



Technical Appendix 8.1 Peat Landslide Hazard and Risk Assessment

Dalfad Wind Farm

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Acronyms and Abbreviations

AOD	Above Ordnance Datum
BESS	Battery Energy Storage System
BGS	British Geological Survey
BNG	British National Grid
BS	British Standard
CEMP	Construction Environmental Management Plan
CMRA	Coal Mining Risk Assessment
DTM	Digital Terrain Model
EAC	East Ayrshire Council
EIA	Environmental Impact Assessment
GCoW	Geotechnical Clerk of Works
GIS	Geographical Information System
GPS	Global Positioning System
GRR	Geotechnical Risk Register
GWDTE	Groundwater Dependent Terrestrial Ecosystem
HER	Historic Environment Records
InSAR	Interferometric Synthetic Aperture Radar
JNCC	Joint Nature Conservation Committee
kPa	Kilopascal
LIDAR	Light Detection and Ranging
Met Office	UK Meteorological Office
M	Metre
M bgl	Metres below ground level
Mm	Millimetre
MRA	Mining Remediation Authority
NGR	National Grid Reference
OS	Ordnance Survey
PCA	Peatland Condition Assessment
PLHRA	Peat Landslide Hazard and Risk Assessment
PMP	Peat Management Plan
PWS	Private Water Supply
SAC	Special Area of Conservation
SEPA	Scottish Environment Protection Agency
SLR	SLR Consulting Limited
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest



UK	United Kingdom
WHS	World Heritage Site



1.0 Introduction

SLR Consulting Limited (SLR) were commissioned by Brockwell Energy Limited ('the Applicant') to undertake a Peat Landslide Hazard and Risk Assessment (PLHRA) at the proposed Dalfad Wind Farm ('the Proposed Development'), located approximately 4 km north-east of Cumnock, and 28 km east of Ayr, within East Ayrshire Council (EAC) administrative area, as shown on **Figure 1.1** of the Environmental Impact Assessment (EIA) Report.

The assessment has been prepared by a team of geotechnical engineers, geologists, peatland specialists and hydrogeologists / hydrologists with extensive experience undertaking surveys and assessments in peatland environments, specialising in the assessment of renewable power generation and grid projects across the UK and Ireland.

The team was led by a Chartered Hydrologist with over 30 years' experience.

The team have worked alongside other technical disciplines including civil engineers, ecologists, archaeologists etc. to identify potential receptors and best practices.

1.1 Proposed Development

The Proposed Development will comprise up to 14 wind turbines and associated infrastructure including Battery Energy Storage System (BESS). In addition to the turbines and BESS, the Proposed Development will include the following ancillary infrastructure:

- turbine foundations;
- crane hardstands;
- a site entrance;
- internal and private access road network;
- watercourse crossings;
- transformers and underground cables; and
- an on-site substation / switchgear building.

Temporary infrastructure required for construction will include:

- two construction compounds;
- crane assist pads;
- blade laydown supports;
- boom supports;
- laydown areas;
- a concrete batching plant; and
- potential excavations/borrow pit workings.

Full details of the Proposed Development are provided in Chapter 2: Project Description and on **Figure 1.2**.



1.2 Methodology

The methods adopted for the assessment follow relevant currently available best practice guidance issued by the Scottish Government for investigation, assessment and reporting for electricity generation developments in peat areas¹.

Where relevant, reference is also made to guidance and research published by the Scottish Environment Protection Agency (SEPA)², NatureScot^{3,4} and wind farm construction good practice guidance⁵ where relevant to construction on peat.

1.2.1 Requirement for a PLHRA

The guidance provides a screening tool to determine whether a PLHRA is required. The requirements to undertake a PLHRA are:

- where peat is present within a blanket bog setting, on slopes exceeding 2 °; and
- where peat is present within a raised bog setting.

The Proposed Development is partly located within a blanket bog setting, where slopes exceed 2 ° and therefore a PLHRA is required.

1.2.2 Objectives

The peat stability assessment is primarily concerned with the influence of the peat on the Proposed Development. The main objective is to assess the potential peat stability at the Site (the area within the red line boundary, within which the Proposed Development sits), identify areas of potential concern and identify mitigation measures to ensure the maintenance of peat stability before, during and after construction. All aspects of construction should be based on ensuring minimum disruption to the peat areas.

The objectives have been achieved by completion of the following:

- A desk-based review of geological, hydrological and topographical information including:
 - Previous site information, including technical reports, feasibility reports, previous ground investigation, and data from adjacent developments or planning applications, where relevant;

¹ Scottish Government (April 2017) *Peat Landslide Hazard and Risk Assessments: Best Practice for Proposed Electricity Generation* (2nd Edition). Available at: [Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments](#)

² Scottish Government, Scottish Natural Heritage (NatureScot), SEPA (2017) *Peatland Survey: Guidance on Developments on Peatland, on-line version only*. Available at: [Guidance+on+developments+on+peatland+-+peatland+survey+-+2017.pdf](#)

³ NatureScot (June 2023). *Advising on Peatland Habitats and Carbon-rich Soils in Development Management*. Revised March 2026. Available at: [Advising on peatland habitats and carbon-rich soils in development management | NatureScot](#)

⁴ Mills, A.J. and Rushton, D. (2023). *A Risk Based Approach to Peatland Restoration and Peat Instability*. NatureScot Research Report 1259. Available at: [NatureScot Research Report 1259 - A risk-based approach to peatland restoration and peat instability | NatureScot](#)

⁵ NatureScot (July 2024). *Good Practice During Wind Farm Construction*. (4th Edition). Available at: [Good practice during wind farm construction | NatureScot](#)



- British Geological Survey (BGS) data, maps and memoirs available through the BGS Information Hub⁶ and Onshore GeoIndex⁷;
- NatureScot Carbon and Peatland (2016) map⁸ and National Soil Map of Scotland (James Hutton Institute)⁹;
- Current and historical Ordnance Survey mapping;
- Ordnance Survey Terrain 5 Digital Terrain Model (DTM), publicly available LiDAR or InSAR data;
- Information available through the SEPA website;
- Rainfall and Climate data available through SEPA and Met Office websites;
- Academic literature and publications, newspaper archives and online searches, where relevant;
- Local or site knowledge relayed by landowners / users.
- Geomorphological mapping of the Site to identify prevailing conditions influencing the potential for, or any evidence of, active, incipient or relict peat instability, through review of historical and recent satellite imagery.
- Site reconnaissance and multiple phases of peat depth surveying including hand pitting and coring;
- Reporting on evidence of any active, incipient or relict peat instability, and the likelihood of future instability occurring at the Site, describing the likely causes and contributory factors;
- Providing recommendations for further work or specific construction methodologies to suit the ground conditions at the Site, to mitigate any unacceptable risk of potential peat instability.

The risk assessment is based on ground models developed using a Geographical Information System (GIS) specifically for the Proposed Development. A numerical analysis was undertaken in which coefficients were allocated for each of the factors influencing peat stability. The method is described in detail in Section 0.

The system outlined was developed in accordance with guidelines on PLHRA by the Scottish Government¹ for investigation, assessment and reporting for electricity generation in peat areas.

The analysis and interpretation are based upon the results obtained from this process, as well as previous experience and the results of case studies elsewhere. Where deviations from this guidance have occurred, this is highlighted and explained within the report text.

This report has been developed alongside and should be read in conjunction with Chapter 8: Geology, Hydrology, Hydrogeology and Peat and the following Technical Appendices:

- Technical Appendix 8.2: Peat Management Plan (PMP); and
- Technical Appendix 8.3: Peatland Condition Assessment (PCA).

⁶ British Geological Survey (BGS) (2026) *Information Hub* Available at: [Information hub - British Geological Survey](#) (Accessed June 2026)

⁷ British Geological Survey (BGS) (2026). *GeoIndex Onshore*. Available at: <https://mapapps.bgs.ac.uk/geoindex/home.html> (Accessed June 2026)

⁸ NatureScot (2016) *Carbon and Peatland Map*. Available at: [Carbon and peatland 2016 map | Scotland's soils](#)

⁹ Scotland's Environment Website. *Scotland's Soils Interactive Map*. Available at [Scotland's Soils - soil maps](#) (Accessed June 2026)





2.0 Peat Instability

Although peat slides are naturally occurring events, they are a relatively rare phenomenon occurring in upland and lowland peats in the UK, Ireland and globally (Mills and Rushton, 2023⁴). However, high-profile incidents occurring during the construction of Derrybrien Wind Farm in Ireland in 2003¹⁰ (and more recently at Meenbog Wind Farm in 2020¹¹) have highlighted the need for greater consideration of the potential impact of development on peat stability. While no fatalities were associated with these failures, they resulted in significant environmental impact.

Blanket bog is the most common peat habitat in the UK and is associated with thick peat deposits. Renewable energy developments, including wind farms, pumped storage and transmission projects are commonly located on upland moorland terrain comprising blanket bog (though raised bogs, intermediate bogs and fens may also be impacted).

Within these settings, peat instability can occur, particularly where deep peat deposits (> 1 m) are present.

Peat instability is complex and can be influenced by many factors. This section reviews the nature of peat and how current and past activities can influence stability. The factors which are likely to influence the potential for peat instability are:

- Significant peat depths over impermeable bedrock or mineral soil;
- The presence of slope gradients > 2 ° and relief;
- Natural drainage paths and subsurface hydrology;
- Evidence of past failures, including soil creep;
- Drainage features at the base of slopes which could lead to undercutting;
- Forestry plantations and artificial drainage;
- Climate (and rainfall).

Other anthropogenic factors may also increase the likelihood of peat instability events occurring, which are explored further within this report.

It should be noted that peat instability is not a recent phenomenon and there is documentary evidence of peat landslides dating back over 500 years¹². Many landslides that involve peat have no human interference that could be considered as a trigger, and this should be borne in mind when considering the susceptibility of a site to potential instability.

2.1 Background Information Regarding Peat

2.1.1 Definitions of Peat

Peat is defined as an organic soil comprising the partly decomposed plant remains that have accumulated in-situ, rather than being deposited by sedimentation. When peat forming plants die, they do not decay completely as their remains become waterlogged due to regular rainfall. The effect of waterlogging is to exclude air and hence limit the degree of decomposition.

¹⁰ Lindsay, R.A. and Bragg, O., (2004), 'Windfarm and Blanket Peat, The Bog Slide of 16th October 2003 at Derrybrien, Co. Galway, Ireland'. University of East London

¹¹ Geological Survey Ireland (GSI) & National Parks and Wildlife Service (NPWS), (2023-24) *Assessment of main contributing factors leading to three major peatland failures (Leitrim, Kerry, Donegal)*.

¹² Smith, L.T., (Ed) (1910), 'The literary of John Leland in or about the years 1535-1543.' Vol.5, Part IX. London: AF Bell and Sons.



Consequently, instead of decaying to carbon dioxide and water, the partially decomposed material is incorporated into the underlying material, and the peat 'grows' in-situ.

