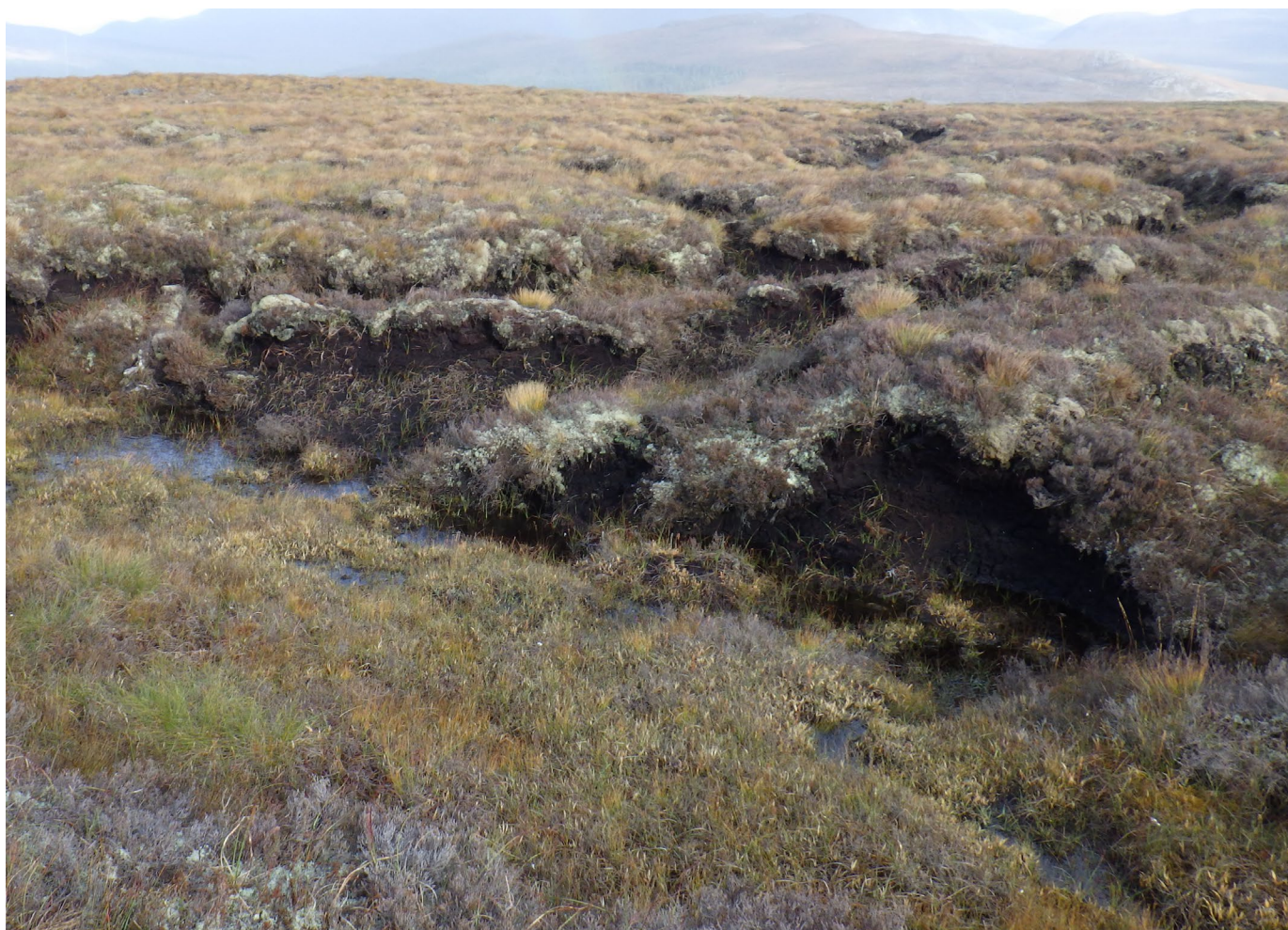




RWE Renewables Ltd

Pen March Wind Farm: Peat Slide Risk Assessment

Technical Appendix 6.1

2760801-P6.1 (00)

JULY 2023

RSK



RSK GENERAL NOTES

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Date:	<u>July 2023</u>		

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1 INTRODUCTION

- 1.1 This report provides a Peat Slide Risk Assessment (PSRA) for Pen March Wind Farm and associated infrastructure (hereafter, the 'Proposed Scheme').
- 1.2 The report forms a Technical Appendix to the Environmental Statement (ES) for the Proposed Scheme and should be read in conjunction with this document. It has been produced in response to concerns over development in areas of peatland relating specifically to the risk of induced instability within peat caused by the Proposed Scheme.
- 1.3 This report describes the existing peatland conditions at the site and identifies and assesses the potential impacts that may be caused by the Proposed Scheme. This includes potential risks from induced peat instability. Design and mitigation methods to avoid or minimise these risks are set out, along with a number of good construction practices that would be employed during all project works.

Site location

- 1.4 The Proposed Scheme is located in South Wales, approximately 1.5 km north-east of Merthyr Tydfil and 1.5 km north-west of Rhymney. The site lies across the Merthyr Tydfil and Caerphilly County Borough Council areas. The land is currently a mix of common land and Countryside and Rights of Way Act 2000 (CRoW) land with open access.
- 1.5 The development area covers a broadly sloping area of Purple Moor Grass-dominated grassland, with small scattered areas of dense scrub, exposed rock, dry heath and standing open water habitats. The western side borders the town of Merthyr Tydfil, the northern side borders the Bannau Brycheiniog National Park (formerly Brecon Beacons National Park), the eastern side stops at the top of the valley slope down towards the Rhymney River, and the southern side borders the Heads of the Valleys Road (A465).
- 1.6 The development area is underlain by soils and peat of variable depth, with some areas of notable peat depth.

Development proposals

- 1.7 The Proposed Scheme includes the following key elements:
 - Six wind turbines with a maximum tip height of 180m;
 - Hardstanding areas at the base of each turbine, with a maximum total area of approximately 9,147 m²;
 - Approximately 5,376 m of new access track with associated watercourse crossings and passing places;
 - Two temporary construction and storage compounds, one of which would form the energy storage facility.

- 1.8 Full details of the Proposed Scheme design are provided in **Chapter 4 (Volume 2)** of the ES.

Aims

- 1.9 This report aims to undertake a review of available relevant baseline information, including all peat depth and peat condition records, in order to provide an assessment of the risk of peat instability within the Proposed Scheme. Recommendations will be made for mitigation measures and specific construction methods that should be implemented in order to minimise the risk of inducing instability in the peat during construction works.

Assessment method

- 1.10 The assessment has involved the following stages:

- Desk study;
- Site reconnaissance;
- Peat condition assessment;
- Hazard and risk assessment;
- Detailed assessment;
- Mitigation.

2 DESK STUDY

Information sources

- 2.1 The desk study involved a review of available relevant information sources on the ground conditions at the Proposed Scheme. Information sources included:
- Ordnance Survey mapping at 1:50,000, 1:25,000 and VectorMap Local raster mapping, Terrain 5 digital terrain model, and OpenData mapping;
 - Historical OS mapping as available to view online;
 - High-resolution orthorectified aerial imagery;
 - British Geological Survey online geological mapping, 1:50,000 scale;
 - Cranfield University's Soilscales digital soil mapping, 1:250,000 scale;
 - Data provided by the applicant relating to wind farm and renewable energy developments nearby;
 - Archive data from local newspapers, as available online;
 - Peat depth data collected by RSK;
 - Archive and extensive site data held by RSK.

Historical information

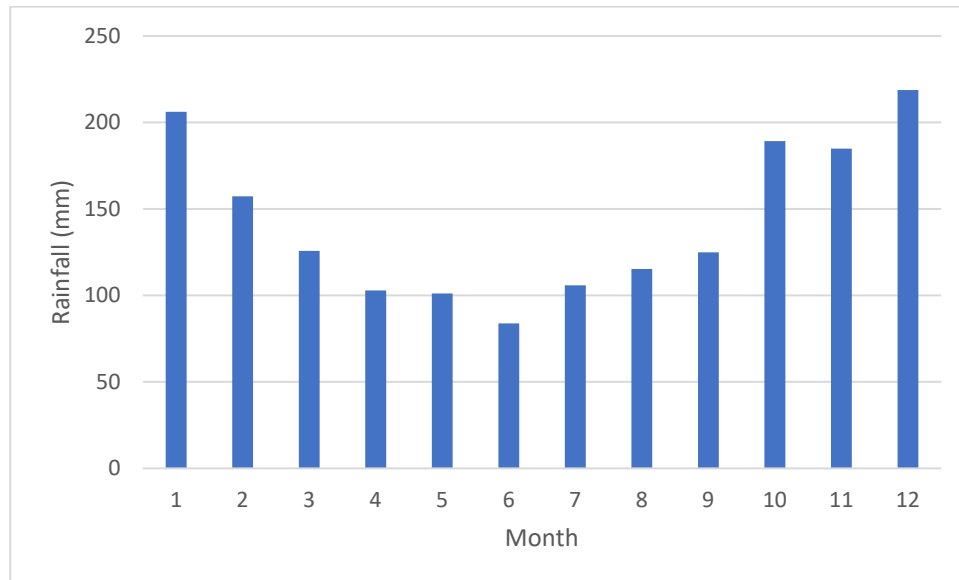
- 2.2 There are a number of news reports of landslides in the area within 5 km of the Site. The nearest records are from the area around Pontsticill and Pontsarn, approximately 2 km west of the Site boundary. The landslides are typically associated with roads located in steep-sided valleys, leading to road closures and road damage. The most recent record identified is from 2020 (Wales Online, 2020).
- 2.3 Additional landslide records are present to the south of Merthyr Tydfil and Rhymney. Some of these are known to be associated with mining activity, including unstable spoil tips and collapsed mine workings (for example, Wales Online, 2010).
- 2.4 BGS GeoIndex (BGS, 2022) shows mapped landslide deposits in the area to the south of the Heads of the Valleys Road, with some landslides indicated in each of the main valleys. One large area is indicated on Merthyr Common in the upper part of Cwm Bargod, approximately 4 km south of the Site. Smaller landslide deposits are indicated on Cefn Cil-Sanws, along the valley beside Nant Trefil and near the headwaters of the Nant Ddu to the west, east and north of the Site respectively.
- 2.5 The land to the north and west of the Site boundary is noted to be an area of shake holes. Ground instability is associated with shake holes, although these are not peat slides.
- 2.6 No records have been found that identify peat landslides or where the debris could be described as peat.

