Technical Appendix 9.3

Peat Slide Risk Assessment

Dunbeg South Extension Wind Farm

FEI Technical Appendix 9.3 Peat Slide Risk Assessment

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Document history

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1. Introduction

This report details the Peat Stability Assessment undertaken at the proposed Dunbeg South Extension Wind Farm Stage 2. The Proposed Development comprises x4 wind turbine generators, along with ancillary infrastructure and access tracks. The report is accompanied by the following mapping:

- Figure A. 1: Site Layout
- Figure A. 2: Site Location
- Figure A. 3: Aerial Imagery
- Figure A. 4: Site Topography
- Figure A. 5: Major Geomorphological Features
- Figure A. 6: Terrain Slope Angle
- Figure A. 7: Superficial Geology Map
- Figure A. 8: Peat Depth Map
- Figure A. 9: Solid Geology Map
- Figure A. 10: Peat Stability Risk Ranking
- Figure A. 11: Environmental Impact Zones
- Figure A. 12: Factor of Safety Map

1.1. Reporting Experience

Reporting Team: – Evelin Erős is a Geotechnical Engineer at Natural Power and archaeologist by training (BA Hons Archaeology) with greater than 8 years of relevant EIA planning phase and field experience for infrastructure projects. Evelin was supported by Orrin Bryers a Geo-Survey Project Manager of more than x3 years geotechnical and geophysical field and reporting experience. Sam Fisher is the Senior Geotechnical Engineer who has overseen the field work and reporting and has more than 8 years of relevant geotechnical and geological expertise.

Report Checker: – Gavin Germaine is a Principal Geotechnical Engineer at Natural Power and engineering geologist by training (MSc Engineering Geology) with greater than 15 years of relevant geotechnical experience. Gavin is a chartered Geologist (CGeol) and a Fellow of the Geological Society of London. Over the last decade has completed multiple peat slide risk assessments for wind energy projects across the UK and Ireland. Gavin has further provided expert technical advice as part of planning enquiries and being part of an international team examining new geotechnical investigation techniques for in-situ testing and sampling of peat.

The peat slide risk assessment for Dunbeg South Extension Wind Farm was supported by a multidisciplinary team comprising hydrologists (x2), engineering geologist (x1) and geotechnical engineers (x2) who contributed to desk study elements, and two main phases of field work. The reporting has been reviewed by a competent person (Chartered Geologist) with extensive experience in managing geotechnical risk in upland environments. Therefore, the delivery team make-up complies with Section 1.6 of national guidance for this subject.

1.2. Objectives & Scope

The primary objectives of this report are:

- Present a desk study pertinent to the subject of peat stability assessment at the Proposed Development;
- Report on walkover survey, field survey probing & geomorphological mapping exercise to inform the risk assessment;
- Identify any areas of existing instability or which may pose a risk to the Proposed Development;
- Qualitative and quantitative peat slide risk assessment; and
- Provide robust and targeted recommendations for any future construction process required to mitigate any potential contributory factors to elevated risk of instability.

This report and survey work has been undertaken in general accordance with current Peat Slide Hazard and Risk Assessment: Best Practice Guide for Proposed Electricity Development, issued by the Scottish Executive, 2017. This Peat Slide Risk Assessment (PSRA) is semi-quantitative.

The Peat Stability Risk Assessment utilises field data and visual reconnaissance assessment collected during two main phases of site survey. This data is combined with desk study information and review of all salient published materials. The following data sources have been integrated into this assessment: (Table 1.1).

Table 1.1: PSRA Data Sources

Data Source	Location	Date
GSI – Onshore Geological Map Data: (Linear Features, Mass movement deposits, Artificial ground, superficial deposits, hydrogeology, bedrock geology, faulting,1:50,000 scale)	https://dcenr.maps.arcgis.com/apps/webappviewer/index.html	2024
GSI – Engineering Geology Viewer: 1:1M Superficial Engineering Geology; 1:1M Bedrock Engineering Geology	https://dcenr.maps.arcgis.com/apps/webappviewer/index.html	2024
National Library of Scotland – Online viewer	https://maps.nls.uk/	Various
Historical Aerial Photograph Data ESRI Satellite World Imagery Google Earth Professional	https://server.arcgisonline.com/ArcGIS/rest/services/World_Imagery/MapServer/tile/{z}/{y}/{x}	2024
Online news archival search	Various web-based search engines	2024
Infrastructure NI Flood Maps – Online viewer.	https://dfi-ni.maps.arcgis.com/apps/webappviewer/index.html	2024

Assessment was carried out according to the following work programme:

- Desk Study and review of existing site information carried out in January 2024, including desk-based mapping and site modelling.
- Site reconnaissance survey (December 2023). This comprised a walkover survey of the site and identification of potential geo-hazards.
- Development-wide mapping and assessment of salient features such as active, incipient or relic instability within the peat deposits, geomorphological features, peat depth and composition (May 2024).

- Development-wide probing survey comprising: An initial site wide probe survey within the turbine envelope on a grid resolution of 100m (December 2023), Stage 1 survey.
- Detailed peat probing survey covering areas of confirmed peatland and designed infrastructure at higher resolution (April 2024).
- Assessment of peat undrained shear strength through in-situ hand shear vane testing across representative turbine locations within the design envelope (April 2024).
- Quantitative slope stability assessment based on in-situ shear strength data.
- Assessment of the potential risk of peat failure across the turbine envelope.
- Comparison of the potential risk of peat failure with the site hydrological model including proximity to watercourses and sensitivity of those features.
- Recommendations for detailed design/construction control with specific examination the need for measures to mitigate potential peat failure as part of any future wind farm development.

1.3. Detailed Description of Development

The Proposed Development occupies an approximately 111.5 Ha area situated on land west of the existing Dunbeg Wind Farm, and land to the south of the A37 adjacent to a disused quarry. The development is in the townlands of Dunbeg and Dunmore approximately 6.2km northeast from Limavady, Co. Derry/ Londonderry. At the time of writing the Proposed Development will comprise x4 Wind Turbines with associated infrastructure including foundations, hardstanding's, internal track network and ancillary infrastructure.

Wind turbines are likely to be installed on reinforced concrete gravity foundations depending on ground conditions.

Each wind turbine requires an area of hard standing (a "crane pad") to provide a level and firm base for the construction phase at the location of each turbine.

There would be a temporary construction compound / storage area to provide a secure area for site office facilities and storage of materials, a small construction compound along with the proposed new track, alternative track and the turning heads. The compounds would be constructed adjacent to the site track, with a hardcore base surrounded by a security fence and locked gates. All temporary features would be removed from site and all areas disturbed by the works would be reinstated in accordance with an approved Construction Environmental Management Plan.

Individual electrical transformers would either be placed within the wind turbines themselves, or in a small secure external transformer housing placed next to each wind turbine tower. High voltage and communications / control cables would be placed in trenches (dimensions to be determined by the ground conditions, but typically 0.5 m x 1 m deep) routed alongside the access tracks.

A single storey substation building would be built and will house the switchgear and control equipment, in addition to acting as a secure storage space.

1.4. Location

Regional and local setting is shown below in Figure A 2 and Figure A 3 in Appendix A. Access is from the A37 Broad Road (Irish Grid Reference TM65, 274328E, 426222N).

1.5. Terrain Description

The Proposed Development is covered by gently sloping terrain of grassland / moorland used for grazing. There are sporadic areas of wetter heather moorland with flush and bog communities. The land on the development gently rises from a low of 130m AOD (Above Ordnance Datum) in the northeast corner of the site by the east to west flowing river, to a high of 294m AOD in the southwest corner adjacent to the commercial forestry. The river in the northern part of the site is moderately to steeply banked and has deciduous trees and shrubs along its trajectory. The valley sides of the river are gentle to moderately steep. A topographical map of the Proposed Development is provided in Figure A 4 in Appendix A.