The Scottish Government PLHRA Guidance¹ uses the following Joint Nature Conservation Committee (JNCC) report 445 'Towards an Assessment of the State of UK Peatlands' (2011)¹³ definition for classification of peat deposits:

- Peaty (or organo-mineral) soil: a soil with a surface organic layer less than 0.5 m deep;
- Peat: a soil with a surface organic layer greater than 0.5 m deep which has an organic matter content of more than 60 %; and
- Deep Peat: a peat soil with a surface organic layer greater than 1.0 m deep.

Peat is found in extensive areas in the upland and lowland regions of the UK and is defined as the partly decomposed plant remains that have accumulated in-situ, rather than being deposited by sedimentation. When peat forming plants die, they do not decay completely as their remains become waterlogged due to regular rainfall. The effect of waterlogging is to exclude air and hence limit the degree of decomposition. Consequently, instead of decaying to carbon dioxide and water, the partially decomposed material is incorporated into the underlying material, and the peat 'grows' in-situ.

Peat is characterised by low density, high moisture content, high compressibility and low shear strength, all of which are related to the degree of decomposition and hence residual plant fabric and structure. To some extent, it is this structure that affects the retention or expulsion of water in the system and differentiates one peat from another.

Lindsay¹⁴ defined two main types of peat bog, raised bog and blanket bog, which are prevalent on the west coast of Europe along the Atlantic seaboard. In Britain, the dominant peatland is blanket bog which occurs on the gentle slopes of upland plateaux, ridges and benches and is predominantly supplied with water and nutrients via precipitation. Blanket peat is generally considered to be hydrologically disconnected from the underlying mineral layer.

There are two principal types of peat in a near natural peatland (see Plate 2-1):

- The upper (acrotelm) layer in which the water table fluctuates, which is fibrous and comprises plant roots etc. The acrotelm is relatively dry and has some tensile strength and its thickness typically ranges from 0.1 m to 0.6 m..
- The lower (catotelm) layer, which is saturated, sitting permanently below the water table. The catotelm layer is highly decomposed, generally becoming more amorphous/liquid in nature and losing structure with increasing depth. The structure of catotelmic peat tends to disrupt completely on excavation and handling.

The acrotelm is the fibrous surface to the peat bog¹⁵ which exists between the growing bog surface and the lowest position of the water table in dry summers. The relative position of the water table within the peat controls the balance between accumulation and decomposition, and therefore its stability, hence artificial adjustment of the water table by drainage can have significant impacts.

¹³ Joint Nature Conservation Committee (JNCC), 2011. *Towards an assessment of the state of UK peatlands*. JNCC Report No. 445. JNCC, Peterborough.

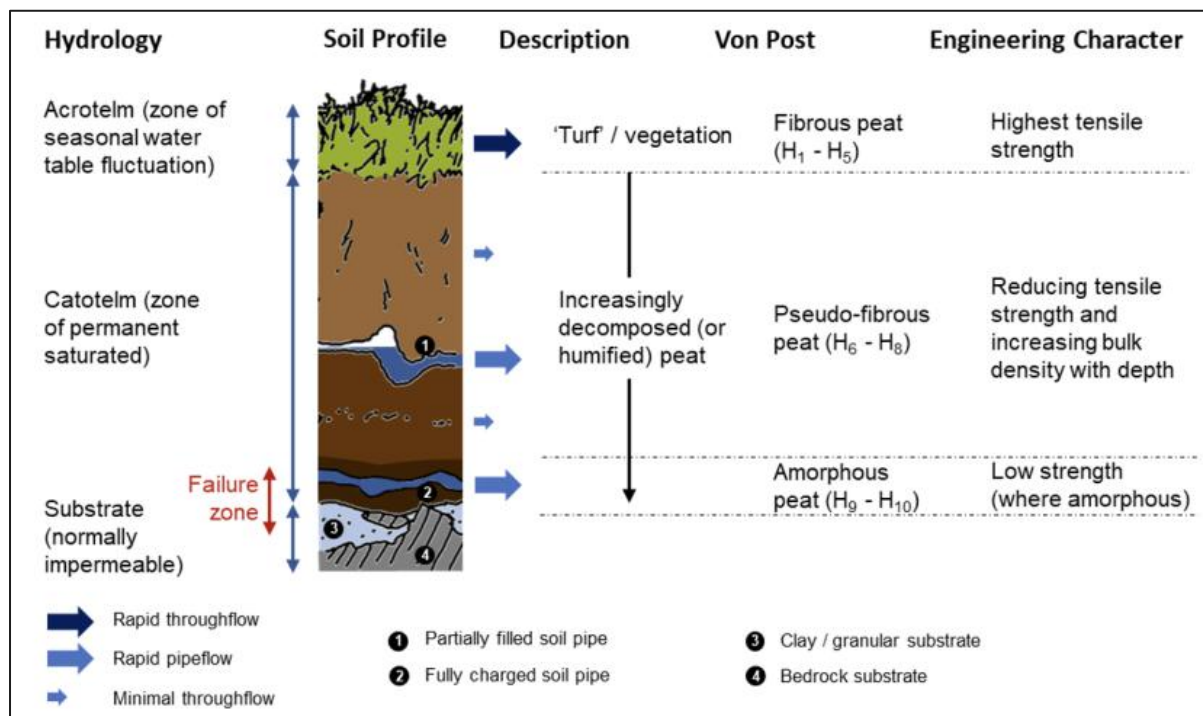
¹⁴ Lindsay, R.A, (1995), *Bogs: The ecology, classification and conservation of ombrotrophic mires*. Scottish Natural Heritage. Perth.

¹⁵ Ingram, H.A.P., (1978), 'Soil layers in mires: function and terminology'. *Journal of Soil Science*, 29, 224-227.



For geotechnical purposes the degree of decomposition (humification) can be estimated in the field by applying the 'squeezing test' proposed by von Post and Grunland (1926)¹⁶ and as shown in Plate 2-1. The humification value ranges from H1 (no decomposition) to H10 (highly decomposed). The extended system set out by Hobbs¹⁷ provides a means of correlating the types of peat with their physical, chemical and structural properties.

Plate 2-1 Typical Peat Profile



2.1.2 Peat Shear Strength

In geotechnical terms, the shear strength of a soil is the maximum stress that a soil can sustain without experiencing failure. The physical characteristic of a soil impacts on the overall shear strength. For mineral soils such as clay or sands, such strength is variously given by an interparticle friction value and cohesion. Whether the mineral soil is predominantly cohesive (clay) or non-cohesive (sand & gravels) governs which of the component strengths control the behaviour of the soil.

In the case of peat soils, where the major constituent is organic, there is likely to be little or no mineral component; the geotechnical definition of shear strength therefore does not strictly apply. At present, there is no real alternative to defining shear strength of peat, therefore the geotechnical definition is usually adopted, in the knowledge that it should be used with caution.

As noted, the acrotelm or near surface peat comprises a tangle of fresh and slightly rotted roots and plant fibres. These roots and fibres impart a significant tensile strength capacity to the material which provides it with a significant load carrying capacity. The acrotelm is in effect, a fibre reinforced soil.

In the more decomposed catotelm, the tensile shear strength is reduced as the roots and fibres become increasingly rotted. However, the loss of strength is offset to a limited degree, by a

¹⁶ Von Post, L and Grunland, E., (1926) Sodra Sveriges torvillganger 1, Sverges Geol. Unders. Avh., C335, 1-127.

¹⁷ Hobbs, N.B. (1986) *Mire morphology and the properties and behaviour of some British and foreign peats*. Quarterly Journal of Engineering Geology, London, 19, 7-80).



gain in strength due to the overburden pressure. In geotechnical engineering there is an established relationship for recently deposited soils, between the shear strength of a sample and thickness of overburden above it.

Consequently, it is almost impossible to predict a shear strength profile in peat and attempts to measure the shear strength using normal geotechnical methods can be misleading (Evans & Warburton 2007¹⁸; Gosling and Keeton 2008¹⁹, Winter et al 2005²⁰). Typical values of shear strength from hand shear vanes would be in the range 10-60 kilopascal (kPa) although values of over 100 kPa have been recorded in peat elsewhere. The higher strengths are almost certainly influenced by the roots or other non-decomposed material. It is believed that the strength of peat should be quoted as a cohesion value as there are few, if any, discrete particles to give the material a significant frictional resistance. It should be noted that any quotation of shear strength for peat should be treated with extreme caution.

2.1.3 Peat Stability – Factors to be Considered

There is considerable observational information relating to debris and peat flows although the actual mechanisms involved in peat instability are not fully understood. The main influences on slope stability are geological, geotechnical, geomorphic, hydrological, topographic, climatic, agricultural and human influences such as drainage and construction activity. Peat is affected to a degree by changes in any of the above list and it is vital to appreciate that changes to the existing equilibrium would affect the level of slope stability during construction and operation of the Proposed Development.

Some of the contributory factors to peat instability are summarised as follows:

- The geographical limits which could be affected by potential instability are not confined to the artificial boundaries imposed by land ownership; landslip occurring above a site could affect the site and property down slope or downstream of the site for several kilometres.
- Agriculture and grazing have a substantial effect on peat areas, and this can be compounded in areas that have been managed to improve grazing. Grazing compacts the peat surface reducing the rainwater infiltration and the additional nutrients change the ecological balance of the original peat bog. Agricultural management can include surface drainage and periodic burning, both of which can leave the surface of the peat bare for a period of time, resulting in temporary desiccation of the surface. Subsequent wetting of the peat and resumption of peat accumulation results in the former desiccated and possibly ash covered surface being incorporated into the body of the peat which introduces a weak discontinuity in the profile; this in turn becomes another unknown factor in the stability assessment.
- Forestry has a substantial effect on slope stability particularly in the early stages as the creation of a forest involves disruption of the natural equilibrium and drainage of the slopes and the installation of artificial drains by deep ploughing. The construction of access tracks further disrupts the drainage and concentrates groundwater flow into narrow, fast flowing erosive streams. The work by Winter et al²⁰ noted that forest tracks can act to retard or concentrate the down slope flow

¹⁸ Evans, E. and Warburton, J (2007). *Geomorphology of Upland Peat: Erosion, Form and Landscape Change*. John Wiley & Sons.

¹⁹ Gosling, D., and Keeton, P. (2008). *Problems with Testing Peat for Stability Analysis*.

Paper presented at Reinforced Water, Geological Society Conference;

²⁰ Winter, M.G., MacGregor, F. and Shackman, L. (2005) *Scottish Road Network Landslides Study*, ISBN 0 7559 4649 9.



of water and thus aid its penetration into the slope below. Such a mechanism has been observed at a number of recent landslips that have affected the road network in Scotland.