Climate

- 2.7 The Site is situated in the south of Wales, located in the southern part of the UK Meteorological (Met) Office's 'Wales regional climatic area'. Wales has a maritime climate, characterised by often mild, wet and windy conditions. The Site is located immediately to the south of the Bannau Brycheiniog National Park, which is part of the central upland spine that runs from the Bannau Brycheiniog north to Snowdonia. This central upland spine tends to have a wetter and harsher climate than the coastal and eastern parts of Wales.
- 2.8 Within the southern region of Wales, the upland area of the Bannau Brycheiniog provides the key topographical feature, with an elevation over 400 m above Ordnance Datum (AOD). The highest mountain in southern Britain at 886m AOD, Pen y Fan is located 12 km north of the Site and has an important climatic control on the surrounding area. As westerly winds from the Atlantic move east over Wales and reach higher altitudes, they cool and produce rainfall; for this reason, areas of higher altitudes in this region have higher average annual rainfall. Rainfall in Wales varies widely, with the highest average annual totals being recorded in the central upland spine.
- 2.9 Snowdonia is the wettest area with average annual totals exceeding 3,000 mm, comparable with those in the English Lake District or the western Highlands of Scotland. In contrast, areas along the coast and, particularly, close to the border with England, are drier receiving less than 1,000 mm a year; the Proposed Scheme is found around the middle of this range.

Rainfall

- 2.10 The Site lies 2.5 km north-west of the Tredegar climate monitoring station (Met Office, 2022). Due to its proximity, the rainfall data from the climate station is likely to be representative of the whole Site.
- 2.11 Average annual rainfall for the climate monitoring station is 1,715.9 mm. The altitude at this monitoring station is 324 m above sea level. Graph 6.1 shows the average rainfall distribution through the year from the Tredegar monitoring station.
- 2.12 Snowfall in Wales is generally confined within the months from November to April. The average number of days of snowfall in Wales varies from 10 days or fewer per year along the coast to 30 days over Snowdonia. The location and elevation of the Site means it is likely to fall somewhere between these two extremes.



Graph 6.1: Monthly rainfall averages for monitoring station at Tredegar climate station. Averages cover the period 1981-2010 (Met Office, 2022).

Topography and Geomorphology

- 2.13 The Site is located on Pen March, part of the southern slope of Cefn y Ystrad. The area slopes down to the south and south-east, with the highest land lying on the northern boundary at approximately 535 m AOD and the lowest land at approximately 355 m AOD by the A465 Heads of the Valleys Road on the south-eastern boundary.
- 2.14 The area forms a broad ridge with watercourse valleys to east and west. As the watercourses diverge, the ridge becomes broader and less distinct, having more of the character of a wide slope along the southern margin. Across the A465 Heads of the Valleys Road the ground rises to the south. The land in this area has undergone significant modification as a result of coal mining activity.
- 2.15 Prominent breaks-in-slope are largely absent from the area. Two key topographical features are notably incised watercourse channels, one to the east and one to the west of the Site. These are associated with the main channels of the Nant Pitwellt to the east side and the Nant Morlais to the west. A pond or wetland feature on the northern boundary, Pwll Mere, has a notably steep back wall with a pronounced break-in-slope on the northern side.
- 2.16 In the area to the east of the Site, two reservoirs are visible. The northern one is on the Nant Pitwellt, and the southern where the Nant Pitwellt joins the Rhymney River.
- 2.17 The area to the west of the Site includes a number of disused quarries. These appear to have faces of 20-30 m in height with a near-vertical slope.
- 2.18 Within the Site, two reservoirs are indicated on the maps – Pitwellt Pond and Jepson's Pond. Pitwellt Pond is shown to be dry on aerial imagery and this was found to be the case during visits to the site. There are a number of watercourse channels that are either artificial or have been channelised, in addition to watercourses that appear to be fully natural.

- 2.19 Some bedrock exposure is apparent in parts of the Site, notably between Pitwellt and Jepson's Ponds in the western part of the site and on the mid-part of the slope in the eastern part of the site.
- 2.20 Slope mapping for the site is available on **Figure 6.1.1** and geomorphological mapping on **Figure 6.1.2**.

Geology

- 2.21 Geological information is derived from the BGS GeoIndex online geological mapping and the Geological Survey of England and Wales, 1:63,360/1:50,000 geological map series (Taylor *et al.*, 1979; Barclay *et al.*, 1990; BGS, 2022).

Bedrock geology

- 2.22 The Site is underlain by bedrock from the middle Carboniferous era, mainly from the South Wales Coal Measures and Marros Groups.
- 2.23 The older Marros Group rocks are located around the margins of the Site to the west, north and east and include the Twrch Sandstone, Bishopston Mudstone and Millstone Grit. These consist mainly of thick sandstones and interbedded mudstones, siltstones and sandstones.
- 2.24 The younger South Wales Coal Measures Group rocks underlie the main part of the Site, with all bedrock from the South Wales Lower Coal Measures Formation. The rocks are characterised by a sequence of sandstones, siltstones and mudstones with coal-bearing beds and seatearths. No coal or seatearths are mapped within the site and site bedrock is dominated by thick sandstones.
- 2.25 Further west and north, a section of the Carboniferous Limestone Supergroup is present, including the Oxwich Head and Dowlais Limestone Formations. A number of areas of shakeholes are associated with these limestone areas.
- 2.26 There are a number of normal (extension) faults in the area, mainly trending north-west to south-east. A small number of earthquakes have been recorded in the region, although none within 5 km of the Site. The largest dates from 2012 with a Richter local magnitude R_L of 2.5. This occurred near Garnlydan, approximately 7.5 km east of the Site.

Mineral extraction

- 2.27 There are no coal seams mapped within the Site. The Coal Authority (2022) indicates that the extreme south-west corner of the Site lies within a development high risk area, but has no records of former mines or mine workings in the majority of the site. No Proposed Scheme infrastructure is located within the development high risk area.
- 2.28 To the south of the Site, and particularly south of the A465 Heads of the Valleys Road, there have been extensive open-cast coal workings including a currently active opencast coal mine.

- 2.29 One disused quarry is noted next to Jepson's Pond in the south-western corner of the site boundary, with a number of associated disused tips. A number of active and disused quarries are indicated on BGS GeoIndex and OS mapping, although the only active sites are more than 2 km from the application boundary. Several disused quarries are present within 1 km of the western site boundary.

Superficial geology

- 2.30 Superficial deposits at the site are dominated by diamicton till. Diamicton is a very variable glacial sediment deposited in the Late Pleistocene, consisting of unsorted material ranging in size from clay to boulders, usually with a matrix of clay to sand. The till deposits are concentrated on the lower slopes and around the main watercourses within the east and west parts of the site. No other superficial material is mapped within the application boundary.

Soils and peat

- 2.31 Soil and peat information are derived from Cranfield University's National Soils Mapping (Cranfield University, 2015) and extensive site data gathered for the Proposed Scheme.
- 2.32 The site is almost entirely underlain by soils described as slowly permeable seasonally waterlogged fine loamy soil and fine loamy soil over clayey upland soils with a peaty surface horizon. The very south-westernmost corner is identified as restored opencast coal workings.
- 2.33 Parts of the site have widespread evidence of drainage with straightened or artificial watercourses in a number of areas. The area is mainly common land and is used extensively for rough grazing for sheep and horses.
- 2.34 No areas of blanket peat are present within or adjacent to the Site, although pockets of blanket peat are mapped within 5 km to the north and east.
- 2.35 Peat depth surveys were undertaken between February and July 2021, with additional surveys in April 2022. A peat coring exercise was undertaken in October 2021.
- 2.36 Areas of peat were identified in parts of the site, with one recorded depth deeper than 5 m. Most of the site has no peat, or peaty soils under 0.5m in thickness. Areas of deeper peat tend to be restricted to pockets in some of the boggy areas of ground.