1.6. Site Photographs

The following series of images provide an overview of the terrain for the proposed Dunbeg South Extension Wind Farm.

Source: Natural Power, Phase II Study (May 2024)

Figure B. 1: View South of site

Source: Natural Power, Phase II Study (May 2024)

Figure B. 2: View West of site.

Source: Natural Power, Phase II Study (May 2024)

Figure B. 3: View East of site, showing woodland.

Source: Natural Power, Phase II Study (May 2024)

Figure B. 4: View to the North of site, showing Dunbeg Windfarm Phase I.

2. Survey Methodology

2.1. Data Review

Initial desk-based assessment has been undertaken which has allowed the field surveys to be targeted. Table 1.1 highlights the key sources of information for this report.

Publicly accessible aerial imagery records dating to 1832 do not show any major land use changes occurring through to the present day other than forestry operations, public roadworks and land boundaries.

Ordnance Survey of Northern Ireland Historical mapping available from the National library of Scotland has been reviewed and shows the site as open moorland until commercial forestry was planted between 1957 and 1986 in the northwest and southwest corners of the Site.

Natural Power’s project directory and online sources were searched for reports of peat slide incidents on adjacent wind farm developments (Document no.: 1149761). These searches did not provide any pertinent information.

2.2. Geomorphology

Reconnaissance and geomorphological mapping were carried out during April 2024. This exercise provided opportunity for geotechnical engineers to visualise the terrain, access geological and soil exposures, examine slope systems, vegetation cover and record any hydrological features impacting peat stability.

No evidence of cracking, compression features of peat creep was identified during the site walkover. No historical peat slides were identified during the site walkover or from aerial photographs.

The culmination of this survey and desk-based review of aerial photographs was the production of a geomorphology map, Figure A.5 (Appendix A). This map was used in the qualitative stability risk assessment and maps the major features across the development pertinent to the risk model.

2.3. Peat Survey

The soil probing coverage has allowed for:

- Stage 1 probe survey implementing a 100 m grid of probes across the Proposed Development infrastructure areas.
- Stage 2 prove survey with detailed coverage of proposed wind farm infrastructure locations.
  - 50m intervals along tracks with probing at 10m offset either side to capture data across the construction corridor;
  - 10m grid spaced probes across turbine foundations; and
  - 10m grid spacing across temporary infrastructure locations.

Peat depths were recorded using probes inserted into the peat and measuring the depth to refusal. This field data carries the following limitations:

- Peat probes may record depth to obstructions (e.g., tree roots, rock clasts) and not the true depth of the peat;
- Peat probes may over-estimate peat depth where the underlying soil strata is very soft;
- Peat probes can underestimate peat depth in very dry peat deposits due to early refusal of the probe;
- Peat probes do not differentiate between peat and mineral sub-soils.

Detailed peat probing survey was focussed across areas of peat determined from desk study and site reconnaissance. In-situ hand shear vane tests were conducted to provide an estimate of undrained shear strength within the peat mass at relevant turbine locations. Supplementary to this, peat cores have been taken at select locations to provide confirmation of probe depth correlation, material classification and morphology.

Peat depth mapping is shown on drawing no: 1341129, Figure A.8. To prepare the interpolated peat depth mapping; a spatial interpolation method termed 'Ordinary Kriging' was applied.

This is a statistical interpolation function that examines point data (and weights the surrounding measured values) to derive a prediction for unmeasured locations. Ordinary Kriging is considered generally acceptable for geological / soil science applications. Limitations of the Kriging method are widely accepted to be:

- Confidence in the output related to number and density of points within the input dataset.
- Search window needs to be set to limit the influence of distant data points.

The interpolation parameters and peat depth data set are deemed suitable for informing the peat slide risk assessment. Figure A 8 appended to this report, indicates interpolated peat depth across site, a total of 589 peat probe data points were acquired during the phase one and two surveys.

2.4. Slope Mapping

Terrain Slope Angle Map, drawing no.1341130, Figure A.6 is comprised from digital elevation model data, calculated based on a 10m resolution OSNI Digital Elevation Model using GIS (Appendix A).

The risk assessment considers slope angle in two aspects. Firstly, the slope angle is used to screen the site for instability within the slope stability analysis numerical calculation. This is adjoined to qualitative assessment of the slope in terms of a contributory factor to failure. This combined approach ensures a robust assessment of the risk.

There are several steeper areas found on the site, reaching up to 21° such as in the southwest and southeast of the site where the terrain slopes down to the north (274556E, 425887N and 275022E, 426054N respectively). There is also moderately steep terrain up to 20° on the sides of the Curley River tributary that flows east to west along the northern part of the site (e.g. at 274394E, 426813N). These areas of steeper terrain were found to have almost entirely peat depths less than 0.50m during the stage 1 probing survey and satellite imagery shows no signs of slope instability.

3. Geology & Environment

3.1. Superficial Deposits

The GSNI (Geological Survey of Northern Ireland) online viewer indicates the majority of site to be covered by Till (Diamicton). localised deposits of glacial till. There are also several areas throughout the site shown to have Glaciofluvial Ice Contact Deposits (Silt, Sand, Gravel and Boulders), Alluvium (Clay, Silt, Sand and Gravel) and Peat. The superficial geology of the site is shown in Figure A. 7. in Appendix A.

Till is described by the Geological Survey of Northern Ireland (GSNI) as unsorted and unstratified drift, generally over consolidated, deposited directly by and underneath a glacier without subsequent reworking by water from the glacier. It consists of a heterogenous mixture of clay, sand, gravel, and boulders varying widely in size and shape (diamicton).

Glaciofluvial Ice Contact Deposits are described by the GSNI as stratified sand and gravel and interbedded diamicton deposited by meltwater and ice under (subglacial), within (englacial), and at the margins of, glaciers. Sand and gravel, locally with lenses of silt, clay and organic material. Moundy topography is characteristic, but flat-topped mounds are common.

Alluvium is described by the GSNI as a general term for clay, silt, sand and gravel. It is the unconsolidated detrital material deposited by a river, stream or other body of running water as a sorted or semi-sorted sediment in the bed of the stream or on its floodplain or delta, or as a cone or fan at the base of a mountain slope. Synonym: alluvial deposits. Normally soft to firm consolidated, compressible silty clay, but can contain layers of silt, sand, peat and basal gravel. A stronger, desiccated surface zone may be present.

Peat is described by the GSNI as a partially decomposed mass of semi-carbonized vegetation which has grown under waterlogged, anaerobic conditions, usually in bogs or swamps.

The 1:1M Superficial Engineering Geology Map by the GSNI shows Fine Till (boulder) and Organic Soil on the site. The GSNI provides the following engineering geology information on these:

Fine Till (bouldery)

Description: Firm to very stiff or hard gravelly sandy CLAY with many cobbles and boulders, which may be strong. Often fissured particularly in the upper few metres. Occasional medium to extremely widely spaced interbeds and lenses of sand and gravel may be present. Generally low permeability flow through fissures and lenses/interbeds of sand and gravel where present.

Foundations: Variable but generally good foundation conditions, dependant on shear strength, consolidation characteristics and presence of water-bearing sand and silt layers/lenses. Potential for differential settlement associated with the presence of boulders should be accounted for in foundation design.