- Natural drainage: some of the precipitation falling onto a natural upland peat bog would be absorbed into the low permeability catotelm peat. However, most of the water would run-off as sheet flow through upper, high permeability acrotelm. Thus, the water is transmitted to the lower slopes in a reasonably controlled manner through a range of interconnections that operate at different scales and speed. Failure to understand this and to disrupt the transmission process for the groundwater could result in instability.
- Artificial drainage: where agricultural drainage has been used to improve the quality of the grazing or to promote forestry, it reduces the overall volume of water entering the bog and transfers this water to the edges more rapidly. This can result in ditches and streams becoming enlarged, causing increased erosion and a greater silt burden in the stream water.
- Slope gradient: as noted in the best practice guidance¹, peat slides have a greater likelihood of occurrence where slope angles range from 5 to 15 °. Deposits with shallower slope gradients are less susceptible to failure due to the reduced influence of gravity. Deposits with steeper slope gradients are less susceptible to failure due to the general lack of peat presence (although peaty debris slide may occur).
- Peat Depth: Boylan et al. (2008)²¹ describe three common types of peat, controlled to an extent by rainfall and elevation:
 - Upland Blanket Bog: blanket bogs are typically about 3 m thick, however, they can be up to 5 m thick, generally thinning at higher elevations.
 - Lowland Blanket Bog: similar to the upland version, however, they form around sea level in areas of very high rainfall.
 - Raised Bog: generally, 3–12 m thick, averaging 7 m, with growth occurring above the water table.
- Peat depth can give an indication of peat strength and the potential magnitude of a slide, where the generalisation can be made that the potential for peat instability increases with peat depth provided gradients exist to allow movement. However, when combined with other instability indicators, any depth of peat can fail. Factors that influence the potential include:
 - Peat Strength: the shear strength of peat is an important aspect in assessing the risk of landslide in blanket peat areas, with areas of lower shear strength likely to be the cause of any peat slide. However, due to the influence of fibres within the deposits and of stratification with depth, reliable values of shear strength are difficult to near impossible to obtain using common place in situ and laboratory soil strength tests. Where data is available, it can be used, with extreme caution, to assist in assessing likely risk.
 - Relief: the combination of slope gradient and variation in elevation can result in confined and unconfined zones i.e., where undulating or hummocky terrain (confined) exists, the natural relief has the potential to mitigate the occurrence

²¹ Boylan, N., Jennings, P., Long, M. (2008). *Peat Slope Failure in Ireland*. Quarterly Journal of Engineering Geology and Hydrogeology.



of a peat slide. However, convex sloping hillsides (unconfined) can increase the slide potential.

- Evident and/or Potential Areas of Instability: the presence of certain geomorphological characteristics may signify an increased risk of peat instability. However, peat instability events may occur in areas where no such geomorphological characteristics are present, if the general characteristics match those mentioned above.
- Vegetation Cover: the vegetation cover of an area of bog/mire gives an indication as to its hydrological setting and therefore physical characteristics, as noted in the Best Practice Guide¹ and detailed by Hobbs, 1986¹⁷.
- Peat Stratification: the peat formation process causes peat to show natural anisotropic strength. The interface between the three distinct layers (indicating three hydrosere stages) within a peat mass is defined by hydrology. The three layers are:
 - Top Mat: living vegetation of herbaceous plants, grasses and mosses;
 - Acrotelm: decomposing peat which is saturated periodically and is of relatively high permeability; and
 - Catotelm: permanently saturated dense peat of relatively low permeability.
- Peat stratification is linked to peat depth (Dykes, 2006²²), with thinner peat deposits having a thinner or no catotelm layer. A minimal or absent catotelm layer leads to the peat mass having a higher shear strength, as the overlying top mat and acrotelm layers are more fibrous in nature compared to the underlying catotelm layer.
- Hydrology (Surface and Subsurface): surface (seeps and springs, wet flushes, watercourses, concentration of drainage networks etc.) and subsurface (pipe systems, underground channels etc.) drainage pathways can provide areas of peat with a water supply which may be absorbed by and potentially increase the mass of the peat. This can cause pooling/piping within the peat mass, or an increase in water at the base of the peat mass, each of which increases the susceptibility of the peat mass to failure.

The presence of several of the above natural factors may create the potential for peat instability to occur, however, the actual instability is generally the result of a combination of further contributing factors. These factors have been grouped into two categories within the Best Practice Guide¹ described as preparatory and triggering factors.

Preparatory factors, which affect the stability of peat slopes in the medium to long-term (tens to hundreds of years), are:

- Increase in mass of the peat through peat formation;
- Increase in mass of the peat through increase in water content;
- Increase in mass of the peat through afforestation;
- Reduction in shear strength from changes in the physical structure of the peat due to creep, weathering or vertical tension cracks in the material;

²² Dykes, A.P. and Kirk, K.J. (2006) *Slope Instability and Mass Movements in Peat Deposits*. In Martini, I.P., Martinez Cortizas, A. and Chesworth, W. (Eds.) *Peatlands: Evolution and Records of Environmental and Climatic Changes*. Elsevier, Amsterdam.



- Loss of surface vegetation and associated tensile strength (e.g. deforestation);
- Changes in the subsurface hydrology (water filled pools and/or pipes etc.); and
- Afforestation reducing the water held in the peat body, increasing the potential for formation of desiccation cracks which can be exploited by rainfall on forest harvesting.

Triggering factors, which can have an immediate effect on peat stability and act on susceptible slopes, include:

- Intensive rainfall or snow melt causing development of high porewater pressures within the peat;
- Alterations to drainage patterns generating high porewater pressures within the peat;
- Peat extraction at the toe of the slope i.e. fluvial incision, cut slopes etc. reducing the support of the upslope material;
- Peat loading commonly due to stockpiling or plant during construction (or natural causes i.e. landslide) causing an increase in shear stress;
- Changes to the vegetation cover i.e. by stripping the surface cover or afforestation; and
- Earthquakes or man-made rapid ground accelerations, such as blasting or mechanical vibrations, causing an increase in shear stress.

Evidence of the potential for peat instability within an area may be observed through the recording of the geomorphological conditions of the area. These existing geomorphological characteristics may indicate the presence of existing or historical failures or areas of future potential instability. The characteristics of particular interest include the presence of the following:

- Historical failure scars and debris;
- Tension cracking and tearing;
- Compression ridges/thrusts or extrusion;
- Peat creep;
- Subsurface drainage (pools and/or piping);
- Seeps and springs;
- Cracking related to drying;
- Concentration of surface drainage networks; and
- The presence of organic clays at the peat and bedrock interface.

2.2 Types of Failure

The result of peat instability is the down-slope mass movement of the peat material. There are several definitions of peat instability which are used to characterise the type of failure, including:



- Bog bursts or bog flows – the emergence of a fluid form of well humified, amorphous peat from the surface of a bog, followed by the settling of the residual peat, in-situ²³.
- Peat slides – the failure of the peat at, or below, the peat/substratum interface leading to translational sliding of detached blocks of surface vegetation together with the whole underlying peat stratum²⁰.
- Bog slides – an intermediate form of instability where failure occurs on a surface within the peat mass with rafts of surface vegetation being carried by the movement of a mass of liquid peat.

2.2.1 Bog Bursts (or Bog Flows)

Particularly fluid (amorphous) failures involving rupture of the peat blanket surface or margin due to subsurface creep or swelling, with liquefied basal material expelled through surface tears followed by settlement of the overlying peat mass, in-situ (Hemingway and Sledge, 1941-46²⁴, Bowes, 1960²⁵).

Accounts of bog bursts are generally associated with very wet climates or areas which have received storm rainfall events. Bog bursts can be associated with particularly wet peat landscapes; therefore, it is possible to identify broad regions of a higher susceptibility to these failures. The constraints used to identify the areas of higher susceptibility to bog burst failures are given below:

- Peat thicknesses typically >1.5 m;
- Shallow gradients, ranging from 2 – 10 ° though typically 2 – 5 °, peat thicknesses associated with bog bursts are generally not observed on slopes steeper than 10 °, where moisture content is reduced due to natural drainage;
- Ground which is annually waterlogged to within the upper 1 m below ground level (the groundwater level may rise but rarely falls below this level (Crisp et al, 1964²⁶));
- Greater humification of the lower catotelm within the waterlogged ground; and
- Lower surface tensile strength of the fibrous peat and vegetation.

The humified mass can be considered as analogous to a heavy liquid, and the stability of this mass is maintained by the strength of the surface or acrotelm peat. Should the surface become weakened through erosion or desiccation or the construction of a surface drainage ditch for agricultural or forestry reasons or through turbary (peat cutting), failure is made more likely.

2.2.2 Peat Slides

Peat slides tend to be translational failures with a defined shear surface at or close to the interface with the substrate. The factors generally considered to influence susceptibility to peat slide failures are listed below:

²³ Dykes, A.P and Kirk, K.J., (2001), 'Initiation of a multiple peat slide on Cuilcagh Mountain, Northern Ireland.' Earth Surface Processes and Landforms, 26, 395-408.

²⁴ Hemingway, J.E. and Sledge, W.A. (1941-46) *A Bog Burst near Danby in Cleveland*.

²⁵ Bowes, D.R. (1960) *A bog burst in the Isle of Lewis*. Scottish Geographical Magazine, 76, pp21-23

²⁶ Crisp, D.T., Dawes, M. & Welch, D. (1964), 'A Pennine Peat Slide', The Geographical Journal, Vol 130, No4, pp519-524.



- Peat depth up to 2 m, though typically observed between 0.5 and 1.5 m;
- Slope gradients between 5 and 15 °;
- Natural or artificial drainage cut into the surrounding peat landscape;
- Greater humification of the lower catotelm within the waterlogged ground; and
- Lower surface tensile strength of the fibrous peat and vegetation.

It is noted that some of the factors causing instability are common to both bog bursts and peat slides. The peat – substrate interface is the primary zone of failure and is enhanced by elevated water content at this boundary and softening or weathering of the lower mineral surface. For this reason, any investigation or probing should try to distinguish the nature of the lower mineral substrate.

2.2.3 Bog Slides

A bog slide is a variation on a peat slide where part of the peat mass is subject to movement, usually on an internal layer of material, which may be more prone to movement, such as an interface between the acrotelmic and catotelmic layer.

2.2.4 Natural Instability

The stability of a peat mass is controlled by a complex interrelationship of factors. Key factors include sloping rock head, and proximity to water bodies. Rainfall often acts as a trigger after the slope has been conditioned to fail by natural processes.

It should also be remembered that peat bogs are growing environments and that there would come a time, on sloping ground, where the forces causing instability, the weight of the bog, can no longer be resisted by the internal strength of the peat and its interface with the underlying mineral surface. At this point, failure would occur.

The weight of the peat bog or any soils mantling steep hill slopes would be increased during periods of very heavy rain and it is common to see landslips occurring following extreme rain events. This may be a concern for future developments where one of the predicted effects of global warming is greater frequency of extreme weather, including intense storm events.



3.0 Desk Based Review

3.1 Geological Setting

3.1.1 Artificial Ground

BGS mapping indicates two areas of made ground deposits present across the north of the Site. Artificial ground is indicated at T3 and the proposed construction compound to its west, and to the west of T1, associated with historical mining features.

3.1.2 Soils

The National Soil Map for Scotland (1:250 k scale) indicates that the Site is primarily underlain by mineral gleys, with an area of peat indicated in the northeastern extent of the Site.

3.1.3 Peatland Classification

NatureScot's Carbon and Peatland map⁸ indicates that the Site is predominantly located on mineral soil and class 5 peatland. Class 5 peatlands are not identified as priority peatland habitats; however, soils may be carbon-rich and deep peat may be present. An area of class 1 peatland is indicated in the southwest of the Site. Class 1 peatland is considered nationally important priority peatland with carbon rich soils and areas of deep peat which are likely to be considered of high conservation value. There is no proposed infrastructure located within the area of class 1 peatland.

