FEHILY TIMONEY

CONSULTANTS IN ENGINEERING, ENVIRONMENTAL SCIENCE & PLANNING

GEOTECHNICAL & PEAT STABILITY REPORT

PROPOSED SUBSTATION, UNDERGROUND CABLING & ACCESS ROADS TO KNOCKNAMORK RENEWABLE ENERGY DEVELOPMENT

Prepared for: **MKO Ltd**

MKO

Date: July 2022

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GEOTECHNICAL & PEAT STABILITY ASSESSMENT REPORT

PROPOSED SUBSTATION, UNDERGROUND CABLING & ACCESS ROADS TO KNOCKNAMORK RENEWABLE ENERGY DEVELOPMENT

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Abstract: Fehily Timoney and Company (FT) were engaged by McCarthy Keville O'Sullivan to undertake a geotechnical assessment of the Proposed Substation, Underground Cabling and Access Roads to the Knocknamork Renewable Energy Development with respect to peat stability. As part of the geotechnical assessment of the proposed development, FT completed walkover surveys at the site. The findings of the geotechnical and peat stability assessment showed that the site has an acceptable margin of safety and is suitable for the proposed development.

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1. NON-TECHNCIAL SUMMARY

Fehily Timoney and Company (FT) was engaged by McCarthy Keville O'Sullivan (MKO) to undertake a geotechnical and peat stability assessment of the Proposed Development comprising a substation, underground cabling, access roads and associated works for the Knocknamork Renewable Energy Development. In accordance with planning guidelines compiled by the Department of the Environment, Heritage and Local Government (DoEHLG), where peat is present on a proposed wind farm development, a peat stability assessment is required.

A walkover including intrusive peat depth probing, desk study, stability analysis and risk assessment was carried out to assess the susceptibility of the site to peat failure following the principles in Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (PLHRAG, 2017). Trial pits were excavated at the proposed substation location and adjacent proposed borrow pit to determine the ground conditions at these locations.

The findings, which involved the stability analysis of approximately 260 locations, show that the site has an acceptable margin of safety and is suitable for the Proposed Development. Based on the findings, recommendations and control measures for construction work in peat lands are suggested to ensure that all works adhere to an acceptable standard of safety.

The site is located along an upland ridge and southern slopes of the Derrynasaggart Mountains. The site is an upland blanket peat area comprising forestry and open grazing land. The blanket peat areas contain typically shallow peat with deeper peat deposits in the flatter areas on site. Several existing access roads are present across the site and have been in use for a number of years.

Peat depth recorded during the site walkovers from approximately 880 probes ranged from 0.0 to 3.25m with an average peat depth of 0.85m. 61% of the probes recorded peat depths of less than 1.0m with 92% of peat depth probes recorded peat depths of less than 2.0m. Localised deeper peat areas were recorded in flatter areas (<2 degrees) across the Proposed Development.

Slope inclinations across the site range from 2 to 14 degrees. Ground conditions comprise mainly of blanket peat overlying clay overlying bedrock.

An analysis of peat sliding was carried out across site for both the undrained and drained conditions. The purpose of the stability analysis was to determine the stability i.e. Factor of Safety (FoS), of the peat slopes. The FoS provides a direct measure of the degree of stability of a peat slope. A FoS of less than 1.0 indicates that a slope is unstable; a FoS of greater than 1.0 indicates a stable slope. An acceptable FoS for slopes is generally taken as a minimum of 1.3. From the stability analysis for both the undrained and drained conditions, which analysed proposed infrastructure locations, the calculated values were above the minimum acceptable FoS of 1.3 at all of the locations analysed.

A peat stability risk assessment was undertaken at each infrastructure location. The peat stability risk assessment uses the results of the stability analysis in combination with qualitative factors, which cannot be reasonably included in a stability calculation but nevertheless may affect the occurrence of peat instability, to assess the risk of peat failure at the site. The results of the risk assessment are given in Appendix B.

In summary, the findings of the peat assessment showed that the Proposed Development site has an acceptable margin of safety, is suitable for the Proposed Development and is considered to be at low risk of peat failure.

2. INTRODUCTION

2.1 Fehily Timoney and Company

Fehily Timoney and Company (FT) is an Irish engineering, environmental science and planning consultancy with offices in Cork, Dublin and Carlow. The practice was established in 1990 and currently has about 80 members of staff, including engineers, scientists, planners and technical support staff. FT deliver projects in Ireland and internationally in our core competency areas of Waste Management, Environment and Energy, Civils Infrastructure, Planning and GIS and Data Management.

2.2 Project Description

FT was engaged in August 2021 by McCarthy Keville O'Sullivan (MKO) to undertake a geotechnical & peat stability assessment of the Proposed Development.

The Proposed Development site is located approximately 3km northwest of Ballyvourvey, Co. Cork.

The site is located on the border between Co. Cork and Co. Kerry. The surrounding landscape is hilly with land-use comprising forestry and poor-quality agricultural land.

The Proposed Development is described in detail in Chapter 4 of the EIAR.

The peat depth data recorded by FT during the site walkover from the 5th to the 7th October 2021, and by MKO (2021 and 2022), has been used in the assessment of peat stability for the proposed site. Previous peat probes taken by AGEC (now part of FT) and HES on the site during 2017 have also been used.

2.3 Peat Stability Assessment Methodology

FT undertook the assessment following the principles in Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (PLHRAG, 2017). The Peat Landslide Hazard and Risk Assessment Guide (PLHRAG) is used in this report as it provides best practice methods to identify, mitigate and manage peat slide hazards and associated risks in respect of consent applications for electricity generation projects.

The best practice guide was produced following peat failures in the Shetland Islands, Scotland in September 2003 but more pertinently following the peat failure in October 2003, during the construction of a wind farm at Derrybrien, County Galway, Ireland.

This peat stability assessment has been undertaken taking into account peat failures that have occurred on peatland sites (such as recent failures at Shass Mountain 2020, Co. Leitrim and Meenbog 2020, Co. Donegal). The lessons learned from both peat slide events have been incorporated into the design of this project and the construction methodologies to be implemented. The Meenbog failure occurred during the construction of a section of floating road on sidelong ground in an area of weak peat. This construction technique is not proposed on the Proposed Development site. It is important that the existing site drainage is maintained during construction to avoid a similar failure to that on Shass Mountain, which occurred following heavy rainfall, and this is referenced in the Risk Assessments.

A constraints study was initially undertaken by the Environmental, Hydrogeological and Ecological members of the design team to determine the developable area on the site, prior to the site reconnaissance by engineering geologists/geotechnical engineers from FT. The extent and depth of ground investigation and peat stability analysis by FT have been undertaken in accordance with guidance within Eurocode 7 and PLHRAG (2nd Edition, 2017) to investigate peat slopes that have the potential to impact on the Proposed Development, as applicable. Sufficient peat depth data has been recorded during the site walkovers to enable the characterisation of the peat depth across the Proposed Development site as shown in Figure 4.1 of the EIAR. The peat stability assessment is undertaken to identify peat slopes at risk from the Proposed Development, and to identify peat slopes that may pose a risk to the Proposed Development.

The geotechnical and peat stability assessment at the site included the following activities:

(1) Desk study, involving the review of publicly available soils and geology maps, records of historical peat failures, aerial photography.

(2) Site reconnaissance including shear strength and peat depth measurements

(3) Trial pitting (6 no. pits) at the proposed 110kV substation platform and new proposed borrow pit.

(4) Peat stability assessment of the peat slopes on site using a deterministic and qualitative approach

(5) Peat contour depth plan – compiled based on the peat depth probes carried out across the site by FT (2021), MKO (2021 and 2022), AGEC (2017) and HES (2017).

(6) Factor of safety plan – compiled for the short-term critical condition (undrained) for approximately 260 no. FoS points analysed along the proposed infrastructure envelope on site

(7) Construction buffer zone plan – identifies areas with an elevated or higher construction risk where mitigation/control measures will need to be implemented during construction to minimise the potential risks and ensure they are kept within an acceptable range

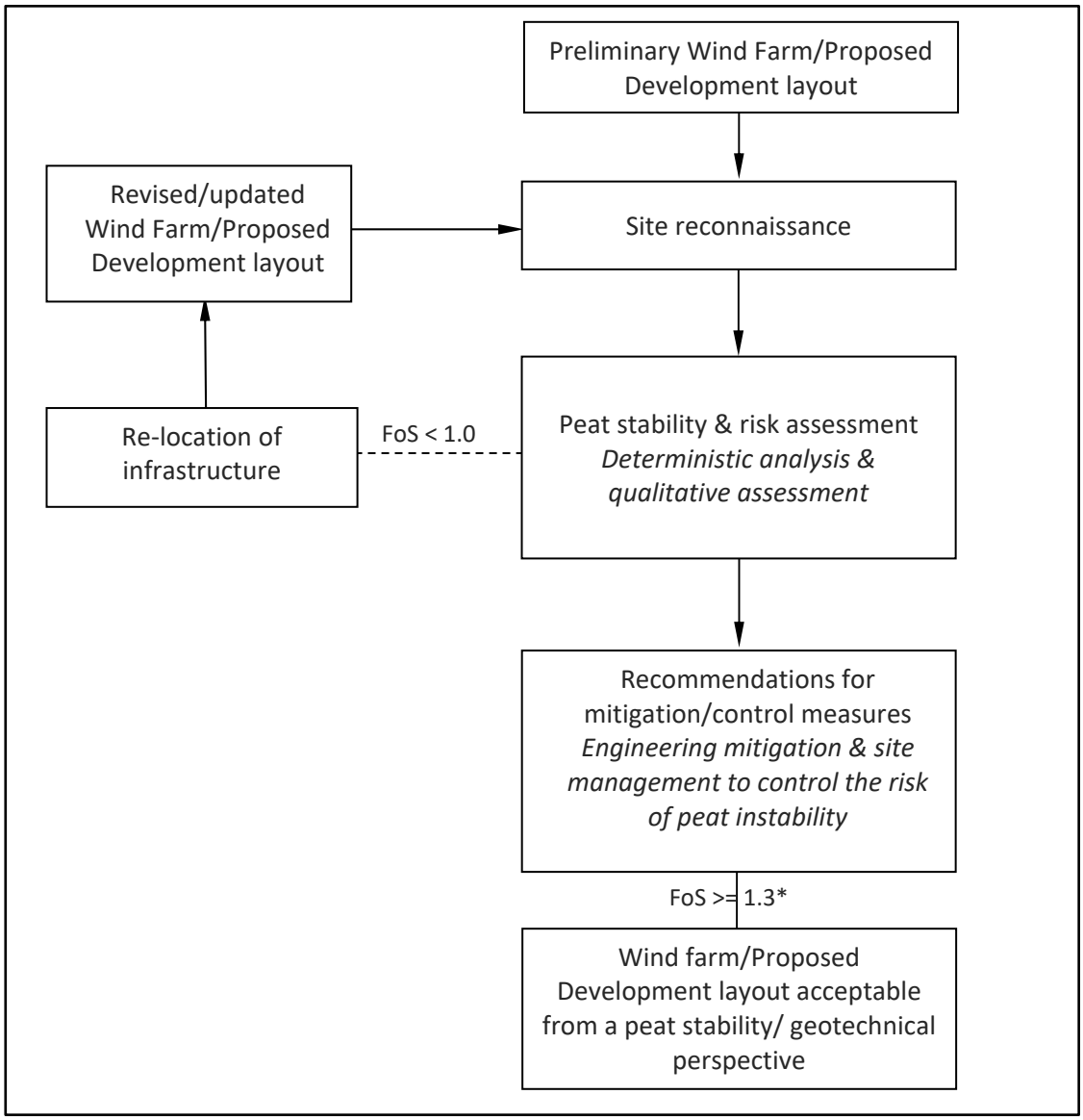
(8) A peat stability risk register was compiled to assess the potential design/construction risks at the infrastructure locations and determine adequate mitigation/control measures for each location to minimise the potential risks and ensure they are kept within an acceptable range, where necessary

(9) Review of ground investigation carried out at the site by FT

(10) Commentary of founding details for infrastructure elements such as access roads and substation compound platforms

A flow diagram showing the general methodology for a peat stability assessment is shown in Figure 2.1. The methodology illustrates the optimisation of a Proposed Development layout based on the findings from the site reconnaissance and stability analysis and subsequent feedback.

Figure 2.1: Methodology for Peat Stability Assessment



*An FoS of between 1.0 and 1.3 does not mean that a failure will occur, but that the area requires attention. Mitigation measures can be provided for areas with an FoS of between 1.0 and 1.3 to reduce the risk of failure.

As for all construction projects, a detailed engineering construction design must be carried out by the appointed construction stage designer prior to any construction work commencing on site. This must take account of the consented project details and any conditions imposed by that consent. This must include a confirmatory peat stability assessment to account for any changes in the environment which may have occurred in the time leading up to the commencement of construction.

2.4 Peat Failure Definition

Peat failure in this report refers to a significant mass movement of a body of peat that would have an adverse impact on the Proposed Development and the surrounding environment. Peat failure excludes localised movement of peat that would occur below an access road, creep movement or erosion type events.

The potential for peat failure at this site is examined with respect to the Proposed Development and associated activity.

2.5 Main Approaches to Assessing Peat Stability

The main approaches for assessing peat stability for wind farm developments include the following:

(1) Geomorphological

(2) Qualitative (judgement)

(3) Index/Probabilistic (probability)

(4) Deterministic (factor of safety)

Approaches (1) to (3) listed above are considered subjective and do not provide a definitive indication of stability; in addition, a high level of judgement/experience is required which makes it difficult to relate the findings to real conditions. FT apply a more objective approach, the deterministic approach (as discussed in Section 2.6).

As part of FT's deterministic approach, a qualitative risk assessment is also carried out taking into account qualitative factors, which cannot necessarily be quantified, such as the presence of mechanically cut peat, quaking peat, bog pools, sub peat water flow, slope characteristics and numerous other factors. The qualitative factors used in the risk assessment are compiled based on FT's experience of assessments and construction in peat land sites and peat failures throughout Ireland and the UK. FT have been involved with in excess of 100 wind farm developments across Ireland and the UK at various stages of development, from preliminary feasibility stage through planning and from scheme development at tender design and detailed design stage, through to the construction and operational stages. This approach follows the guidelines for geotechnical risk management as given in Clayton (2001), as referenced in the best practice for Peat Landslide Hazard and Risk Assessment Guide (PLHRAG, 2017), and takes into account the approach of MacCulloch (2005).

The risk assessment uses the results of the deterministic approach in combination with qualitative factors, which cannot be reasonably included in a stability calculation but nevertheless may affect the occurrence of peat instability to assess the risk of instability on a peat land site.

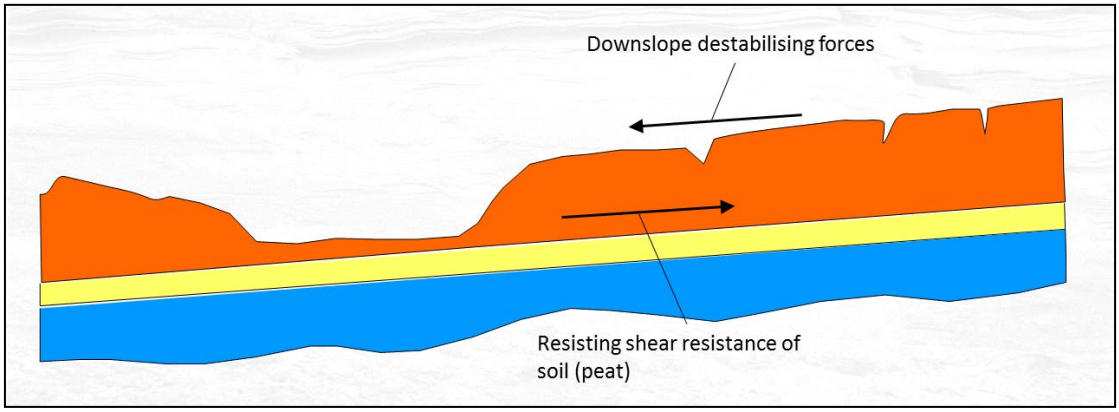
2.6 Peat Stability Assessment – Deterministic Approach

The peat stability assessment is carried out across a wide area of peatland to determine the stability of peat slopes and to identify areas of peatland that are suitable for development; this allows the layout of infrastructure on a particular wind farm site to be optimised. The assessment provides a numerical value (factor of safety) of the stability of individual parcels of peatland. The findings of the assessment discriminate between areas of stable and unstable peat, and areas of marginal stability where restrictions may apply. This allows for the identification of the most suitable locations for turbines, access roads and infrastructure.

A deterministic assessment requires geotechnical information and site characteristics which are obtained from desk study and site walkover, e.g. properties of peat/soil/rock, slope geometry, depth of peat, underlying strata, groundwater, etc. An adverse combination of the factors listed above could potentially result in instability. Using the information above, a factor of safety is calculated for the stability of individual parcels of peatland on a site (as discussed in Section 7).

The factor of safety is a measure of the stability of a particular slope. For any slope, the degree of stability depends on the balance of forces between the weight of the soil/peat working downslope (destabilising force) and the inherent strength of the peat/soil (shear resistance) to resist the downslope weight, see Figure 2.2.

Figure 2.2: Peat Slope Showing Balance of Forces to Maintain Stability



The factor of safety provides a direct measure of the degree of stability of a slope and is the ratio of the shear resistance over the downslope destabilising force. Provided the available shear resistance is greater than the downslope destabilising force then the factor of safety will be greater than 1.0 and the slope will remain stable. If the factor of safety is less than 1.0 the slope is unstable and liable to fail. The acceptable range for factor of safety is typically from 1.3 to 1.4 (BS5930:1981). For the purposes of this assessment a result of >1.3 is required.

2.7 Applicability of the Factor of Safety (Deterministic) Approach for Peat Slopes

The factor of safety approach is a standard engineering approach in assessing slopes which is applied to many engineering materials, such as peat, soil, rock, etc.

The factor of safety approach is included in the Peat Landslide Hazard and Risk Assessments Best Practice Guide for Proposed Electricity Generation Developments (PLHRAG, 2017); see Section 5.3.1 of the guide. This guide provides best practice methods to identify, mitigate and manage peat slide hazards and associated risks in respect of consent applications for electricity generation projects.

Furthermore, the best practice guide notes that the results from the factor of safety approach 'has provided the most informative results' with respect to analysing peat stability (Section 5.3.1 of the guide).

The factor of safety approach in this report includes undrained (short-term stability) and drained (long-term stability) analyses. The undrained condition is the critical condition for the development. The purpose of the drained analysis is to identify the relative susceptibility of rainfall-induced failures at the site.

Notwithstanding the above, the stability analysis used by FT in this report also includes qualitative factors to determine the potential for peat stability i.e. the analysis used does not solely rely on the factor of safety approach.

The deterministic analysis is considered an acceptable engineering design approach. This concurs with the best practice guide referenced above.

2.8 Assessment of Intense Rainfall and Extreme Dry Events on the Peat Slope

The deterministic approach carried out by FT examines intense rainfall and extreme dry events. The deterministic approach includes and undrained (short-term stability) and drained (long-term stability) analysis to assess the factor of safety for the peat slopes against a peat failure.

The drained loading condition applies in the long-term. This condition examines the effect of the change in groundwater level as a result of rainfall on the existing stability of the natural peat slopes. For the drained analysis the level of the water table above the failure surface is required to calculate the factor of safety for the peat slope.