Excavation: Easy digging. Large boulders may require hard digging, hydraulic braking tools or possibly blasting. Excavations may be stable in the short term but water-bearing layers/lenses of silt, sand and gravel and fissuring will significantly decrease stability.

Engineered Fill: May be suitable as general cohesive fill depending upon grading, plasticity and water content. Separation of larger fraction may be necessary to meet grading requirement. Generally, should be placed as soon as possible after excavation and subject to minimum construction traffic when wet.

Site Investigation: Important to determine deposit thickness and lithological variation, including the presence of laminated silt and clay, water-bearing sand and gravel layers/ lenses and the size, strength and lithology of incorporated boulders.

Organic Soil

Description: Very soft to firm fibrous to amorphous PEAT. Deposits may be selectively worked to shallow depth in some areas. Very low to moderate permeability flow dominantly through matrix.

Foundations: Very poor foundation conditions. Very weak and highly compressible deposits acidic groundwater may pose a risk to buried steel and concrete. Specialist very low load or 'floating' foundations may be suitable in some cases but, where possible, deposits at surface should be removed or pile foundations to stronger deposits employed.

Excavation: Easy digging but poor trafficability may require specialist machinery. Requires immediate support and dewatering. Dewatering will lead to surface lowering and oxidation of peat.

Engineered Fill: Unsuitable for use as fill. May be suitable for reuse as topsoil if mixed with other material.

Site Investigation: Important to determine extent and depth of peat deposits. Groundwater acidity should be determined prior to selection of buried concrete.

Peat details

x4 peat cores were carried out across the site using a gouge auger. Peat cores were undertaken at Turbines T1-T4 and along access tracks where deep peat was encountered.

Each core is photographed, given a general description, water content estimate (B) and Von Post rating (H) (Table 3.1). Peat deposit characteristics vary across the site. All Peat Cores and photographs are displayed in Figure B.5 of this report. An examples peat core is shown below.

Source: Natural Power

Figure B. 5: Peat core photograph from peat probe position 108 showing firm dark brown plastic pseudo fibrous peat (H7/B2)

Hand shear vanes were undertaken at all peat core locations where there was sufficient peat for a reading. (Generally, peat depths >0.4m were appropriate). Undrained shear strength values are generally very low to medium strength across the locations.

None of the deposits are considered dry and have humification levels between H6 and H7.

3.2. Peat Depth Analysis

Natural Power carried out 589 peat probes across the site during the Phase I peat survey. Table 3.1 below presents the combined data collected from the survey.

Table 3.1: Peat probe data

Peat Depth	Number of probes	% (of total)
≤ 0.3m	366	62%
0.3m < x ≤ 0m	102	17%
0.5m < x ≤ 1.0m	107	18%
1.0m < x ≤ 2.0m	12	2%
2< x ≤ 3.0m	2	<1%

Source: Natural Power peat probing survey data. (Each percentage has been rounded to the nearest whole number, so may not equal 100%) Total probes 589.

The collected peat probe depths suggest that some areas mapped as peat by GSI data are in fact just very shallow peat topsoil soil deposits. The deepest pockets of peat in excess of 1 m have been avoided in the scheme layout.

Turbines with probing depths less than 0.50m are peat soil or topsoil. The peat depth interpolation map is appended to this report (Figure A. 8).

Peat Depth at Turbine Bases

Table 3.2 summarises the peat depths recorded across the proposed wind turbine location, borrow pits, construction compound and substation.

Table 3.2: Overview of Peat Depths at Turbines and Anciallary Structures

Depth Range	0 – 1.0m	1.0 – 2.0m	2.0m – 3.0m	>3.0m
Location	**Peat Depth Turbine Centre (m)**	**Peat Depth (m) Crane hardstanding**	**Slope Geometry (Degrees)**	**Comments**
T1	0.2	0.2	5	Located within moorland
T2	0.7	0.5	3	
T3	0.4	0.5	3	
T4	0.2	0.3	1	

Source: Natural Power

Peat Depth on Access Tracks

The peat depths across the proposed new access tracks are generally low, with a site wide average of 0.3m over all proposed new tracks. Deeper areas are confined to localised pockets. Table 3.3 summarises the mean peat depth along sections of the proposed new wind farm access tracks.

Table 3.3: Overview of Peat Depths at Track areas

Depth Range	0 – 1.0m	1.0 – 2.0m	2.0m – 3.0m	>3.0m
Location	**Average Peat Depth (m)**			**Comments**
Access Track Section 1 (Cut)	0.2			Located within moorland
Access Track Section 2 (Cut)	0.3			
Access Track Section 3 (Cut)	0.5			
Proposed Alternative Track Turning Head (Cut)	0.2			
Access Track Section 5 (Proposed Alternative Track) (Cut)	0.5			
Access Track Section 6 (Turning head) (Cut)	0.2			
Access Track Section 7 (Cut)	0.5			

Source: Natural Power

Estimation of Peat Shear Strength

Hand shear tests were carried out at core locations where peat depths allowed. Each test was carried out using a Geonor H-60 Hand Shear Vane Tester using a 33mm steel vane. The corrected HSV results are presented within Figure B.6. Locations for each peat core and HSV are presented on Figure A.10 in the appendices.