The Carbon and Peatland Map provides an indication of the likely presence of peatland and should not be used in development management decision making with on-site specific detailed peat surveying and assessment required to determine the presence of peat, which is detailed in later sections.

Figure 8.5 shows peatland classification and the Proposed Development.

3.1.4 Peatland Restoration

A review of the Peatland ACTION Open Data²⁷ portal indicated that there are no recorded peatland restoration works, peat depth surveys, or peat condition data within the Site. However, a desk-based assessment of aerial imagery identified evidence of drain-blocking activities at Low Moss, located in the western part of the Site. Peatland ACTION Open Data records show that a peat condition survey was undertaken at Dornal Moss, approximately 400 m east of the Site. The survey results indicate that the majority of the peat within the surveyed area is classified as being in a drained condition.

3.1.5 Superficial Geology

BGS 1:50 k scale mapping indicates that the majority of the Site is underlain by till deposits. Peat is also identified across the Site, located on the western edges but most prominent in the centre, in the east and in the northeast of the Site. Alluvial deposits are mapped along the riverbanks of the Glenmuir Water in the south of the Site and the Gass Water in the north of the Site. Glacifluvial deposits are mapped in the north of the Site.

Figure 8.4 shows the superficial geology BGS mapping and the Proposed Development.

²⁷ NatureScot (2026) Peatland ACTION – Open Data. Available at: <https://www.nature.scot/climate-change/nature-based-solutions/nature-based-solutions-practice/peatland-action/peatland-action-data-research-and-monitoring/peatland-action> (Accessed: 27 July 2026)



3.1.6 Bedrock Geology

BGS 1:50 k scale mapping indicates that the main geological units underlying the northern extent of the Site are the Upper Limestone Formation, the Limestone Coal Formation and the Strathclyde Group. These units comprise sedimentary rocks including limestone and sandstone. The south of the Site is predominantly underlain by the Strathclyde Group.

Figure 8.7 shows the bedrock geology BGS mapping and the Proposed Development.

Table 3-1 presents a summary of the bedrock geology underlying the Site.

Table 3-1 Bedrock Geology

Age	Stratigraphic Group	Stratigraphic Formation	Description
Westphalian – Early Permian	Midland Valley Igneous Suite	Quartz-microgabbro sills	Intrusive dolerite/ microgabbro bodies emplaced into Carboniferous strata
Late Carboniferous	Clackmannan Group	Upper Limestone Formation	Repetitive sedimentary cycles (cyclothems) of limestone, mudstone, siltstone and sandstone
Late Carboniferous	Clackmannan Group	Passage Formation	Predominantly sandstone with mudstone and thin coals
Mid-Late Carboniferous	Clackmannan Group	Limestone Coal Formation	Cyclical sequences of sandstone, mudstone, limestone and coal
Early–Mid Carboniferous	Strathclyde Group	Sedimentary rocks and lavas	Interbedded sandstone, mudstone, siltstone with basaltic lava flows.

3.1.7 Structural Geology

BGS 1:50 k scale mapping indicates that the Site is underlain by several bedrock units which are heavily influenced by faulting. The faults across the Site are predominantly inferred faults trending west/northwest to east/southeast.

3.1.8 Mining and Quarrying

The Mining Remediation Authority (MRA) map²⁸ indicates that much of the north and west of the Site is located within a development high-risk area due to historic underground and opencast coal mining. These areas include sections of the former Duncanziemere, Dalfad and Gasswater collieries. Recent mining disturbance remains visible across parts of the Site, though much of the Site has been backfilled, there are areas requiring restoration.

JWHRoss prepared a Coal Mining Risk Assessment (CMRA)²⁹ at the Site in August 2023, the results of which have informed the Proposed Development layout. The CMRA is presented as Technical Appendix 8.6.

²⁸ Mining Remediation Authority (MRA) (2026) Map Viewer, Available at: [Mining Remediation Authority Map Viewer](#) (Accessed June 2026)

²⁹ JWHRoss (August 2023), Mining Stability Report Including Past Mining Risk Assessment. Proposed Windfarm Development, Glenmuir, East Ayrshire.



Although BGS records don't record historical aggregate pits within the Site, however there is evidence on freely available historical OS maps of limestone quarries and limekilns alongside the Glenmuir Burn and "whinstone" quarries within the intrusive igneous rocks to the west of the Site.

The historical coal mining has removed and/or disturbed much of the peat that may have been present on Site historically.

Photograph 3-1 Overview from T6 showing modified landscape from historic mining, taken from National Grid Reference (NGR): 262343, 622749.



Photograph 3-2 Outcropping rock alongside Glenmuir Burn



Photograph 3-3 Ground disturbance alongside Glenmuir Burn



Photograph 3-4 Existing tracks from mining activity, west of T2. NGR 263112, 623446.



3.1.9 Ground Stability Hazards

BGS online records indicate that there is no risk regarding the mass movement or instability of materials.

3.2 Land Use and Topography

A five metre DTM has been used to generate a map of the slope gradient across the Site and is presented on **Figure TA8.1.1**.

From a review of OS mapping, the Site can be characterised by a gentle sloping topography that generally slopes southwest. The elevation varies from 285 m Above Ordnance Datum (AOD) in the north to 192 m AOD in the south. The Site contains several independent hills including, Peat Hill (244 m AOD) in the north and Hawk Hill (264 m AOD) in the centre of the Site.

The coal mining legacy dominates much of the north and west of the Site, with large voids, ponds, areas of restored opencast and a network of tracks.

Small areas of conifer forestry plantation, partly felled in places, are present in the east of the Site, with much of the central portion of the Site bound by an extensive area of forestry plantation to the east, outside of the Site.

The south of the Site generally comprises areas of open, improved grassland utilised for livestock grazing.



Photograph 3-5 Google Earth extract of Northern area of Site



Photograph 3-6 Google Earth extract of Southern area of Site



Photograph 3-7 Grassland and Forestry in South of Site, looking North.



Photograph 3-8 Large opencast void



3.3 Hydrology and Climate

3.3.1 Hydrology

A review of the Scotland's Environment map shows that the Site is drained primarily by the Glenmuir Water, located to the south of the Site, which flows east to west and subsequently joins the Lugar Water to the southwest.

Surface water within the Site is drained by a network of tributaries, including the Glenmuir Burn and Duncanzemere Burn, which generally follow the topographic gradient and drain towards the southwest into the Glenmuir Water.

The Gass Water drains the northern extent of the Site, flowing east to west before joining the Lugar Water. Several unnamed tributaries within the north of the Site contribute to the Gass Water.

In addition, there are several anthropogenic drainage channels across the Site, associated with historic mining activity. These drainage channels flow to the subsequent tributaries and streams.

Photograph 3-9 Modified Drainage Channel at BNG 262904,622674



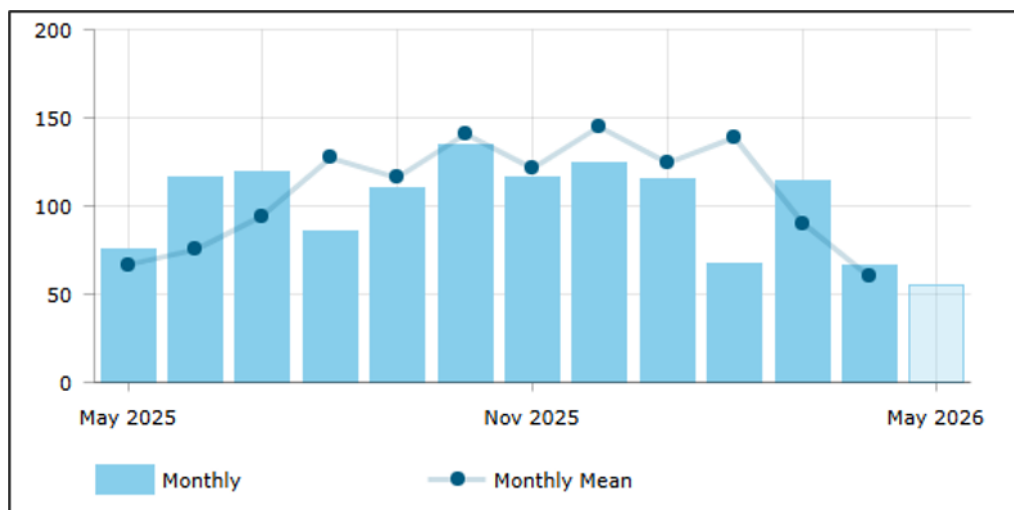
3.3.2 Rainfall

Periods of intense, heavy rainfall are often seen as triggers for instability events. The nearest SEPA weather station to the Site is Dalblair, approximately 0.7 km southeast.

Monthly rainfall averages range from 67.2 mm in February to 148 mm in October. The wettest months are October, December and January.



Plate 3-1 Rainfall Data from Dalblair Weather Station (May 2025 to May 2026)



3.3.3 Hydrogeology

BGS online data indicates that the Site is predominantly underlain by Carboniferous sedimentary rocks as part of the Clackmannan Group and the Strathclyde Group. These deposits are characterised as a moderately productive aquifer where flow is virtually all through fractures and other discontinuities within a multi layered aquifer.

The Scottish Coal Measures Group is also classified as a moderately productive cyclic multi layered aquifer.

An unnamed igneous intrusion located on the western extent of the Site is classed as a low productivity aquifer whereby flow is virtually all through fractures and other discontinuities. Small amounts of groundwater would be expected in near surface weathered zones.

The SEPA Water Classification Hub identifies the Proposed Development to be underlain by the Cumnock waterbody (ID:150646) with an overall classification of “poor”.

3.3.4 Private Water Supplies

There are 11 properties located within the Site study area (500 m buffer of the Site). Of these, five are supplied by a private water supply (PWS), three are connected to the mains water network, and the water supply source for the remaining three properties has not been confirmed. All properties either supplied by a PWS or with an unconfirmed water supply source are located more than 250 m from the proposed infrastructure. With no PWS or watercourses supplying PWS located downgradient of any increased likelihood locations, PWS are not considered a receptor to potential peat instability. Further details on PWS are provided in Technical Appendix 8.5.

3.3.5 Groundwater Dependent Terrestrial Ecosystems (GWDTE)

Chapter 8 concludes that the potential GWDTE habitats are predominantly underlain by low permeability peat and glacial deposits or are associated with existing watercourses and surface water flow paths. These settings are more characteristic of habitats sustained by rainfall, surface water ponding and waterlogging than by groundwater discharge. Additionally, no evidence of groundwater emergence was identified during the hydrological walkover survey. It is therefore concluded that the potential GWDTE habitats are not groundwater dependent and therefore there is no potential risk to GWDTE from a potential peat slide.



3.4 Environmental Designations

A review of NatureScot SiteLink map³⁰ confirms that the Muirkirk and North Lowther Uplands, designated as a Special Protection Area (SPA), Site of Special Scientific Interest (SSSI) and Special Area of Conservation (SAC), borders the west of the Site, and extends north of the Site. This area has been designated for blanket bog, breeding bird assemblages as well as many non-breeding birds.

Airds Moss SAC is located approximately 500 m north of the Site on the opposing side of the Bellow Water and has been designated for blanket bog habitats which are considered sensitive to changes to the surrounding geological or water environment.