Hydrogeology

- 2.37 Both the South Wales Coal Measures and Marros Group strata are classed as Secondary A aquifers. They are described moderately productive, multi-layered aquifers with moderate yields from sandstones. Where mines are present the water quality is poor, but elsewhere it is reasonable (BGS, 2022).
- 2.38 North and west of the site, the Carboniferous Limestone sequence is classed as a Principal aquifer. Bedrock is described as a moderately productive massive karstic limestone aquifer with highly variable yields from dry to 40 litres/second.

- 2.39 The superficial deposits are classified as a Secondary undifferentiated aquifer, as a result of the highly variable composition of the diamicton till (BGS, 2022).
- 2.40 The north-eastern half of the site is located within one of Natural Resources Wales's (NRW) source protection zones for public drinking water supply (NRW, 2022a). The public water supply is drawn from the Carboniferous limestone bedrock in the area south of the site.
- 2.41 Regional groundwater flow will tend to mimic the natural topography, except in areas significantly affected by mining and in karstic areas of limestone where flow pathways can be very different from surface water flow.
- 2.42 No springs or significant seepage zones were identified within the planning application boundary although much of the site has a boggy surface layer. A number of springs are indicated in nearby areas, although it was not possible to confirm their presence owing to land access restrictions.

Hydrology

- 2.43 The Proposed Scheme lies across two catchment areas: the River Rhymney and the River Taff catchments. The catchment areas are shown on **Figure 6.4 (Volume 3)** of the ES.

River Rhymney catchment

- 2.44 The River Rhymney catchment has a total area of approximately 73.9 km² down to Ystrad Mynach, and drains 68% of the site.
- 2.45 The River Rhymney lies immediately east of the site boundary. Within the site boundary, drainage is provided by the Nant Pitwellt and tributaries in the northern part of the site, and a number of unnamed and modified watercourses in the southern and central section.
- 2.46 Within the site, the Rhymney catchment has been described by NRW's Environmental Information Portal (NRW, 2022b) as an area of grassland and marshland mainly used for upland grazing. Smaller regions on steeper slopes are described as upland hills or plateau. The watercourses within the site have been modified during the period of mining and quarrying activity, with Jepson's Pond described as an industrial reservoir, with sluices upstream to divert flow into the pond; these form part of the Dowlais Free Drainage System (Roberts & Jones, 2007).

River Taff catchment

- 2.47 The River Taff catchment has a total area of 188.8 km² down to Abercynon, and drains 32% of the site.
- 2.48 The River Taff is formed by the confluence of the Taf Fawr and Taf Fechan at the west side of Merthyr Tydfil. The Taf Fechan is located approximately 1.5 km west of the site boundary. Within the site, drainage is provided by the Nant Morlais and its tributary the Nant Tor-gwyn and a number of unnamed smaller watercourses.

- 2.49 Within the site, the Taff catchment has been described by NRW (2022b) as an area of grassland and marshland mainly used for upland grazing. Smaller sections on the steeper slopes surrounding the Taff Fechan are described as an upland valley. The watercourses within the site have been modified during the period of mining and quarrying activity, with part of the Nant Morlais diverted in the area near Pitwellt Pond and additional connections across the catchment divide towards Jepson's Pond. As with Jepson's Pond, Pitwellt Pond is an industrial reservoir with sluices upstream to divert flow into the pond; these form part of the Dowlais Free Drainage System (Roberts & Jones, 2007).

Dowlais Free Drainage System

- 2.50 The interconnected system of reservoirs, ponds, leats and culverts in the area is known as the Dowlais Free Drainage System (Dowlais FDS). The full extent of the system is not clearly defined and much of it has not been mapped, partly as a result of poor documentary evidence of the drainage works (Roberts & Lawler, 2003). The system was established to provide water to the Dowlais Iron Company and was developed over a period of roughly 50 years as required by the works, dating from the mid 19th Century.
- 2.51 As a result of the system's extent, the River Taff and River Rymney catchments are now partially interconnected although the Dowlais FDS is no longer maintained and parts of the system have fallen into disrepair.

Aerial photography

- 2.52 Available online aerial and satellite imagery has been used for this assessment.
- 2.53 The site appears mainly as a series of green, brown and grey areas. The grey areas largely indicate bedrock at surface. Within the site boundary, the largest area of bedrock outcrop is south of Turbine T3 with other areas located further east. Significant bedrock outcrop is apparent outside the boundary to the west and north.
- 2.54 The central part of the ridge of Pen March is a darker green than much of the site. This area is characterised by short grassy turf. Brown areas within the dark green mainly indicate patches of rush vegetation, indicating surface water flow channels.
- 2.55 The north-eastern section is a mix of tan and mid-brown, indicative of more boggy ground with *Molinia* grassland and rushes. Additional areas of rush growth are apparent along the eastern boundary, marked by areas of brown colouration. The lower slopes are mainly indicated by a paler greenish colour; this is a mix of short grass turf with mixed rough grass tussocks.
- 2.56 A number of linear features are visible. Three features that show as straight lines with distinct corners are the surface markers for three underground gas pipelines. Most of the other linear features are either paths or drainage features. The clearest drainage features are either prominent watercourses with incised channels or the various constructed watercourse channels that run parallel or subparallel to the contours. Natural drainage channels appear more sinuous and irregular, cutting across the contours as the drain downslope.

- 2.57 A number of tracks and footpaths are visible across the site. Most of the paths appear to be from movement of livestock, although some vehicle tracks are apparent. The mapped footpaths are visible, although some of the unmapped paths are clearer on the ground.
- 2.58 The three water features of Pwll Mere, Pitwellt Pond and Jepson's Pond are all clear. Jepson's Pond is visible as a wind-blown waterbody. Pitwellt Pond appears to be completely dry with bare earth around the margins and rush-dominated vegetation within the main pond area. Pwll Mere is shown as a mixed brown and green area with a distinct back wall to the north and a minor drainage feature to the south.

Habitats and vegetation

- 2.59 The survey area is dominated by grassland and moorland habitats that are typical of south Wales, including areas of marshy grassland, acid grassland, heath, flush and degraded bog. Most of the habitats occur as mosaics. The majority of the habitats present within the Site have been heavily modified by livestock grazing and/or fires, both of which have reduced the species diversity. Most of the habitats present are relatively species-poor and are dominated by common, vigorous plant species that are most resilient to the effects of grazing.
- 2.60 Active bog habitats and active peatland are largely absent from the site.

3 SITE RECONNAISSANCE

- 3.1 A walkover survey was undertaken by RSK on 19 May 2021. The scope of the survey included a reconnaissance survey of the Site and its immediate surroundings, plus mapping of the geomorphology and local-scale hydrology of the area. The survey covered the entire planning boundary, with a particular focus on the development where infrastructure is planned, as well as potential access routes into and across the Proposed Scheme. The weather during the survey was sunny with cloudy periods, occasional showers and a moderate breeze. Visibility was excellent throughout.
- 3.2 The areas described below provide good coverage of the site, detailing the range of landforms, vegetation and erosion patterns encountered.

	(A) View of western part of site, NGR SO 0791 1103 View looking S from track to Turbine 1. View shows a typical area of the site with close-cropped turf in the foreground and more boggy ground with extensive rushes further down the slope. The foreground area is mainly without peat. Peat depths in the boggy area are up to 1.5 m but are mainly <0.5m.
	(B) View of central part of site, NGR SO 0863 1010 View looking SE across the central site area near Turbine 6. View shows typical section of the slope with short grass turf, rough grass tussocks and rushes. Peat in this area is variable. Most of the grass turf has peat <0.5 m but some rushy areas include peat up to 0.8 m deep.

	(C) View of central part of site, NGR SO 0863 1010 View looking SW across the central site area near Turbine 6. View shows typical section of the slope with short grass turf, rough grass tussocks and rushes. Rock outcrop is visible on the skyline to the right. Peat in this area is variable, ranging from 0 to >1.0 m in boggy areas.
	(D) View of eastern part of site, NGR SO 0884 1133 View looking SE from the narrow site section. View shows an area of mown and burned rush pasture in the foreground, with the Nant Pitwellt valley and the two reservoirs behind. Limited peat depth records are available for this section as a high-pressure gas pipeline passes through this area.
	(E) View of eastern part of site, NGR SO 0905 1056 View looking SE from near Turbine 4. View shows an area of rush pasture; this is extensive in this part of the site. The ground is wet in places but flow channels are poorly defined. Peat depths in this area are variable, ranging from 0.2 to 1.0 m.
	(F) View of northern part of site, NGR SO 0832 1116 View looking SE from the northern site boundary. View shows an area of extensive Molinia grassland with rushes, characteristic of this part of the site. Much of this area is boggy. Peat depths in this area range from 0.4 to 1.0 m. Deeper peat is likely to be present in areas north of the boundary.