Source: Natural Power

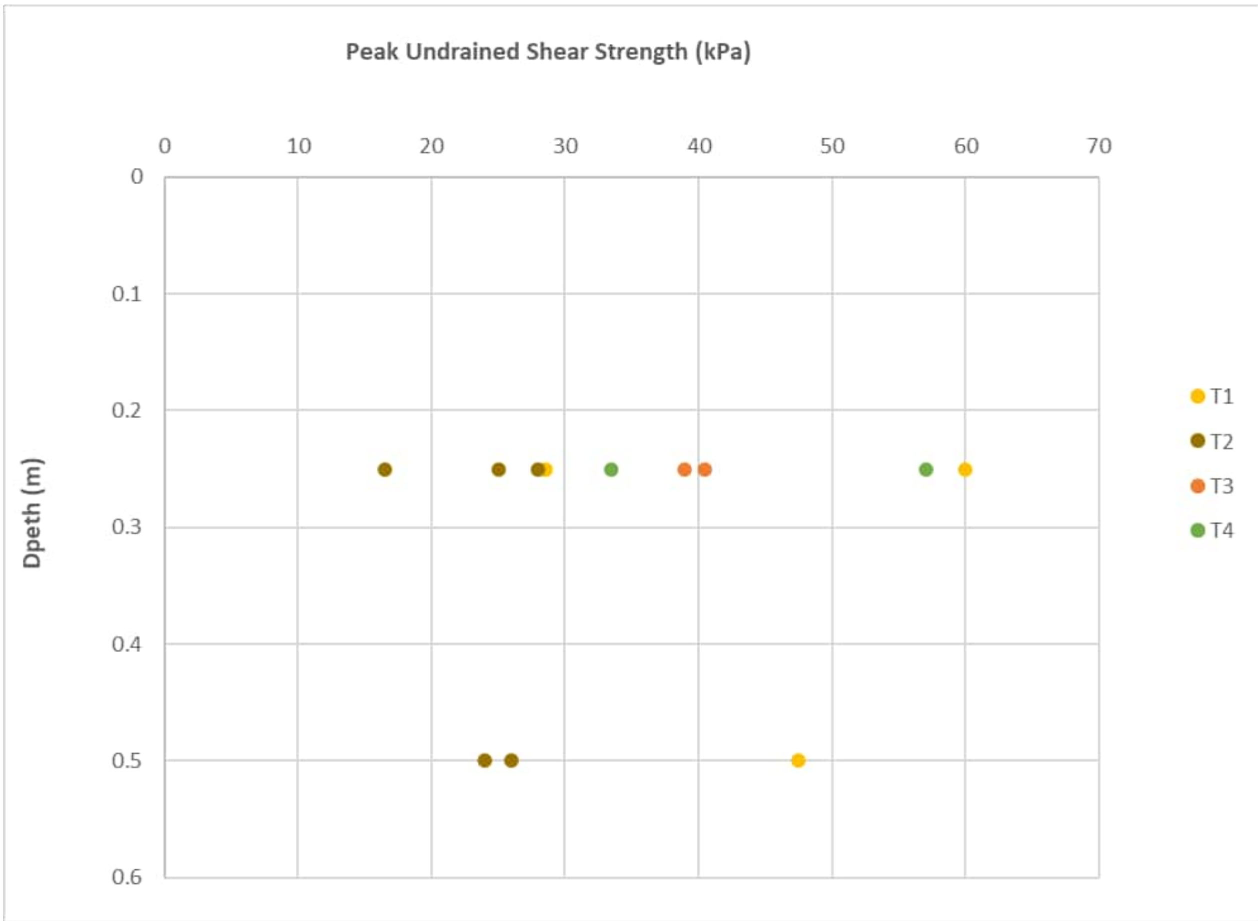


Figure B. 6: Peak undrained shear strength against depth across the site. *A, denotes previous turbine locations.

The peak undrained shear strength is seen to be variable within the peat deposits with no clear trend against depth. The site wide average is 35kPa (Medium strength) however a conservative value of 17kPa (Very low strength) is considered appropriate for the site wide slope analysis.

Humification of Peat

The peat cores undertaken on site are presented in Figure B.6. The peat has been characterised according to the von post classification (Von Post & Granland, 1924). Table 3.4 sets out the Von Post classification.

Table 3.4: Von Post Classfication

Degree of Humification	Peat Description
H1	Completely unconverted and mud-free peat which when pressed in the hand only gives off clear water. Plant remains are easily identified.
H2	Practically unconverted and mud free peat which when pressed in the hand gives off almost clear colourless water. Plant remains are still easily identifiable.
H3	Very slightly decomposed or very slightly muddy peat which when pressed in the hand gives off marked muddy water, but no peat substance passes through the fingers. The pressed residue is thickish. Plant remains have lost some of their identifiable features.
H4	Slightly decomposed or slightly muddy peat which when presses in the hand gives off marked muddy water. The pressed residue is thick. Plant remains have lost more of their identifiable features.
H5	Moderately decomposed or muddy peat. Growths structure evident but slightly obliterated. Some amorphous peat substance passes through the fingers when pressed but, mostly muddy water. The pressed residue is very thick.
H6	Moderately decomposed or very muddy peat with indistinct growth structure. When pressed approximately 1/3 of the peat substance passes through the fingers. The remainder extremely thick but with more obvious growth structure than in the case of unpressed peat
H7	Fairly well decomposed or markedly muddy peat but the growth structure can just be seen. When pressed about half the peat substance passes through the fingers. If water is also released this is dark and peaty.
H8	Well decomposed or very muddy peat with very indistinct growth structure. When pressed about 2/3 of the peat substance passes through the fingers and at times a thick liquid. The remainder consists mainly of more resistant fibres and roots.
H9	Practically completely decomposed or mud-like peat in which almost no growths structure is evident. Almost all the peat substance passes through the fingers as a uniform paste when pressed.
H10	Completely decomposed or mud peat where no growth structure can be seen. The entire peat substance passes through the fingers when pressed.

Source: Von Post & Granland, 1926.

The peat encountered on site is variable with von post classifications between H6 and H7 generally becoming fairly decomposed within the deeper peat deposits.

3.3. Solid Geology

The GSNI online viewer indicates the entire site is underlain by dykes and sills of the Upper Basalt Formation which is Palaeogene (43 - 66 million years ago) in age. To the west of the site boundary, this formation rests conformably on the Ulster White Limestone Group. The bedrock geology is shown in Figure A. 9. In Appendix A.

The 1:1M Bedrock Engineering Geology Map by the GSNI shows Basaltic rock on the site. The GSNI provides the following engineering geology information on this:

Description: Very strong medium, irregular or columnar jointed generally dark-coloured fine-grained BASALTIC-ROCK. May weather to gravel and/or gravelly clay beyond the limit of Anglian glaciation in SW England. In Northern Ireland, may be locally altered to very weak clay-rich rock. Medium to very low permeability flow is through discontinuities. Includes ANDESITIC-ROCK, PHONOLITIC-ROCK other fine-grained mafic and ultra-mafic igneous rocks. Often associated with interbedded tuffs.

Foundations: Usually very good foundation conditions when fresh or slightly weathered. However, highly weathered and altered rock (and possible presence of palaeosols) may need to be accounted for in foundation design.

Excavation: Highly weathered zones may be excavatable by hard digging or ripping in some areas but blasting usually required for fresher material, depending spacing and orientation of discontinuities.

Engineered Fill: Suitable as selected granular fill if care taken in selection and abstraction. Some basalts may exfoliate to a slight extent after long periods of weathering.

Site Investigation: Important to determine spacing, orientation and nature of discontinuities and depth and properties of weathered/altered zone materials, including the possible presence of tuff layers and palaeosols.

No outcrops of bedrock were observed during the site survey.

3.4. Hydrogeology

Base flow is provided to the streams and lower areas of the site by the water-saturated peat deposits. Drainage is dominated by overland flow due to impermeable clay rich subsoils and impermeable bedrock.

The site is underlain by the basalt bedrock, classed by the GSNI as a locally important aquifer. Hydraulic conductivity varies from low to moderate; some primary conductivity in the weathered horizons, but principally secondary development of joints and other fissures. Sustainable borehole yields range from only 0.5l/s to 20l/s, a yield between 5 and 10l/s is however typical.

Additionally, groundwater may be present in limited quantities with superficial deposits of peat and till found across the site.

3.5. Hydrology, Flooding and Draining

There are multiple natural watercourses which intersect the site, and which drain northward to join the Curley River which runs east to west across the northern part of the site. These watercourses start as shallow wet flushes sourced and join to form shallow streams and associated surface water that have shallow or incised valley types. The watercourses have been artificially altered in some places. There are multiple man-made elongate drainage features associated with commercial forestry and farming practices across the site, in the area north of the A37. The Northern Ireland flood map[1] does not indicate any significant areas at risk from flooding.

[1] https://dfi-ni.maps.arcgis.com

3.6. Designated Sites and Receptors

According to the Natural Environment Map Viewer[2], the Site is within the Binevenagh Area of Outstanding Natural Beauty. In the northern part of the site, there is a single Areas of Special Scientific Interest; the River Roe and Tributaries ASSI (River, Oakwood with Atlantic Salmon and Otters). Therefore, special care will be required to ensure there is no disruption or environmental impacts to this key habitat during any site works.

As identified in the analysis of historical maps (section 2.4), two archaeological features are recorded within the site boundary. However. neither of these features are positioned close to the peat deposits that were identified during the survey.

[2] https://www.daera-ni.gov.uk/services/natural-environment-map-viewer

4. Peat Slide Hazard – Risk Assessment Method

4.1. Processes Contributing to Peat Instability

The key principals of the peat slide risk assessment are presented below. Discussions of the factors which contribute to peat failure have been presented in Table 4.1.