Additional information regarding this designation is outlined in Chapter 8.

3.4.1 Cultural Heritage

There are no designated heritage assets recorded within the Site. Historic Environment Record (HER) data have been identified within the Site; however, owing to the site's extensive mining history, some recorded features have been removed and are no longer present as a result of previous mining and restoration works. With no areas of increased likelihood identified across the Site, cultural heritage assets are not considered a receptor to a potential peat slide at the Site.

3.5 Historical Mappy Review and Anecdotal Evidence

Freely available historical OS mapping has been reviewed, confirming that prior to coal mining, much of the Site may have comprised peat with marshland mapped and place names including "Dalfad Moss", "Hillhead Moss", "Low Moss", "Peat Hill", "Boghead Wood".

There is no anecdotal evidence of peat slides from historical mapping or from online searches or feedback from landowners.

3.6 Geomorphology and Satellite Imagery Review

Satellite imagery review indicates that the Site is predominantly characterised by features from the opencast mining history, where much of the natural landscape is now modified and disturbed as a result. Predominant features onsite include old open cast mines which are now water filled, areas of restored ground and existing track network built for the mine works. There is an area of coniferous plantation forestry located to the east of the Site, with smaller areas of the plantation extending into the Site.

Satellite imagery was used in conjunction with DTM data to identify major geomorphological features, mainly as disturbed ground, breaks in slope, significant watercourses etc.

Interpretation of available satellite imagery was undertaken to assess and identify (where present) evidence of historic peat instability. The photographs were examined to highlight features of interest, where present, including:

- Possible extension and/or compression features;
- Areas of historic failure scars and debris;
- Evidence of soil/peat creep;
- Areas with apparent poor drainage;
- Areas with concentrations of surface drainage networks; and

³⁰ NatureScot Data, available at <https://sitelink.nature.scot/map>



- Steeply incised stream cuttings within peat deposits.

The Site was further assessed during site visits when more detailed mapping was undertaken.

The geomorphological analysis of the Site is presented on **Figure TA8.1.2: Satellite Imagery with Geomorphological Mapping**. A detailed assessment of peatland condition has been undertaken within Technical Appendix 8.3.

3.6.1 Peat Erosional Features

A desk-based review of peat areas within the Site indicates that no features of active peat erosion are present. One area identified during desk study initially thought to exhibit microerosion characteristics was confirmed during field survey to comprise made ground with a thin layer of redeposited peaty soil. The Site shows no evidence of haggling, gullyng, microerosion or other erosional forms typically associated with degraded peatland. Instead, the landscape is dominated by restored substrates and extensive made ground surfaces.

Therefore, no areas of instability were noted in relation to erosional features across the Site.

3.6.2 Drainage

Almost the entire Site is modified either through previous mine workings or artificial drainage features and forestry.

No areas of instability were noted in relation to artificial drainage across the Site.

3.6.3 Cuttings

No peat cuttings were evident through aerial imagery or field observations.

3.6.4 Forestry

Commercial forestry is locally present within the Site, primarily in the central eastern extents. These forested areas are at varying stages of maturity, with some areas exhibiting evidence of historic felling with young growth now present. No forestry operations were observed to be ongoing during site surveys. In addition, small areas of natural and semi-natural woodland are present in the northern and south-western extents of the Site.

Peat was not identified within forested areas, and therefore no areas of peat instability were noted in relation to forestry across the Site.



Photograph 3-10 Mixed age forestry found on Site



3.6.5 Bedrock

From review of aerial photography and observations during site walkovers, areas of bedrock exposures are limited to areas of former opencast or in and adjacent to watercourses. Bedrock is not identified in areas where peat is present, therefore no areas of instability were noted in relation to bedrock exposures across the Site.

3.6.6 Previous Instability

No areas of historic peat instability were identified through satellite imagery or from field observations.

3.7 Surface Water and Sensitive Receptors

The effects of peat failures are felt locally, both in the long and short term, but they can also have wider off-site implications.

A key part of the risk assessment process is to identify the potential scale of peat failure, should it occur, and identify the potential environmental effects as well as the receptors of such an event.

Peat failure associated with the Proposed Development could affect the following key receptors:

- The Proposed Development itself including associated infrastructure;
- Property and infrastructure, for example roads or utilities;
- Human Health (Construction workers and publicly accessible areas)



- Land based ecological effects (damage to habitats);
- On-site and downstream watercourses / waterbodies;
- Archaeological assets (e.g. scheduled monuments); and
- Visual amenity (scarring of the landscape).



4.0 Site Work

4.1 Site Reconnaissance

A site walkover was undertaken in February 2026 by an experienced geologist, to validate and ground truth the findings of the desk study and to assess any evidence of peat instability.

The walkover generally validated the conditions identified during desk-study, confirming a heavily disturbed site, with limited evidence of active peatland and an absence of peat instability.

Photograph 4-1 Area of peat to the west of T5, taken from NGR 263287, 622778.



4.2 Peat Depth and Coring Survey

Peat depth surveys were undertaken by MacArthur Green (now SLR) and SLR across several phases between November 2024 and April 2026.

4.2.1 Methodology

Peat depth surveys were carried out in accordance with best practice guidance for developments on peatland².

Phase I (low resolution) probing was conducted on a 100 m grid across the Site, to identify the extent and depth of peat and inform preliminary site layout designs. Peat probing was not undertaken in areas of made ground, where natural ground conditions have been disturbed, and peat has (where present) been removed.

Phase II (detailed) probing focussed on infrastructure on undisturbed ground and was typically undertaken on tracks at 50 m spacings with offset probing 10 m either side. At other infrastructure locations (turbines, hardstands, compounds etc.) at approximately 10 m



spacings, with microsites areas probed at approximately 25 m spacings along a 25 m and 50 m buffer.

Where minor changes to the Proposed Development infrastructure have occurred following phase II probing, the extent of peat has been informed by inferring conditions by review of interpolation, habitat data and satellite imagery.

The thickness of peat and soft sediment was assessed using a graduated fibre glass peat probe, approximately 12 mm diameter and capable of probing depths of up to 10 m. This was pushed vertically into the ground to refusal and the depth recorded, together with a unique location number and the co-ordinates from a handheld Global Positioning System (GPS) instrument.

The accuracy of the GPS was quoted as ± 2 m under open-sky conditions, with slightly reduced accuracy in areas of poor satellite visibility e.g. within dense forestry.

Depths were recorded at 0.1 m intervals. Where refusal was met at surface and shallow soil / vegetation was present a depth of 0.1 m was recorded, distinguishing it from areas of outcropping rock, where a depth of zero is recorded.

Where appropriate, conditions have also been assessed using visual interpretation e.g.:

- On steep slopes not conducive to peat formation;
- Areas of outcropping bedrock, or where conditions indicate a clear absence of peat e.g. glacial hummocks;
- Artificial or made ground deposits;
- Areas where probing is prohibited but conditions can be interpreted based on clear evidence at surface e.g. scheduled monuments;
- Areas where cuttings expose the underlying substrate;
- Assessment of surface vegetation / habitat.

Where probing met refusal on hard substrate, the 'feel' of the refusal can provide an insight into the nature of the substrate. The following criteria were used to assess material:

- Solid and abrupt refusal – rock;
- Solid but less abrupt refusal with grinding or crunching sound – sand/gravel or weathered rock;
- Rapid and firm refusal – silt/clay; or
- Gradual refusal – dense peat or soft clay.

The relative stiffness of the peat was also assessed from the resistance to penetration of the probe and to the effort required to extract probes. In all instances refusal was met on an obstruction, allowing for an interpretation of subsurface geology.

Given the potential for the probe to advance through soft mineral soils, or silt/clay layers beneath the peat, it is likely that probe depths are in some instances an over-estimate of the true peat depths, or represent soft, non-peat soils. In areas where there was uncertainty, some limited hand pits were excavated to inspect underlying soils and assess the potential presence of peat.

To determine the underlying condition of peat on the Site, and help identify the depth to acrotelm, several peat cores and hand pits were extracted at targeted locations across the Site, representative of local conditions.



Cores were extracted using a ‘Russian auger’. The Russian Auger allows for the collection of an undisturbed sample. Cores were photographed and logged in line with the Von Post scale of humification.

4.3 Survey Results

4.3.1 Peat Depth Analysis

Peat is generally defined as a soil with a surface organic layer >0.5 m, therefore where probing recorded depths outside of this range, it has been assumed to be a peaty or mineral (non-peat) soil. Soils with a peaty, organic horizon over mineral soil are often referred to as ‘peaty’ or carbon-rich soils. These organo-mineral soils are extensive across the UK uplands, but do not meet recognised definitions of peat as they are either shallower than true peat or have a lower carbon density.

A total of 2,620 probe or survey points were undertaken across the survey phases, with the results summarised in **Table 4-1**. The average depth of probes across the Site is 0.4 m, with the deepest deposits being 6.3 m.

Probe recorded ≤0.5 m account for 78 % of the probe locations, with the remaining 22 % accounting for probe locations >0.5 m. It should be noted that soft mineral soil was present throughout the Site and will account for some of the probe depths > 0.5 m rather than peat.

Peat is generally absent across the Site, with some localised deposits as seen on **Figure TA8.1.3**.

Table 4-1 Probing Results

Description	Probe Thickness (m)	No. of Probes	Percentage (of all probes undertaken)
No peat	0	254	9.7
Peaty or Mineral Soils	0.1 – 0.5	1796	68.5
Peat	0.5 – 1.0	465	17.7
Deep Peat	1.01 - 1.5	37	1.4
	1.51 – 2.0	23	0.9
	2.01 – 3.0	19	0.7
	3.01 – 4.0	11	0.4
	4.01 – 5.0	7	0.3
	5.01 – 6.0	7	0.3
	>6	1	<0

4.3.2 Coring

Four peat cores and five hand pits were completed alongside Phase II surveys, using a Russian auger and a shovel. Ground sampling was used to inform interpretations of the underlying physical peat condition and underlying substrate. Peat samples were undertaken to depths of between 0.5 and 1.0 m bgl and hand pits between 0.3 and 0.5 m bgl. The peat cores recorded pseudo-fibrous conditions when peat was present, with mineral soils also present as sand and as clay at the base of the cores. Hand pitting further identified sand and clay conditions on the Site, with soft mineral soils identified in every hand pit. Ground intrusive



sampling found that conditions were predominantly that of soft mineral soil rather than that of peat.

As a result, probe points classified as peat (>0.5 m) may be misidentified and could be subject to the soft mineral soil conditions identified during sampling.

Underlying soils and peat are described using British Standard (BS) 5930³¹ and the modified Von Post Classification¹⁶. Details are presented in Annex 1 Logs and Photographs.