	(G) View of Pwll Mere, NGR SO 0803 1103 View looking E from track to Turbine 1. View shows the northern margin of Pwll Mere, clearly showing the bog vegetation within the mere. No open water is visible. Peat depths were not measured here as the mere surface is unstable. Nearby soil profiles indicate soil depths <0.2 m.
	(H) View of south-western part of site, NGR SO 0828 0908 View looking E across former quarry to Jepson's Pond. View includes the lower part of the access and construction compound, in the distance behind Jepson's Pond. Most of this area is without peat, although the boggy ground N of Jepson's Pond has some peat. The foreground is made ground from former quarry spoil.
	(I) View of Pitwellt Pond, NGR SO 0800 0981 View looking E across Pitwellt Pond near the substation. View shows Pitwellt Pond with no standing water and extensive vegetation within the former flooded area. This area is largely without peat. Soils here are all very thin, <0.2 m.

	(J) View of artificial watercourse channel, NGR SO 0791 0968 View looking SW across the southern site area. View shows a former outflow channel from Pitwellt Pond, cut into bedrock. Channel was dry during the survey with no signs of recent flow. This area is largely without peat.
	(K) View of a natural flush, NGR SO 0940 0981 View looking NW across the south-eastern site area. Flushes of this type are relatively common, collecting water from boggy ground upslope. Further downslope a more defined watercourse becomes visible. Peat in this area varies between 0.4 and 0.8 m in depth.

4 MAPPING

Peat depth survey

- 4.1 Initial peat depth surveying was undertaken by RSK in February and March 2021. This Phase 1 survey consisted of a 100 m grid across the main development area in order to develop a picture of the overall pattern of peat development across the site. In areas where peat was identified, additional probing on a 25m grid was undertaken to help in defining the peat bodies and the peat margins more effectively. The survey results were used to inform the infrastructure design, in order to minimise incursion into areas of peat as far as possible.
- 4.2 Subsequent phases of peat depth surveying were undertaken by RSK in May, July and August 2021 and in April 2022. For these Phase 2 surveys, peat depths were recorded at 50 m intervals along proposed tracks, crosshair probing at turbine base locations and in grids across hardstanding areas, site compounds and buildings. Additional records were collected in some areas to help delineate areas of peat.
- 4.3 A site visit to collect peat core samples was undertaken in October 2021, with samples collected at 14 locations across the site. Core samples were targeted at turbine locations, with additional samples taken along the proposed access route.
- 4.4 Peat probing point locations were recorded using a handheld GPS with typical accuracy of ± 5 m and peat depths were measured to an accuracy of ± 0.05 m. All measurements were recorded to full depth/point of refusal.
- 4.5 The survey results are summarised in Table 4-1.
- 4.6 The peat depth survey indicates that approximately one third of the development area has no peat, with 31.6% of the measured locations having topsoil or peaty soil cover up to 0.3 m deep. 70.4% of the area has peat or soil less than 0.5 m in depth. Only 4.4% of the area has peat depths of 1.5 m or deeper. The deepest recorded peat was 5.2 m.
- 4.7 The peat depth surveys and reconnaissance survey confirm that peat deeper than 1 m is located in relatively small and isolated pockets although these are distributed across the site. Most pockets are associated with watercourses and areas of boggy ground. The most extensive area of peat deeper than 1 m was identified to the east of Jepson's Pond. It is likely that this is a result at least in part of waterlogging relating to the former sluice-controlled watercourses in this area, as these sluices are no longer in use but still act to control flow.
- 4.8 The deepest peat record for the site is located to the east of the crane hardstanding for Turbine 1.

Table 4-1: Summary of peat depth probing results

Peat depth range (m)	No. of points	Percentage of points
0.0-0.2	329	25.5%
0.2-0.3	294	22.8%
0.3-0.4	236	18.3%
0.4-0.5	147	11.4%
0.5-0.75	169	13.1%
0.75-1.0	73	5.7%
1.0-1.25	14	1.1%
1.25-1.5	11	0.9%
1.5-1.75	8	0.6%
1.75-2.0	6	0.5%
2.0-2.5	1	0.1%
>2.5	2	0.2%
Total	1290	100%

Indicative peat depth mapping

- 4.9 The combined peat depth survey results were used to produce an extrapolated indicative peat depth map for the Proposed Scheme. The extrapolated peat depth map was produced using a Gravity interpolation across the survey area with a 10 m cell size.
- 4.10 The advantage of using a digital interpolation is that the process is fully objective and there can be no subjective influence. However, the process is not able to allow for known variation in peat development in varying topographical settings. As a result, there may be over-estimation of peat development in areas of steep or well-drained ground, and potential under-estimation of peat development in flatter or poorly drained areas. Owing to the good resolution of the underlying data, the interpolation appears largely to give a representative indication of peat depth across the site.
- 4.11 The indicative peat depth map for the Proposed Scheme is provided in **Figure 6.1.3**.

Peat sampling and analysis

- 4.12 Peat core samples were taken at 14 locations and the peat cores were logged using the modified Von Post humification and wetness scale. Core logs and photographs are provided in Annex 1.
- 4.13 Four peat core samples were sent for analysis by Envirolab. Analysis results are provided in Table 4-2 and sampling locations are shown on **Figure 6.1.3**

Table 4-2: Peat sample analysis results

Client Sample ID	Units	Limit of Detection	Method	C01b	C05a	C05b	C06b
Depth to Top				0.4	0.2	0.35	0.3
Depth to Bottom				0.6	0.3	0.5	0.4
Date Sampled				21-Oct-21	21-Oct-21	21-Oct-21	21-Oct-21
Sample Type				Soil	Soil	Soil	Soil
% Moisture at <40°C	% w/w	0.1	A-T-044	83.6	63.6	67.0	72.1
% Stones >10mm	% w/w	0.1	A-T-044	<0.1	<0.1	<0.1	<0.1
pH	pH	0.01	A-T-031s	4.01	4.95	4.7	4.76
Total Carbon	% w/w	0.1	A-T-032s	47.1	35.7	24.2	19.4
Wet weight of soil	g	0.1		190.2	112.0	194.3	163.7
Dry weight of soil	g	0.1		47.17	52.20	76.50	58.11
Bulk density	g cm ⁻³			1.12	0.95	0.82	0.65

5 PEAT CONDITION

Developments on peat

Definition of peat

- 5.1 There is no internationally accepted definition of peat. The International Peatland Society (IPS, 2022) define peat as the following:

Peat is the surface organic layer of a soil that consists of partially decomposed organic matter, derived mostly from plant material, which has accumulated under conditions of waterlogging, oxygen deficiency, high acidity and nutrient deficiency.

- 5.2 In Wales, NRW considers organic-rich soils to be peat if they have a thickness of more than 40 cm of organic material within the upper 80 cm of a soil profile (NRW, 2022c).
- 5.3 Organic soils which are 40 cm or thinner can also support peatland vegetation and as a result are also considered within Wales's broader peatland system. These soils are typically described as 'peaty gleys' or 'peaty podzols', or as having a 'peaty surface layer'. Peaty soils typically have a higher plant fibre content and are less decomposed than peat.
- 5.4 Active peat typically consists of two layers: the surface layer or acrotelm and the deeper layer or catotelm. The acrotelm contains the living vegetation and consists of living and partially decayed plant material. It typically has a low but variable hydraulic conductivity and allows some through-flow of water within the plant material. The underlying catotelm is denser, with a very low hydraulic conductivity, and is formed from older decayed plant material. The catotelm varies in structure, in some areas retaining a proportion of fibrous material and in other areas being more humified and amorphous. The degree of humification typically increases with depth.
- 5.5 Underneath the peat-forming layers, the basal substrate can be a mineral soil, a superficial deposit such as glacial material, or bedrock. There may be a transition zone through a mineral-rich peaty layer at the base of the peat, although this is usually no more than 5 cm in thickness.

Importance of peat

- 5.6 Peat forms a key part of the Welsh landscape, despite covering approximately only 4.3% of Wales's total land area (NRW, nd). In addition, peatland is an internationally important habitat.
- 5.7 Active and healthy peatlands develop continuously, removing carbon dioxide from the atmosphere and storing it within the peat soil. Peatland protection and restoration form key parts of the Welsh Government's Climate Change Plan, promoted and enacted by NRW's National Peatland Action Programme (NPAP). The NPAP is a five-year plan of peatland restoration in Wales.

- 5.8 The programme is designed to target peatlands that need the most restoration and aims to restore 600-800 hectares of public and private land every year. Over 650 ha were restored in the first programme year, 2020-21 (NRW, 2022d).
- 5.9 It is therefore important that developments in peatland areas take recognition of the importance of peat as both a habitat and as a carbon store and sink. Careful planning of developments, and careful infrastructure design, can remove or minimise the disturbance of peat that would be needed to allow the development to proceed.

Peat condition survey

- 5.10 As part of the peat depth surveys, information was collected concerning the condition of the peat present within the site. It has not been possible to find a definitive classification system for peatland condition used in Wales; as a result, the system derived by NatureScot for peatlands in Scotland has been used in this assessment. This system recognises five categories of peatland condition: (1) Near-natural; (2) Modified; (3) Drained; (4) Actively eroding; and (5) Forested/Previously Afforested (NatureScot, 2017).
- 5.11 The Proposed Scheme is located within an area of categories 2 (modified) and 3 (drained) peatland. No actively eroding peat was observed within the site.