In order to represent varying water levels within the peat slopes, a sensitivity analysis is carried out which assesses varying water level in the peat slopes i.e. water levels ranging from 0 to 100% of the peat depth is conducted, where 0% equates to the peat been completely dry and 100% equates to the peat being fully saturated.

By carrying out such a sensitivity analysis with varying water level in the peat slopes, the effects of intense rainfall and extreme dry events are considered and analysed. The results of which are presented in Section 7 of this report.

3. DESK STUDY

3.1 Desk Study

The main relevant sources of interest with respect to the site include:

- Geological plans and Geological Survey of Ireland database
- Ordnance survey plans
- Literature review of peat failures

The Geological Survey of Ireland (GSI, 1997) geological plans for the site were used to verify the soil and bedrock conditions.

The Ordnance Survey plans were reviewed to determine if any notable features or areas of particular interest (from a geotechnical point of view) are present on the site.

The desk study also includes a review of both published literature and GSI online dataset viewer (GSI, 2020) on peat failures/landslides in the vicinity of the site.

3.2 Soils, Subsoil & Bedrock

A review of the Geological Survey of Ireland (GSI) online database and published documents from the GSI was carried out.

The underlying bedrock was described by the Geological Survey of Ireland (GSI, 1997) and shown on Sheet 21 (Geology of Kerry-Cork). In the area of the Proposed Development site, Sheet 21 shows two bedrock formations.

The bedrock formations include:

- Glenflesk chloritic sandstone formation - green medium to coarse grained sandstone, rare pebbly sandstones, exotic and intraformational conglomerates, with thick sequences of purple or green siltstones
- Gunpoint formation – green-grey to purple medium to coarse-grained sandstones interbedded with thick sequences of purple siltstones and fine-grained purple parallel and cross-laminated red sandstones

A number of fault lines are present on the site with typically northwest to southeast and north to south trends.

No karst features were identified within 5km of the Proposed Development.

No geological heritage sites are noted within 5km of the Proposed Development.

3.3 Previous Failures

There are no recorded peat failures within the Proposed Development site (GSI, 2022). The nearest recorded failures are located 2km to the north within the valley of the River Clydagh. Limited information is available for these failures, which appear to be a mix of peat failures and failures in the overburden.

The landslide susceptibility of the site was classified by the GSI (2021) as low to high susceptibility, which is expected given the undulating terrain present.

The presence, or otherwise, of relict peat failures or clustering of relict failures within an area is an indicator that particular site conditions exist that pre-dispose a site to failure or not as the case may be.

4. FINDINGS OF SITE RECONNAISSANCE

4.1 Site Reconnaissance

As part of the assessment of the potential for peat failure at the Proposed Development site, site reconnaissance was undertaken in conjunction with the desk study review described in Section 3. The site reconnaissance comprises a walkover inspection of the site with recording of salient geomorphological features with respect to the Proposed Development, which included peat depth and preliminary assessment of peat strength. Site visits were undertaken by FT in 2021, and by MKO in 2021 and 2022. Historical site visits have been undertaken by AGEC (now part of FT) and HES. The information gathered from these site visits provide sufficient information for a site-wide assessment of the extent, depth and strength of peat present on the Proposed Development site.

The FT site reconnaissance undertaken in 2021 focused on the infrastructure associated with the Proposed Development.

The following salient geomorphological features were considered:

- Active, incipient or relict instability (where present) within the peat deposits
- Presence of shallow valley or drainage lines
- Wet areas
- Any change in vegetation
- Peat depth
- Slope inclination and break in slope

The method adopted for carrying out the site reconnaissance relied on experienced practitioners carrying out a visual assessment of the site supplemented with measurement of slope inclinations.

4.2 Findings of Site Reconnaissance

The main findings of the site walkover of the Proposed Development site are as follows:

(1) The site is typically covered in a layer of peat and has an undulating terrain. Peat depths vary across the site depending on mainly topography. Localised deeper peat was encountered in the flatter areas of the site with thinner peat on the surrounding slopes. Mature forestry, young forestry, and open peatland are present across the site (see Appendix A).

(2) A total of approximately 880 no. peat depth probes have been carried out on site during the various site visits. Peat depths recorded within the Proposed Development site ranged from 0.0 to 3.25m with an average depth of 0.85m (Figure 4-1). Approximately 92 percent of peat depth probes recorded peat depths of less than 2.0m.

(3) Trial pits (6 no.) were undertaken within the proposed substation platform and new proposed borrow pit. Ground conditions comprised up to 1.6m of Peat overlying granular glacial deposits. Intact bedrock was recorded at between 2.0 and 3.0m bgl. Trial pit logs are included in Appendix F.

(4) The peat depths recorded at the substation varied from 0.6 to 1.8m with an average depth of 1.0m.

(5) With respect to the proposed Turbine Delivery Route (TDR), peat depths are typically less than 2.0m (average 1.8m) with a localised depth of 3.25m recorded at one localised location adjacent to the existing access road. This appears to be an isolated pocket of peat and is not considered representative of the general area.

(6) Peat depths along the route of the 33kV underground electrical cabling and associated roads generally ranged from 0.2 to 1.7m, with a localised area (around 60m in length) recording peat depths of 2.5-3.0m. This deeper area is in an area of flatter ground when compared to the remainder of the 33kV route.

(7) Peat depths along the route of the 110kV underground cabling and associated access road ranged from 0 to 1.5m.

(8) Slope angles across the Proposed Development ranged from 2 to 14 degrees. These slope angle readings were obtained using a combination of readings taken during the site reconnaissance by FT using handheld equipment, such as the Silva Clino Master which has an accuracy of +/- 0.25 degrees and from contour survey plans for the site.

(9) No evidence of past failures or any significant signs of peat instability were noted on site.

(10) The results of the peat depth probing, shear strength testing of the peat and qualitative factors identified on site have been used in the stability and risk assessments, see Sections 6, 7 and 8 of this report for details.

In summary, based on the findings from the site reconnaissance, the Proposed Development footprint for the site is considered to have a low risk of peat instability.

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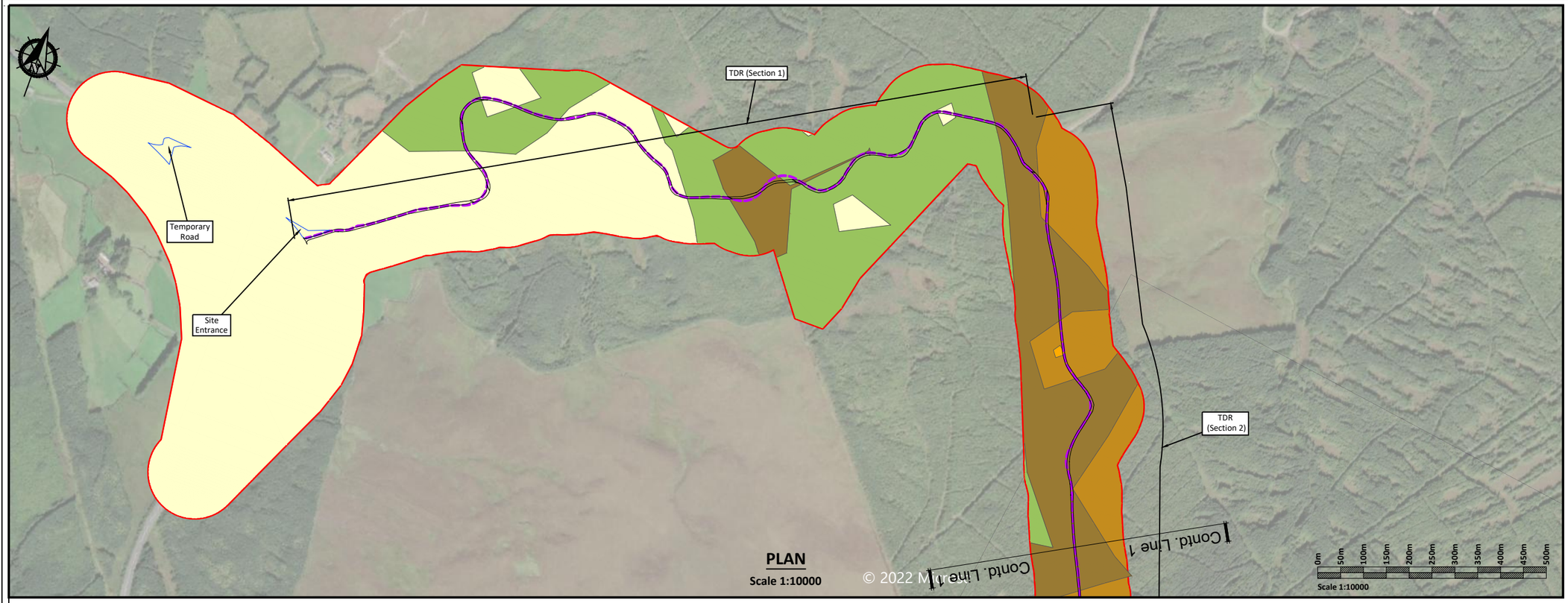
Legend:

- EIAR Planning Boundary
- Proposed Access Track
- Turbine Delivery Route (TDR)
- Underground Cabling 33kV
- Underground Cabling 110 kV
- 33kV Underground Cabling in Permitted Development
- Permitted Development

Peat Depth Legend:

- ≥ 0 < 0.5
- ≥ 0.5 < 1
- ≥ 1 < 1.5
- ≥ 1.5 < 2
- ≥ 2 < 2.5
- ≥ 2.5 < 3
- ≥ 3 < 3.5
- ≥ 3.5 < 4
- > 4



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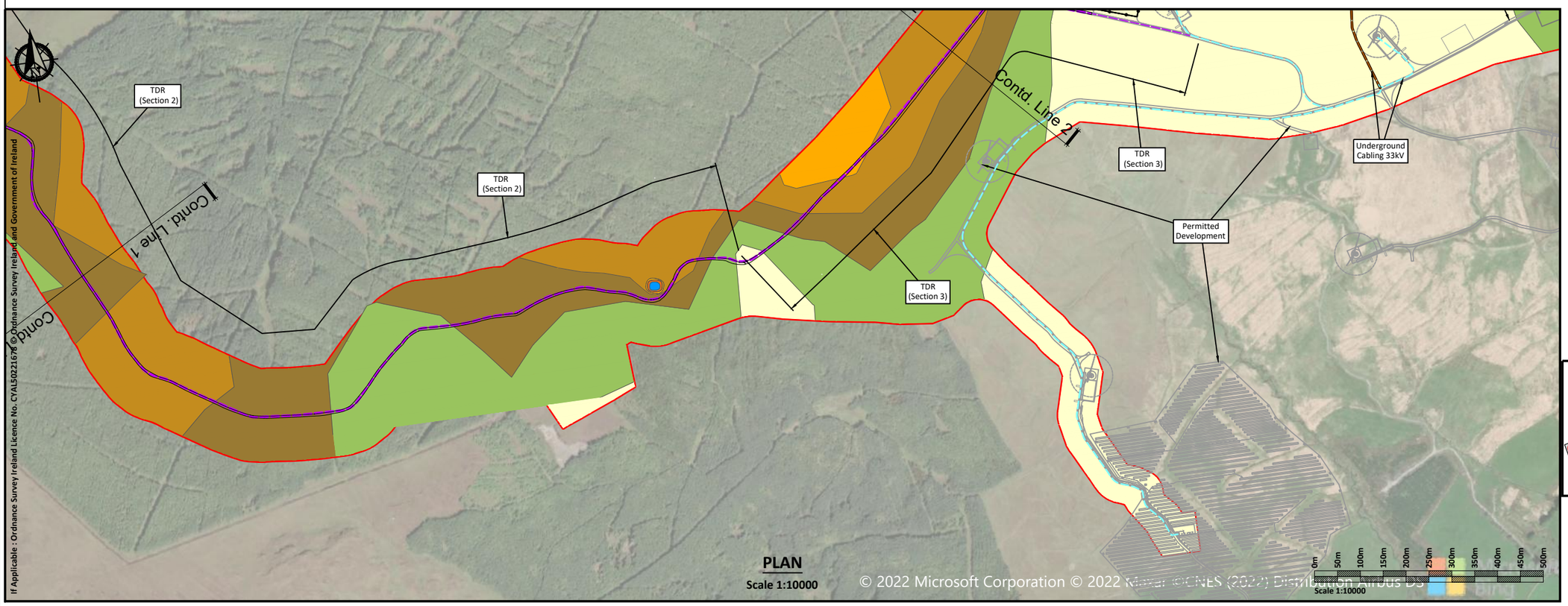

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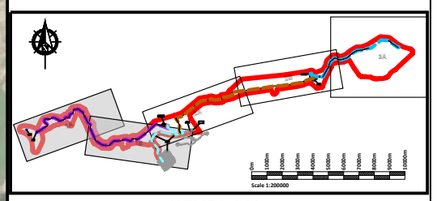

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FIGURE 4.1 - PEAT DEPTH CONTOURS SHEET 1 OF 3

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Legend:

- EIAR Planning Boundary
- Proposed Access Track
- Turbine Delivery Route (TDR)
- Underground Cabling 33kV
- Underground Cabling 110 kV
- 33kV Underground Cabling in Permitted Development
- Permitted Development

Peat Depth Legend:

- ≥ 0 < 0.5
- ≥ 0.5 < 1
- ≥ 1 < 1.5
- ≥ 1.5 < 2
- ≥ 2 < 2.5
- ≥ 2.5 < 3
- ≥ 3 < 3.5
- ≥ 3.5 < 4
- > 4

Contd. Line 2

Extension To Previously Permitted Borrow Pit

Contd. Line 2

TDR (Section 3)

Permitted Development

Underground Cabling 33kV

Permitted Development

Underground Cabling 33kV

Omitted 38kV Electrical Substation & Battery Storage

Contd. Line 3

Contd. Line 3

PLAN

Scale 1:10000

0m 50m 100m 150m 200m 250m 300m 350m 400m 450m 500m

Scale 1:10000

Contd. Line 3

Contd. Line 3

Underground Cabling 110kV (Section 2)

Contd. Line 4

Underground Cabling 110kV (Section 1)

Proposed Substation

Contd. Line 4

Proposed Borrow Pit

PLAN

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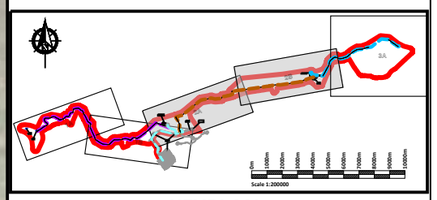

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FIGURE 4.1 - PEAT DEPTH CONTOURS SHEET 2 OF 3

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Underground Cabling 110kV (Section 2)

Underground Cabling 110kV (Section 3)

Contd. Line 4

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PLAN
Scale 1:10000

0m 50m 100m 150m 200m 250m 300m 350m 400m 450m 500m
Scale 1:10000

Legend:

- EIAR Planning Boundary
- Proposed Access Track
- Turbine Delivery Route (TDR)
- Underground Cabling 33kV
- Underground Cabling 110 kV
- 33kV Underground Cabling in Permitted Development
- Permitted Development

Peat Depth Legend:

- ≥ 0 < 0.5
- ≥ 0.5 < 1
- ≥ 1 < 1.5
- ≥ 1.5 < 2
- ≥ 2 < 2.5
- ≥ 2.5 < 3
- ≥ 3 < 3.5
- ≥ 3.5 < 4
- > 4

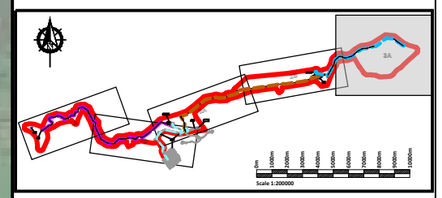

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FIGURE 4.1 - PEAT DEPTH CONTOURS SHEET 3 OF 3

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5. PEAT DEPTHS, STRENGTH & SLOPE AT PROPOSED INFRASTRUCTURE LOCATIONS

As part of the site walkover, peat depth, in-situ peat strength and slope angles were recorded at various locations across the site.

5.1 Peat Depth

Peat depth probes were carried out across the Proposed Development site, including at/near to proposed access roads, substation and underground electrical cabling (33 and 110kV) and associated infrastructure.

5.2 Peat Strength

The strength testing was carried out in-situ using a Geonor H-60 Hand-Field Vane Tester. From FT's experience hand vanes give indicative results for in-situ strength of peat and is considered best practice for the field assessment of peat strength.

5.3 Slope Angle

The slope angles at each of the main infrastructure locations were obtained using a combination of readings taken during the site reconnaissance by FT using handheld equipment, such as the Silva Clino Master and from contour survey plans for site.

The slope angle quoted typically reflects the slope within the footprint of each location. It should be noted that slope angles derived from contour survey plans would be considered approximate, as such surveys are dependent on the density of survey data and do not always reflect local variations in ground topography. Slope angles recorded during the site reconnaissance by FT using handheld equipment would generally be deemed more accurate and representative of local topography.

5.4 Summary of Findings

Based on the peat depths recorded across the site by FT, MKO and HES, the peat varied in depth from 0.0 to 3.25m with an average depth of 0.85m. All peat depth probes carried out on site have been utilised to produce a peat depth contour plan for the site (Figure 4.1).

A summary of the peat depths across the Proposed Development is given in Table 5.1. The data presented in Table 6.1 is used in the peat stability assessment of the site.

Table 5.1: Peat Depth & Slope Angle at Proposed Infrastructure Locations

Location	Easting	Northing	Peat Depth Range (m) (1)	Average Peat Depth (m)	Slope Angle (°) (2)
TDR	Varies	Varies	0 – 3.25	0.85	2-12
Underground Electrical Cabling (33kV)	Varies	Varies	0 – 3.0	0.75	2-12
Extension to Existing proposed Borrow Pit	Varies	Varies	0 – 0.3	0.1	3
Substation	Varies	Varies	0.45 – 1.7	0.95	6-8
Borrow Pit (Substation)	Varies	Varies	0.3 – 1.0	0.9	6-8
Underground Electrical Cabling (110kV)	Varies	Varies	0 – 2.0	0.65	2-14

Note (1) Based on probe results from the site walkovers.

Note (2) The slope angles at each location were obtained using a combination of readings taken during the site reconnaissance by FT using handheld equipment, such as the Silva Clino Master (which has an accuracy of +/- 0.25 degrees) and from contour survey plans for site. The slope angle quoted typically reflects the slope within the footprint of each infrastructure location.