Table 4.1: Contributory Factors to Peat Instability

Factor	Discussion
Groundwater Infiltration	There are two processes which may facilitate groundwater infiltration: • Periods of drying, resulting in cracking of the peat surface; and • Slope creep resulting in additional tension cracks. Drying out of the upper peat, particularly in areas of thinner peat, is likely to result in the development of near-surface cracks which could facilitate ingress of water into the peat.
Surface Loading	Any mechanisms which increase the surface load on a peat deposit can increase the likelihood of failure. This can include surface water ponding and surcharge loading, for example; construction works, stockpiling and forestry operations.
Vegetation Loss	Loss of vegetation can have a negative impact, making the peat susceptible to weathering, increasing rates of infiltration and a loss of strength.
Soil Weathering/Erosion	Weathering can weaken in-situ peat materials and destabilise a slope system. This may be in the form of weathering of peat or underlying mineral soils which could reduce shear strength at the peat/ mineral soil interface. Vertical cracking and slope creep may slowly break down peat structure over long periods of time. This can develop into peat 'hagging', which is a strong indication that natural weathering processes are ongoing. Peat hags expose the peat to increased weathering rates and may provide preferential surface water flow pathways. There was no marked peat hagging across the Site.
Precipitation	The likely failure mechanism following a period of heavy rainfall is linked to the infiltration of surface water. There is a resulting build-up of pore water pressures within the soils and therefore reduced effective shear strength. This may be focussed within the peat deposit or at the interface between the peat and underlying mineral soil. Secondary effects may include swelling of the peat deposit and increased loading due to surface water ponding. Snow and subsequent melt can have a similar effect.
Slope Morphology	There are three main effects arising from slope morphology: • Firstly, the concentration of tensile stress at the apex of a convex slope predisposes the slope for failure initiation at that point. In a convex slope the material lower down supports the material above which is held in compression. A concave slope has the opposite characteristics as material at the base maintains the apex in tension. • Secondly at the point of maximum slope convexity, because of favourable down-slope drainage conditions, a body of relatively well-drained and relatively strong peat material develops. This body of peat acts as a barrier providing containment for growth of peat upslope. This relatively well drained body of peat can subsequently fail due to a build-up of lateral pressure on the upslope face. In this scenario the slope is not supported from below so eventually the lateral pressures exceed the forces resisting sliding. The apex or point of convexity is also a likely initiation point for slope failure due to the slope tension being concentrated at this point. • Thirdly, a failure mechanism, analogous to a piping failure underneath a dam, is postulated where springs are present in locations immediately down-slope of the relatively well drained peat body. Under these circumstances high pore pressure gradients within the peat can lead to hydraulic failure and undermining of the relatively well drained peat body resulting in a breach and loss of lateral support to peat upslope. Evolving slope morphology can be significant, for example, in the case of slope undercutting by water erosion. Any mechanism by which mass is removed from a slope toe or deposited on a slope crest will contribute to instability.

Factor	Discussion
Peat Depth & Slope Angle	Peat slides correspond in appearance and mechanism to translational landslides and tend to occur in shallow peat (up to 2.0m) on slopes between (5° – 15°). A great majority of recorded peat landslides in Scotland, England & Wales are of the peat slide type. MacCulloch, (2005) highlights that a slope angle of 20° appears to be the limiting gradient for the formation of deep peat. Therefore, the risk assessment has assigned slope angles >20° to be an unlikely contributory factor to failure. Slope angle indicators and corresponding probability factors have been similarly adapted from MacCulloch, (2005). Boylan et al, (2008) indicates that most peat failures occur on slope angles between 4° and 8°. It is postulated that this may correspond to the slope angles that allow a significant amount of peat to develop that over time becomes potentially unstable. Thus, for this assessment <3degrees has been assigned a low risk.
Hydrology	Natural watercourses and artificial drainage measures have often been identified as a contributory factor of peat failure. Preferential drainage paths may allow the migration of water to a failure plane therefore triggering failure when groundwater pressures become elevated. Within a peat mass, sub surface peat pipes can enable flow into a failure plane and facilitate internal erosion of slopes. It is also noted that in some instances, agricultural works can lead to the disturbance of existing drainage networks and cause failures. Drainage ditch networks are present across parts of the Site as a result of historical upland agricultural drainage practices.
Existing / Relict Failures	The presence of relict failures and any indication of previous instability are often important, indicating that site conditions exist that are conducive to peat failure. Relict peat slides may be dormant over long periods and be re-activated by any number of the contributory factors discussed in this table.
Anthropogenic Effects	Human impact on peat environments can include a range of affects associated with wind farm construction. Activities such as drainage, access tracks across peat, peat cutting, and slope loading are all examples. Rapid ground acceleration is one such example where shear stress may be increased by trafficking or mechanical vibrations.

Source: Natural Power

4.2. Peat Failure Modes

Peat failure in this assessment refers to the mass movement of a body of peat that would have a significant adverse impact on the surrounding environment or infrastructure. This definition excludes localised movement of peat, for example movement that may occur below an access track, creep movement or erosion events and failures in underlying mineral soils.

The potential for peat failure across the development is examined with respect to the activities envisaged during construction and operation of the wind farm. There are several classification systems for the mass movement of peat that were drawn together by PLHRAG, (2017).

Hutchinson (1988) defines the two dominant failure mechanisms namely peat flows and peat slides.

- Peat Flows & Bog Bursts: are debris flows involving large quantities of water and peat debris. These flow down slope using pre-existing channels and are usually associated with raised bog conditions.
- Peat Slides: comprise intact masses of peat moving bodily down slope over comparatively short distances. A slide which intersects an existing surface water channel may evolve into a debris flow and therefore travel further down-slope. Slides are historically more common within blanket bog settings.

Due to the discrete areas of peat recorded across the development widespread instability comprising peat flows and bog bursts are considered unlikely at this stage. Smaller scale peat slides and debris flows are therefore the focus of the study and characterised by the definition above.

4.3. Geotechnical Principles

The main geotechnical parameters that influence peat stability are:

- Shear strength of peat;
- Peat depth;
- Pore water pressure (PWP); and
- Loading conditions.

The stability of any slope is defined by the relationship between resisting and destabilising forces. In the case of a simplified infinite slope model with a translational failure mode, sliding is resisted by the shear strength of the basal failure plane and the element of self-weight acting normal to the failure plane. The stability assessments within this report considers an undrained 'total stress' scenario when the internal angle of friction (φ') = zero.

An undrained peat deposit may be destabilised by; mass acting down the slope, angle of the basal failure plane and any additional loading events. The ratio between these forces is the Factor of Safety (FoS). When the FoS is equal to unity (1) the slope is in a state of 'limiting equilibrium' and is sensitive to small changes in the contributory factors leading to peat failure.

The infinite slope model as defined in Skempton et al. (1957) has been adapted to determine the FoS of a peat slope. A modified approach has been used; assuming a minimum FoS (Typically 1.3 after, BS6031: 2009).

The infinite slope analysis is based on a translational slide. This analysis adopts total stress (undrained) conditions in the peat. This state applies to short-term conditions that occur during construction and for a time following construction until construction induced pore water pressures (PWP) dissipate. (PWP requires time to dissipate as the hydraulic conductivity can be low in peat deposits). The following assumptions were used in the analysis of peat deposits across the Site:

- The groundwater is resting at ground level;
- Minimum acceptable factor of safety required is 1.3;
- Failure plane assumed at the basal contact of the peat layer;
- Slope angle on base of sliding assumed to be parallel to ground surface and that the depth of the failure plane is small with respect to the length of the slope;
- Thus, the slope is considered as being of infinite length with any end effect ignored;
- The peat is homogeneous.