Proposed peatland restoration

- 5.12 The potential to provide beneficial measures for peatland restoration within the Proposed Scheme is limited as a result of the majority of the land being classified as common land and also the highly degraded nature of the peatland habitat within the Application Boundary, making delivery of peatland restoration impractical. It is therefore intended to provide compensation for the potential loss of peat and peaty soils arising from the Proposed Scheme, and additional biodiversity and habitat enhancement, via a contribution to peatland restoration currently being undertaken by the National Peatland Action Plan (NPAP).
- 5.13 Peatland restoration opportunities have been identified within the Bannau Brycheiniog National Park (BBNP) within approximately 5 km of the Pen March Wind Farm site. At the time of writing, discussions regarding off-site measures are ongoing with the BBNP Authority peatland specialists as to the most suitable options available. It is intended to provide further details of proposed measures within the final ES.

6 HAZARD AND RISK ASSESSMENT

- 6.1 For the purposes of this peat slide risk assessment, the following definition of risk has been adopted:

Risk = Probability of a Peat Landslide x Adverse Consequences

- 6.2 Probability, or likelihood, can be estimated in a number of ways and should take account of both natural factors and man-made or man-imposed factors that could influence slope stability. Man-made or man-imposed factors can include overgrazing from over-stocking, excavation of drainage ditches or grips, or heather burning for land management purposes. Natural factors can include extreme weather events such as very high intensity rainfall, or prolonged dry periods followed by storms.
- 6.3 The methods of assessment of likelihood and adverse consequences used here are described below.

Assessing likelihood

- 6.4 As peat slope failures are mainly considered to resemble planar translational slides, the assessment of likelihood of a peat landslide makes use of the Infinite Slope Model (Boylan & Long, 2014) to assess stability of the peat across the slopes in the Site, in line with the Scottish Government guidance (Scottish Government, 2017). The Infinite Slope Model assesses slope stability by calculating the forces resisting failure (shear strength or cohesion) and the forces inducing failure (shear stress) and taking a ratio of these, known as the Factor of Safety. The modified Infinite Slope Model equation is as follows:

$$F = \frac{c'}{\gamma z \sin \beta \cos \beta}$$

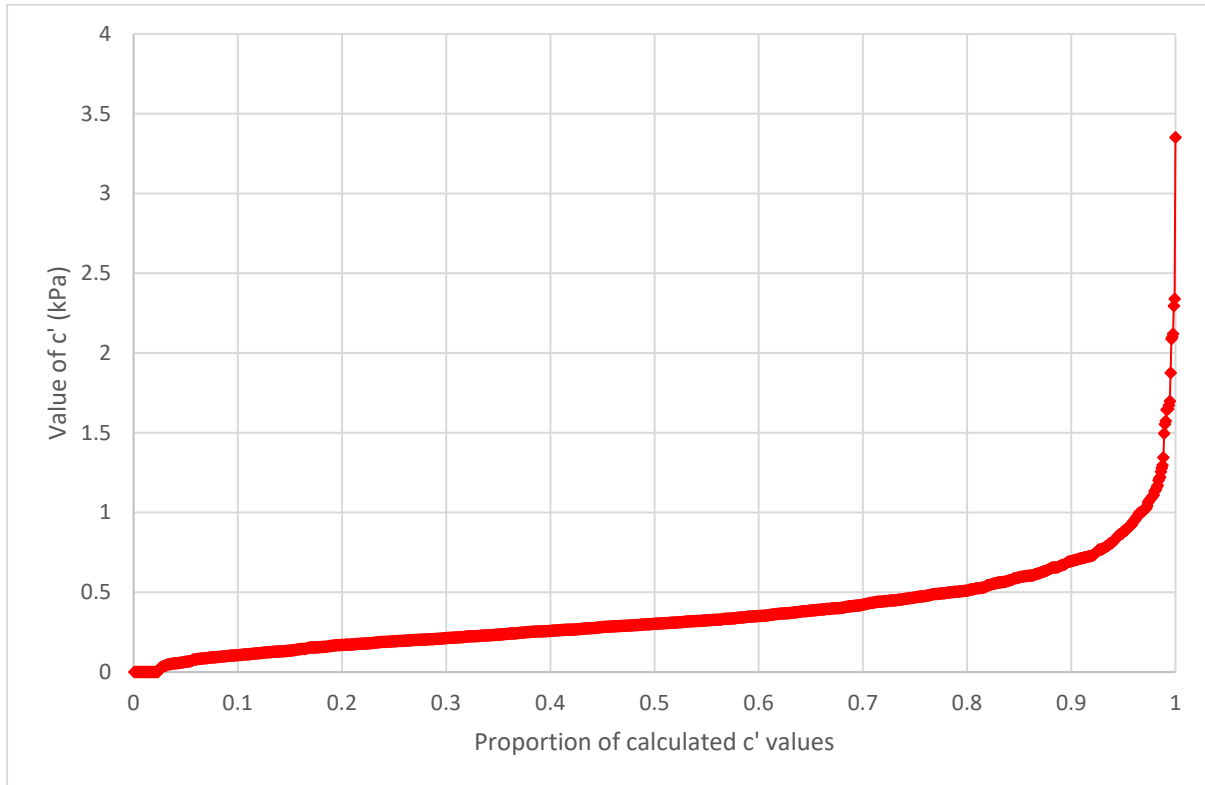
- where
- F = Factor of Safety, the ratio of forces resisting a slide to forces causing a slide
 - c' = undrained shear strength of the material; kPa
 - γ = specific weight of peat, undrained in situ; kN/m³
 - z = peat depth; m
 - β = slope of ground surface, assumed to be parallel to the slope of the failure plane; degrees

- 6.5 If $F > 1$, the slope is stable; if $F < 1$ the slope is unstable; if $F = 1$ the forces are exactly balanced. It is possible to state with some confidence, therefore, that if $F > 1.3$ the slope is stable and would have some resistance to change.
- 6.6 Values assigned to the parameters are provided in Table 6.1.3, along with an explanation for their selection.

Table 6-1: Parameters for the Infinite Slope Model

Parameter	Value and Derivation
F	Calculated value
c'	3.4 kPa Published shear strength values for peat vary from 4.5 to 60 kPa or more (for example, Long, 2004). Published values from recent field tests tend to cluster between 10 and 20 kPa with some higher and lower values recorded. The selected value represents the maximum of a back-calculated minimum, c' (see explanation below).
γ	10.99 kN/m³ Derived from density of peat multiplied by acceleration due to gravity (9.81 m/s²). Density of peat varies depending on degree of decomposition and water content; published values range from 500 to 1,400 kg/m³. This value is derived from peat core samples collected from the development, which gave a maximum value of 1120 kg/m³.
z	Where available, measured peat depths have been used. For grid analysis, the maximum interpolated depth within the grid has been taken to provide a conservative estimate.
β	Slope angles have been derived from the DTM for the Site. Grid cell slopes were all derived from the Site DTM. The DTM used for slope angle generation has a resolution of 5 m. The slope raster map was generated within the GIS software used for the analysis. Average (mean) slope angles were used for each cell.

- 6.7 The shear strength, c', has been estimated from development area data. This is undertaken by assuming that the slope is just marginally stable at each point where peat depth has been measured, in other words the slope has $F = 1$. The Infinite Slope Model equation can be rearranged to derive a value for c', using the other parameters as described in Table 6-1.
- 6.8 It is important to note that the calculated values of c' for each location represent the minimum shear strength needed for the peat to be stable. In fact, the shear strength may be, and in most cases probably is, considerably higher. For example, on very shallow slopes the peat needs only a very low shear strength to remain stable, whereas on steeper slopes a much higher shear strength is required to hold the peat on the slope. For this reason, the higher estimated values of c' are of more relevance as they are more likely to be representative of the actual shear strength of the peat on the development area. For this assessment, the maximum value of the calculated shear strengths has been used in the stability analysis. This gives a value of 3.4 kPa, as stated in Table 6-1.
- 6.9 At Pen March, 1,290 locations have been probed during the phases of fieldwork. c' values have been calculated for each of these and the distribution is provided in Graph 6-2.



Graph 6-2: Estimate of minimum shear strength, c'

- 6.10 In order to produce a development area-wide dataset for Factor of Safety, a grid of 50 x 50m cells was overlain across the development area and a Factor of Safety calculated for each cell. It is a standard and widely recognised GIS technique to use a regular grid for terrain analyses of this kind. It allows a systematic process across the landscape and minimises the subjectivity of the analysis. The 50 x 50m cells are referred to as 'grid cells' throughout the analysis.
- 6.11 The Factor of Safety, F , has been calculated for each peat probing location within the development area, and for each grid cell within the development area. A buffer of 200 m around the application boundary has also been included. The Factors of Safety have been divided into classes, which have been used to map the likelihood of a peat landslide occurring at each point and for each grid cell across the development area.
- 6.12 For most wind farm assessments, the calculated Factor of Safety results are considered together with field observations and geomorphological assessment to take into account additional risk factors including breaks in slope or risk reduction factors such as areas of bedrock exposure. These factors have been applied to the calculated Factor of Safety results and the grid cell classes have been changed as appropriate based on the geomorphological mapping.
- 6.13 For cells where additional risk factors and risk reduction factors are both present, no change has been made to the calculated results. The results are presented in Table 6-2.