Table 4-2 Peat Coring / Hand Pitting Results

Location	Depth (m)	Von Post Classification	Description
PC01:	GL-0.30 0.30-0.50	N/A	Dark brown organic rich clayey SAND. Sand is fine to medium Soft grey sandy CLAY. Sand is fine to medium.
PC02:	GL-0.20 0.20-0.70 0.7-1.00	H4, B3 H6, B3	Dark brown fibrous PEAT Dark brown pseudo-fibrous PEAT. Occasional wood chunks at 0.4m Soft mottled light grey and brown slightly sandy CLAY. Sand is fine.
PC03:	GL-0.50 0.50-0.80	H5, B2	Dark brown pseudo-fibrous PEAT Soft bluish grey sandy CLAY
PC04:	GL-0.50 0.50-0.60	H5, B2	Dark brown clayey PEAT becoming mottled at 0.45m Soft grey sandy CLAY. Sand is fine to medium.
HP01	GL-0.15 0.15-0.40	N/A	Soft brown slightly silty SAND. Sand is fine to medium. Soft mottled orangish grey slightly sandy CLAY. Sand is fine to medium
HP02	GL-0.5	N/A	Brown slightly clayey PEAT. Possibly reworked.
HP03	GL-0.10 0.10-0.30	N/A	Light brown slightly clayey SAND. Sand is fine to medium. Stiff mottled grey and orange slightly gravelly sandy CLAY. Sand is fine to coarse. Gravel is fine to medium subangular of coal.
HP04	GL-0.25 0.25-0.30	N/A	Brown slightly silty SAND Soft grey slightly sandy gravelly CLAY. Sand is fine to coarse. Gravel is fine to medium subangular and subrounded of siltstone and mudstone. Occasional cobbles of sandstone.
HP05	GL-0.10 0.10-0.30	N/A	Light brown slightly clayey SAND. Sand is fine to medium. Soft mottled orangish grey sandy CLAY. Sand is fine to medium.

³¹ BS 5930:2015+A1:2020, Code of practice for ground investigations



4.3.3 Peatland Condition

Peatland condition across the Site is assessed within the PCA, presented in Technical Appendix 8.3.

4.3.4 Interpretation of Underlying Substrate

Typically, probing terminated on granular substrate.



5.0 Peat Landslide Hazard and Risk Assessment

5.1 Introduction

The best practice guidance¹ acknowledges that there is no universally agreed definition of hazard and risk that can be applied in the context of peat landslides. However, there is general acceptance in the literature that risk is '*the potential for adverse consequences, loss, harm, or detriment*'¹.

The guidance is noted as illustrative only, and developers can present their own methodology providing, it is clearly explained and incorporates consideration of the likelihood of hazards (instability events) and consequences should it occur.

The following sections detail the preferred methodology used within this assessment.

5.2 Methodology

The guidance describes the calculation of risk from the following formula:

Risk = Likelihood (Probability) of a Peat Landslide x Adverse Consequence³²

The probability or likelihood of a peat landslide reflects the combined influence of pre-condition preparatory factors, triggering factors, or collectively 'controls' on the stability of a peat deposit.

Adverse consequences may include accidents, loss of life, environmental impacts or damage to site infrastructure and associated financial losses. Adverse consequences and exposure to identified receptors are dependent on variables including the scale of a peat landslide, the distance it will travel, and the sensitivity of the receptor(s).

The first phase of assessment is to identify the probability or likelihood of a peat landslide occurring based on existing conditions and parameters that influence peat landslide occurrence (prior to the influence of construction).

Once areas of increased likelihood of a peat landslide occurring have been identified, an assessment of adverse consequence (impact) and risk assessment would be undertaken on these areas, assessing the impact of a potential peat slide on identified receptors. For this further assessment, impact coefficient scores are determined, combined with an assessment of the vulnerability of receptors to establish a final risk score.

5.3 Likelihood Assessment

A quantitative assessment requires a numerical input, but such an analysis cannot account for the unquantifiable input required for a comprehensive peat stability assessment. For this reason, a purely quantitative assessment should only be considered as a guide, and a qualitative assessment of stability should be used to inform the final recommendations.

The natural moisture content and undrained shear strength of the peat are important; however, it is generally accepted that where present, the peat would be saturated and have a very low strength. It is believed to be unrealistic to rely on specific values of shear strength to maintain stability when back analysis of failed slopes indicates that there is often a significant discrepancy between measured strength in peat and stability. Shear strength has been assumed to be constant and worst case, throughout this assessment. It has also been assumed, as a worst case, that the groundwater level is coincident with the ground surface.

³² Lee, E.M & Jones, D.K.C (2013) *Landslide Risk Assessment (Second Edition)* ICE Publishing, London.



The probability or likelihood of a peat landslide occurring is controlled by a number of natural controlling and trigger factors. These are typically:

- Slope gradient;
- Peat depth;
- Peat strength;
- Nature of the substrate beneath peat deposits;
- Relief;
- Evidence of historical failures/potential instability (e.g. tension cracks, creep, compression ridges);
- Vegetation cover;
- Land use; and
- Hydrology and drainage.

Of these, the assessor deems peat depth and slope gradient to be principal factors. Without a sufficient peat depth and a prevailing slope, the likelihood of a peat landslide would be negligible.

Key parameters influencing peat stability have been scored and provided a coefficient value.

The coefficient scores for four key factors have been multiplied together to produce a likelihood rating.

This has allowed for the identification of potential areas of concern, based on prevailing conditions at the Site (pre-construction).

It is important to note that this study only focuses on peat (>0.5 m) and the criteria used is specifically tailored to the key factors affecting peat stability. As such it does not account for the stability of other mineral soils or rock.

Peat strength has not been included as a factor in the likelihood scoring process. Site-specific peat strength data was not collated for the Site given the difficulty in obtaining reliable values of shear strength using common place in situ and laboratory soil strength tests (as described in Section 2.1.2). The shear strength is also linked to peat depth as strength is considered to decrease with thickness. As such this parameter is deemed to be factored into the coefficient scoring for peat depth.

5.3.1 Input Data

The input data sets used for the analysis were as follows:

- Peat Depth: Site survey information for peat depths gathered through probing, augering and visual site observations.
- Slope Gradient: Five metre DTM.
- Nature of Substrate: Surveyor observations of substrate “feel” at refusal point during probing, or as identified from augering / hand pits, together with BGS geological mapping, geomorphological mapping and surveyor observations of exposed substrate at Site.
- Emerging or Existing Instability: Where there is evidence of instability or factors which may increase the likelihood of a slide event occurring e.g. soil creep, slumping, possible extension / compression features, poor drainage etc. Based on field observations and geomorphological mapping.



Although other controlling and triggering factors can influence the likelihood of a peat landslide, the quantitative assessment focuses on the key factors identified.

There is no guidance available on how to combine the likelihood coefficient scoring for each of the factors used in the assessment. The assessment team have used the methodology set out below.

5.3.1.1 Peat Depth

Peat thickness is seen as one of the key factors associated with peat stability. Typically, the deeper the peat the more humified, and therefore potentially weaker and more unstable it is. Peat depth surveys have been completed on the Site and this data then interpolated (**Figure TA8.1.3**).

The spline method was employed to create the interpolated probe depth surface, using ArcGIS Pro. The spline method produces a smooth surface through data points, therefore is particularly sensitive to outliers, which can distort the interpolated surface and may not fully capture abrupt changes in peat depth.

Detailed probing has been undertaken at all infrastructure locations within the scope of the assessment, reducing the overall level of uncertainty, and limiting the impact of potential interpolation flaws.

Peat depths can still vary over small distances and therefore topographic changes in the bedrock profile, historical ground disturbance etc. may impact the overall accuracy of the interpolated surface.

The highest hazard scores have been assigned to peat depth ranges most frequently associated with peat slides on upland sites (Evans and Warburton, 2007¹⁸).

While it is acknowledged that some probe depths exceeding 0.5 m may represent soft mineral soils rather than peat, these have been conservatively included in the assessment unless otherwise stated.

The peat depths recorded at the Site have been assigned coefficients, based on the scoring system presented in **Table 5-1**.

Table 5-1 Coefficient for Peat Depth

Peat Depth Range (m)	Description	Peat Depth Coefficient	Notes
<0.5	Mineral / peaty soil	0	Peat is absent, therefore there is no potential for a peat slide to occur.
0.5 – 1.5	Thin peat	3	Sufficient peat thickness for peaty debris or peat slide.
>1.5	Thick peat	2	Sufficient peat thickness for peat slide, however less often recorded at this thickness, due to thicker peat generally occurring in areas of shallow gradients. Bog bursts more typical at this thickness (on shallow gradients).

5.3.1.2 Slope Gradients

The limiting factor governing the formation of thick peat deposits is topography. In the case of blanket peat, it tends to be deepest in closed depressions, and typically thin as the slope gradient increases (Boylen et al. 2008)²¹.

Coefficients for slope gradient have been assigned to ensure the potential for both peat slides (gradients of 5 –15 °) and bog slides (gradients of 2 –10 °) are addressed. By simple



inspection, it is clear that steeper slopes (up to 20 °) pose a greater risk of instability than shallow gradients. Therefore, a graduated gradient scale from 0 – 15 ° (the practical maximum gradient on which peat is commonly observed) has been applied.

The slope gradients at the Site were generated from a DTM, at 5 m resolution, with the slope recorded at each investigation location assigned a coefficient, based on the scoring system presented in **Table 5-2**. The interpolated slope is presented on **Figure TA8.1.1**.

It should be noted that the 5 m DTM resolution may not capture subtle variations in slope or small-scale geomorphological features, such as localised hummocks or micro-topographic variability, however it is deemed suitable for this stage of quantitative assessment, on the basis that it provides a conservative assessment, and more detailed topographic models would require site specific surveying.

Table 5-2 Coefficient for Slope Gradient

Slope (°)	Slope Coefficient	Notes
≤2	1	Failure unlikely due to flat ground.
2.01 – 5	2	Failure in blanket bog areas would typically occur as bog slides, due to low slope angle.
5.01 – 10	4	Failure in blanket bog areas would typically occur as peat slides or bog slides.
10.01 – 15	6	Failure in blanket bog areas would typically occur as peat slides or peaty-debris slides. This is a key slope range for reported peat failures.
15.-1 to 20	2	Failure would typically occur as peaty debris slides due to low thickness of peat on steeper slopes.
> 20	1	Failure in blanket bog areas would typically occur as bog slides, due to low slope angle.

5.3.1.3 Substrate

The nature of the substrate beneath peat deposits can have a bearing on the likelihood of instability arising, with failure often occurring at the interface between the base of the peat mass and the top of the substrate.

Peat failures often occur within glacial till deposits in which an iron pan is observed in the upper few centimetres (Dykes and Warburton, 2007³³). They have also been observed over glacial till without an obvious iron pan, or over impermeable bedrock. They are rarely cited over permeable bedrock as the formation of peat deposits is deemed to be less likely.

Where granular soils (sand/gravel derived from glacial till) or weathered rock form the substrate, the effective strength of the interface can be considered to be good, with comparatively high friction values. Under these conditions, failure is likely to occur in a zone within the peat, just above the interface. Further factors are necessary to cause a failure of this nature (increased pore pressures within the peat), and occurrence of such events is rare.

Where cohesive soils (clay) form the interface, there is likely to be a significant zone of softening in the clay (due to saturation at low normal stresses, poor or non-existent vertical drainage and the effect of organic acids), resulting in either, very low undrained shear strength or low effective shear stress parameters. The result is that potential shearing could occur

³³ Dykes A and Warburton J (2007) Mass movements in peat: A formal classification scheme. *Geomorphology* 86, pp. 73–93



either in the peat, or in the interface or in the clay; all three possibilities have been documented in peat slides.