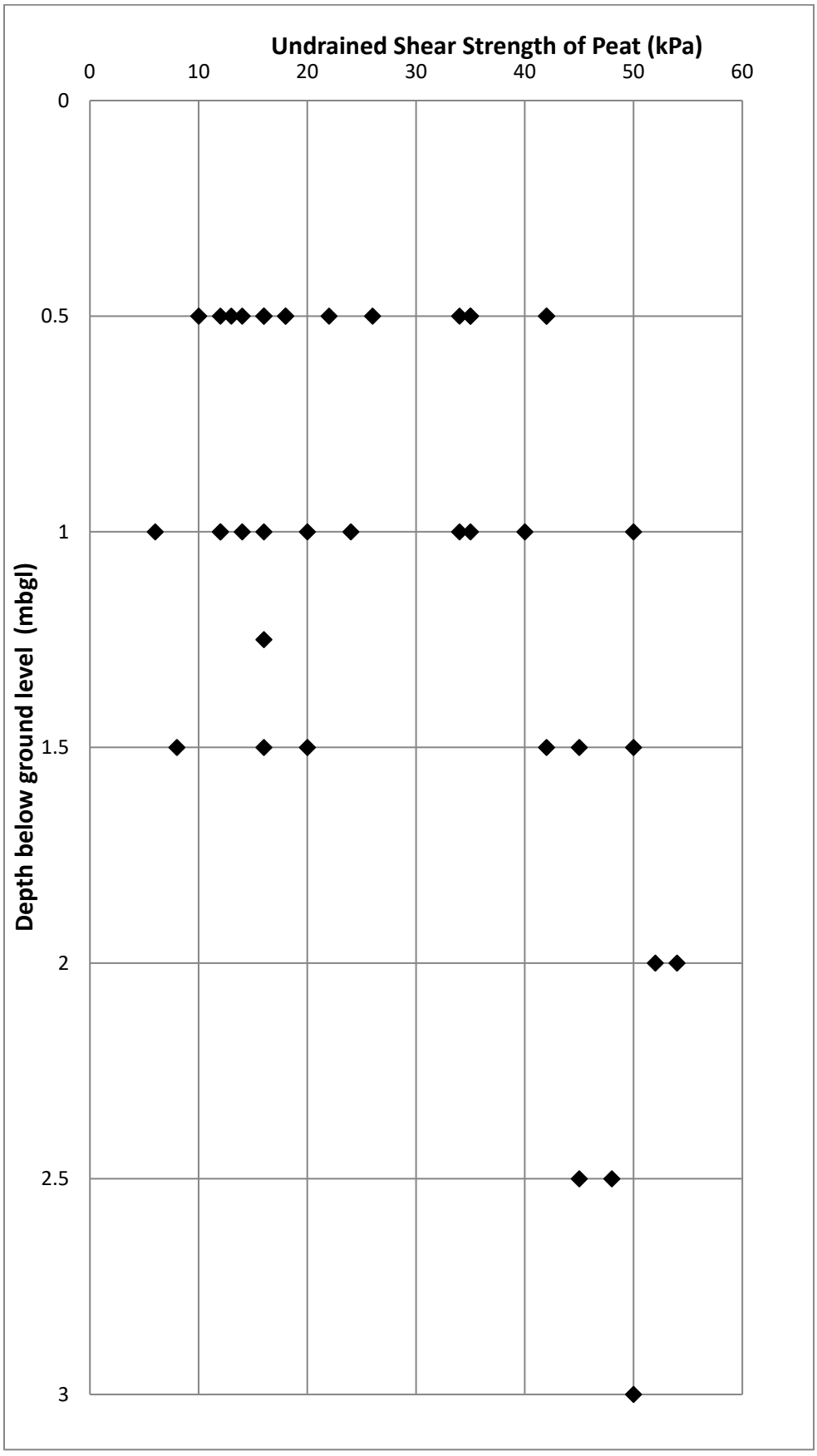
Note (3) The data presented in the table above is used in the peat stability assessment of the site.

In addition to probing, in-situ shear vane testing was carried out as part of the site walkover. Strength testing was carried out at selected locations across the site to provide representative coverage of indicative peat strengths. The results of the vane testing with depth are presented in Figure 5.1 and in Appendix E.

The hand vane results indicate undrained shear strengths in the range 6 to 54kPa, with an average value of about 20kPa. The strengths recorded would be typical of well drained peat as is present on the Proposed Development site.

Peat strength at sites of known peat failures (assuming undrained loading failure) are generally very low, for example the undrained shear strength at the Derrybrien failure (AGEC, 2004) as derived from back-analysis, was estimated at 2.5kPa. The recorded undrained strength at the Proposed Development site is significantly greater than the lower bound values for Derrybrien indicating that there is no close correlation to the peat conditions at the Derrybrien site and that there is significantly less likelihood of failure on the Proposed Development site.

Figure 5.1: Undrained Shear Strength (c_u) Profile for Peat with Depth



6. PEAT STABILITY ASSESSMENTS

The peat stability assessment includes an assessment of the stability of the natural peat slopes for individual parcels across the site including at the substation, along the proposed access road and the underground electrical cabling routes. The assessment also analyses the stability of the natural peat slopes with a surcharge loading of 10kPa, equivalent to placing 1m of stockpiled peat on the surface of the existing peat slope. An additional analysis has been undertaken for a section of the 110kV cabling where works will be undertaken directly on the peat, with a surcharge load of 20kPa used to model the loading from low ground pressure machinery (approximately equivalent to a 21 ton machine).

6.1 Methodology for Peat Stability Assessment

Stability of a peat slope is dependent on several factors working in combination. The main factors that influence peat stability are slope angle, shear strength of peat, depth of peat, pore water pressure and loading conditions.

An adverse combination of factors could potentially result in peat sliding. An adverse condition of one of the above-mentioned factors alone is unlikely to result in peat failure. The infinite slope model (Skempton and DeLory, 1957) is used to combine these factors to determine a factor of safety for peat sliding. This model is based on a translational slide, which is a reasonable representation of the dominant mode of movement for peat failures.

To assess the factor of safety for a peat slide, an undrained (short-term stability) and drained (long-term stability) analysis has been undertaken to determine the stability of the peat slopes on site.

1. The undrained loading condition applies in the short-term during construction and until construction induced pore water pressures dissipate.

2. The drained loading condition applies in the long-term. The condition examines the effect of the change in groundwater level as a result of rainfall on the existing stability of the natural peat slopes.

Undrained shear strength values (c_u) for peat are used for the total stress analysis. Based on the findings of the 2003 Derrybrien failure and other failures in peat, undrained loading during construction was found to be the critical failure mechanism.

A drained analysis requires effective cohesion (c') and effective friction angle (ø') values for the calculations. These values can be difficult to obtain because of disturbance experienced when sampling peat and the difficulties in interpreting test results due to the excessive strain induced within the peat. To determine suitable drained strength values a review of published information on peat was carried out. Table 6.1 shows a summary of the published information on peat together with drained strength values.

From Table 6.1 the values for c' ranged from 1.1 to 8.74kPa and ø' ranged from 21.6 to 43°. The average c' and ø' values are 4.5kPa and 30° respectively. Based on the above, it was considered to adopt a conservative approach and to use design values below the averages. For design the following general drained strength values have been used for the site:

c' = 4kPa
$ø'$ = 25°

Table 6.1: List of Effective Cohesion and Friction Angle Values for Peat

Reference	Cohesion, c' (kPa)	Friction Angle, ø' (degs)	Testing Apparatus/ Comments
Hanrahan et al (1967)	5 to 7	36 to 43	From triaxial apparatus
Rowe and Mylleville (1996)	2.5	28	From simple shear apparatus
Landva (1980)	2 to 4	27.1 to 32.5	Mainly ring shear apparatus for normal stress greater than 13kPa
	5 to 6	-	At zero normal stress
Carling (1986)	6.5	0	-
Farrell and Hebib (1998)	0	38	From ring shear and shear box apparatus. Results are not considered representative.
	0.61	31	From direct simple shear (DSS) apparatus. Result considered too low therefore DSS not considered appropriate
Rowe, Maclean and Soderman (1984)	1.1	26	From simple shear apparatus
	3	27	From DSS apparatus
McGreever and Farrell (1988)	6	38	From triaxial apparatus using soil with 20% organic content
	6	31	From shear box apparatus using soil with 20% organic content
Hungr and Evans (1985)	3.3	-	Back-analysed from failure
Dykes and Kirk (2006)	3.2	30.4	Test within acrotelm
Dykes and Kirk (2006)	4	28.8	Test within catotelm
Warburton et al (2003)	5	23.9	Test in basal peat
Warburton et al (2003)	8.74	21.6	Test using fibrous peat
Hendry et al (2012)	0	31	Remoulded test specimen
Komatsu et al (2011)	8	34	Remoulded test specimen
Zwanenburg et al (2012)	2.3	32.3	From DSS apparatus
Den Haan & Grognet (2014)	-	37.4	From large DSS apparatus
O'Kelly & Zhang (2013)	0	28.9 to 30.3	Tests carried out on reconstituted, undisturbed and blended peat samples

6.2 Analysis to Determine Factor of Safety (Deterministic Approach)

The purpose of the analysis was to determine the Factor of Safety (FoS) of the peat slopes using infinite slope analysis. The analysis was carried out along the TDR, at the proposed 110kV substation, at borrow pit locations and along the underground electrical cabling routes across the site.

The FoS provides a direct measure of the degree of stability of the slope. A FoS of less than unity indicates that a slope is unstable, a FoS of greater than unity indicates a stable slope.

The acceptable safe range for FoS typically ranges from 1.3 to 1.4. The previous code of practice for earthworks BS 6031:1981 (BSI, 1981), provided advice on design of earthworks slopes. It stated that for a first-time failure with a good standard of site investigation the design FoS should be greater than 1.3.

As a general guide the FoS limits for peat slopes in this report are summarised in Table 6.2.

Table 6.2: Factor of Safety Limits for Slopes

Factor of Safety (FoS)	Degree of Stability
Less than 1.0	Unstable (red)
Between 1.0 and 1.3	Marginally stable (yellow)
1.3 or greater	Acceptable (green)

Eurocode 7 (EC7) (IS EN 1997-1:2005) now serves as the reference document and the basis for design geotechnical engineering works. The design philosophy used in EC7 applies partial factors to soil parameters, actions and resistances. Unlike the traditional approach, EC7 does not provide a direct measure of stability, since global Factors of Safety are not used.

As such, and in order to provide a direct measure of the level of safety on a site, EC7 partial factors have not been used in this stability assessment. The results are given in terms of FoS. This is considered to be in line with best practice guidance as provided in PLHRAG (2017).

A lower bound undrained shear strength, c_u for the peat of 6kPa was selected for the assessment, based on the c_u values recorded at the site and irrespective of the recorded peat depth. It should be noted that a c_u of 6kPa for the peat is considered a conservative value for the analysis and is not representative of all peat present across the site. In reality the peat generally has a higher undrained strength, as shown on Figure 5.1.

The formula used to determine the factor of safety for the undrained condition in the peat (Bromhead, 1986) is as follows:

$$F = \frac{c_u}{\gamma z \sin\alpha \cos\alpha}$$

Where:

F = Factor of Safety

c_u = Undrained strength
γ = Bulk unit weight of material
z = Depth to failure plane assumed as depth of peat
α = Slope angle

The formula used to determine the factor of safety for the drained condition in the peat (Bromhead, 1986) is as follows:

$$F = \frac{c' + (\gamma z - \gamma_w h_w)\cos^2 \alpha \tan \phi'}{\gamma z \sin \alpha \cos \alpha}$$

Where:

F = Factor of Safety
c' = Effective cohesion
γ = Bulk unit weight of material
z = Depth to failure plane assumed as depth of peat
γ_w = Unit weight of water
h_w = Height of water table above failure plane
α = Slope angle
ϕ' = Effective friction angle

For the drained analysis the level of the water table above the failure surface is required to calculate the factor of safety for the slope. Since the water level in blanket peat can be variable and can be recharged by rainfall, it is not feasible to establish its precise location throughout the site. Therefore, a sensitivity analysis using water level ranging between 0% and 100% of the peat depth was conducted, where 0% equates to the peat being completely dry and 100% equates to the peat been fully saturated.

The following general assumptions were used in the analysis of peat slopes at each location:

(1) Peat depths are based on the maximum peat depth recorded at each location from the walkover surveys.

(2) The slope angles used in the peat stability assessment were obtained using a combination of readings taken during the site reconnaissance by FT using handheld equipment and from contour survey plans for site. It should be noted that slope angles derived from contour survey plans would be considered approximate, as such surveys are dependent on the density of survey data and do not always reflect local variations in ground topography.

(3) Slope angle at base of sliding assumed to be parallel to ground surface.

(4) A lower bound undrained shear strength, c_u for the peat of 6kPa was selected for the assessment. The lowest recorded value on the Proposed Development site during the site walkover was 6kPa. It should be noted that a c_u of 6kPa for the peat is considered a conservative value for the analysis and is not representative of all peat present across the site. In reality, the peat has a significantly higher undrained strength as a result of the extensive drainage on site.

For the stability analysis two load conditions were examined, namely

Condition (1): no surcharge loading
Condition (2): surcharge of 10 kPa, equivalent to 1m of stockpiled peat assumed as a worst case. This case assumes that the groundwater stays at the original surface level.

6.3 Results of Analysis

6.3.1 Undrained Analysis for the Peat

The results of the undrained analysis for the natural peat slopes across the Proposed Development are presented in Appendix C and the results of the undrained analysis for the most critical load case (load condition 2) are shown on Figure 6.1. The undrained analysis for load condition 2 is considered the most critical load case as most peat failures occur in the short term upon loading of the peat surface. The results are summarised in Table 6.3. Both the TDR and underground electrical cabling (110kV) have been divided into sections, as shown on the site layout drawings, with the typical FoS results quoted in the table below for each section.

The calculated FoS for load condition 1 is in excess of 1.30 for each of the locations (approx. 220 no. locations) analysed with a range of FoS of 2.16 to 122.13, indicating a low risk of peat instability.

The calculated FoS for load condition 2 is in excess of 1.30 for each of the locations (approx. 220 no. locations) analysed with a range of FoS of 1.39 to 14.48, indicating a low risk of peat instability.

The location with the deepest peat (3.25m) was located along the TDR (Section 2, waypoint MKO161) and recorded an FoS of 5.29 (load condition 1) and 4.05 (load condition 2). A short section of the 33kV cabling route recorded peat depths of 3m (waypoint MKO226) and recorded an FoS of 3.83 (load condition 1) and 2.87 (load condition 2).

A part of 110kV underground cabling (part of Section 2 of the cable route) will be constructed using low ground pressure machinery operating directly on the peat surface. The peat in this area is shallow (<0.7m) and of high strength (c_u>40kPa from shear vane reading). The load condition 2 analysis for this area (point MKO 552 below) assumes a load of 20kPa from the machinery and uses a factored shear strength of 20kPa for this location. As the loading from this operation is temporary, only an undrained assessment is required at this location. An FoS of 3.88 is recorded for this location, indicating a low risk of peat instability.

Table 6.3: Factor of Safety Results (Undrained Condition)

Location	Waypoint	Easting	Northing	Factor of Safety for Load Condition	
				Condition (1)	Condition (2)
TDR (Section 1)	WP20	514589	581992	**14.51**	**3.35**
	MKO181	514216	581689	**34.41**	**3.13**
	MKO170	515112	582060	**3.85**	**2.10**
TDR (Section 2)	WP31	516082	581207	**2.34**	**1.40**
	MKO157	515816	581577	**2.16**	**1.39**
	MKO161	517018	581310	**5.29**	**4.05**

Location	Waypoint	Easting	Northing	Factor of Safety for Load Condition	
				Condition (1)	Condition (2)
	MKO163	515581	582092	**2.85**	**1.66**
TDR (Section 3)	MKO218	517455	581435	**5.10**	**3.20**
	WP40	517954	581846	**4.79**	**3.08**
Upgrade of Existing Permitted Borrow Pit	MKO185	518111	581750	**86.22**	**7.84**
Underground Electrical Cabling (33kV)	WP41	519013	582133	**3.31**	**1.98**
	MKO226	518844	582153	**3.83**	**2.87**
	MKO223	520911	582935	**3.71**	**2.00**
	MKO243	522580	583167	**5.88**	**3.18**
Substation	WP55	522865	583428	**2.42**	**1.55**
Proposed Borrow Pit	MKO206	523128	583303	**5.12**	**2.71**
Underground Electrical Cabling (110kV) (Section 1)	WP61	523407	583500	**3.84**	**2.47**
	MKO264	523241	583451	**5.40**	**3.32**
	WP61	523407	583500	**3.84**	**2.47**
Underground Electrical Cabling (110kV) (Section 2)	MKO086	524652	584256	**2.46**	**1.34**
	MKO552	525159	584489	**14.24**	**3.88**
Underground Electrical Cabling (110kV) (Section 3)	No peat recorded				

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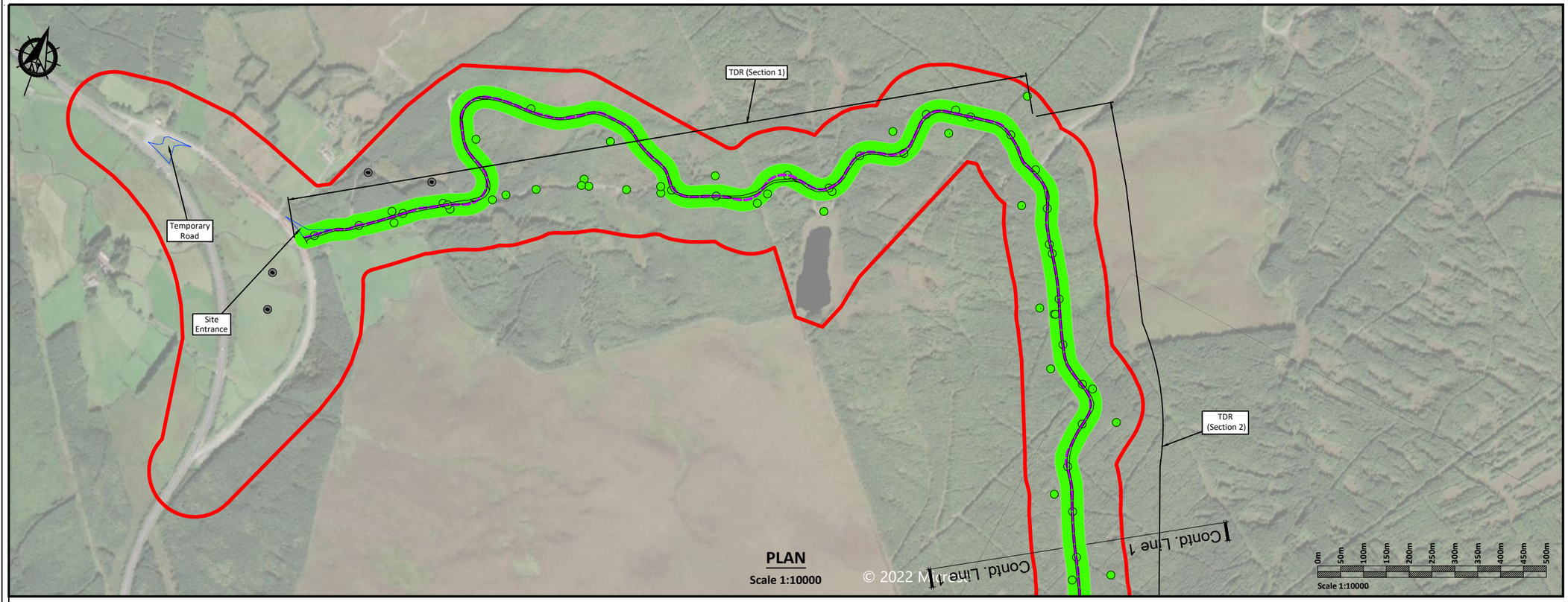
Legend:

