;
- Changes in the character of natural or artificial peat drainage within a 50 m buffer strip of tracks and infrastructure (e.g., development of quaking bog, waterlogging of previously dry drains);
- Blockage or underperformance of the installed site drainage system;
- Slippage or creep of stored peat deposits (including in restored peat cuttings); and
- Development of tension cracks, compression features, bulging or quaking bog anywhere in a 50 m corridor surrounding the site of any construction activities or site works.

8.6.8.11 Monitoring would be undertaken during construction and as part of the commissioning phase the need for on-going monitoring would be reviewed and any ongoing monitoring requirements identified.

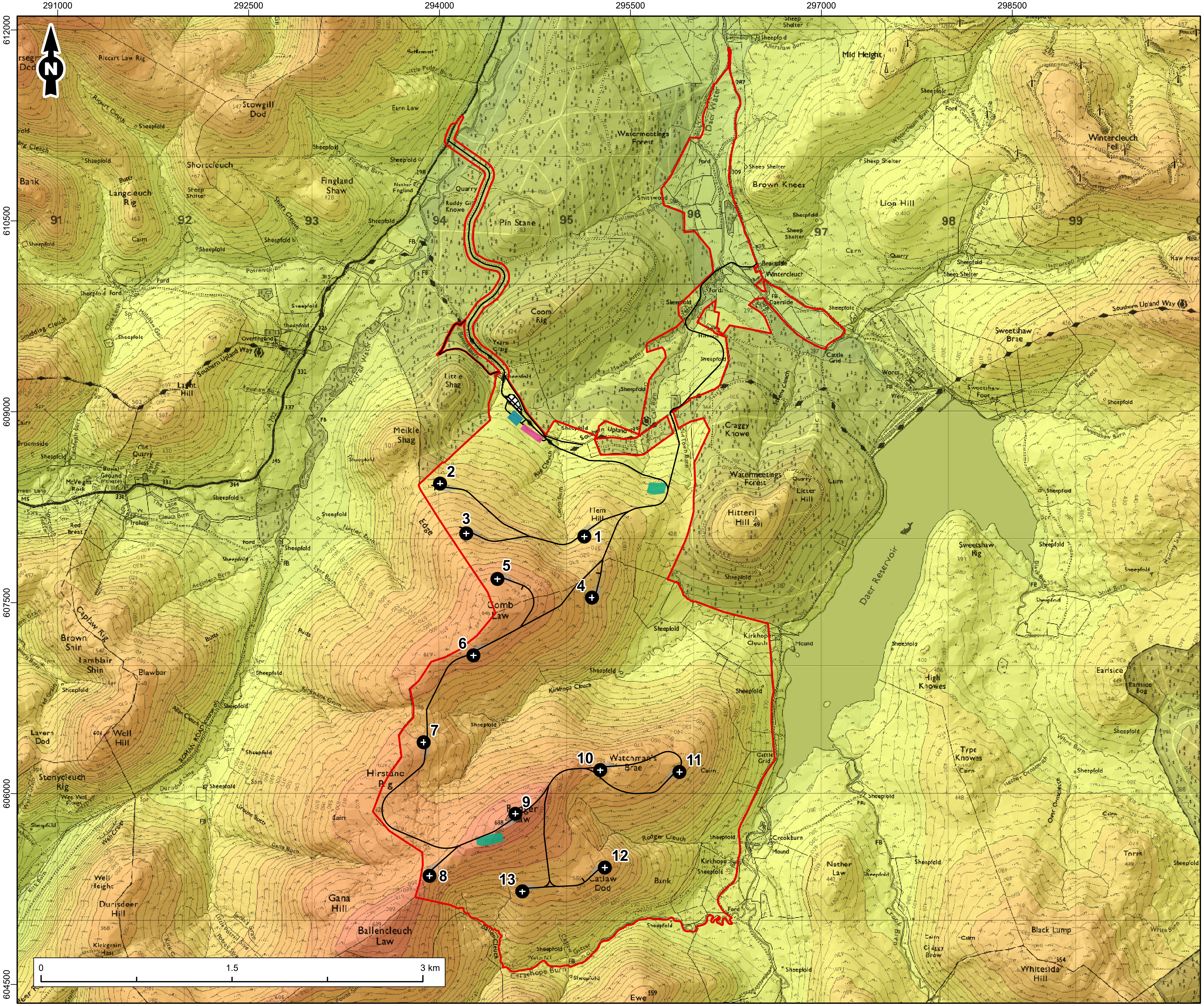
8.6.9 Conclusion

8.6.9.1 The Proposed Development Site is considered to be Low or Very Low risk with regards to peat slide risk with the exception of three track locations (2, 6 and 10) which are considered to be Moderate.

8.6.9.2 It is considered that the general good practice mitigation measures included within **Section 8.6.8** of this Technical Appendix would be sufficient to provide mitigation for very low and low risk areas of the Site.

8.6.9.3 For areas of moderate risk, micrositing of infrastructure following additional post-consent ground investigation and detailed design should be considered. Where micrositing is not practicable then excavation of the peat to remove the potential risk would be required. The approach to mitigation for areas of moderate peat slide risk (i.e., micrositing or peat excavation) would be confirmed post-consent and be based on detailed ground investigation at the Site.

Annex 8.6.1: Figures



Legend

- Site Boundary
- Turbine Locations
- Access Track
- Turbine Hardstanding
- Construction Compound
- Substation
- BESS
- Borrow Pit Excavation Area

Elevation (m AOD)

- 250.1 - 300
- 300.1 - 350
- 350.1 - 400
- 400.1 - 450
- 450.1 - 500
- 500.1 - 550
- 550.1 - 600
- 600.1 - 650
- 650.1 - 700

Figure Title Elevation		
Project Name Watchman Energy Park		
Project No./Filery ID 1620016964 / REH2024N01805		
Date February 2026	Figure No. 8.6.1	Revision 1.0
Prepared By RD	Scale 1:28,000 @A3	
Client Watchman Energy Park Ltd		

RAMBOLL

Coordinate System: British National Grid. Projection: Transverse Mercator. Datum: OSGB 1936.
1620016964-RAM-MA-GT-00037-Elevation_03.pagx