Table 6-2: Summary of likelihood ratings

Likelihood	Factor of Safety (FoS)	No. of points	% of points	No. of cells (FoS)	% of cells (FoS)
Nil	No peat	859	66.6%	1,870	62.81%
Negligible	2.5 +	415	32.2%	1,029	34.56%
Unlikely	1.3 to <2.5	15	2.1%	75	2.52%
Likely	1.1 to <1.3	0	0%	2	0.07%
Probable	1.0 to <1.1	1	0.1%	1	0.03%
Almost certain	<1.0	0	0%	0	0%
	Totals	1,290	100%	2,977	100%
N.B. Numbers in brackets for the grid cells are the original results from the Infinite Slope Model analysis, to provide a comparison with the Likelihood Rating results					

6.14 The Likelihood map is provided in **Figure 6.1.4**.

Assessing adverse consequences

6.15 Potential adverse consequences resulting from a peat landslide cover a wide range, from environmental through to economic and, potentially, harm to life. Scottish Government (2017) gives five examples, as follows:

- Potential for harm to life during construction;
- Potential economic costs associated with lost infrastructure or delays in the construction programme;
- Potential for reputational damage associated with the occurrence of a peat landslide in association with construction activities;
- Potential for permanent, irreparable damage to the peat resource, in terms of both carbon store and habitat, through mobilisation and loss of peat in a landslide;
- Potential for ecological damage to watercourses and waterbodies subject to inundation by peat debris.

6.16 Adverse consequences have been assessed taking account of environmental sensitivity, including potential consequences to water quality from peaty debris and habitat loss by peat removal and by blanketing of sensitive areas with peat debris, and economic significance, including damage to infrastructure and construction delays resulting from a peat landslide, in line with current guidance (Scottish Government, 2017).

6.17 Adverse consequence has been assigned as follows:

- **Very high consequence:** buildings, wind turbine foundations, substations, public roads, private water supply infrastructure, overhead power lines, gas pipelines;
- **High consequence:** main watercourses and waterbodies, areas of sensitive habitat, turbine hardstandings, compounds;

- **Moderate consequence:** access tracks, minor watercourses;
- **Low consequence:** areas of low sensitivity habitat, ditches and artificial waterbodies;
- **Very low consequence:** damaged or degraded habitat.

6.18 Table 6-3 provides a summary of the grid cells in the development area assigned the various consequence ratings. The adverse consequence map is provided in **Figure 6.1.5**.

Table 6-3: Summary of adverse consequence ratings

Adverse consequence	No. of cells	% of cells
Very high consequence	806	27.1%
High consequence	603	20.3%
Moderate consequence	235	7.9%
Low consequence	270	9.1%
Very low consequence	1063	35.7%

Risk assessment

6.19 The Likelihood and Adverse Consequence are combined to produce an estimate of risk for each grid cell within the development area. The risk assessment matrix used to combine these two parameters is provided in Table 6-4.

Table 6-4: Risk assessment matrix

		Adverse consequence				
		Extremely high	High	Moderate	Low	Very Low
Peat landslide likelihood	Almost certain	High	High	Moderate	Moderate	Low
	Probable	High	Moderate	Moderate	Low	Negligible
	Likely	Moderate	Moderate	Low	Low	Negligible
	Unlikely	Low	Low	Low	Negligible	Negligible
	Negligible	Low	Negligible	Negligible	Negligible	Negligible

6.20 Table 6-5 below provides a summary of the risk ranking for the grid cells across the Site, together with an indication of appropriate mitigation from Scottish Government (2017). The risk ranking map is provided in **Figure 6.1.6**.

Table 6-5: Summary of risk ranking and appropriate mitigation

Risk ranking	No. of grid cells	% of grid cells	Appropriate mitigation
High	0	0%	Avoid project development at these locations
Moderate	1	0.03%	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
Low	254	8.53%	Project may proceed pending further investigation to refine assessment, and mitigate hazard through relocation or re-design at these locations
Negligible	852	28.62%	Project should proceed with monitoring and mitigation of peat landslide hazards at these locations as appropriate
No peat	1,870	62.81%	No peat landslide hazard

- 6.21 Most of the development area has been assessed as having a negligible risk of peat landslide, or of having no peat (91.4%). One grid cell has been assessed as having a moderate risk of peat landslide and none with a high risk.
- 6.22 The one cell assessed as having moderate risk is not located near any proposed infrastructure. This cell and its immediate surroundings have been considered in relation to natural peat slide and the risk this may cause to proposed infrastructure.
- 6.23 Both aspects are detailed in Section 7.

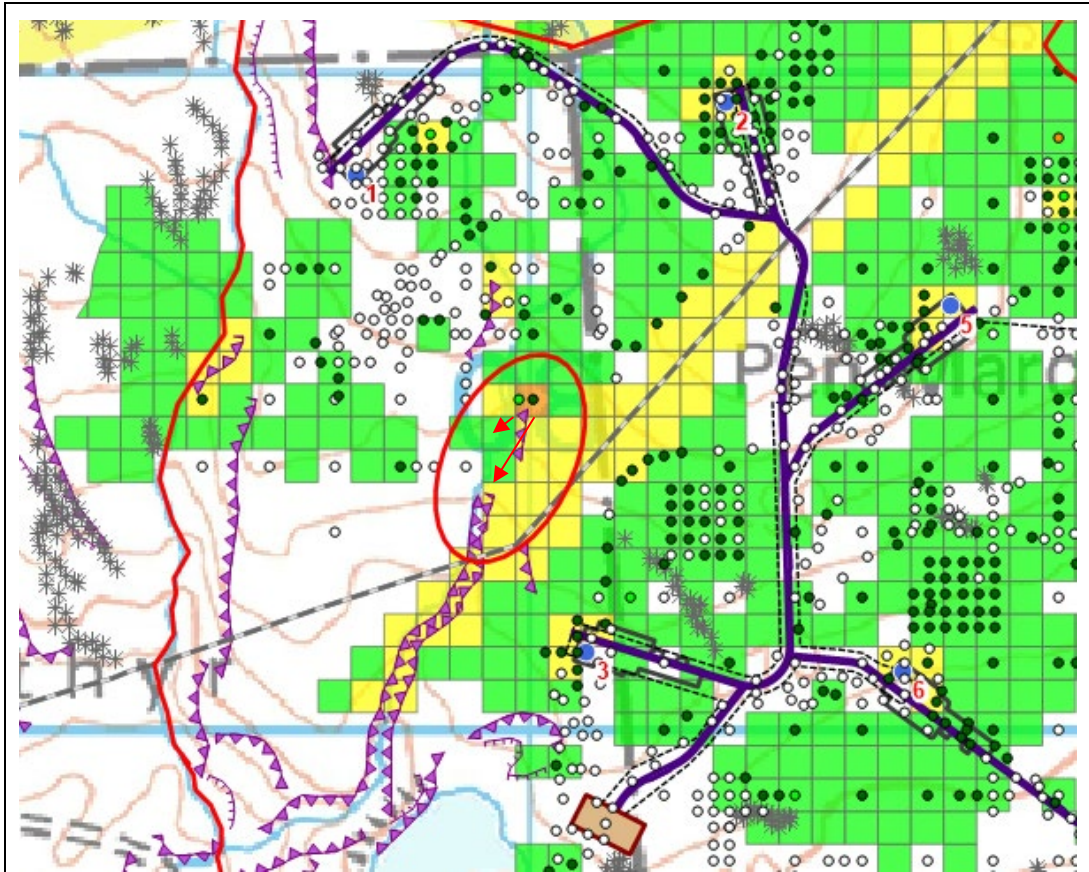
Peat slide risk associated with blasting for aggregate

- 6.24 For many renewable energy developments, aggregate extraction is achieved by blasting of bedrock. The shock waves from blasting have the potential to travel through the bedrock and could, potentially, be associated with triggering instability in peat areas at some distance from borrow pit sites. No suitable sites for borrow pits were identified within the Proposed Scheme, and as a result blasting is not required as part of the construction process.

7 DETAILED ASSESSMENT AND MITIGATION

Detailed assessment

- 7.1 One grid cell within the application boundary has been identified as having a moderate risk of peat landslide. The area identified for detailed assessment is indicated on **Figure 6.1.6**.
- 7.2 This cell, the cells immediately around and downslope of it, have been inspected in more detail to provide a better understanding of the potential risk in this part of the site. This has included consideration of the measured peat depths, slope angles, drainage features and the nature of any nearby or downslope infrastructure. Mitigation measures are recommended to reduce or control the risk for this area.
- 7.3 Following detailed consideration, the risk ranking has been re-appraised in the light of the presented information and proposed mitigation. The description is accompanied by a map of the highlighted cell and its immediate surroundings. The grid cells in each map are 50 x 50 m, to give an indication of scale. Green cells have negligible risk; yellow cells have low risk; orange cells have moderate risk; red cells have high risk. Blank cells have no peat, for the purposes of this analysis taken as 0.4 m in line with NRW's definition of peat (NRW, 2022c).
- 7.4 The points on the maps show the calculated Likelihood rating for all locations with directly measured peat depth, where white is no peat, blue is negligible; green is unlikely; yellow is likely; orange is probable; and red is almost certain.