- EIAR Planning Boundary
- Proposed Access Track
- Turbine Delivery Route (TDR)
- Underground Cabling 33kV
- Underground Cabling 110 kV
- 33kV Underground Cabling in Permitted Development
- Permitted Development



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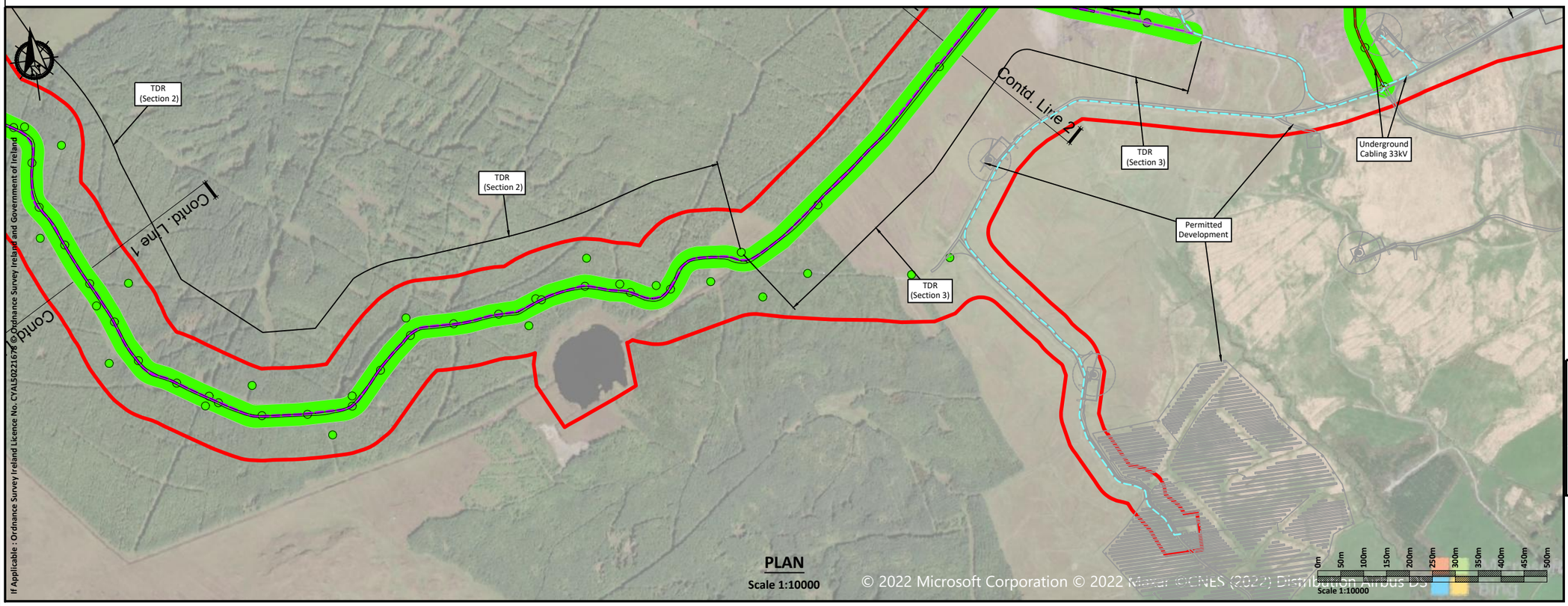

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Factor of Safety Legend:

0 < 1.0	
≥ 1.0 < 1.3	
≥ 1.3	

Increasing Stability

No Peat Recorded
At This Location

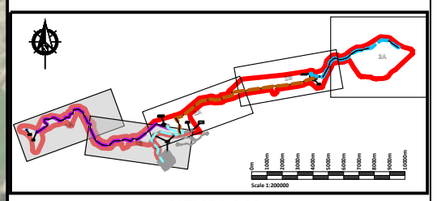

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FIGURE 6.1 - FACTOR OF SAFETY SHEET 1 OF 3

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Legend:

- EIAR Planning Boundary
- Proposed Access Track
- Turbine Delivery Route (TDR)
- Underground Cabling 33kV
- Underground Cabling 110 kV
- 33kV Underground Cabling in Permitted Development
- Permitted Development

Contd. Line 2

Extension To Previously Permitted Borrow Pit

Contd. Line 2

TDR (Section 3)

Permitted Development

Underground Cabling 33kV

Permitted Development

Omitted 38kV Electrical Substation & Battery Storage

Underground Cabling 33kV

Contd. Line 3

Contd. Line 3

0m 50m 100m 150m 200m 250m 300m 350m 400m 450m 500m

PLAN

Scale 1:10000

Scale 1:10000

Contd. Line 3

Contd. Line 3

Underground Cabling 110kV (Section 2)

Contd. Line 4

Underground Cabling 110kV (Section 1)

Proposed Substation

Contd. Line 4

Proposed Borrow Pit

0m 50m 100m 150m 200m 250m 300m 350m 400m 450m 500m

PLAN

Scale 1:10000

Scale 1:10000

Factor of Safety Legend:

- 0 < 1.0
- ≥ 1.0 < 1.3
- ≥ 1.3

Increasing Stability

No Peat Recorded At This Location

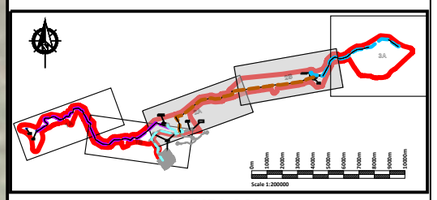

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FIGURE 6.1 - FACTOR OF SAFETY SHEET 2 OF 3

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Underground Cabling 110kV (Section 2)

Underground Cabling 110kV (Section 3)

Contd. Line 4

Contd. Line 4

Legend:

- EIAR Planning Boundary
- Proposed Access Track
- Turbine Delivery Route (TDR)
- Underground Cabling 33kV
- Underground Cabling 110 kV
- 33kV Underground Cabling in Permitted Development
- Permitted Development

Factor of Safety Legend:

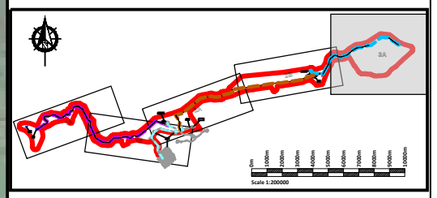
- 0 < 1.0
- ≥ 1.0 < 1.3
- ≥ 1.3

Increasing Stability

No Peat Recorded
At This Location

PLAN
Scale 1:10000

0m 50m 100m 150m 200m 250m 300m 350m 400m 450m 500m
Scale 1:10000



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Date - 13.07.22

FIGURE 6.1 - FACTOR OF SAFETY SHEET 3 OF 3

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6.3.2 Drained Analysis for the Peat

The results of the drained analysis for the peat are presented in Appendix C. The results are summarised in Table 6.4. As stated previously, the drained loading condition examines the effect of rainfall and water on the existing stability of the natural peat slopes and represents the post construction phase of the development.

The calculated FoS for load condition 1 is in excess of 1.30 for each of the locations (approx. 220 no. locations) analysed with a range of FoS of 1.44 to 81.42, indicating a low risk of peat instability.

The calculated FoS for load condition 2 is in excess of 1.30 for each of the locations (approx. 220 no. locations) analysed with a range of FoS of 1.98 to in excess of 20.89, indicating a low risk of peat instability.

The results of Condition (2) are slightly higher than for Condition (1) in the drained case because the water level is assumed to be at original ground level, rather than at the top of the additional 1m of peat. This results in a slightly higher FoS because the effective height of the water in the peat is no longer 100% of the height of the peat.

The location with the deepest peat (3.25m) was located along the TDR (Section 2, waypoint MKO161) and recorded an FoS of 3.53 (load condition 1) and 5.84 (load condition 2). A short section of the 33kV cable route recorded peat depths of 3m (waypoint 226) and recorded an FoS of 2.55 (load condition 1) and 4.14 (load condition 2).

Table 6.4: Factor of Safety Results (Drained Conditions)

Location	Waypoint	Easting	Northing	Factor of Safety for Load Condition	
				Condition (1)	Condition (2)
TDR (Section 1)	WP20	514589	581992	**9.67**	**4.78**
	MKO181	514216	581689	**22.94**	**4.44**
	MKO170	515112	582060	**2.57**	**3.01**
TDR (Section 2)	WP31	516082	581207	**1.56**	**2.25**
	MKO157	515816	581577	**1.44**	**1.98**
	MKO161	517018	581310	**3.53**	**5.84**
	MKO163	515581	582092	**1.90**	**2.37**
TDR (Section 3)	MKO218	517455	581435	**3.40**	**4.61**
	WP40	517954	581846	**3.19**	**4.43**
Upgrade of Existing Permitted Borrow Pit	MKO185	518111	581750	**57.48**	**11.29**
Underground Electrical Cabling (33kV)	WP41	519013	582133	**2.20**	**2.84**
	MKO226	518844	582153	**2.55**	**4.14**
	MKO223	520911	582935	**2.47**	**2.86**
	MKO243	522580	583167	**3.92**	**4.57**
Substation	WP55	522865	583428	**1.61**	**2.22**
Proposed Borrow Pit	MKO206	523128	583303	**3.41**	**3.89**

Location	Waypoint	Easting	Northing	Factor of Safety for Load Condition	
				Condition (1)	Condition (2)
Underground Electrical Cabling (110kV) (Section 1)	WP61	523407	583500	**2.56**	**3.55**
	MKO264	523241	583451	**3.60**	**4.78**
	WP61	523407	583500	**2.56**	**3.55**
Underground Electrical Cabling (110kV) (Section 2)	MKO086	524652	584256	**1.64**	**1.89**
Underground Electrical Cabling (110kV) (Section 3)	No peat recorded				

6.4 Stability of Borrow Pit Buttress

A stability check has been undertaken to demonstrate the stability of the perimeter berms around the proposed substation borrow pit. The perimeter berm is considered to be more critical than any internal buttresses, as peat is only present on one side of the buttress. Slope stability has been checked using Slope/W slope stability software. The analysis was carried out without using partial factors, and as such a minimum Factor of Safety (FoS) of 1.3 is required to demonstrate the stability of the proposed berms, as explained in Section 2 of this report.

The following material properties have been used in the stability assessment. A low strength for the peat retained within the borrow pit/repositories has been used to model the effect of disturbance on the saturated peat mass.

Table 6.5: Material Properties

Material	Unit Weight (kN/m^3)	Undrained Shear Strength, c_u (kPa)	Angle of Shearing Resistance, ϕ (degrees)	Effective Cohesive, c' (kPa)
Intact Peat	10.5	10	25	4
Granular fill (berm)	21	-	46	0
Retained Peat within Borrow Pit (disturbed)	10.5	2	5	2
Sandy Gravel	20	-	34	0
Bedrock	21	-	34	250

The berm along the northern side of the borrow pit may be up to 3.5m in height. Bedrock has been assessed at 2m below ground level based on the available ground investigation information, overlain by 0.75m of peat and 1.25m of sandy Gravel. All peat will be excavated from below the perimeter berm. The base of the berm will be benched into the overburden to create a level platform (not shown in stability output). The inside slope of the perimeter berm has been modelled as a 60 degree slope, and the outside slope as 45 degrees. Groundwater has been assumed at ground level on the downslope side of the berm.

The stability analysis has been undertaken using both undrained (short term) and drained (long term) strength parameters.

Table 6.6: Borrow Pit Stability Analysis

Borrow Pit	Factor of Safety
Undrained Analysis	1.33
Drained Analysis	1.35

7. PEAT STABILITY RISK ASSESSMENT

A peat stability risk assessment was carried out for individual sections of the TDR, underground electrical cabling routes, the proposed 110kV substation and the borrow pits. This approach takes into account guidelines for geotechnical/peat stability risk assessments as given in PLHRA (2017) and MacCulloch (2005).

The risk assessment uses the results of the stability analysis (deterministic approach) in combination with qualitative factors, which cannot be reasonably included in a stability calculation but nevertheless may affect the occurrence of peat instability, to assess the risk for each infrastructure element.

For each of the main infrastructure elements, a risk rating (product of probability and impact) is calculated and rated as shown in Table 7.1. Where a subsection is rated 'Medium' or 'High', control measures are required to reduce the risk to at least a 'Low' risk rating. Where a subsection is rated 'Low' or 'Negligible', only routine control measures are required.

Table 7.1: Risk Rating Legend

17 to 25	High: avoid works in area or significant control measures required
11 to 16	Medium: notable control measures required
5 to 10	Low: only routine control measures required
1 to 4	Negligible: none or only routine control measures required

A full methodology for the peat stability risk assessment is given in Appendix D.

7.1 Summary of Risk Assessment Results

The results of the peat stability risk assessment for potential peat failure at the main infrastructure elements is presented as a Geotechnical Risk Register in Appendix B and summarised in Table 7.2.

The risk rating for each infrastructure element across the Proposed Development is designated low following some mitigation/control measures being implemented.

Details of the required mitigation/control measures can be found in the Geotechnical Risk Register for each infrastructure element (Appendix B).

Table 7.2: Summary of Peat Stability Risk Register

Infrastructure	Pre-Control Measure Implementation Risk Rating	Pre-Control Measure Implementation Risk Rating Category	Notable Control Measures Required	Post-Control Measure Implementation Risk Rating	Post-Control Measure Implementation Risk Rating Category
TDR (Section 1)	Low	5 to 10	No	Low	5 to 10
TDR (Section 2)	Low	5 to 10	No	Low	5 to 10
TDR (Section 3)	Negligible	1 to 4	No	Negligible	1 to 4
Extension to Existing Permitted Borrow Pit	Negligible	1 to 4	No	Negligible	1 to 4
Underground Electrical Cabling (33kV)	Low	5 to 10	No	Low	5 to 10
Substation	Low	5 to 10	No	Low	5 to 10
Borrow Pit (Substation)	Negligible	1 to 4	No	Negligible	1 to 4
Underground Electrical Cabling (110kV) (Section 1)	Low	5 to 10	No	Low	5 to 10
Underground Electrical Cabling (110kV) (Section 2)	Low	5 to 10	No	Low	5 to 10
Underground Electrical Cabling (110kV) (Section 3)	No peat recorded along this section				

8. SUMMARY AND RECOMMENDATIONS

8.1 Summary

The following summary is given.

FT was engaged by MKO to undertake a geotechnical and peat stability assessment of the Proposed Development for the Knocknamork Renewable Energy Development. In accordance with planning guidelines compiled by the Department of the Environment, Heritage and Local Government (DoEHLG), where peat is present on a proposed wind farm development, a peat stability assessment is required.

A walkover including intrusive peat depth probing, desk study, stability analysis and risk assessment was carried out to assess the susceptibility of the site to peat failure following the principles in Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (PLHRAG, 2017). Trial pits were excavated at the proposed 110kV substation location and the adjacent proposed borrow pit to determine the ground conditions at these locations.

The findings of the peat assessment showed that the site has an acceptable margin of safety and is suitable for the Proposed Development. The findings include recommendations and control measures for construction work in peat lands to ensure that all works adhere to an acceptable standard of safety.

The site is located along an upland ridge and southern slopes of the Derrynasaggart Mountains. The site is an upland blanket peat area comprising forestry and open grazing land. The blanket peat areas contain typically shallow peat with deeper peat deposits in the flatter areas on site. Several existing access tracks are present across the site and have been in use for a number of years.

Peat thicknesses recorded during the site walkovers from approximately 880 probes ranged from 0.0 to 3.25m with an average depth of 0.85m. 61% of the probes recorded peat depths of less than 1.0m. 92% of peat depth probes recorded peat depths of less than 2.0m. Localised deeper peat areas were recorded in flatter areas (<2 degrees) across the Proposed Development.

Slope inclinations across the site range from 2 to 14 degrees. Ground conditions comprised mainly of blanket peat overlying clay overlying bedrock.

An analysis of peat sliding was carried out across site for both the undrained and drained conditions. The purpose of the analysis was to determine the Factor of Safety (FoS) of the peat slopes. For the undrained condition, the calculated FoS for load conditions 1 and 2 for the locations analysed, showed that all locations have an acceptable FoS of greater than 1.3, indicating a low risk of peat failure. The undrained analysis would be considered the most critical condition for the peat slopes.

A drained analysis was also carried out, which examined the effect of in particular, rainfall on the existing stability of the natural peat slopes on site. For the drained condition, the calculated FoS for load conditions (1) & (2) for the locations analysed, showed that all locations have an acceptable FoS of greater than 1.3.

A peat stability risk assessment was undertaken at each infrastructure location. The peat stability risk assessment uses the results of the stability analysis in combination with qualitative factors, which cannot be reasonably included in a stability calculation but nevertheless may affect the occurrence of peat instability, to assess the risk of peat failure at the site. The results of the risk assessment are given in Appendix B.

In summary, the findings of the peat assessment showed that the Proposed Development site has an acceptable margin of safety, is suitable for the Proposed Development and is considered to be at **low** risk of peat failure. The findings include recommendations and control measures for construction work in peat lands to ensure that all works adhere to an acceptable standard of safety.

8.2 Recommendations

The following recommendations are given.

Notwithstanding that the site has an acceptable margin of safety a number of mitigation/control measures are given to ensure that all works adhere to an acceptable standard of safety for work in peatlands. Mitigation/control measures identified for each of the infrastructure elements in the risk assessment will be taken into account and implemented throughout design and construction works (Appendix B).

The proposed construction method for all the access roads at the Proposed Development is an excavate and replace type construction.

Recommendations and guidelines given in FT's report 'Peat & Spoil Management Plan – Proposed Substation, Underground Cabling and Access Roads to Knocknamork Renewable Energy Development' (FT, 2022) will be taken into consideration during the design and construction stage of the Proposed Development.

To minimise the risk of construction activity causing potential peat instability the Construction Method Statements (CMS's) for the project will take into account, but not be limited, to the recommendations contained in Appendix B. This will ensure that best practice guidance regarding the management of peat stability will be inherent in the construction phase.