A rock substrate provides a high strength stratum; however, the rock surface can be smooth, with a relatively impermeable surface which can result in a 'slippery' interface, accumulation of groundwater and/or low shear strength at the interface, resulting in a higher susceptibility for the overlying peat mass to fail. Peat failures are rarely recorded overlying permeable bedrock, possibly due to a reduced likelihood of peat formation.

The nature of the substrate was inferred at each probe location, based on the methodology described in Section 4.2.1, and assigned a coefficient scoring based on the system presented in **Table 5-3**.

Table 5-3 Coefficient for Substrate

Substrate	Substrate Coefficient	Notes
Granular Sands / Gravels / Weathered Rock	1	Peat failures are less frequently associated with bedrock or granular till substrate
Rock (smooth interface)	2	Peat failures often associated with impermeable 'smooth' bedrock surface.
Cohesive (clay) or iron pan	3	Peat failures often associated with cohesive till substrate and/or iron pans.

5.3.1.4 Emerging or Existing Instability

The presence of existing landslip debris or indicators of meta-stable conditions such as tension cracks or slumping in the peat suggest the material is likely to become even less stable should the existing ground conditions change.

Where evidence of existing or emerging instability was identified by surveyor observations or through mapping and aerial photography a coefficient score has been assigned.

Table 5-4 Coefficient for Existing or Emerging Instability

Evidence of Existing or Emerging Instability	Existing or Emerging Instability Coefficient	Notes
Yes	2	Failures often occur on hillslopes with pre-existing peat landslides or where evidence of emerging/ developing instability is observed (peat pipes/collapsed pipes, areas of diffuse surface drainage such as flushes and pools, tension cracks, compression ridges, bulging, quaking bog).
No	1	No impact on likelihood of peat slide.

5.3.2 Likelihood Rating

The coefficient scores assigned for each of the above factors were multiplied to give a likelihood rating. Identification of the likelihood of a peat landslide occurring (based on conditions, pre-construction) is the first step of the assessment, allowing areas of potential



concern to be identified. The scoring system described in **Table 5-5** has been used to determine the likelihood of a peat landslide occurring.

Table 5-5 Likelihood of a Peat Landslide Occurring

Likelihood Rating Coefficient	Likelihood of a Peat Landslide Occurring	Action
0	None	No mitigation action required, good construction practices should be followed.
<5	Negligible	No mitigation action required, good construction practices should be followed.
5 – 15	Low	As for negligible condition plus development of a site-specific construction and management plan for peat areas.
16 – 30	Medium	Should not proceed unless risk can be avoided or mitigated at these locations, without significant environmental impact, in order to reduce likelihood score to low or negligible.
31 – 50	High	Unacceptable level of risk, the area should be avoided. If unavoidable, detailed investigation and quantitative assessment required to determine stability and sensitivity to minor changes in strength and groundwater regime combined with long term monitoring.
>50	Very High	Unacceptable level of risk, the area should be avoided.

5.3.3 Results

The assessment of all investigation locations is included in Annex 2 Peat Landslide Likelihood Data. The results show that data was collected at 2,620 investigation locations within the extent of the DTM, with peat (>0.5 m) recorded at 490 locations. The following likelihood ratings were identified:

- No peat was recorded at 254 location (9.69 %), hence no likelihood;
- The likelihood of a peat landslide was recorded as Negligible at 2,026 locations (77.33 %);
- The likelihood of a peat landslide was recorded as Low at 339 locations (12.94 %);
- The likelihood of a peat landslide was recorded as Medium at 1 location (0.04 %); and
- No High or Very High likelihood locations were identified.

The spline method was employed to create the interpolated likelihood surface (**Figure TA8.1.4**) using ArcGIS Pro.

Table 5-5 shows the likelihood rating for all infrastructure locations. As T01, T02, T03 and T06 are not located on peat they have been excluded from assessment, Technical Appendix 8.2 provides further detail on criteria used to determine what infrastructure was scoped out of assessment.



As can be seen from **Table 5-6** all infrastructure locations have no or negligible likelihood of a peat landslide. Only one location of medium likelihood has been identified on the Site, however, it is not within influencing distance of Proposed Development infrastructure.



Table 5-6 Likelihood Rating at Infrastructure Locations

Infrastructure Element	Likelihood Rating	Probe Depth (m)*	Slope (°)*	Suitability of Location
T4	Negligible	0.90	1.7	Suitable
T4 Hardstand	Negligible	0.66	2.1	Suitable
T5	Negligible	0.39	1.5	Suitable
T5 Hardstand	Negligible	0.43	1.8	Suitable
T7	Negligible	0.24	3.8	Suitable
T7 Hardstand	Negligible	0.12	3.8	Suitable
T8	Negligible	0.90	3.9	Suitable
T8 Hardstand	Negligible	0.62	1.9	Suitable
T9	Negligible	0.20	6.1	Suitable
T9 Hardstand	Negligible	0.36	4.7	Suitable
T10	Negligible	0.70	0.7	Suitable
T10 Hardstand	Negligible	0.64	0.6	Suitable
T11	Negligible	0.20	2.9	Suitable
T11 Hardstand	Negligible	0.25	3.0	Suitable
T12	Negligible	0.40	5.7	Suitable
T12 Hardstand	Negligible	0.54	5.4	Suitable
T13	Negligible	0.39	3.8	Suitable
T13 Hardstand	None	0.30	4.3	Suitable
T14	None	0.11	3.8	Suitable
T14 Hardstand	None	0.15	4.1	Suitable
BESS	None	0.26	2.2	Suitable
Compound Mid	None	0.27	1.8	Suitable



Infrastructure Element	Likelihood Rating	Probe Depth (m)*	Slope (°)*	Suitability of Location
Compound North	None	0.17	2.5	Suitable
Compound South	None	0.26	1.7	Suitable
Substation	None	0.26	1.9	Suitable
New track	None	0.28	4.6	Suitable
Track to be upgraded	None	0.14	5.2	Suitable

*The recorded probe depth and slope gradient are derived from the interpolated surface generated in ArcGIS Pro, using field survey and DTM inputs.



5.4 Adverse Consequence Assessment

In line with best practice guidance¹, where areas with a likelihood ('medium', 'high' or 'very high') of a peat landslide have been identified within influencing distance of proposed infrastructure, further assessment is required to determine the potential adverse consequence (impact) should a peat landslide occur.

No such areas have been identified; therefore, an assessment of adverse consequence is not required. However, the assessment methodology is presented below for completeness.

The assessment only considers receptors where exposure exists i.e. where there is a credible pathway from the hazard location (potential peat landslide) to the identified receptor.

It should also be noted that the adverse consequence assessment is primarily concerned with impacts that affect the environment, ecology, public or infrastructure associated with the Proposed Development, both on-site and potentially off-site. This assessment does not consider the detailed ecological impact of construction induced peat instability; however, the majority of the sensitive on-site receptors are the watercourses and thus the inferred ecological and environmental issues are addressed.

The proposed mitigation measures identified in Section 0 would limit the potential for any slope failures into watercourses and drainage features, hence limit such impacts. The effect a slope failure may have on the construction site, and infrastructure can be easily identified. However, the effect of an instability event on features impacted by an event not associated with the construction of the Proposed Development is harder to predict. In order to address this effect, it is not considered appropriate to assess the effect at every potential receptor location close to the Proposed Development but rather to assess the effect a particular infrastructure feature could have on the structures of features surrounding it.

By adopting such an approach, the assessment of infrastructure features where a likelihood of low or negligible (assessed in Section 5.3) have been identified, are discounted from further assessment.

The assessment follows the methodology presented below, and considers the following factors:

- The sensitivity of the identified receptor(s);
- The distance between the potential source of instability and the receptor;
- The relative elevation of the source compared to the receptor.

5.4.1 Receptor Sensitivity Ranking

Should a peat landslide occur, nearby structures or features may be adversely impacted. Generally, only features down gradient should be considered, therefore a review of topography and geomorphological features needs to be undertaken prior to identifying receptors. However, it should be noted that instability occurring on steep slopes do risk the back scarp of instability migrating up-slope, affecting areas not previously considered to be at risk. The receptors detailed in **Table 5-7** have been ranked according to their size and sensitivity with corresponding coefficients assigned.

Potential consequences such as reputational risk, increased costs, or programme delays have not been included, as these impacts are inherently difficult to quantify in a consistent and objective manner.



Table 5-7 Coefficients for Receptor Sensitivity

Receptor	Receptor Sensitivity Coefficient
Non-critical infrastructure (including minor / private roads, estate tracks etc.)	1
Proposed Development infrastructure	2
- Un-designated watercourses / waterbodies - Critical infrastructure (roads, railway, utilities etc.) - Un-designated sensitive environmental / ecological features e.g. GWDTE, cultural heritage assets.	3
- Highly sensitive environmental designations e.g. World Heritage Site (WHS), SSSI, SAC, Scheduled Monuments etc. - Protected watercourses / waterbodies or public or private water supply sources.	4
Human health* (communities / occupied dwellings, recreational site users / general public in proximity to the site e.g. via public paths)	5

*Construction personnel (and plant) have the potential to act as receptors of peat instability during the construction phase. However, the associated risks are considered to be inherently managed through the implementation of construction-phase health and safety procedures and site management controls. As these receptors are transient and limited to the construction period, they are not regarded as sensitive receptors within the context of this assessment.

Mitigation measures to address peat instability risks to construction workers during the construction phase are set out in Section 0.

5.4.2 Receptor Proximity and Relative Elevation

The proximity of a receptor is also critical in assessing the likely level of disruption it may suffer should a peat landslide occur.

Predicting the size of a failure and the distance it may travel is very difficult. The high moisture content of peat makes it especially mobile once it fails and the structure of the peat breaks down. If a peat slide enters a watercourse this can mobilise the slide further and have impacts many kilometres beyond the bounds of the Site. In many instances, minor slumps are localised and have little or no impact. Other failures may travel at 100 – 200 m and those entering watercourses, many kilometres, as was the case of the Derrybrien failure in Co. Galway, Ireland in 2003 (Lindsay & Bragg 2004¹⁰).

Published research recorded in a recent NatureScot study by Mills and Rushton (2023)⁴ considers typical runout pathways, and the potential for impacts from peat landslides to have impacts beyond those distances.

For peat slides:

- The majority of peat slides partially or fully excavate the scarp area and undergo runout downslope;
- The combined scarp and runout lengths are typically in the order of 250 – 500 m, with 90% of peat slides being < 500 m in length from headscarp to the downslope limit of runout. The average length is 250 m.
- Peat slide debris rapidly thins with distance (peat blocks reduce in size and number).



The logic is similar for bog bursts:

- The majority of bog bursts only partially excavate their 'source zones' (which can lack a clear headscarp).
- However, runout from the source zone is often similar in character and behaviour to that of peat slides.
- The combined length of the source and runout zone in bog bursts is generally greater than for peat slides, with over 35 % of failures > 500 m in length. The average total length is 430 m.

The receptor proximity and relative elevation coefficient scoring is presented in **Table 5-8** and **Table 5-9**.