Area 1:

One cell approximately mid-way between Turbines 1 and 3 has been assigned Moderate Risk. The cell lies just north of a gas pipeline buffer zone. The assigned risk level relates to the cell's location on a prominent convex break-in-slope and within a 50 m watercourse buffer.

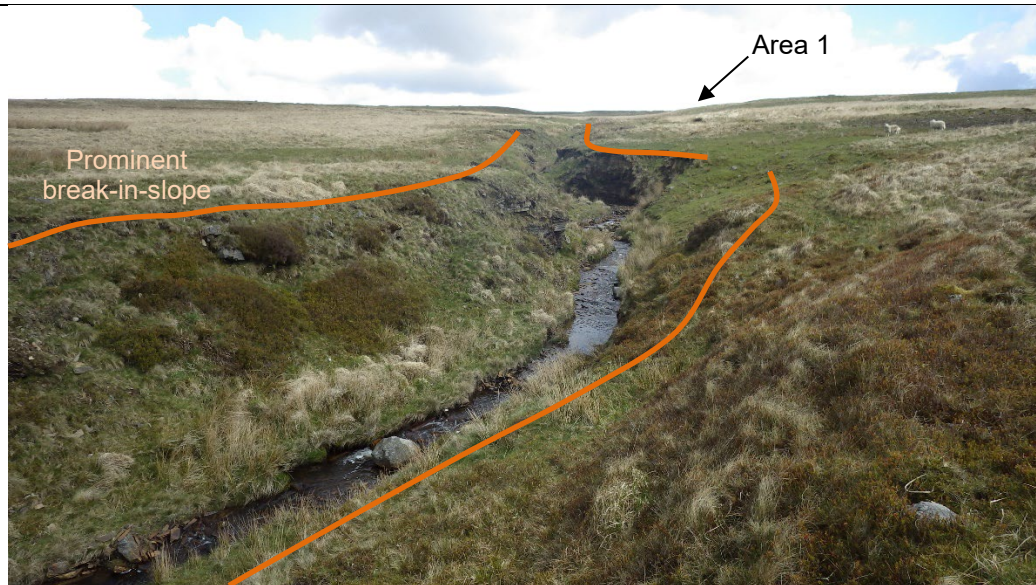
Calculated Likelihood for the cell is Likely, reflecting the presence of the break-in-slope. The assigned Consequence level is High as a result of the proximity of the watercourse.

The maximum peat depth record in the cell is 1.65 m, within 20 m of the watercourse channel. The average slope for the cell is 4.9°. Ground conditions were noted to be boggy at the time of the peat survey.

Potential runout from any failure: Any failure in this or adjacent cells would travel south-west or south down the slope. A failure would be likely to reach the watercourse quickly, and that debris would be transported downstream for some distance.

There is a possibility of a failure destabilising part of the slope to the north-east of the highlighted cell.

The nearest infrastructure to the cell is Turbine 3, approximately 320 m to the south. The access track and cable route to Turbine 2 are approximately 340 m east. Turbine 1 is approximately 390 m to the north-west. No development infrastructure is located immediately downslope of the highlighted cell.



Photograph looking upstream towards Area 1

The highlighted area has very variable peat depths, with recorded depths changing over very short distances. A number of deep records (1.0 m or deeper) are present, typically in close association with boggy sections of the watercourse valley. Nearby depths vary from 0.9 m to 0.15 m in different sections.

The deep peat record (1.65 m) within the highlighted cell has an adjacent record of 0.6 m but all other nearby records are below 0.4 m. This indicates that the deep peat in this area forms an isolated pocket.

Calculated likelihood for the measured peat depth records is shown on the figure above, with the dark green point indicating a Negligible likelihood and the paler green point indicating Low likelihood. Both likelihood classes make use of the actual slope present at that peat depth record.

Mitigation

There are no plans for any development activity to take place within 250 m of the highlighted cell and it is unlikely that any construction activity would have any influence on the area's stability.

Although the nearby break-in-slope has increased the Likelihood class from Unlikely to Likely, realistically this is most likely to be an over-estimate as all the steep watercourse banks in this area reveal bedrock at surface (see photograph above). Such banks would help to prevent a peat landslide rather than facilitating one.

The most likely cause of natural instability would be undercutting of the slope by the watercourse. There was no evidence of channel mobility or undercutting present in the channel near the identified cell or within the channel either upstream or downstream of the identified risk location, and as a result this is not considered to pose a risk to the Proposed Scheme, the natural environment or any existing economically valuable infrastructure in this area.

Revised Risk Ranking

Low

Mitigation

- 7.5 The following mitigation measures would be implemented to ensure that slope stability is maintained across the Proposed Scheme and to minimise the risk of inducing a peat slide.
- 7.6 Construction work would make use of current best practice guidance relating to developments in peatland areas. A risk management system, such as a geotechnical risk register, would be developed as part of the post-consent detailed design works. This would be maintained through all subsequent stages of the project and updated as necessary whenever new information becomes available. During construction, members of project staff would undertake advance inspections and carry out regular monitoring for signs of peat landslide indicators. A geotechnical specialist would be on call to provide advice, if required by site conditions.
- 7.7 Micrositing would be used to avoid possible problem areas. This would be assisted by additional verification of peat depths, to full depth, in any highlighted areas where construction work is required. Track drainage would be installed in accordance with published good practice documentation and would be minimised in terms of length and depth in order to minimise concentration of flows.
- 7.8 Construction activities would be restricted during periods of very wet weather, particularly for any work occurring within 20 m of a watercourse or within areas of identified peat. Careful track design would ensure that the volume and storage timescale for excavated materials would be minimised as far as practicable during construction works.
- 7.9 Vegetation cover would be re-established as quickly as possible on track and infrastructure verges and cut slopes, by re-laying of excavated peat acrotelm and turf, to improve slope stability and provide erosion protection. Additional methods, including hydroseeding and/or use of a biodegradable geotextile, would be considered if necessary in specific areas.
- 7.10 Construction staff would be made aware of peat slide indicators and emergency procedures. Emergency procedures would include measures to be taken in the event that an incipient peat slide is detected.
- 7.11 Key early indicators of peat instability are:
- Tension cracks in the upper layers or to full depth of peat, and may indicate an accumulation of stress in peat soils. In addition, cracking can provide a route for surface water to infiltrate rapidly through the peat body, contributing to elevated pore water pressure and lubrication along lines of weakness.
 - Compression ridges, usually indicative of displacement upslope which has led to formation of ridges within the peat body.
 - Peat creep, usually visible as tilting of fence posts or young trees. This may be accompanied by tension cracking and/or compression ridges.

Infrastructure design

- 7.12 Careful and informed infrastructure design forms a key measure for prevention of induced instability in peat. The collated peat depth information has been used to inform the proposed infrastructure layout throughout the design process. Incursion into areas of peat has been kept to a practical minimum by careful design and will be reinforced by careful micro-siting, in order to minimise disruption to peatland ecosystems and hydrology, and to avoid the risk of induced peat instability.
- 7.13 Access tracks are anticipated to be constructed using established cut-and-fill construction methods. Any peat present along the cut-and-fill track routes would be excavated and stored for use in reinstatement of trackside verges and other elements of project infrastructure where appropriate.
- 7.14 Trackside ditches would be constructed as required. For tracks parallel or sub-parallel to contours, best practice recommendations are for a ditch along the uphill side only, with cross-drains installed at regular intervals below the track to minimise flow concentration. Cross-drains would discharge onto vegetated ground where possible, to encourage spread of surface flow rather than focused flow and the consequent development of new drainage channels. Tracks crossing contours may require ditches or swales on both sides. In all cases, lengths and depths of trackside drainage would be minimised, particularly in areas where peat is present. There would be a requirement for some trackside drainage to minimise track surface erosion and damage.

8 CONCLUSIONS

- 8.1 A detailed assessment of peat slide risk has been carried out for the Proposed Scheme. All proposed new infrastructure has been covered by the assessment. There are no proposals for upgrading existing infrastructure.
- 8.2 The assessment found that the majority of the Proposed Scheme has a negligible or low risk of peat landslide.
- 8.3 One area, consisting of one individual cell, of apparent Moderate risk has been identified. This area was flagged as a result of the coincidence of an area of deep peat, a watercourse channel and a distinct concave break-in-slope. The watercourse gave a High consequence rating and the break-in-slope increased the Likelihood rating from the initial Unlikely to Likely. Closer inspection of the risk area and its surroundings indicate that the peat forms a small, isolated pocket of deep peat immediately upstream of a rocky bank. Rather than facilitating a slide, the rocky bank would act to hold the peat in place, meaning that the identified risk class is overstated.
- 8.4 The area is distant from all proposed infrastructure and there would be no requirement for construction activity to approach the area. It is recommended that construction areas are demarcated and all site staff are made aware of the requirement to stay within the marked construction corridor at all times.
- 8.5 Mitigation measures have been recommended to control the peat landslide hazard for the identified area. The principal control would be the maintenance of a buffer zone between all construction activity and the highlighted area. A revised risk ranking taking into account location-specific details and mitigation measures is Low for the identified area.
- 8.6 Good construction methods and appropriate micro-siting would also be effective at controlling residual peat landslide risk for the remainder of the Proposed Scheme. Providing that the recommended mitigation measures are put in place and adhered to, the risk of peat landslide as a result of the Pen March Wind Farm is not significant.