9. REFERENCES

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APPENDIX A

Photos from Site Walkover

Photo 1: Existing access track on TDR

Photo 2: Peat exposed alongside existing track on TDR

Photo 3: Typical ground conditions along 33kV underground cabling route

Photo 4: Existing track along section of 110kV underground cabling route

Photo 5: View north along 110kV route from existing Ballyvouskill substation

Photo 6: Proposed substation location

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APPENDIX B

Peat Stability Risk Registers

Proposed Substation, Underground Cabling and Access Roads to Knocknamork Renewable Energy Development - Peat Stability Risk Register (Rev 0)

Location:	**TDR (Section 1)**

Grid Reference (Eastings, Northings):	**Varies**	**Varies**
Distance to Watercourse (m)	**< 50**	
Min & Max Measured Peat Depth (m):	**0-1.5**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 2.10 (u), 2.57 (d)	1	4	4	Negligible	No	See Below	1	4	4	Negligible
2	Evidence of sub peat water flow	1	4	4	Negligible	No		1	4	4	Negligible
3	Evidence of surface water flow	2	4	8	Low	No		2	4	8	Low
4	Evidence of previous failures/slips	0	4	0	Not Applicable	No		0	4	0	Not Applicable
5	Type of vegetation	2	4	8	Low	No		2	4	8	Low
6	General slope characteristics upslope/downslope from infrastructure location	2	4	8	Low	No		2	4	8	Low
7	Evidence of very soft/soft clay at base of peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	4	0	Not Applicable	No		2	4	8	Low
10	Evidence of bog pools	0	4	0	Not Applicable	No		0	4	0	Not Applicable
11	Other	0	4	0	Not Applicable	No		0	4	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **TDR (Section 1)**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Proposed Substation, Underground Cabling and Access Roads to Knocknamork Renewable Energy Development - Peat Stability Risk Register (Rev 0)

Location:	**TDR (Section 2)**

Grid Reference (Eastings, Northings):	**Varies**	**Varies**
Distance to Watercourse (m)	**< 50**	
Min & Max Measured Peat Depth (m):	**0.5-3.25**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 1.40 (u), 2.25 (d)	1	4	4	Negligible	No	See Below	1	4	4	Negligible
2	Evidence of sub peat water flow	1	4	4	Negligible	No		1	4	4	Negligible
3	Evidence of surface water flow	2	4	8	Low	No		2	4	8	Low
4	Evidence of previous failures/slips	0	4	0	Not Applicable	No		0	4	0	Not Applicable
5	Type of vegetation	2	4	8	Low	No		2	4	8	Low
6	General slope characteristics upslope/downslope from infrastructure location	2	4	8	Low	No		2	4	8	Low
7	Evidence of very soft/soft clay at base of peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
10	Evidence of bog pools	0	4	0	Not Applicable	No		0	4	0	Not Applicable
11	Other	0	4	0	Not Applicable	No		0	4	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **TDR (Section 2)**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Proposed Substation, Underground Cabling and Access Roads to Knocknamork Renewable Energy Development - Peat Stability Risk Register (Rev 0)

Location:	**TDR (Section 3)**

Grid Reference (Eastings, Northings):	**Varies**	**Varies**
Distance to Watercourse (m)	**> 150**	
Min & Max Measured Peat Depth (m):	**0.0-1.8**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 3.08 (u), 4.43 (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	2	1	2	Negligible	No		2	1	2	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	2	1	2	Negligible	No		2	1	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	2	1	2	Negligible	No		2	1	2	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **TDR Section 3**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Proposed Substation, Underground Cabling and Access Roads to Knocknamork Renewable Energy Development - Peat Stability Risk Register (Rev 0)

Location:	**Substation**

Grid Reference (Eastings, Northings):	**522895**	**583408**
Distance to Watercourse (m)	**< 50**	
Min & Max Measured Peat Depth (m):	**0.5-1.8**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 1.55 (u), 2.22 (d)	1	4	4	Negligible	No	See Below	1	4	4	Negligible
2	Evidence of sub peat water flow	1	4	4	Negligible	No		1	4	4	Negligible
3	Evidence of surface water flow	2	4	8	Low	No		2	4	8	Low
4	Evidence of previous failures/slips	0	4	0	Not Applicable	No		0	4	0	Not Applicable
5	Type of vegetation	2	4	8	Low	No		2	4	8	Low
6	General slope characteristics upslope/downslope from infrastructure location	2	4	8	Low	No		2	4	8	Low
7	Evidence of very soft/soft clay at base of peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
10	Evidence of bog pools	0	4	0	Not Applicable	No		0	4	0	Not Applicable
11	Other	0	4	0	Not Applicable	No		0	4	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Substation**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Proposed Substation, Underground Cabling and Access Roads to Knocknamork Renewable Energy Development - Peat Stability Risk Register (Rev 0)

Location:	**33kV Cabling**

Grid Reference (Eastings, Northings):	**Varies**	**Varies**
Distance to Watercourse (m)	**< 50**	
Min & Max Measured Peat Depth (m):	**0.5-1.0**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 1.98 (u), 2.84 (d)	1	4	4	Negligible	No	See Below	1	4	4	Negligible
2	Evidence of sub peat water flow	1	4	4	Negligible	No		1	4	4	Negligible
3	Evidence of surface water flow	2	4	8	Low	No		2	4	8	Low
4	Evidence of previous failures/slips	0	4	0	Not Applicable	No		0	4	0	Not Applicable
5	Type of vegetation	2	4	8	Low	No		2	4	8	Low
6	General slope characteristics upslope/downslope from infrastructure location	2	4	8	Low	No		2	4	8	Low
7	Evidence of very soft/soft clay at base of peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
10	Evidence of bog pools	0	4	0	Not Applicable	No		0	4	0	Not Applicable
11	Other	0	4	0	Not Applicable	No		0	4	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **33kV Cable Route**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Proposed Substation, Underground Cabling and Access Roads to Knocknamork Renewable Energy Development - Peat Stability Risk Register (Rev 0)

Location:	**110kV Cabling (Section 1)**

Grid Reference (Eastings, Northings):	**Varies**	**Varies**
Distance to Watercourse (m)	**< 50**	
Min & Max Measured Peat Depth (m):	**0.7-1.2**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 2.47 (u), 3.55 (d)	1	4	4	Negligible	No	See Below	1	4	4	Negligible
2	Evidence of sub peat water flow	1	4	4	Negligible	No		1	4	4	Negligible
3	Evidence of surface water flow	2	4	8	Low	No		2	4	8	Low
4	Evidence of previous failures/slips	0	4	0	Not Applicable	No		0	4	0	Not Applicable
5	Type of vegetation	2	4	8	Low	No		2	4	8	Low
6	General slope characteristics upslope/downslope from infrastructure location	2	4	8	Low	No		2	4	8	Low
7	Evidence of very soft/soft clay at base of peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
10	Evidence of bog pools	0	4	0	Not Applicable	No		0	4	0	Not Applicable
11	Other	0	4	0	Not Applicable	No		0	4	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **110kV Cable Route (Section 1)**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Proposed Substation, Underground Cabling and Access Roads to Knocknamork Renewable Energy Development - Peat Stability Risk Register (Rev 0)

Location:	**110kV Cabling Route (Section 2)**

Grid Reference (Eastings, Northings):	**Varies**	**Varies**
Distance to Watercourse (m)	**< 50**	
Min & Max Measured Peat Depth (m):	**0-1.2**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 1.34 (u), 1.64 (d)	1	4	4	Negligible	No	See Below	0	4	0	Not Applicable
2	Evidence of sub peat water flow	1	4	4	Negligible	No		0	4	0	Not Applicable
3	Evidence of surface water flow	2	4	8	Low	No		0	4	0	Not Applicable
4	Evidence of previous failures/slips	0	4	0	Not Applicable	No		0	4	0	Not Applicable
5	Type of vegetation	2	4	8	Low	No		0	4	0	Not Applicable
6	General slope characteristics upslope/downslope from infrastructure location	2	4	8	Low	No		0	4	0	Not Applicable
7	Evidence of very soft/soft clay at base of peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
10	Evidence of bog pools	0	4	0	Not Applicable	No		0	4	0	Not Applicable
11	Other	0	4	0	Not Applicable	No		0	4	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **110kV Cable Route (Section 2)**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Use of low ground pressure machinery for area where works directly on peatland are required.

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Proposed Substation, Underground Cabling and Access Roads to Knocknamork Renewable Energy Development - Peat Stability Risk Register (Rev 0)

Location:	**110kV Cabling Route (Section 3)**

Grid Reference (Eastings, Northings):	**Varies**	**Varies**
Distance to Watercourse (m)	**< 50**	
Min & Max Measured Peat Depth (m):	**No peat**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = N/A (u), N/A (d)	0	4	0	Not Applicable	No		0	4	0	Not Applicable
2	Evidence of sub peat water flow	0	4	0	Not Applicable	No		0	4	0	Not Applicable
3	Evidence of surface water flow	0	4	0	Not Applicable	No		0	4	0	Not Applicable
4	Evidence of previous failures/slips	0	4	0	Not Applicable	No		0	4	0	Not Applicable
5	Type of vegetation	0	4	0	Not Applicable	No		0	4	0	Not Applicable
6	General slope characteristics upslope/downslope from infrastructure location	0	4	0	Not Applicable	No	See Below	0	4	0	Not Applicable
7	Evidence of very soft/soft clay at base of peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
10	Evidence of bog pools	0	4	0	Not Applicable	No		0	4	0	Not Applicable
11	Other	0	4	0	Not Applicable	No		0	4	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **110kV Cable Route (Section 3)**

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Proposed Substation, Underground Cabling and Access Roads to Knocknamork Renewable Energy Development - Peat Stability Risk Register (Rev 0)

Location:	**Proposed Borrow Pit**

Grid Reference (Eastings, Northings):	**523081**	**583314**
Distance to Watercourse (m)	**> 150**	
Min & Max Measured Peat Depth (m):	**0.3-1.1**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 2.71 (u), 3.41 (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	2	1	2	Negligible	No		2	1	2	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	2	1	2	Negligible	No		2	1	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	2	1	2	Negligible	No		2	1	2	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Proposed Borrow Pit**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Proposed Substation, Underground Cabling and Access Roads to Knocknamork Renewable Energy Development - Peat Stability Risk Register (Rev 0)

Location:	**Borrow Pit (Extension to Permitted)**

Grid Reference (Eastings, Northings):	**518173**	**581777**
Distance to Watercourse (m)	**> 150**	
Min & Max Measured Peat Depth (m):	**0-0.3**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 7.84 (u), 11.29 (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	2	1	2	Negligible	No		2	1	2	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	2	1	2	Negligible	No		2	1	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	2	1	2	Negligible	No		2	1	2	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Upgrade to Existing Proposed Borrow Pit**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

FEHILY TIMONEY

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APPENDIX C

Calculated FOS for Peat Slopes on Site

Calculated FoS of Natural Peat Slopes for Proposed Substation, Underground Cabling and Access Roads for Knocknamork Renewable Energy Development - Undrained Analysis

Turbine No./Waypoint	Easting	Northing	Slope	Undrained shear strength	Bulk unit weight of Peat	Peat Depth	Surcharge Equivalent Placed Fill Depth (m)	Factor of Safety for Load Condition	
			β (deg)	c_u (kPa)	γ (kN/m^3)	(m)	Condition (2)	Condition (1)	Condition (2)
WP1	526191	584175	No peat encountered at this location						
WP2	525972	583981	No peat encountered at this location						
WP3	525780	583800	No peat encountered at this location						
WP4	525610	583660	No peat encountered at this location						
WP5	525292	583412	No peat encountered at this location						
WP6	524844	583460	No peat encountered at this location						
WP7	524655	583470	No peat encountered at this location						
WP8	524537	583586	No peat encountered at this location						
WP9	524574	583817	No peat encountered at this location						
WP10	524709	584042	No peat encountered at this location						
WP11	524922	584280	No peat encountered at this location						
WP12	524726	584270	No peat encountered at this location						
WP13	524451	584218	No peat encountered at this location						
WP14	524375	584183	No peat encountered at this location						
WP15	524215	584089	No peat encountered at this location						
WP16	524087	583975	No peat encountered at this location						
WP17	514114	581747	No peat encountered at this location						
WP18	514252	581775	No peat encountered at this location						
WP19	514401	582000	10	6	10	0.3	1.3	**11.70**	**2.70**
WP20	514589	581992	8	6	10	0.3	1.3	**14.51**	**3.35**
WP21	514951	582002	5	6	10	0.5	1.5	**13.82**	**4.61**
WP22	514830	582000	1	6	10	2.0	3.0	**17.19**	**11.46**
WP23	515080	582008	3	6	10	0.4	1.4	**28.70**	**8.20**
WP24	515162	582224	3	6	10	1.5	2.5	**7.65**	**4.59**
WP25	515278	582262	3	6	10	0.2	1.2	**57.40**	**9.57**
WP26	515482	582168	2	6	10	0.4	1.4	**43.01**	**12.29**
WP27	515630	581969	4	6	10	0.8	1.8	**10.78**	**4.79**
WP28	515596	581971	5	6	10	0.8	1.8	**8.64**	**3.84**
WP29	515664	581854	8	6	10	1.5	2.5	**2.90**	**1.74**
WP30	515942	581475	4	6	10	1.4	2.4	**6.16**	**3.59**
WP31	516082	581207	10	6	10	1.5	2.5	**2.34**	**1.40**
WP32	524085	583974	8	6	10	1.2	2.2	**3.63**	**1.98**
WP33	516337	581086	4	6	10	1.0	2.0	**8.62**	**4.31**
WP34	516531	581316	8	6	10	0.5	1.5	**8.71**	**2.90**
WP35	516794	581262	2	6	10	1.4	2.4	**12.29**	**7.17**
WP36	517200	581302	2	6	10	1.0	2.0	**17.20**	**8.60**
WP37	517636	581256	3	6	10	0.5	1.5	**22.96**	**7.65**
WP38	517724	581281	2	6	10	0.5	1.5	**34.41**	**11.47**
WP39	518221	581728	No peat encountered at this location						
WP40	517954	581846	4	6	10	1.8	2.8	**4.79**	**3.08**
WP41	519013	582133	7	6	10	1.5	2.5	**3.31**	**1.98**
WP42	520224	582714	8	6	10	1.2	2.2	**3.63**	**1.98**
WP43	520670	582891	5	6	10	1.2	2.2	**5.76**	**3.14**
WP44	523919	583926	No peat encountered at this location						
WP45	520757	583053	8	6	10	0.5	1.5	**8.71**	**2.90**
WP46	520850	583265	12	6	10	0.3	1.3	**11.80**	**2.36**
WP47	520987	583183	8	6	10	0.3	1.3	**14.51**	**3.35**
WP48	521229	583108	12	6	10	0.3	1.3	**11.80**	**2.36**
WP49	521443	583121	10	6	10	0.2	1.2	**17.54**	**2.92**
WP50	521624	583141	4	6	10	0.3	1.3	**34.49**	**6.90**
WP51	521792	582877	14	6	10	0.4	1.4	**7.30**	**1.89**
WP52	521920	583324	6	6	10	0.2	1.2	**28.86**	**4.81**
WP53	522220	583415	5	6	10	0.2	1.2	**34.55**	**5.76**
WP54	522386	583349	10	6	10	0.2	1.2	**17.54**	**2.92**
WP55	522865	583428	8	6	10	1.8	2.8	**2.42**	**1.55**
WP56	522854	583281	7	6	10	0.4	1.4	**12.40**	**3.54**
WP57	522961	583281	6	6	10	0.4	1.4	**16.49**	**4.28**
WP58	523059	583240	4	6	10	0.3	1.3	**28.74**	**6.63**
WP59	523218	583089	4	6	10	0.3	1.3	**34.49**	**6.90**
WP60	523350	583363	4	6	10	0.5	1.5	**17.24**	**5.75**
WP61	523407	583500	5	6	10	1.8	2.8	**3.84**	**2.47**
WP62	523512	583670	3	6	10	0.3	1.3	**38.27**	**8.83**
WP63	523600	583877	4	6	10	0.4	1.4	**21.56**	**6.16**
WP64	523764	583990	5	6	10	0.5	1.5	**13.82**	**4.61**
WP65	518714	581518	3	6	10	0.1	1.1	**114.80**	**10.44**
WP66	518684	581608	6	6	10	0.3	1.3	**19.24**	**4.44**
WP67	518677	581725	No peat encountered at this location						
WP68	518666	581825	5	6	10	0.2	1.2	**34.55**	**5.76**
WP69	518633	581895	6	6	10	0.4	1.4	**14.43**	**4.12**
WP70	518605	581941	9	6	10	0.1	1.1	**38.83**	**3.53**
WP71	518551	582025	5	6	10	0.3	1.3	**23.04**	**5.32**
110kV Section 2 (MKO552)	525159	584489	11	20	10	0.75	2.8	**14.24**	**3.88**
MKO Waypoints									
MKO086	524652	584256	12	6	10	1.2	2.2	**2.46**	**1.34**
MKO161	517081	581310	2	6	10	3.3	4.3	**5.29**	**4.05**
MKO194	520681	582899	7	6	10	1.4	2.4	**3.52**	**2.06**
MKO195	520625	582895	6	6	10	1.7	2.7	**3.41**	**2.14**
MKO196	520541	582882	4	6	10	0.4	1.4	**22.93**	**6.27**
MKO197	520428	582868	6	6	10	0.3	1.3	**20.47**	**4.50**
MKO198	520402	582815	6	6	10	0.3	1.3	**20.47**	**4.50**
MKO203	523066	583266	8	6	10	0.4	1.4	**11.58**	**3.16**

Calculated FoS of Natural Peat Slopes for Proposed Substation, Underground Cabling and Access Roads for Knocknamork Renewable Energy Development - Undrained Analysis