The quantitative assessment presented here does not account for the credibility of potential runout pathways e.g. the presence of physical barriers (such as forestry), the volume of source material (and therefore the likely scale of any landslide), or topographic constraints that may limit or prevent material from reaching identified receptors.

Table 5-8 Coefficients for Receptor Proximity

Distance from Source of Instability (m)	Receptor Proximity Coefficient
>500	1
250 – 500	2
10 – 100	3
<10	4

Table 5-9 Coefficients for Relative Elevation

Relative Elevation of Receptor (m)	Relative Elevation Coefficient
<10	1
10 – 49	2
50 – 100	3
>100	4

The adverse consequence is determined by multiplying the above coefficients, as detailed in **Table 5-10**.

Table 5-10 Adverse Consequence Rating

Adverse Consequence Coefficient	Adverse Consequence Rating
0	None
1 – 10	Negligible
11 – 20	Moderate
21 – 30	High
31 – 50	Very High
0	None



5.5 Risk Assessment

To achieve a meaningful and manageable result, the likelihood and adverse consequence ratings have been normalised into a numerical score to allow for a calculation of risk.

The normalised likelihood and adverse consequence coefficients are multiplied together to provide a risk rating, with the scoring of risk detailed in **Table 5-12** and



Table 5-13.

Table 5-11 Rating Normalisation

Likelihood		Adverse Consequence	
Current Scale	Normalised Scale	Current Scale	Normalised Scale
None	0	None	0
Negligible	1	Very Low	1
Low	2	Low	2
Medium	3	High	3
High	4	Very High	4
Very High	5	Extremely High	5

Table 5-12 Risk Rating

		Adverse Consequence					
		Extremely High (5)	Very High (4)	High (3)	Low (2)	Very Low (1)	None (0)
Likelihood Rating	Very High (5)	High	High	Medium	Medium	Low	None
	High (4)	High	Medium	Medium	Low	Negligible	None
	Medium (3)	Medium	Medium	Low	Low	Negligible	None
	Low (2)	Low	Low	Low	Negligible	Negligible	None
	Negligible (1)	Low	Negligible	Negligible	Negligible	Negligible	None
	None (0)	None	None	None	None	None	None



Table 5-13 Risk Rating Description

Risk Rating Coefficient	Risk Rating	Action
0	None	There is no identified risk, no action required.
1 - 4	Negligible	Project should proceed with monitoring and mitigation of peat landslide hazards at these locations as appropriate. Management should include development of a site-specific construction plan for peat areas.
5 - 10	Low	Project may proceed pending further investigation to refine assessment combined with quantitative assessment, to determine appropriate mitigation of the hazard through relocation or re-design at these locations.
11 – 16	Medium	Project should not proceed unless risk can be avoided or mitigated at these locations, without significant environmental impact, in order to reduce risk ranking to low or negligible.
17 - 25	High	Avoid project development in these areas.



6.0 Slide Risk, Design and Mitigation

6.1 Overview

Mitigation measures can be implemented to further reduce the risk levels identified across the Site. These range from infrastructure specific measures to general good practice that should be applied across the Site to increase awareness of peat instability and enable early identification of potential displacement and opportunities for mitigation.

Risks may be mitigated by:

- Undertaking site specific stability analysis using better quality geotechnical data, final design loads for infrastructure and detailed ground models in areas of specific concern.
- Precautionary construction measures – including use of monitoring, good practice and a Geotechnical Risk Register (GRR) relevant to all locations.

6.2 Embedded Mitigation (Good Practice)

The sections below detail good practice that is recommended during construction and follow the principles detailed in the NatureScot Guidance (2024)⁵. These measures are considered 'embedded mitigation' for the purposes of the assessment, and have been assumed to be in place for the purposes of the assessment presented in the EIA Report:

6.2.1 Excavated Groundworks

- Use of appropriate supporting structures around peat excavations to prevent collapse and the development of tension cracks.
- Avoid cutting trenches or aligning excavations across slopes (which may act as incipient head scarps for peat failures) unless appropriate mitigation has been put in place.
- Implement methods of working that minimise the cutting of the toes of slopes, 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.
- 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).

6.2.2 Permanent Tracks

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



- Where upgraded tracks are required, existing tracks and surrounding areas should be further investigated to determine the most suitable sections to upgrade. Avoiding deeper areas of peat adjacent to the existing track is deemed a priority.
- Where possible, upgraded sections of track should tie into the existing track construction.

6.2.3 Temporary Tracks

- Prior to the construction, setting out the centreline of the proposed track should include a walk over performed by the site manager or general foreman, along with the suitably qualified Geotechnical Engineer, and appropriate Clerk of Works. This should be carried out to check that the ground conditions/drainage paths are as expected, and “fine-tuning/micrositing” of the alignment if required.
- Weather policy should be agreed and implemented during works, e.g. identifying ‘stop’ rules (i.e. weather dependent criteria) for cessation of track construction or trafficking (e.g. allowing tracks to thaw following periods of hard frost).
- Allow peat to undergo primary consolidation by adopting rates of road construction appropriate to weather conditions.

6.2.4 Peat Storage

The following control measures and good practice when considering temporary storage of peat during the construction, as described in Technical Appendix 8.2.

- Ensure stored peat is not located in areas identified with ‘medium’ or higher peat landslide likelihoods.
- Undertake site specific stability analysis for all areas of peat storage to ensure the likelihood of destabilisation of underlying peat is minimised. Analysis should consider the slope angle of the storage location, the thickness of peat being stored and being loaded, and use representative parameters for both the stored and underlying peat.
- Avoid storage of peat in areas of peat >1 m in depth.
- Ensure adequate drainage is maintained for any peat storage areas.
- Minimise haul distances for peat, storing as near to excavation as possible.
- Monitor effects of wetting/re-wetting stored peat on surrounding peat areas and prevent water build up on the upslope side of peat mounds. Mitigate any run-off.

6.2.5 Monitoring

The following activities will be built into any monitoring of groundworks undertaken for the development:

- Ponding on the upslope side of infrastructure sites and on the upslope side of access tracks.
- Subsidence and lateral displacement of tracks.
- Blockage or underperformance of the installed site drainage system.
- 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.



This monitoring should be undertaken on a quarterly basis in the first year after construction, biannually in the second year after construction and annually thereafter; in the event that unanticipated ground conditions arise during construction, the frequency of these intervals should be reviewed, revised and adjusted accordingly.

Where appropriate, remote monitoring may be appropriate longer term e.g. InSAR.

6.2.6 Good Practice

In addition to these control measures, the following good practice should be followed:

- A GRR should be prepared for the Proposed Development following intrusive investigations post-consent and location specific stability analyses – the risk register should be considered a live document and updated with site experience as infrastructure is constructed.
- The observation of any peat instability and pre-failure indicators should be recorded in the GRR during the setting out of proposed works.
- All construction activities and operational decisions that involve disturbance to peat deposits should be overseen by an appropriately qualified geotechnical engineer with experience of construction on peat sites.
- Awareness of peat instability and pre-failure indicators should be incorporated in site induction and training to enable all site personnel to recognise ground disturbances and features indicative of incipient instability.
- Monitoring checklists should be prepared with respect to peat instability addressing all construction activities proposed for site.
- A documented procedure shall be in place and rapid reaction strategy in place prior to the commencement of construction on peat land. This strategy shall be enacted should signs of peat movement be recorded across the Proposed Development. This approach requires periodic and continued monitoring of the construction process by a suitably qualified geotechnical engineer.
- A detailed Construction Environmental Management Plan (CEMP) shall be produced and incorporate the conclusions of the peat stability report, continuously update the assessment and develop appropriate mitigations to respond to the peat slide risk as development proceeds.
- As part of the GRR, regular inspection and monitoring of stored peat should be undertaken until temporary storage has been completed. This involves the recording of any visual signs of ground movement including identification of tension cracking or slumping of peat material. Future inspection frequency would be determined post construction and be dependent upon meteorological conditions.
- Awareness of peat instability and pre-failure indicators should be incorporated in site induction and training to enable all site personnel to recognise ground disturbances and features indicative of incipient instability.

6.3 Human Health (Construction Workers)

Notwithstanding the mitigation measures outlined above, which principally address the management of peat instability at a site-wide level, it is recognised that specific controls are also required to safeguard construction personnel. These measures are primarily embedded within construction-phase health and safety management procedures but may also include:



- Pre-construction peat stability risk assessment and delineation of high-risk areas following post-consent ground investigation;
- Preparation of detailed method statements for working on peat, including excavation handling and reinstatement;
- Establishment of exclusion zones, or restricted access areas in locations of elevated risk;
- Control of plant movements and avoidance of unnecessary trafficking over deep, saturated peat or in areas of elevated risk;
- Implementation of weather-related controls, including cessation of works during or after periods of heavy or prolonged rainfall.
- Implementation of GRR and emergency response plan.

6.4 Proposed Mitigation

As noted, on **Figure TA8.1.4** where the likelihood of a peat landslide has been identified as negligible or low, no specific mitigation measures are necessary. However, to ensure best practice is employed, there would be a need for careful monitoring, and the construction management must include careful design of both the permanent and temporary works appropriate for peat soils, as detailed in Section 6.2.



7.0 Conclusion and Recommendations

7.1 Summary of Findings

This PLHRA has been undertaken to evaluate the potential for peat instability across the Site and to assess the risks to the Proposed Development and identified receptors.

The assessment has been based on a combination of:

- Desk-based review of geological, hydrological and environmental data;
- Site reconnaissance and peat depth surveying;
- Geomorphological mapping of on-site conditions; and
- Quantitative and qualitative risk assessment.

The results indicate that:

- The majority of the Site has been assessed to have a negligible or low likelihood of a peat landslide occurrence under baseline (pre-construction) conditions, with peat absent across the majority of the Site, which has been heavily disturbed by past mining activities.

No areas of 'medium' (or greater) likelihood were identified within influencing distance of the Proposed Development, and therefore an adverse consequence and risk assessment was not required.

7.2 Recommendations

To ensure peat stability is maintained before, during and after construction, all best practice and mitigation measures identified in Section 0 should be implemented. This includes:

- Further targeted intrusive ground investigation post-consent to refine ground models.
- Implementation of GRR and site-specific stability assessments at hazard locations;
- Appointment of a suitably qualified Geotechnical Clerk of Works (GCoW) to:
 - implement a programme of regular monitoring to identify early signs of peat instability, this may also include longer term monitoring using appropriate remote sensing techniques e.g. InSAR;
 - ensure best practice construction and mitigation methods are adhered to;
 - monitor effectiveness of any site-specific mitigation measures adopted;
 - prepare and implement an emergency response plan in the event of a peat slide.
- Ensure any peat reuse or restoration proposals have appropriately considered peat stability.
- In addition to the measures presented within this report, all handling, storage and reuse of peat should follow the best practice set out within Technical Appendix 8.2.



7.3 Closure

This assessment has been undertaken in accordance with current best practice guidance and is based on the information available at the time of reporting. However, peat stability is inherently complex and influenced by natural variability. Ground conditions can vary spatially and temporally, and therefore a degree of uncertainty is unavoidable. The conclusions presented should be considered within this context, and it is recognised that conditions encountered during construction may differ from those inferred within this assessment.





Annex 1 Logs and Photographs



Annex 2 Peat Landslide Likelihood Data





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