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10 ANNEX 1: PEAT CORE LOGS

Notes to accompany peat coring results

Peat coring was undertaken by RSK on 12 October 2021. Fifteen locations were identified by RSK to be targeted, prior to the works.

Main findings

Ground conditions were slightly boggy at all locations. All locations were situated in open moorland areas. Vegetation at all locations included rushes and grasses, with bog moss largely absent.

In a number of areas, peat and peaty soils were underlain by silty clay sediments, likely to be diamicton till.

In peat sections, decomposition was mainly relatively low with H6 (moderately highly decomposed) being the highest class identified. Most locations returned samples with identifiable plant material within the peat or soil. Moisture classes varied between B2 and B3, indicating low to moderate moisture across the site.

Core recovery was to shallower depths than was probed due to the tip of the peat corer preventing recovery from the basal 0.2 m.

Photographs of all recovered cores are included at the end of this document. Of note, the base of the core is always shown in the right side of the photo.



Peat Core Logs

ID	Label	X	Y	Probe Depth (m bgl)	Layer	Top Depth (m bgl)	Bottom Depth (m bgl)	Von Post	Moisture	Notes
156517	C01a	307732	210853	0.3	1	0.0	0.3	H4	B2	View N. Peat dark brown, slightly fibrous with frequent roots
156526	C01b	307824	210917	0.7	1	0.0	0.2	H3	B2	View S. Peat dark brown fibrous, with frequent roots and identifiable plant material
					2	0.2	0.7	H4	B3	Peat light brown, moist and very fibrous, lots of identifiable plant material.
156518	C02a	308302	210948	0.3	1	0.0	0.0	No peat	No peat	View S. Soil Saturated to ground level. Vegetation over grey and orange silty clay with frequent roots
156527	C02b	308339	210921	0.9	1	0.25	0.6	H4	B2	View SE. Peat fairly dry, black with occasional roots. Clay firm light grey and light orange, slightly silty with occasional roots
156522	C03a	308089	210114	0.35	1	0.0	0.2	H3	B2	View S. Peat dark brown, very fibrous, rooty. Clay dark grey, silty
156528	C03b	308180	210130	0.45	1	0.0	0.15	H4	B2	View N. Base rocky. Peat light brown, slightly fibrous with frequent roots.
					2	0.15	0.3	H5	B3	Peat moist, black and slightly rooty
156520	C04a	309110	210560	0.35	1	0.0	0.15	H3	B2	View E. Base rocky. Peat loose, dark brown and rooty. Clay light grey and silty. Transition from peat to clay gradual over approx. 5cm.
156524	C04b	309126	210463	0.6	1	0.0	0.25	H3	B2	View W. Peat dark brown, rooty, damp. Clay grey and orange, slightly silty with occasional roots and fine gravel



ID	Label	X	Y	Probe Depth (m bgl)	Layer	Top Depth (m bgl)	Bottom Depth (m bgl)	Von Post	Moisture	Notes
156519	C05a	308632	210634	0.65	1	0.0	0.2	H3	B2	View S. Peat light brown very rooty, fairly dry.
	C05a				2	0.2	0.45	H4	B2	Peat black, rooty, slightly moist. Base rock
156525	C05b	308571	210575	0.95	1	0.0	0.1	H4	B2	View S. Peat light brown, very rooty, fibrous
	C05b				2	0.1	0.55	H5	B2	Peat soft dark brown structureless with occasional plant remains
	C05b				3	0.55	0.8	H6	B3	Peat soft black and rooty. Overlying very soft light grey clay
156521	C06a	308565	210076	0.3	1	0.0	0.15	H5	B2	View E. Peat light brown becoming grey to base, very rooty, becoming clayey towards base. Overlying soft dark grey silty clay.
156523	C06b	308638	210008	0.6	1	0.0	0.2	H3	B3	View S. Rock at base. Peat moist brown, very fibrous and rooty.
	C06b				2	0.2	0.3	H5	B2	Peat dark brown slightly fibrous with frequent roots.
	C06b				3	0.3	0.4	H5	B2	Peat very dark brown/black, structureless with occasional roots. Clay very soft light grey, slightly silty.



ID	Label	X	Y	Probe Depth (m bgl)	Layer	Top Depth (m bgl)	Bottom Depth (m bgl)	Von Post	Moisture	Notes
156534	C07	309153	210203	0.65	1	0.0	0.2	H3	B2	View N. dark brown, slightly rooty, damp peat. Overlying grey and orange, slightly silty clay with occasional roots
156532	C08	309176	209810	0.3	1	0.0	0.25	H4	B2	View S. Rock at base. Peat dark brown/black, fibrous, fairly dry.
156533	C09	309208	209331	0.35	1	0.0	0.15	H4	B3	View S. Peat very dark brown, fibrous. Overlying dark grey and brown, very silty clay with occasional roots

Location: C01a	Depth: 0.00 – 0.30 m bgl	Date: 12/10/2021
		
Notes: Thin peaty soil, dark brown and slightly fibrous with frequent roots		

Location: C01b	Depth: 0.20 – 0.70 m bgl	Date: 12/10/2021
		
Notes: Light brown peat, moist & very fibrous with substantial identifiable plant material		

Location: C02a	Depth: 0.00 – 0.30 m bgl	Date: 12/10/2021
		
Notes: No peat. Soil characterised by grey and orange silty clay with frequent roots.		

Location: C02b	Depth: 0.25 – 0.60 m bgl	Date: 12/10/2021
		
Notes: Relatively dry peat with occasional roots. Replaced by firm light grey and orange silty clay at base.		

Location: C03a	Depth: 0.00 – 0.20 m bgl	Date: 12/10/2021
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Notes: Dark brown peaty soil, very fibrous and rooty. Transition to clay at base, dark grey and silty

Location: C03b	Depth: 0.15 – 0.30 m bgl	Date: 12/10/2021
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Notes: Brown fibrous peaty soil with frequent roots.

Location: C04a

Depth: 0.00 – 0.15 m bgl

Date: 12/10/2021



Notes: Very shallow dark brown rooty soil with transition to clay occurring over c. 5 cm.

Location: C04b

Depth: 0.00 – 0.25 m bgl

Date: 12/10/2021



Notes: Dark brown fibrous peaty soil overlying grey and orange silty clay.

Location: C05a	Depth: 0.00 – 0.20 m bgl	Date: 12/10/2021
		
Notes: Upper section of core showing largely undecomposed plant fibres in upper section, very dry, becoming more decomposed at depth		

Location: C05b	Depth: 0.10 – 0.55 m bgl	Date: 12/10/2021
		
Notes: Upper section of core showing fibrous peaty upper section (0.1-0.2 m) with thick soft clay below		

Location: C06a	Depth: 0.00 – 0.15 m bgl	Date: 12/10/2021
		
Notes: Largely undecomposed rooty soil overlying dark grey silty clay		

Location: C6b	Depth: 0.00 – 0.40 m bgl	Date: 12/10/2021
		
Notes: Thin moist peat, fibrous with frequent roots, becoming more decomposed at depth. Transition to very soft light grey clay from about 0.3 m		

Location: C07	Depth: 0.00– 0.20 m bgl	Date: 12/10/2021
		
Notes: Shallow slightly rooty peaty soil, moist/damp, overlying grey and orange silty clay		

Location: C08	Depth: 0.00– 0.25 m bgl	Date: 12/10/2021
		
Notes: Dark brown fibrous peaty soil, fairly dry		

Location: C09	Depth: 0.00– 0.15 m bgl	Date: 12/10/2021
		
Notes: Dark brown fibrous peaty soil, overlying dark grey and brown very silty clay, occasional roots throughout		

11 ANNEX 2: AUTHOR EXPERIENCE

This report was produced by Eilidh Vass Payne and Emma Barrie with assistance from Andrew Cunningham, under the supervision of Catherine Isherwood.

Field surveys were undertaken by Rhyan Law-Cooper, Heather De Quincey and Andrew Cunningham. All three members of staff have significant experience of peat surveying and classification from wind farm developments, peatland restoration surveys, overhead line route studies and ground investigation works, and other infrastructure projects including substation development and major road alignments.

Catherine Isherwood is a Chartered Geologist with an MA and PhD in Geological Sciences from the University of Cambridge and an MSc in Hydrogeology from Newcastle University. She has over 16 years' experience in environmental impact assessment and the assessment of peat and slope stability.

The report has been reviewed and authorised by Catherine Isherwood.

The assessment method was developed with input from a Chartered Engineer and a Chartered Environmentalist with a combined experience of more than 35 years.