Turbine No./Waypoint	Easting	Northing	Slope	Undrained shear strength	Bulk unit weight of Peat	Peat Depth	Surcharge Equivalent Placed Fill Depth (m)	Factor of Safety for Load Condition	
			β (deg)	c_u (kPa)	γ (kN/m^3)	(m)	Condition (2)	Condition (1)	Condition (2)
MKO204	523105	583342	8	6	10	0.5	1.5	**9.26**	**2.96**
MKO205	523147	583397	7	6	10	0.7	1.7	**7.54**	**2.99**
MKO206	523128	583303	6	6	10	1.1	2.1	**5.12**	**2.71**
MKO207	520289	582736	8	6	10	0.2	1.2	**23.16**	**3.66**
MKO209	519902	582623	3	6	10	0.4	1.4	**30.53**	**8.34**
MKO211	519550	582615	6	6	10	0.9	1.9	**6.14**	**2.98**
MKO212	519219	582457	4	6	10	0.8	1.8	**10.19**	**4.67**
MKO213	518924	582214	4	6	10	1.5	2.5	**5.73**	**3.44**
MKO215	518618	582044	3	6	10	0.2	1.2	**61.06**	**9.66**
MKO217	517759	581696	4	6	10	1.3	2.3	**6.55**	**3.72**
MKO218	517455	581435	4	6	10	1.7	2.7	**5.10**	**3.20**
MKO221	520837	582923	12	6	10	0.7	1.7	**4.48**	**1.78**
MKO223	520911	582935	8	6	10	1.2	2.2	**3.71**	**2.00**
MKO224	521053	582952	6	6	10	0.6	1.6	**10.23**	**3.69**
MKO225	521169	582972	6	6	10	0.5	1.5	**12.28**	**3.93**
MKO226	521268	582983	8	6	10	0.1	1.1	**46.31**	**3.98**
MKO228	521355	582998	5	6	10	0.5	1.5	**14.70**	**4.70**
MKO229	521425	583014	5	6	10	0.3	1.3	**24.51**	**5.39**
MKO230	521524	583022	6	6	10	0.7	1.7	**8.19**	**3.39**
MKO232	521640	583034	6	6	10	0.7	1.7	**8.19**	**3.39**
MKO233	521757	582976	4	6	10	0.9	1.9	**9.17**	**4.44**
MKO234	521783	583057	4	6	10	0.9	1.9	**9.17**	**4.44**
MKO235	521849	583072	8	6	10	0.5	1.5	**9.26**	**2.96**
MKO236	521926	583076	8	6	10	0.4	1.4	**11.58**	**3.16**
MKO237	522018	583065	9	6	10	0.8	1.8	**4.59**	**2.10**
MKO238	522075	583086	8	6	10	0.2	1.2	**23.16**	**3.66**
MKO239	522186	583098	6	6	10	0.4	1.4	**15.35**	**4.19**
MKO240	522282	583123	6	6	10	1.1	2.1	**5.12**	**2.71**
MKO241	522420	583143	6	6	10	0.8	1.8	**6.82**	**3.13**
MKO242	522510	583152	5	6	10	0.6	1.6	**12.25**	**4.42**
MKO243	522580	583167	5	6	10	1.2	2.2	**5.88**	**3.18**
MKO245	522669	583212	10	6	10	1.1	2.1	**3.11**	**1.65**
MKO246	522940	583347	7	6	10	0.6	1.6	**8.79**	**3.17**
MKO247	522938	583370	7	6	10	1.7	2.7	**2.93**	**1.84**
MKO248	522927	583393	8	6	10	1.1	2.1	**3.86**	**2.05**
MKO249	522912	583452	8	6	10	1.4	2.4	**3.09**	**1.81**
MKO250	522908	583477	7	6	10	1.9	2.9	**2.64**	**1.72**
MKO251	522843	583451	7	6	10	0.7	1.7	**7.54**	**2.99**
MKO252	522839	583430	8	6	10	1.7	2.7	**2.57**	**1.62**
MKO253	522838	583405	8	6	10	1.5	2.5	**2.89**	**1.74**
MKO254	522850	583382	8	6	10	0.9	1.9	**4.63**	**2.24**
MKO255	522862	583362	7	6	10	0.6	1.6	**8.79**	**3.17**
MKO256	522859	583339	6	6	10	0.5	1.5	**12.28**	**3.93**
MKO257	522790	583296	6	6	10	0.8	1.8	**6.82**	**3.13**
MKO258	522814	583309	7	6	10	0.6	1.6	**8.79**	**3.17**
MKO259	522855	583334	6	6	10	0.8	1.8	**7.68**	**3.29**
MKO260	522903	583345	5	6	10	1.3	2.3	**5.25**	**2.98**
MKO261	523032	583417	5	6	10	1.0	2.0	**6.68**	**3.40**
MKO262	523103	583442	6	6	10	1.2	2.2	**4.72**	**2.60**
MKO263	523193	583461	6	6	10	1.7	2.7	**3.41**	**2.14**
MKO264	523241	583451	4	6	10	1.6	2.6	**5.40**	**3.32**
MKO265	523324	583477	4	6	10	1.8	2.8	**4.83**	**3.09**
MKO266	523409	583497	5	6	10	1.9	2.9	**3.68**	**2.40**
MKO267	514310	581733	6	6	10	0.2	1.2	**30.70**	**4.86**
MKO268	514291	581740	6	6	10	1.0	2.0	**5.58**	**2.84**
MKO269	514192	581685	6	6	10	0.2	1.2	**30.70**	**4.86**
MKO270	514205	581663	6	6	10	0.3	1.3	**20.47**	**4.50**
MKO271	514414	581804	6	6	10	0.5	1.5	**12.28**	**3.93**
MKO272	514578	581884	8	6	10	0.1	1.1	**46.31**	**3.98**
MKO273	514563	581895	8	6	10	0.3	1.3	**15.44**	**3.40**
MKO274	514731	581924	12	6	10	0.2	1.2	**15.69**	**2.48**
MKO275	514726	581937	12	6	10	0.5	1.5	**6.28**	**2.01**
MKO276	515082	582055	3	6	10	0.1	1.1	**122.13**	**10.49**
MKO277	515275	582315	3	6	10	0.5	1.5	**24.43**	**7.81**
MKO278	515568	582109	4	6	10	2.7	3.7	**3.16**	**2.31**
MKO279	515633	581970	6	6	10	0.7	1.7	**8.77**	**3.48**
MKO280	515765	581844	5	6	10	0.8	1.8	**9.19**	**3.94**
MKO281	517275	581356	2	6	10	0.2	1.2	**91.50**	**14.48**
MKO282	517003	581324	3	6	10	0.3	1.3	**40.71**	**8.95**
MKO283	516817	581318	3	6	10	0.4	1.4	**30.53**	**8.34**
MKO284	516391	581164	4	6	10	0.8	1.8	**10.19**	**4.67**
MKO285	516071	581187	4	6	10	1.6	2.6	**5.40**	**3.32**
MKO286	515866	581436	3	6	10	1.1	2.1	**10.18**	**5.39**
MKO287	524423	583746	6	6	10	0.2	1.2	**30.70**	**4.86**
MKO288	524589	583871	12	6	10	0.3	1.3	**10.46**	**2.30**
MKO289	524757	584148	12	6	10	0.2	1.2	**15.69**	**2.48**
MKO290	524936	584338	8	6	10	0.3	1.3	**15.44**	**3.40**
MKO291	524621	584257	10	6	10	0.4	1.4	**9.33**	**2.55**
MKO292	524465	584277	10	6	10	0.3	1.3	**12.44**	**2.74**
MKO005	521264	583242	2	6	10	1.5	2.5	**11.47**	**6.88**
MKO006	521401	583272	2	6	10	2.8	3.8	**6.26**	**4.59**
MKO012	522137	583272	7	6	10	0.4	1.4	**12.40**	**3.54**
MKO031	525200	584411	10	6	10	0.5	1.5	**7.02**	**2.34**

Calculated FoS of Natural Peat Slopes for Proposed Substation, Underground Cabling and Access Roads for Knocknamork Renewable Energy Development - Undrained Analysis

Turbine No./Waypoint	Easting	Northing	Slope	Undrained shear strength	Bulk unit weight of Peat	Peat Depth	Surcharge Equivalent Placed Fill Depth (m)	Factor of Safety for Load Condition	
			β (deg)	c_u (kPa)	γ (kN/m^3)	(m)	Condition (2)	Condition (1)	Condition (2)
MKO039	524129	584126	7	6	10	0.8	1.8	**6.20**	**2.76**
MKO046	524266	584046	11	6	10	0.4	1.4	**8.01**	**2.29**
MKO076	523567	583651	6	6	10	2.2	3.2	**2.62**	**1.80**
MKO082	523416	583597	7	6	10	2.5	3.5	**1.98**	**1.42**
MKO092	517412	581290	7	6	10	0.6	1.6	**9.02**	**3.20**
MKO099	524831	584361	11	6	10	0.8	1.8	**4.27**	**1.83**
MKO106	523817	583885	10	6	10	1.5	2.5	**2.34**	**1.40**
MKO104	518737	581783	6	6	10	0.5	1.5	**11.54**	**3.85**
MKO143	523249	583348	6	6	10	0.9	1.9	**6.41**	**3.04**
MKO146	523212	583220	6	6	10	1.7	2.7	**3.40**	**2.14**
MKO158	515839	581793	8	6	10	1.7	2.7	**2.56**	**1.61**
MKO172	515412	582397	4	6	10	1.4	2.4	**6.16**	**3.59**
MKO185	518111	581750	4	6	10	0.1	1.1	**86.22**	**7.84**
MKO210	516939	581390	4	6	10	2.0	3.0	**4.31**	**2.87**
MKO213	515765	581599	8	6	10	1.0	2.0	**4.35**	**2.18**
MKO214	515876	581308	6	6	10	2.0	3.0	**2.89**	**1.92**
MKO217	516178	581217	5	6	10	2.0	3.0	**3.46**	**2.30**
MKO237	517308	581253	3	6	10	0.9	1.9	**13.51**	**6.21**
MKO239	519449	582519	6	6	10	1.9	2.9	**3.12**	**2.03**
MKO242	520123	582638	6	6	10	1.4	2.4	**4.28**	**2.46**
MKO246	520721	582819	10	6	10	0.4	1.4	**8.77**	**2.51**
MKO259	519719	582713	3	6	10	2.0	3.0	**5.74**	**3.83**
MKO270	520081	582771	4	6	10	1.8	2.8	**4.79**	**3.08**
MKO273	518927	582318	6	6	10	2.6	3.6	**2.22**	**1.60**
MKO042	525377	584604	8	6	10	0.4	1.4	**10.88**	**3.11**
MKO091	524616	584288	8	6	10	0.9	1.9	**5.12**	**2.35**
MKO092	525105	584522	7	6	10	0.4	1.4	**12.40**	**3.54**
MKO052	525269	584468	8	6	10	0.5	1.5	**8.71**	**2.90**
MKO522	525500	584557	No peat encountered at this location						
MKO524	525676	584419	No peat encountered at this location						
MKO552	525159	584489	11	6	10	0.8	1.8	**4.27**	**1.83**
MKO543	524992	584363	10	6	10	0.3	1.3	**11.70**	**2.70**
MKO41	522996	583314	6	6	10	0.2	1.2	**31.45**	**5.24**
MKO154	518750	582079	8	6	10	1.1	2.1	**3.96**	**2.07**
MKO159	523057	583342	6	6	10	1.2	2.2	**4.81**	**2.62**
MKO173	523292	583379	7	6	10	1.3	2.3	**4.10**	**2.32**
MKO199	519671	582638	6	6	10	1.6	2.6	**3.61**	**2.22**
MKO200	514311	581896	10	6	10	0.6	1.6	**5.85**	**2.19**
MKO226	518844	582153	3	6	10	3.0	4.0	**3.83**	**2.87**
MKO230	519780	582631	3	6	10	3.0	4.0	**3.83**	**2.87**
Historical Waypoints									
141	517111	581298	2	6	10	1.3	2.3	**14.90**	**8.42**
142	517023	581303	1	6	10	1.2	2.2	**25.01**	**13.64**
143	516927	581330	4	6	10	1.6	2.6	**5.38**	**3.31**
144	516829	581314	6	6	10	1	2.0	**5.67**	**2.84**
145	516732	581296	3	6	10	1.6	2.6	**7.67**	**4.72**
146	516632	581289	4	6	10	1	2.0	**8.15**	**4.08**
147	516535	581277	8	6	10	0.5	1.5	**8.92**	**2.97**
148	516460	581211	10	6	10	0.6	1.6	**5.71**	**2.14**
149	516388	581142	7	6	10	0.4	1.4	**11.73**	**3.35**
150	516289	581138	6	6	10	1.4	2.4	**4.21**	**2.45**
151	516190	581149	5	6	10	1.4	2.4	**4.80**	**2.80**
152	516100	581190	6	6	10	1.2	2.2	**5.10**	**2.78**
153	516016	581245	10	6	10	1.5	2.5	**2.38**	**1.43**
154	515940	581305	9	6	10	1.4	2.4	**2.75**	**1.60**
155	515900	581396	7	6	10	1.8	2.8	**2.65**	**1.70**
156	515858	581486	8	6	10	0.7	1.7	**5.92**	**2.44**
157	515816	581577	9	6	10	1.8	2.8	**2.16**	**1.39**
158	515772	581666	8	6	10	1.2	2.2	**3.45**	**1.88**
159	515770	581764	11	6	10	1.2	2.2	**2.71**	**1.48**
160	515741	581846	8	6	10	1.5	2.5	**3.02**	**1.81**
161	515671	581913	6	6	10	2.4	3.4	**2.30**	**1.62**
162	515629	582004	7	6	10	0.9	1.9	**5.33**	**2.53**
163	515581	582092	9	6	10	1.4	2.4	**2.85**	**1.66**
164	515537	582181	7	6	10	1.6	2.6	**3.07**	**1.89**
165	515484	582252	5	6	10	2	3.0	**3.32**	**2.22**
166	515407	582305	6	6	10	1.1	2.1	**4.93**	**2.58**
167	515311	582312	3	6	10	1.3	2.3	**7.59**	**4.29**
168	515218	582284	4	6	10	0.5	1.5	**16.31**	**5.44**
169	515201	582187	5	6	10	2	3.0	**3.55**	**2.37**
170	515112	582149	8	6	10	1.2	2.2	**3.85**	**2.10**
171	515073	582060	2	6	10	0.5	1.5	**35.33**	**11.78**
172	514978	582055	5	6	10	0.6	1.6	**12.28**	**4.60**
173	514937	581975	5	6	10	0.3	1.3	**23.43**	**5.41**
174	514847	581959	4	6	10	1.7	2.7	**4.86**	**3.06**
175	514751	581938	5	6	10	1.2	2.2	**6.14**	**3.35**
176	514658	581905	17	6	10	0.1	1.1	**21.86**	**1.99**
177	514562	581880	10	6	10	0.2	1.2	**17.30**	**2.88**
178	514472	581838	11	6	10	0.1	1.1	**31.79**	**2.89**
179	514390	581784	11	6	10	0.1	1.1	**33.21**	**3.02**
180	514302	581740	8	6	10	0.1	1.1	**41.43**	**3.77**
181	514216	581689	10	6	10	0.1	1.1	**34.41**	**3.13**

Calculated FoS of Natural Peat Slopes for Proposed Substation, Underground Cabling and Access Roads for Knocknamork Renewable Energy Development - Undrained Analysis

Turbine No./Waypoint	Easting	Northing	Slope	Undrained shear strength	Bulk unit weight of Peat	Peat Depth	Surcharge Equivalent Placed Fill Depth (m)	Factor of Safety for Load Condition	
			β (deg)	c_u (kPa)	γ (kN/m^3)	(m)	Condition (2)	Condition (1)	Condition (2)
182	514135	581631	7	6	10	0.1	1.1	**49.13**	**4.47**
183	514051	581577	2	6	10	0.3	1.3	**60.67**	**14.00**
307	521610	583034	6	6	10	1	2.0	**5.77**	**2.89**
308	521525	583025	6	6	10	0.4	1.4	**14.43**	**4.12**
309	521411	583018	5	6	10	0.5	1.5	**13.82**	**4.61**
310	521233	582979	8	6	10	0.1	1.1	**43.54**	**3.96**
311	521122	582967	8	6	10	0.1	1.1	**43.54**	**3.96**
312	521026	582950	6	6	10	0.1	1.1	**57.72**	**5.25**
313	520826	582919	12	6	10	0.4	1.4	**7.38**	**2.11**
314	520713	582916	5	6	10	0.6	1.6	**11.52**	**4.32**
315	520504	582873	6	6	10	0.3	1.3	**19.24**	**4.44**
316	520403	582775	No peat encountered at this location						
317	520300	582735	No peat encountered at this location						
318	520189	582709	No peat encountered at this location						
319	520084	582690	7	6	10	0.3	1.3	**16.91**	**3.90**
320	519992	582628	7	6	10	0.8	1.8	**5.82**	**2.59**
321	519896	582644	No peat encountered at this location						
322	519497	582580	6	6	10	1.2	2.2	**4.48**	**2.44**
323	519392	582580	6	6	10	1.2	2.2	**4.48**	**2.44**
324	519294	582512	6	6	10	0.6	1.6	**8.96**	**3.36**
325	519198	582433	6	6	10	1	2.0	**5.38**	**2.69**
326	519095	582344	6	6	10	0.1	1.1	**53.78**	**4.89**
327	518989	582268	6	6	10	0.2	1.2	**26.89**	**4.48**
328	518801	582116	3	6	10	1.5	2.5	**8.35**	**5.01**
329	518693	582069	4	6	10	0.5	1.5	**19.12**	**6.37**

Minimum =	**1.98**	**1.34**
Maximum =	**122.13**	**14.48**
Average =	**14.60**	**3.87**

Notes:

(1) Assuming a bulk unit weight for peat of 10kN/m^3

(2) Assuming a surcharge equivalent to fill depth of 1m of peat i.e. 10kPa

(3) Slope inclination (β) based on site readings and site contour plans

(4) A lower bound undrained shear strength, cu for the peat of 6kPa was selected for the assessment. It should be noted that a cu of 6kPa for the peat is considered conservative value for the analysis and is not representative of all peat present across the site. In reality the peat has a significantly higher undrained strength

(5) Peat depths based on probes carried out by FT, MKO, Enerco and AGEC

(6) For load conditions see report text.

(7) Shear strength and load for waypoint MKO552 (110kV section 2) are specific to that location to model the effect of machine loading on the pea

Calculated FoS of Natural Peat Slopes for Proposed Substation, Underground Cabling and Access Roads for Knocknamork Renewable Energy Development - Drained Analysis