The analysis method for a planar translational peat slide along an infinite slope was for calculated using the following equation in total stress terms highlighted by MacCulloch, (2005) and originally reported by Barnes, (2000):

$$\mathbf{F = Cu / (\gamma * z * \sin\beta * \cos\beta)}$$

Where:

- F = Factor of Safety (FoS)
- Cu = Undrained shear strength of the peat (kPa)
- γ = Bulk unit weight of saturated peat (kN/m^3)
- z = Peat depth in the direction of normal stress
- β = Slope angle to the horizontal and hence assumed angle of sliding plane (degrees)

Un-drained shear strength values (Cu) are used throughout this assessment. Effective strength values are not applicable for the case of rapid loading of the peat during construction hence the Barnes, (2000) formula cited above, has been adopted throughout.

In this study a minimum undrained shear strength of 17kPa has been assumed for the peat to allow for the calculation of FoS. This was based off the minimum value obtained from hand shear vane tests carried out for the Dunbeg South Wind Farm Peat Slide Risk Assessment (document no. 1149761). The Factor of Safety Map for both the minimum undrained shear strength (17kPa) and surcharged case are shown in Appendix A. In both cases, there were no areas within the site boundary that had an FoS of less than 2.0.

4.4. Risk Assessment Method

Natural Power has undertaken this assessment following the principles of the Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (Scottish Executive 2017). This guide provides best practice methods which should be applied to identify, mitigate and manage peat slide hazard and associated risks in respect of consent application for electricity generation projects in the UK.

This guidance clearly acknowledges risk assessment as an iterative process and as such this assessment should be updated throughout the development and as more information becomes available particularly as pre-construction phases are reached.

A semi quantitative risk assessment has been used to determine the risk of peat failure. The methodology is defined in PLHRAG, (2017) and has been augmented with methods set out by Clayton (2001) & MacCulloch, (2005) Risk factors are summarised on Table 4.2.

The assessment uses the numerical stability analysis and presents results for factor of safety (FoS) across the Proposed Development. The calculated FoS, is complimented with an assessment of the slope angle, peat depth and key geomorphological features. A peat slide risk map has been produced using GIS computation of these factors. (Figure A.5 in Appendix A). The risk map is used screening wide areas of the study area, additional engineering judgement has been applied according to discrete conditions within Table 6.1 of this report.

Table 4.2: Risk Factors

Contributory Factor	Comment	Criteria	Probability	Scale
Peat Depth* (A)	Peat slides tend to occur in shallow peat (up to 2.0m) on A great majority of recorded peat landslides in Scotland, England & Wales are of the peat slide type.	0 – 0.5 m	Negligible	1
		>3.0 m	Unlikely	2
		0.5 – 1.0 m	Likely	3
		2.0 – 3.0 m	Probable	4
		1.0 – 2.0 m	Almost certain	5
Slope Angle* (B)	It has been acknowledged that peat slide tends to occur in shallow peat (up to 2.0m) on slopes between 5º and 15º. Slopes above 20º tend to be devoid of peat or only host a thin veneer deposit.	0 – 3º	Negligible	1
		>20º	Unlikely	2
		4 – 9º	Likely	3
		16 – 20º	Probable	4
		10 – 15º	Almost certain	5
FoS* (C)	Values are from Infinite slope model using Cu characteristic value of 10kPa derived from hand shear vane in-situ testing. Slope angle and peat depth also input to this factor.	≥ 1.3	Negligible	1
		1.29-1.20	Unlikely	2
		1.10-1.19	Likely	3
		1.00-1.09	Probable	4
		<1.0	Almost certain	5
Cracking (D)	Visual assessment undertaken in the field during detailed probing survey and covers the same extends of this survey. Field workers examined for evidence of any major crack networks which may allow surface water to penetrate the peat mass.	None	Negligible	1
		Few	Unlikely	2
		Frequent	Likely	3
		Many	Probable	4
		Continuous	Almost certain	5

Contributory Factor	Comment	Criteria	Probability	Scale
Groundwater (E)	Challenging to evaluate without very detailed mapping and/or intrusive data. Look for entry / exit points. Evidence of surface hollows, collapse features at surface reflecting evidence of sub-surface peat pipe network, audible indicators including the sound of sub-surface running ground water surrounding proposed infrastructure locations	None Few Frequent Many Continuous	Negligible Unlikely Likely Probable Almost certain	1 2 3 4 5
Surface *Hydrology (F)	Ranging from wet flushes to running burns to hags. Must be evaluated in conjunction with the season and weather preceding the site visit. Artificial drains (grips) have also been identified across the Site. Their presence is generally linked to historical peat cutting sites which are factored into the risk assessment.	None Few Frequent Many Continuous	Negligible Unlikely Likely Probable Almost certain	1 2 3 4 5
Previous Instability (G)	Visual survey, scale and age are important as small to medium relict failures may be easy to detect but very large ones may require remote imaging. Recent failures should be obvious due to the scar left.	None Few Frequent Many Continuous	Negligible Unlikely Likely Probable Almost certain	1 2 3 4 5
Land Management (H)	Anthropogenic influences: forestry operations and removal of vegetation can be associated with de-stabilising peat deposits. This can occur as a result to surface disturbance and remoulding of peat through excavation, vehicle movements and loading. Changes in land use activities may also be associated with changes in drainage conditions. Criteria based on evidence of disturbance of peat deposit, i.e., broken surface, scarring or disrupted hydrology. For Dunbeg South Extension Wind Farm a land management scale of '2' has been chosen due to the evidence of peat cutting observed during the site walkover and peat probing survey.	None Few Frequent Many Continuous	Negligible Unlikely Likely Probable Almost certain	1 2 3 4 5

Note: Denotes where risk factor applied to GIS model only*

Environmental Impact Zones based on proximity buffer zones applied to the main watercourses within the Proposed Development. Watercourses have been determined to be a primary sensitive receptor to a peat failure event. Table 4.3 denotes the potential impact scales to the environment. Location of existing or planned infrastructure downslope from Proposed Development is also qualitatively assessed in Table 6.1.

The distance to main watercourses has been used as the primary means of impact assessment within the risk assessment. Where watercourses are ephemeral/transient or minor artificial features they were not included as direct receptors. The impact distances are based on experience and guidance values provided within MacCulloch, F. (2006).

The approach advocated by MacCulloch is to divide the survey area into Environmental Impact Zones driven by site specific criteria and survey information. It is noted that defining a definitive distance for impact is extremely challenging due to the complex nature of terrain, peat depth, flow mechanics will all influence the flow path characteristics. At present there exists no defined method to accurately define the flow distances. Therefore Table 4.3 within report provides a framework estimate for the purposes of repeatable and representative semi quantitative risk mapping. Natural Power considers this approach alongside the multitude of site-specific factors which are considered during the risk assessment a valid approach for this development.

Distances to the main watercourses have been assessed within GIS and input to the risk mapping (Figure A.11 in Appendix A). The proximity classes are based on Table 4.3 within the report.

Table 4.3: Environmental Impact Zonation

Criteria	Potential Impact	Scale
Proposed access road/turbine within 50m of watercourse	High	4
Proposed access road/turbine within 50-100m of watercourse	Medium	3
Proposed access road/turbine within 100-150m of watercourse	Low	2
Proposed access road/turbine greater than 150m from watercourse	Negligible	1

Source: Natural Power

For each main infrastructure element, the Risk Ranking is assessed from the combined probability of occurrence for the main contributory factors which are greater than (1), multiplied by the highest impact scale. Table 4.4 identifies the risk ranking based on concepts of PLHRAG, (2017).