Turbine No./Waypoint	Slope	Design c'	Bulk unit weight of Peat	Unit weight of Water	Depth of In situ Peat	Friction Angle	Surcharge Equivalent Placed Fill	Equivalent Total Depth of Peat (m)	Factor of Safety for Load Condition	
	α (deg)	c' (kPa)	γ (kN/m^3)	γ_w (kN/m^3)	(m)	ø' (deg)	Condition (2)	Condition (2)	Condition (1)	Condition (2)
									100% Water	100% Water
WP1	No peat encountered at this location									
WP2	No peat encountered at this location									
WP3	No peat encountered at this location									
WP4	No peat encountered at this location									
WP5	No peat encountered at this location									
WP6	No peat encountered at this location									
WP7	No peat encountered at this location									
WP8	No peat encountered at this location									
WP9	No peat encountered at this location									
WP10	No peat encountered at this location									
WP11	No peat encountered at this location									
WP12	No peat encountered at this location									
WP13	No peat encountered at this location									
WP14	No peat encountered at this location									
WP15	No peat encountered at this location									
WP16	No peat encountered at this location									
WP17	No peat encountered at this location									
WP18	No peat encountered at this location									
WP19	10	4	10.0	10.0	0.3	25	1.0	1.3	**7.80**	**3.83**
WP20	8	4	10.0	10.0	0.3	25	1.0	1.3	**9.67**	**4.78**
WP21	5	4	10.0	10.0	0.5	25	1.0	1.5	**9.21**	**6.62**
WP22	1	4	10.0	10.0	2.0	25	1.0	3.0	**11.46**	**16.55**
WP23	3	4	10.0	10.0	0.4	25	1.0	1.4	**19.13**	**11.82**
WP24	3	4	10.0	10.0	1.5	25	1.0	2.5	**5.10**	**6.62**
WP25	3	4	10.0	10.0	0.2	25	1.0	1.2	**38.27**	**13.79**
WP26	2	4	10.0	10.0	0.4	25	1.0	1.4	**28.67**	**17.73**
WP27	4	4	10.0	10.0	0.8	26	1.0	1.8	**7.19**	**7.07**
WP28	5	4	10.0	10.0	0.8	27	1.0	1.8	**5.76**	**5.79**
WP29	8	4	10.0	10.0	1.5	28	1.0	2.5	**1.93**	**2.67**
WP30	4	4	10.0	10.0	1.4	29	1.0	2.4	**4.11**	**5.70**
WP31	10	4	10.0	10.0	1.5	30	1.0	2.5	**1.56**	**2.25**
WP32	8	4	10.0	10.0	1.2	31	1.0	2.2	**2.42**	**3.26**
WP33	4	4	10.0	10.0	1.0	32	1.0	2.0	**5.75**	**7.34**
WP34	8	4	10.0	10.0	0.5	33	1.0	1.5	**5.80**	**5.02**
WP35	2	4	10.0	10.0	1.4	34	1.0	2.4	**8.19**	**12.83**
WP36	2	4	10.0	10.0	1.0	25	1.0	2.0	**11.47**	**12.41**
WP37	3	4	10.0	10.0	0.5	25	1.0	1.5	**15.31**	**11.03**
WP38	2	4	10.0	10.0	0.5	25	1.0	1.5	**22.94**	**16.55**
WP39	No peat encountered at this location									
WP40	4	4	10.0	10.0	1.8	25	1.0	2.8	**3.19**	**4.43**
WP41	7	4	10.0	10.0	1.5	25	1.0	2.5	**2.20**	**2.84**
WP42	8	4	10.0	10.0	1.2	25	1.0	2.2	**2.42**	**2.83**
WP43	5	4	10.0	10.0	1.2	25	1.0	2.2	**3.84**	**4.52**
WP44	No peat encountered at this location									
WP45	8	4	10.0	10.0	0.5	25	1.0	1.5	**5.80**	**4.15**
WP46	12	4	10.0	10.0	0.3	25	1.0	1.3	**7.87**	**3.33**
WP47	8	4	10.0	10.0	0.3	25	1.0	1.3	**9.67**	**4.78**
WP48	12	4	10.0	10.0	0.3	25	1.0	1.3	**7.87**	**3.33**
WP49	10	4	10.0	10.0	0.2	25	1.0	1.2	**11.70**	**4.15**
WP50	4	4	10.0	10.0	0.3	25	1.0	1.3	**22.99**	**9.93**
WP51	14	4	10.0	10.0	0.4	25	1.0	1.4	**4.87**	**2.65**
WP52	6	4	10.0	10.0	0.2	25	1.0	1.2	**19.24**	**6.90**
WP53	5	4	10.0	10.0	0.2	25	1.0	1.2	**23.04**	**8.28**
WP54	10	4	10.0	10.0	0.2	25	1.0	1.2	**11.70**	**4.15**
WP55	8	4	10.0	10.0	1.8	25	1.0	2.8	**1.61**	**2.22**
WP56	7	4	10.0	10.0	0.4	25	1.0	1.4	**8.27**	**5.07**
WP57	6	4	10.0	10.0	0.4	25	1.0	1.4	**10.99**	**6.14**
WP58	4	4	10.0	10.0	0.3	25	1.0	1.3	**19.16**	**9.55**
WP59	4	4	10.0	10.0	0.3	25	1.0	1.3	**22.99**	**9.93**
WP60	4	4	10.0	10.0	0.5	25	1.0	1.5	**11.50**	**8.28**
WP61	5	4	10.0	10.0	1.8	25	1.0	2.8	**2.56**	**3.55**
WP62	3	4	10.0	10.0	0.3	25	1.0	1.3	**25.51**	**12.73**
WP63	4	4	10.0	10.0	0.4	25	1.0	1.4	**14.37**	**8.87**
WP64	5	4	10.0	10.0	0.5	25	1.0	1.5	**9.21**	**6.62**
WP65	3	4	10.0	10.0	0.1	26	1.0	1.1	**85.84**	**16.26**
WP66	6	4	10.0	10.0	0.3	27	1.0	1.3	**17.67**	**7.81**
WP67	No peat encountered at this location									
WP68	5	4	10.0	10.0	0.2	29	1.0	1.2	**29.37**	**10.17**
WP69	6	4	10.0	10.0	0.4	30	1.0	1.4	**15.11**	**8.24**
WP70	9	4	10.0	10.0	0.1	31	1.0	1.1	**29.68**	**6.15**
WP71	5	4	10.0	10.0	0.3	32	1.0	1.3	**22.50**	**10.69**
MKO Waypoints										
MKO086	12	4	10.0	10.0	1.2	25	1.0	2.2	**1.64**	**1.89**
MKO161	2	4	10.0	10.0	3.3	25	1.0	4.3	**3.53**	**5.84**
MKO194	7	4	10.0	10.0	1.4	25	1.0	2.4	**2.35**	**2.95**
MKO195	6	4	10.0	10.0	1.7	25	1.0	2.7	**2.27**	**3.08**
MKO196	4	4	10.0	10.0	0.4	25	1.0	1.4	**15.29**	**9.02**
MKO197	6	4	10.0	10.0	0.3	25	1.0	1.3	**13.64**	**6.46**
MKO198	6	4	10.0	10.0	0.3	25	1.0	1.3	**13.64**	**6.46**
MKO203	8	4	10.0	10.0	0.4	25	1.0	1.4	**7.72**	**4.52**
MKO204	8	4	10.0	10.0	0.5	25	1.0	1.5	**6.18**	**4.23**
MKO205	7	4	10.0	10.0	0.7	25	1.0	1.7	**5.03**	**4.29**
MKO206	6	4	10.0	10.0	1.1	25	1.0	2.1	**3.41**	**3.89**
MKO207	8	4	10.0	10.0	0.2	25	1.0	1.2	**15.44**	**5.24**
MKO209	3	4	10.0	10.0	0.4	25	1.0	1.4	**20.35**	**12.03**
MKO211	6	4	10.0	10.0	0.9	25	1.0	1.9	**4.09**	**4.27**
MKO212	4	4	10.0	10.0	0.8	25	1.0	1.8	**6.79**	**6.73**
MKO213	4	4	10.0	10.0	1.5	25	1.0	2.5	**3.82**	**4.96**
MKO215	3	4	10.0	10.0	0.2	25	1.0	1.2	**40.71**	**13.93**

Calculated FoS of Natural Peat Slopes for Proposed Substation, Underground Cabling and Access Roads for Knocknamork Renewable Energy Development - Drained Analysis

Turbine No./Waypoint	Slope	Design c'	Bulk unit weight of Peat	Unit weight of Water	Depth of In situ Peat	Friction Angle	Surcharge Equivalent Placed Fill	Equivalent Total Depth of Peat (m)	Factor of Safety for Load Condition	
	α (deg)	c' (kPa)	γ (kN/m^3)	γ_w (kN/m^3)	(m)	ø' (deg)	Condition (2)	Condition (2)	Condition (1)	Condition (2)
									100% Water	100% Water
MKO217	4	4	10.0	10.0	1.3	25	1.0	2.3	**4.37**	**5.36**
MKO218	4	4	10.0	10.0	1.7	25	1.0	2.7	**3.40**	**4.61**
MKO221	12	4	10.0	10.0	0.7	25	1.0	1.7	**2.99**	**2.51**
MKO223	8	4	10.0	10.0	1.2	25	1.0	2.2	**2.47**	**2.86**
MKO224	6	4	10.0	10.0	0.6	25	1.0	1.6	**6.82**	**5.30**
MKO225	6	4	10.0	10.0	0.5	25	1.0	1.5	**8.19**	**5.64**
MKO226	8	4	10.0	10.0	0.1	25	1.0	1.1	**30.88**	**5.69**
MKO228	5	4	10.0	10.0	0.5	25	1.0	1.5	**9.80**	**6.76**
MKO229	5	4	10.0	10.0	0.3	25	1.0	1.3	**16.34**	**7.75**
MKO230	6	4	10.0	10.0	0.7	25	1.0	1.7	**5.46**	**4.86**
MKO232	6	4	10.0	10.0	0.7	25	1.0	1.7	**5.46**	**4.86**
MKO233	4	4	10.0	10.0	0.9	25	1.0	1.9	**6.12**	**6.40**
MKO234	4	4	10.0	10.0	0.9	25	1.0	1.9	**6.12**	**6.40**
MKO235	8	4	10.0	10.0	0.5	25	1.0	1.5	**6.18**	**4.23**
MKO236	8	4	10.0	10.0	0.4	25	1.0	1.4	**7.72**	**4.52**
MKO237	9	4	10.0	10.0	0.8	25	1.0	1.8	**3.06**	**3.00**
MKO238	8	4	10.0	10.0	0.2	25	1.0	1.2	**15.44**	**5.24**
MKO239	6	4	10.0	10.0	0.4	25	1.0	1.4	**10.23**	**6.02**
MKO240	6	4	10.0	10.0	1.1	25	1.0	2.1	**3.41**	**3.89**
MKO241	6	4	10.0	10.0	0.8	25	1.0	1.8	**4.55**	**4.49**
MKO242	5	4	10.0	10.0	0.6	25	1.0	1.6	**8.17**	**6.35**
MKO243	5	4	10.0	10.0	1.2	25	1.0	2.2	**3.92**	**4.57**
MKO245	10	4	10.0	10.0	1.1	25	1.0	2.1	**2.07**	**2.34**
MKO246	7	4	10.0	10.0	0.6	25	1.0	1.6	**5.86**	**4.54**
MKO247	7	4	10.0	10.0	1.7	25	1.0	2.7	**1.95**	**2.64**
MKO248	8	4	10.0	10.0	1.1	25	1.0	2.1	**2.57**	**2.92**
MKO249	8	4	10.0	10.0	1.4	25	1.0	2.4	**2.06**	**2.58**
MKO250	7	4	10.0	10.0	1.9	25	1.0	2.9	**1.76**	**2.47**
MKO251	7	4	10.0	10.0	0.7	25	1.0	1.7	**5.03**	**4.29**
MKO252	8	4	10.0	10.0	1.7	25	1.0	2.7	**1.72**	**2.31**
MKO253	8	4	10.0	10.0	1.5	25	1.0	2.5	**1.93**	**2.48**
MKO254	8	4	10.0	10.0	0.9	25	1.0	1.9	**3.09**	**3.21**
MKO255	7	4	10.0	10.0	0.6	25	1.0	1.6	**5.86**	**4.54**
MKO256	6	4	10.0	10.0	0.5	25	1.0	1.5	**8.19**	**5.64**
MKO257	6	4	10.0	10.0	0.8	25	1.0	1.8	**4.55**	**4.49**
MKO258	7	4	10.0	10.0	0.6	25	1.0	1.6	**5.86**	**4.54**
MKO259	6	4	10.0	10.0	0.8	25	1.0	1.8	**5.12**	**4.73**
MKO260	5	4	10.0	10.0	1.3	25	1.0	2.3	**3.50**	**4.29**
MKO261	5	4	10.0	10.0	1.0	25	1.0	2.0	**4.46**	**4.89**
MKO262	6	4	10.0	10.0	1.2	25	1.0	2.2	**3.15**	**3.73**
MKO263	6	4	10.0	10.0	1.7	25	1.0	2.7	**2.27**	**3.08**
MKO264	4	4	10.0	10.0	1.6	25	1.0	2.6	**3.60**	**4.78**
MKO265	4	4	10.0	10.0	1.8	25	1.0	2.8	**3.22**	**4.46**
MKO266	5	4	10.0	10.0	1.9	25	1.0	2.9	**2.45**	**3.45**
MKO267	6	4	10.0	10.0	0.2	25	1.0	1.2	**20.47**	**6.97**
MKO268	6	4	10.0	10.0	1.0	25	1.0	2.0	**3.72**	**4.07**
MKO269	6	4	10.0	10.0	0.2	25	1.0	1.2	**20.47**	**6.97**
MKO270	6	4	10.0	10.0	0.3	25	1.0	1.3	**13.64**	**6.46**
MKO271	6	4	10.0	10.0	0.5	25	1.0	1.5	**8.19**	**5.64**
MKO272	8	4	10.0	10.0	0.1	25	1.0	1.1	**30.88**	**5.69**
MKO273	8	4	10.0	10.0	0.3	25	1.0	1.3	**10.29**	**4.85**
MKO274	12	4	10.0	10.0	0.2	25	1.0	1.2	**10.46**	**3.50**
MKO275	12	4	10.0	10.0	0.5	25	1.0	1.5	**4.18**	**2.83**
MKO276	3	4	10.0	10.0	0.1	25	1.0	1.1	**81.42**	**15.13**
MKO277	3	4	10.0	10.0	0.5	25	1.0	1.5	**16.28**	**11.26**
MKO278	4	4	10.0	10.0	2.7	25	1.0	3.7	**2.11**	**3.33**
MKO279	6	4	10.0	10.0	0.7	25	1.0	1.7	**5.85**	**5.00**
MKO280	5	4	10.0	10.0	0.8	25	1.0	1.8	**6.13**	**5.67**
MKO281	2	4	10.0	10.0	0.2	25	1.0	1.2	**61.00**	**20.89**
MKO282	3	4	10.0	10.0	0.3	25	1.0	1.3	**27.14**	**12.91**
MKO283	3	4	10.0	10.0	0.4	25	1.0	1.4	**20.35**	**12.03**
MKO284	4	4	10.0	10.0	0.8	25	1.0	1.8	**6.79**	**6.73**
MKO285	4	4	10.0	10.0	1.6	25	1.0	2.6	**3.60**	**4.78**
MKO286	3	4	10.0	10.0	1.1	25	1.0	2.1	**6.78**	**7.78**
MKO287	6	4	10.0	10.0	0.2	25	1.0	1.2	**20.47**	**6.97**
MKO288	12	4	10.0	10.0	0.3	25	1.0	1.3	**6.97**	**3.25**
MKO289	12	4	10.0	10.0	0.2	25	1.0	1.2	**10.46**	**3.50**
MKO290	8	4	10.0	10.0	0.3	25	1.0	1.3	**10.29**	**4.85**
MKO291	10	4	10.0	10.0	0.4	25	1.0	1.4	**6.22**	**3.62**
MKO292	10	4	10.0	10.0	0.3	25	1.0	1.3	**8.29**	**3.89**
MKO005	2	4	10.0	10.0	1.5	25	1.0	2.5	**7.65**	**9.93**
MKO006	2	4	10.0	10.0	2.8	25	1.0	3.8	**4.17**	**6.62**
MKO012	7	4	10.0	10.0	0.4	25	1.0	1.4	**8.27**	**5.07**
MKO031	10	4	10.0	10.0	0.5	25	1.0	1.5	**4.68**	**3.32**
MKO039	7	4	10.0	10.0	0.8	25	1.0	1.8	**4.13**	**3.95**
MKO046	11	4	10.0	10.0	0.4	25	1.0	1.4	**5.34**	**3.24**
MKO076	6	4	10.0	10.0	2.2	25	1.0	3.2	**1.75**	**2.59**
MKO082	6	4	10.0	10.0	2.5	25	1.0	3.5	**1.54**	**2.37**
MKO092	7	4	10.0	10.0	0.6	25	1.0	1.6	**6.01**	**4.58**
MKO099	11	4	10.0	10.0	0.8	25	1.0	1.8	**2.85**	**2.59**
MKO106	10	4	10.0	10.0	1.5	25	1.0	2.5	**1.56**	**1.99**
MKO104	6	4	10.0	10.0	0.5	25	1.0	1.5	**7.70**	**5.52**
MKO143	6	4	10.0	10.0	0.9	25	1.0	1.9	**4.28**	**4.36**
MKO146	6	4	10.0	10.0	1.7	25	1.0	2.7	**2.26**	**3.07**
MKO158	8	4	10.0	10.0	1.7	25	1.0	2.7	**1.71**	**2.30**
MKO172	4	4	10.0	10.0	1.4	25	1.0	2.4	**4.11**	**5.17**
MKO185	4	4	10.0	10.0	0.1	25	1.0	1.1	**57.48**	**11.29**
MKO210	4	4	10.0	10.0	2.0	25	1.0	3.0	**2.87**	**4.14**
MKO213	8	4	10.0	10.0	1.0	25	1.0	2.0	**2.90**	**3.11**
MKO214	6	4	10.0	10.0	2.0	25	1.0	3.0	**1.92**	**2.76**

Calculated FoS of Natural Peat Slopes for Proposed Substation, Underground Cabling and Access Roads for Knocknamork Renewable Energy Development - Drained Analysis

Turbine No./Waypoint	Slope	Design c'	Bulk unit weight of Peat	Unit weight of Water	Depth of In situ Peat	Friction Angle	Surcharge Equivalent Placed Fill	Equivalent Total Depth of Peat (m)	Factor of Safety for Load Condition	
	α (deg)	c' (kPa)	γ (kN/m^3)	γ_w (kN/m^3)	(m)	ø' (deg)	Condition (2)	Condition (2)	Condition (1)	Condition (2)
									100% Water	100% Water
MKO217	5	4	10.0	10.0	2.0	25	1.0	3.0	**2.30**	**3.31**
MKO237	3	4	10.0	10.0	0.9	25	1.0	1.9	**9.00**	**8.95**
MKO239	6	4	10.0	10.0	1.9	25	1.0	2.9	**2.08**	**2.91**
MKO242	6	4	10.0	10.0	1.4	25	1.0	2.4	**2.85**	**3.53**
MKO246	10	4	10.0	10.0	0.4	25	1.0	1.4	**5.85**	**3.56**
MKO259	3	4	10.0	10.0	2.0	25	1.0	3.0	**3.83**	**5.52**
MKO270	4	4	10.0	10.0	1.8	25	1.0	2.8	**3.19**	**4.43**
MKO273	6	4	10.0	10.0	2.6	25	1.0	3.6	**1.48**	**2.30**
MKO042	8	4	10.0	10.0	0.4	25	1.0	1.4	**7.26**	**4.44**
MKO091	8	4	10.0	10.0	0.9	25	1.0	1.9	**3.41**	**3.36**
MKO092	7	4	10.0	10.0	0.4	25	1.0	1.4	**8.27**	**5.07**
MKO052	8	4	10.0	10.0	0.5	25	1.0	1.5	**5.80**	**4.15**
MKO522	No peat encountered at this location									
MKO524	No peat encountered at this location									
MKO552	11	4	10.0	10.0	0.8	25	1.0	1.8	**2.85**	**2.59**
MKO543	10	4	10.0	10.0	0.3	25	1.0	1.3	**7.80**	**3.83**
Enerco Waypoints										
41	6	4	10.0	10.0	0.2	25	1.0	1.2	**20.96**	**7.53**
154	8	4	10.0	10.0	1.1	25	1.0	2.1	**2.64**	**2.96**
159	6	4	10.0	10.0	1.2	25	1.0	2.2	**3.21**	**3.77**
173	7	4	10.0	10.0	1.3	25	1.0	2.3	**2.74**	**3.33**
199	6	4	10.0	10.0	1.6	25	1.0	2.6	**2.40**	**3.19**
200	10	4	10.0	10.0	0.6	25	1.0	1.6	**3.90**	**3.11**
226	3	4	10.0	10.0	3.0	25	1.0	4.0	**2.55**	**4.14**
230	3	4	10.0	10.0	3.0	25	1.0	4.0	**2.55**	**4.14**
Historical Waypoints										
141	2	4	10.0	10.0	1.3	25	1.0	2.3	**9.94**	**12.16**
142	1	4	10.0	10.0	1.2	25	1.0	2.2	**16.67**	**19.69**
143	4	4	10.0	10.0	1.6	25	1.0	2.6	**3.59**	**4.77**
144	6	4	10.0	10.0	1	25	1.0	2.0	**3.78**	**4.07**
145	3	4	10.0	10.0	1.6	25	1.0	2.6	**5.11**	**6.81**
146	4	4	10.0	10.0	1	25	1.0	2.0	**5.44**	**5.87**
147	8	4	10.0	10.0	0.5	25	1.0	1.5	**5.95**	**4.25**
148	10	4	10.0	10.0	0.6	25	1.0	1.6	**3.80**	**3.04**
149	7	4	10.0	10.0	0.4	25	1.0	1.4	**7.82**	**4.80**
150	6	4	10.0	10.0	1.4	25	1.0	2.4	**2.80**	**3.52**
151	5	4	10.0	10.0	1.4	25	1.0	2.4	**3.20**	**4.03**
152	6	4	10.0	10.0	1.2	25	1.0	2.2	**3.40**	**4.00**
153	10	4	10.0	10.0	1.5	25	1.0	2.5	**1.59**	**2.03**
154	9	4	10.0	10.0	1.4	25	1.0	2.4	**1.83**	**2.28**
155	7	4	10.0	10.0	1.8	25	1.0	2.8	**1.76**	**2.44**
156	8	4	10.0	10.0	0.7	25	1.0	1.7	**3.95**	**3.48**
157	9	4	10.0	10.0	1.8	25	1.0	2.8	**1.44**	**1.98**
158	8	4	10.0	10.0	1.2	25	1.0	2.2	**2.30**	**2.69**
159	11	4	10.0	10.0	1.2	25	1.0	2.2	**1.81**	**2.10**
160	8	4	10.0	10.0	1.5	25	1.0	2.5	**2.01**	**2.59**
161	6	4	10.0	10.0	2.4	25	1.0	3.4	**1.53**	**2.33**
162	7	4	10.0	10.0	0.9	25	1.0	1.9	**3.56**	**3.62**
163	9	4	10.0	10.0	1.4	25	1.0	2.4	**1.90**	**2.37**
164	7	4	10.0	10.0	1.6	25	1.0	2.6	**2.05**	**2.71**
165	5	4	10.0	10.0	2	25	1.0	3.0	**2.22**	**3.19**
166	6	4	10.0	10.0	1.1	25	1.0	2.1	**3.29**	**3.70**
167	3	4	10.0	10.0	1.3	25	1.0	2.3	**5.06**	**6.19**
168	4	4	10.0	10.0	0.5	25	1.0	1.5	**10.87**	**7.82**
169	5	4	10.0	10.0	2	25	1.0	3.0	**2.37**	**3.41**
170	8	4	10.0	10.0	1.2	25	1.0	2.2	**2.57**	**3.01**
171	2	4	10.0	10.0	0.5	25	1.0	1.5	**23.56**	**17.00**
172	5	4	10.0	10.0	0.6	25	1.0	1.6	**8.18**	**6.62**
173	5	4	10.0	10.0	0.3	25	1.0	1.3	**15.62**	**7.78**
174	4	4	10.0	10.0	1.7	25	1.0	2.7	**3.24**	**4.41**
175	5	4	10.0	10.0	1.2	25	1.0	2.2	**4.09**	**4.82**
176	17	4	10.0	10.0	0.1	25	1.0	1.1	**14.57**	**2.74**
177	10	4	10.0	10.0	0.2	25	1.0	1.2	**11.53**	**4.09**
178	11	4	10.0	10.0	0.1	25	1.0	1.1	**21.19**	**4.09**
179	11	4	10.0	10.0	0.1	25	1.0	1.1	**22.14**	**4.28**
180	8	4	10.0	10.0	0.1	25	1.0	1.1	**27.62**	**5.38**
181	10	4	10.0	10.0	0.1	25	1.0	1.1	**22.94**	**4.44**
182	7	4	10.0	10.0	0.1	25	1.0	1.1	**32.75**	**6.40**
183	2	4	10.0	10.0	0.3	25	1.0	1.3	**40.45**	**20.20**
307	6	4	10.0	10.0	1	25	1.0	2.0	**3.85**	**4.14**
308	6	4	10.0	10.0	0.4	25	1.0	1.4	**9.62**	**5.92**
309	5	4	10.0	10.0	0.5	25	1.0	1.5	**9.21**	**6.62**
310	8	4	10.0	10.0	0.1	25	1.0	1.1	**29.02**	**5.65**
311	8	4	10.0	10.0	0.1	25	1.0	1.1	**29.02**	**5.65**
312	6	4	10.0	10.0	0.1	25	1.0	1.1	**38.48**	**7.53**
313	12	4	10.0	10.0	0.4	25	1.0	1.4	**4.92**	**2.97**
314	5	4	10.0	10.0	0.6	25	1.0	1.6	**7.68**	**6.21**
315	6	4	10.0	10.0	0.3	25	1.0	1.3	**12.83**	**6.37**
316	No peat encountered at this location									
317	No peat encountered at this location									
318	No peat encountered at this location									
319	7	4	10.0	10.0	0.3	25	1.0	1.3	**11.27**	**5.59**
320	7	4	10.0	10.0	0.8	25	1.0	1.8	**3.88**	**3.70**
321	No peat encountered at this location									
322	6	4	10.0	10.0	1.2	25	1.0	2.2	**2.99**	**3.51**
323	6	4	10.0	10.0	1.2	25	1.0	2.2	**2.99**	**3.51**
324	6	4	10.0	10.0	0.6	25	1.0	1.6	**5.98**	**4.82**
325	6	4	10.0	10.0	1	25	1.0	2.0	**3.59**	**3.86**

Calculated FoS of Natural Peat Slopes for Proposed Substation, Underground Cabling and Access Roads for Knocknamork Renewable Energy Development - Drained Analysis

Turbine No./Waypoint	Slope	Design c'	Bulk unit weight of Peat	Unit weight of Water	Depth of In situ Peat	Friction Angle	Surcharge Equivalent Placed Fill	Equivalent Total Depth of Peat (m)	Factor of Safety for Load Condition	
	α (deg)	c' (kPa)	γ (kN/m^3)	γ_w (kN/m^3)	(m)	ø' (deg)	Condition (2)	Condition (2)	Condition (1)	Condition (2)
									100% Water	100% Water
326	6	4	10.0	10.0	0.1	25	1.0	1.1	**35.85**	**7.01**
327	6	4	10.0	10.0	0.2	25	1.0	1.2	**17.93**	**6.43**
328	3	4	10.0	10.0	1.5	25	1.0	2.5	**5.57**	**7.23**
329	4	4	10.0	10.0	0.5	25	1.0	1.5	**11.50**	**8.28**
								Minimum =	**1.44**	**1.89**
								Maximum =	**85.84**	**20.89**
								Average =	**9.88**	**5.62**

Notes:

(1) Assuming a bulk unit weight of peat of 10 (kN/m^3)

(2) Assuming a surcharge equivalent to fill depth of 1.0m.

(3) Slope inclination (β) based on site readings and contour survey plans of site.

(4) FoS is based on slope inclination and shear test results obtained from published data.

(5) Peat depths based on probes carried out by FT.

(6) For load conditions see Report text.

(7) Minimum acceptable factor of safety required of 1.3 for first-time failures based on BS: 6031:1981 Code of practice for Earthworks.

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APPENDIX D

Methodology for Peat Stability Risk Assessment

Methodology for Peat Stability Risk Assessment

A peat stability risk assessment was carried out for each of the main infrastructure elements at the proposed wind farm development. This approach takes into account guidelines for geotechnical/peat stability risk assessments as given in PLHRAG (2017) and MacCulloch (2005). The degree of risk is determined as a Risk Rating (R), which is the product of probability (P) and impact (I). How these factors are determined and applied in the analysis is described below.

The main approaches for assessing peat stability include the following:

(a) Geomorphological

(b) Qualitative (judgement)

(c) Index/Probabilistic (probability)

(d) Deterministic (factor of safety)

Approaches (a) to (c) listed above would be considered subjective and do not provide a definitive indication of stability; in addition, a high level of judgement/experience is required which makes it difficult to relate the findings to real conditions. FT apply a more objective approach, the deterministic approach. As part of FT's deterministic approach, a qualitative risk assessment is also carried out taking into account qualitative factors, which cannot necessarily be quantified.

Probability

The likelihood of a peat failure occurring was assessed based on the results of both the quantitative results of stability calculations (deterministic approach using factors of safety) and the assessment of the severity of several qualitative factors which cannot be reasonably included in a stability calculation but nevertheless may affect the occurrence of peat instability.

The qualitative factors used in the risk assessment are outlined in Table A and have been compiled based on FT's experience of assessments and construction in peat land sites and peat failures throughout Ireland and the UK.

Table A: Qualitative Factors used to Assess Potential for Peat Failure

Qualitative Factor	Type of Feature/Indicator for each Qualitative Factor [1]	Explanation/Description of Qualitative Factor
Evidence of sub peat water flow	No	Based on site walkover observations. Sub peat water flow generally occurs in the form of natural piping at the base of peat. Where there is a constriction or blockage in natural pipes a build-up of water can occur at the base of the peat causing a reduction in effective stress at the base of the peat resulting in failure; this is particularly critical during periods of intense rainfall.
	Possibly	
	Probably	
	Yes	

Qualitative Factor	Type of Feature/Indicator for each Qualitative Factor [1]	Explanation/Description of Qualitative Factor
Evidence of surface water flow	Dry	Based on site walkover observations. The presence of surface water flow indicates if peat in an area is well drained or saturated and if any additional loading from the ponding of surface water onto the peat is likely.
	Localised/Flowing in drains	
	Ponded in drains	
	Springs/surface water	
Evidence of previous failures/slips	No	Based on site walkover observations. The presence of clustering of relict failures may indicate that particular pre-existing site conditions predispose a site to failure.
	In general area	
	On site	
	Within 500m of location	
Type of vegetation	Grass/Crops	Based on site walkover observations. The type of vegetation present indicates if peat in an area is well drained, saturated, etc. Vegetation that indicates wetter ground may also indicate softer underlying peat deposits.
	Improved Grass/Dry Heather	
	Wet Grassland/Juncus (Rushes)	
	Wetlands Sphagnum (Peat moss)	
General slope characteristics upslope/downslope from infrastructure location	Concave	Based on site walkover observations. Slope morphology in the area of the infrastructure location is an important factor. A number of recorded peat failures have occurred in close proximity to a convex break in slope.
	Planar to concave	
	Planar to convex	
	Convex	
Evidence of very soft/soft clay at base of peat	No	Based on inspection of exposures in general area from site walkover. Several reported peat failures identify the presence of a weak layer at the base of the peat along which shear failure has occurred.
	Yes	
Evidence of mechanically cut peat	No	Based on site walkover observations. Mechanically cut peat typically cut using a ‘sausage’ machine to extract

Qualitative Factor	Type of Feature/Indicator for each Qualitative Factor [1]	Explanation/Description of Qualitative Factor
	Yes	peat for harvesting. Areas which have been cut in this manner have been linked to peat instability. The mechanical cuts can notably reduce the intrinsic strength of the peat and also allow ingress of rainfall/surface water.
Evidence of quaking or buoyant peat	No	Based on site walkover observations. Quaking/buoyant peat is indicative of highly saturated peat, which would generally be considered to have a low strength. Quaking peat is a feature on sites that have been previously linked with peat instability.
	Yes	
Evidence of bog pools	No	Based on site walkover observations. Bog pools are generally an indicator of areas of weak, saturated peat. Commonly where there are open areas of water within peat these can be interconnected, with the result that there may be sub-surface bodies of water. The presence of bog pools have been previously linked with peat instability.
	Yes	
Other	Varies	In addition to the above features/ indicators and based on site recordings the following are some of the features which may be identified: Excessively deep peat, weak peat, overly steep slope angles, etc.

Note (1) The list of features/indicators for each qualitative factor are given in increasing order of probability of leading to peat instability/failure.

It should be noted that the presence of one of the qualitative factors alone from Table A is unlikely to lead to peat instability/failure. Peat instability/failure at a site is generally the combination of a number of these factors occurring at the same time at a particular location. The probability rating assigned to the quantitative and qualitative factors is judged on a 5-point scale from 1 (indicating negligible or no probability of failure) to 5 (indicating a very likely failure), as outlined in Table B.

Table B: Probability Scale

Scale	Factor of Safety	Probability
1	1.30 or greater	Negligible/None
2	1.29 to 1.20	Unlikely
3	1.19 to 1.11	Likely
4	1.01 to 1.10	Probable
5	≤1.0	Very Likely

Scale	Likelihood of Qualitative Factor leading to Peat Failure	Probability of Failure
1	Negligible/None	Least
2	Unlikely	
3	Probable	
4	Likely	
5	Very Likely	Greatest

Impact

The severity of the risk is also assessed qualitatively in terms of impact. The impact of a peat failure on the environment within and beyond the immediate wind farm site is assessed based on the potential travel distance of a peat failure. Where a peat failure enters a watercourse, it can travel a considerable distance downstream. Therefore, the proximity of a potential peat failure to a drainage course is a significant indicator of the likely potential impact.

The risk is determined based on the combination of hazard and impact. A qualitative scale has been derived for the impact of the hazard based on distance of infrastructure element to a watercourse (Table C).

The location of watercourses is based on topographic maps and supplemented by site observations from walkover survey. Note that not all watercourses are shown on maps.

Table C: Impact Scale

Scale	Criteria	Impact
1	Proposed infrastructure element greater than 150m of watercourse	Negligible/None
2	Proposed infrastructure element within 150 to 101m of watercourse	Low
3	Proposed infrastructure element within 100 to 51m of watercourse	Medium

4	Proposed infrastructure element within 50 m of watercourse	High
5	Proposed infrastructure element within 50 m of watercourse, in an environmentally sensitive area	Extremely High

Risk Rating

The degree of risk is determined as the product of probability (P) and impact (I), which gives the Risk Rating (R) as follows:

The Risk Rating is calculated from: R = P x I

Due to the 5-point scales used to assess Probability and Impact, the Risk Rating can range from 1 to 25 as shown in Table D.

Table D: Qualitative Risk Rating

		Probability				
		1	**2**	**3**	**4**	**5**
Impact	**5**	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5

Risk Rating & Control Measures	
17 to 25	High: avoid working in area or significant control measures required
11 to 16	Medium: notable control measures required
5 to 10	Low: only routine control measures required
1 to 4	Negligible: none or only routine control measures required

The risk rating is calculated individually for each contributory factor. Control measures are required to reduce the risk to at least a 'Low' risk rating. The control measures in response to the qualitative risk ratings are included in the peat stability risk registers for each main infrastructure element in Appendix B.

The risk rating is calculated individually for each contributory factor. Control measures are required to reduce the risk to at least a 'Tolerable' risk rating

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APPENDIX E

Shear vane results (FT, 2022)

Knocknamork - Shear vane results

ID	Easting	Northing	Depth (m)	Shear Strength
WP22	514830	582000	1	35
			1.5	45
WP24	515162	582224	1	50
WP27	515630	581969	0.5	22
WP28	515596	581971	0.5	18
WP29	515664	581854	0.5	35
WP30	515942	581475	0.5	35
WP32	524085	583974	0.5	14
			1	14
WP36	517200	581302	0.5	16
WP40	517954	581846	0.5	10
			1	6
			1.5	8
WP41	519013	582133	0.5	13
			1	12
			1.25	16
WP42	520224	582714	0.5	16
			1	16
WP43	520670	582891	0.5	18
			1	20
WP55	522865	583428	0.5	26
			1	24
			1.5	20
WP61	523407	583500	0.5	12
			1	12
			1.5	16
WP100	517081	581309	0.5	42
			1	40
			1.5	50
			2	52
			2.5	48
			3	50
WP102	518831	582141	0.5	34
			1	34
			1.5	42
			2	54
			2.5	45
WP102	525159	584489	0.5	42

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APPENDIX F

Trial pit Logs (FT, 2022)

Trial Pit Log

Trialpit No **TP01**

Sheet 1 of 1

Project Name: Knocknamork WF	Project No. P21-199	Co-ords: 523007.28 - 583293.50 Level:	Date 03/02/2022
Location: Co. Kerry		Dimensions (m): 3 × 1.5, Depth 2.60	Scale 1:25
Client: MKO			Logged EA

Water Strike	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
	Depth	Type	Results				
	1.20	B					Brown sandy silty GRAVEL with sub-angular cobbles
				2.50			Brown sandy gravelly COBBLES. Angular cobbles of weathered bedrock (Sandstone)
				2.60			End of pit at 2.60 m

Remarks: Terminated due to refusal - bedrock

Stability: Stable

Trial Pit Log

Trialpit No **TP02**

Sheet 1 of 1

Project Name: Knocknamork WF	Project No. P21-199	Co-ords: 523072.50 - 583271.50 Level:	Date 03/02/2022
Location: Co. Kerry		Dimensions (m): 3 × 1.5 Depth 2.00	Scale 1:25
Client: MKO			Logged EA

Water Strike	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
	Depth	Type	Results				
							Soft dark brown fibrous PEAT
				0.80			
	1.20	B					Brown/ grey sandy silty cobbly GRAVEL. Sand and gravel coarse. Cobbles are angular (weathered bedrock - Sandstone)
				2.00			End of pit at 2.00 m

1 2 3 4 5

Remarks: Terminated due to refusal - bedrock

Stability: Stable

Trial Pit Log

Trialpit No **TP03** Sheet 1 of 1

Project Name: Knocknamork WF	Project No. P21-199	Co-ords: 523089.50 - 583376.70 Level:	Date 03/02/2022
Location: Co. Kerry		Dimensions (m): 3 × 1.5, Depth 2.10	Scale 1:25
Client: MKO			Logged EA

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
							Soft dark brown fibrous PEAT
				0.60			Brown sandy silty GRAVEL with angular cobbles of weathered bedrock (Sandstone)
	1.20	B					
				2.00			Grey sandy gravelly COBBLES. Cobbles are angular weathered bedrock (Sandstone)
				2.10			End of pit at 2.10 m

Remarks: Terminated due to refusal - bedrock

Stability: Stable

Trial Pit Log

Trialpit No **TP04** Sheet 1 of 1

Project Name: Knocknamork WF	Project No. P21-199	Co-ords: 522966.10 - 583387.70 Level:	Date 03/02/2022
Location: Co. Kerry		Dimensions (m): 3 × 1.5, Depth 3.20	Scale 1:25
Client: MKO			Logged EA

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
							Soft dark brown fibrous PEAT
				1.60			Brown sandy silty cobbly GRAVEL. Sand and gravel coarse. Cobbles are angular (weathered bedrock - Sandstone)
				2.00 2.10			Grey sandy gravelly COBBLES. Cobbles are angular (weathered bedrock - Sandstone)
							End of pit at 3.20 m

1 2 3 4 5

Remarks: Terminated due to refusal - bedrock

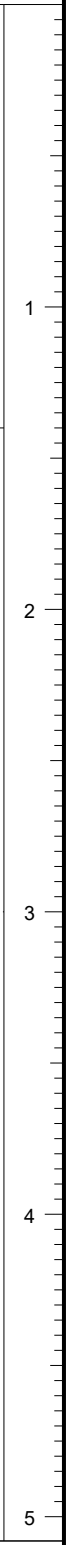
Stability: Stable

Trial Pit Log

Trialpit No **TP05** Sheet 1 of 1

Project Name: Knocknamork WF	Project No. P21-199	Co-ords: 522948.90 - 583463.30 Level:	Date 03/02/2022
Location: Co. Kerry		Dimensions (m): 3 × 1.5, Depth 3.00	Scale 1:25
Client: MKO			Logged EA

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
							Soft brown fibrous PEAT with roots
				1.40			Brown sandy silty cobbly GRAVEL. Sand and gravel are coarse. Cobbles are angular (weathered bedrock - Sandstone)
	2.50	B					
				3.00			End of pit at 3.00 m



Remarks: Terminated due to refusal - bedrock

Stability: Stable

Trial Pit Log

Trialpit No **TP06**

Sheet 1 of 1

Project Name: Knocknamork WF	Project No. P21-199	Co-ords: 522942.90 - 583330.40 Level:	Date 03/02/2022
Location: Co. Kerry		Dimensions (m): 3 × 1.5 Depth 1.70	Scale 1:25
Client: MKO			Logged EA

Water Strike	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
	Depth	Type	Results				
							Soft dark brown fibrous PEAT
				0.60			
	1.00	B					Brown sandy silty cobbly GRAVEL. Coarse sand and gravel. Cobbles are angular (weathered bedrock - Sandstone)
				1.70			End of pit at 1.70 m

Remarks: Terminated due to refusal - bedrock

Stability: Stable

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