The risk to existing or proposed infrastructure has been scoped out and is not considered a determining factor to the severity of a peat slide over the proposed development. This is due to the spacing of the proposed layout and the large distance from existing settlements.

Access track sections have screened through the GIS based stability risk model and the elevated risk sections reviewed with further risk analysis and control measures. It is important to highlight that the full scope of the proposed infrastructure layout has been subject to field survey and review of stability risk factors.

Table 4.4: Risk Rankinng and Actions

Risk Ranking Score	Actions
17 - >25	**High**: Avoid project development at these locations.
11 - 16	**Medium**: Project should not proceed unless risk can be avoided or mitigated at these locations, without significant environmental impact, to reduce risk ranking to low or negligible.
5 - 10	**Low**: Project may proceed pending further investigation to refine risk assessment and mitigate hazard through relocation or re-design at these locations.
1 - 4	**Negligible**: Project should proceed with monitoring and mitigation of peat landslide hazards at these locations as appropriate.

Source: Natural Power

5. Stability Analysis of Peat Slopes

5.1. Introduction

Assessing the desk study information, site layout and ground investigation data; a preliminary infinite slope analysis and subsequent peat slide risk assessment has been undertaken. Slope stability was assessed at each turbine location using slope angle measurements, peat depth, and undrained shear strength measured using an in-situ hand shear vane. This assessment should be viewed as semi – quantitative as it draws on both qualitative assumptions and numerical parameters.

For each proposed turbine location, the recorded peak undrained shear strength values have been input into the infinite slope model to calculate the potential factor of safety against peat slide.

5.2. Numerical Slope Analysis

A preliminary numerical slope analysis has been undertaken. Numerical slope stability was assessed across the development location using slope angle measurements (DTM derived), peat depth, and the minimum undrained shear strength measured using an in-situ hand shear vane. In addition, a 20 kPa surcharge has been modelled thus the sensitivity of slopes to failure is assessed under construction conditions. GIS modelling was used to produce a factor of safety (FoS) map for the proposed development (Figure A.12 in Appendix A).

The numerical stability analysis indicates no potential for translational peat slide at proposed turbine and infrastructure locations under current equilibrium and modelled surcharge loading conditions. The natural slope condition has been calculated to be stable and was observed to be so around the wind turbine locations during the field survey.

In the absence of more detailed sub-surface data, the surface slope angle has been used as a reference to the likely slope surface angle at the base of the peat in the analysis. The potential of disturbing sensitive peat deposits during pre-construction survey access should be considered during future phases of intrusive investigation work.

The FoS accounts for a 20 kPa surcharge representing scenarios at infrastructure such as temporary storage stockpiles. A Peat Management Plan (PMP) shall detail mitigation measures for peat stockpiling. Slope stability assessments would be carried out during design phase for site tracks, hardstands and other relevant structures ensuring the proposed design results are safe, stable and environmentally compliant.

6. Peat Slide Risk Assessment

Risk rankings for the proposed wind farm infrastructure positions are presented in Table 6.1. Across each turbine the qualitative risk scoring has been provided along with key inset map information.

The peat slide risk map, Figure A.10 in Appendix A; provides a representation of the risk zonation across the Site and includes all infrastructure elements. The map is based on a Site wide GIS analysis and should not be viewed in isolation without the narrative of this report. The Risk Mapping does not show residual risk following implementation of targeted or routine control measures.

The indicative residual risk rating is provided assuming implementation of appropriate mitigation measures. Further detail of the risk assessment is highlighted within the preliminary geotechnical risk register presented in Table 6.3.

Table 6.1: Hazard Ranking Proposed Turbine Location

WTG ID	Development Infrastructure	Environmental	Contributary Factors (Probability/Exposure		Risk Ranking
T01	1	1	Probe Depth (Mean = 0.2m)	1	2 (Negligible)
			Slope Angle (2°)	1	
			FoS (Min = Cu_{min} > site mean)	1	
			Peat cracking / Infiltration	1	
			Groundwater Flow	1	
			Hydrology	1	
			Previous Instability	1	
			Land Management	2	

WTG ID	Development Infrastructure	Environmental	Contributary Factors (Probability/Exposure	Risk Ranking

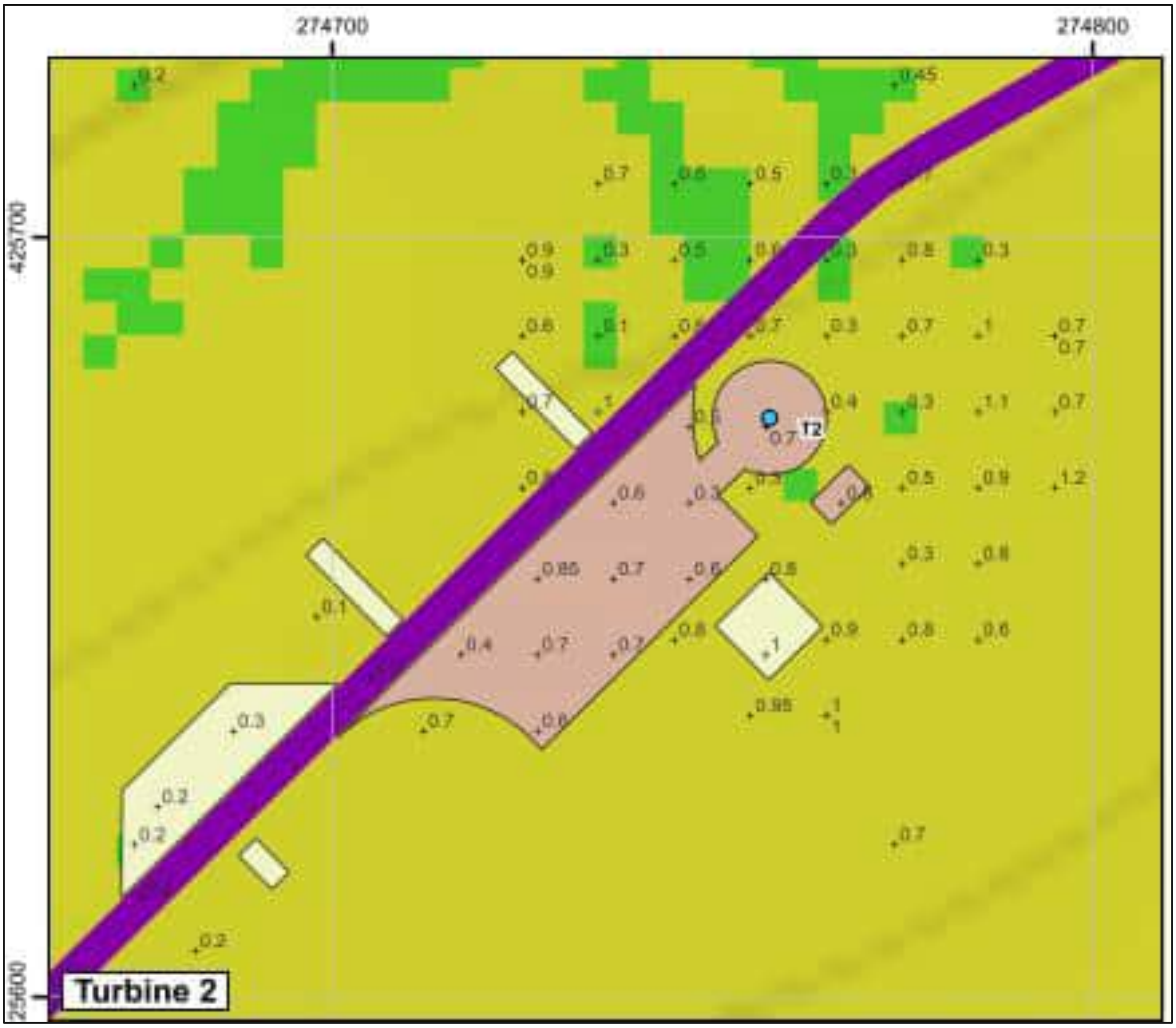
T01 Location – OS Mapping 1:25,000 – 1:5000 Scale

Location Specific Mitigation:

None.

T02	1	1	Peat Depth (Mean = 0.7m)	3	**5 (Low) Peat**
			Slope Angle (3°)	1	
			FoS (Min = Cu_{min} > site mean)	1	
			Peat cracking / Infiltration	1	
			Groundwater Flow	1	
			Hydrology	1	
			Previous Instability	1	
			Land Management	2	

WTG ID	Development Infrastructure	Environmental	Contributary Factors (Probability/Exposure		Risk Ranking



T02 Location – OS Mapping 1:25,000 – 1:5000 Scale

Location Specific Mitigation:

The slope angle is conducive for peat sliding. Care should be taken when stockpiling peat around this turbine to avoid steeper gradients.

T03	1	1	Peat Depth (Mean = 0.4m)	1	**2 (Negligible)**
			Slope Angle (2°)	1	
			FoS (Min = Cu_{min} > site mean)	1	
			Peat cracking / Infiltration	1	
			Groundwater Flow	1	
			Hydrology	1	
			Previous Instability	1	
			Land Management	2	

WTG ID	Development Infrastructure	Environmental	Contributary Factors (Probability/Exposure)		Risk Ranking

T03 Location – OS Mapping 1:25,000 – 1:5000 Scale

Location Specific Mitigation:

None.

T04	1	1	Peat Depth (Mean = 0.2 m)	1	**2 (Negligible)**
			Slope Angle (2°)	1	
			FoS (Min = Cu_{min} > site mean)	1	
			Peat cracking / Infiltration	1	
			Groundwater Flow	1	
			Hydrology	1	
			Previous Instability	1	
			Land Management	2	

WTG ID	Development Infrastructure	Environmental	Contributary Factors (Probability/Exposure		Risk Ranking

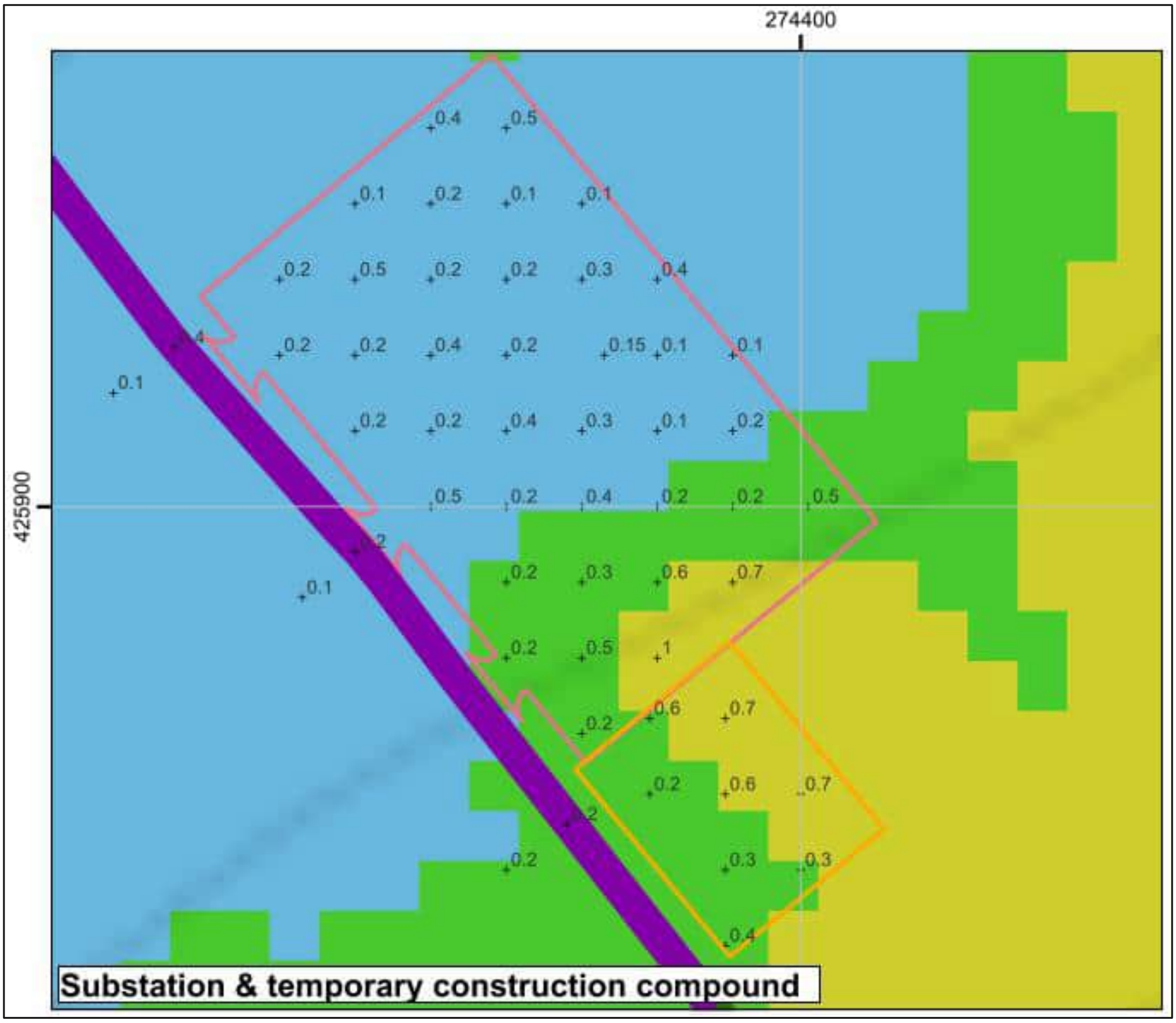
T04 Location – OS Mapping 1:25,000 – 1:5000 Scale

Location Specific Mitigation:

None.

Construction Compound	1	1	Peat Depth (Mean = 0.4m)	1	**2 (Negligible)**
			Slope Angle (2°)	1	
			FoS (Min = Cu_{min} > site mean)	1	
			Peat cracking / Infiltration	1	
			Groundwater Flow	1	
			Hydrology	1	
			Previous Instability	1	
			Land Management	2	

WTG ID	Development Infrastructure	Environmental	Contributary Factors (Probability/Exposure	Risk Ranking



Construction Compound – OS Mapping 1:25,000 – 1:5000 Scale

Location Specific Mitigation:

None.

Source: Natural Power

6.1.1. Turbine Bases

Table 6.2 below summarises the risk assessment outcome and hazard ranking assignments for each turbine location. The principal contributory factors and impact scales used to derive these assignments are also stated.

Table 6.2: Risk Assessment Outcome and Hazard Ranking Assignment

Turbine ID	Risk Ranking Baseline	Principal Contributary Factors in Risk Assessment	Risk Ranking and Targeted Mitigation and Best Practice Construction
T01	**(Negligible)**	Low Peat	Negligible
T02	**(Low)**	Low Peat.	Negligible
T03	**(Negligible)**	Low Peat	Negligible
T04	**(Negligible)**	Low Peat.	Negligible
Construction Compounds	**(Negligible)**	Low Peat	Negligible

Source: Natural Power

**T01 is in an area with potential for localised higher risk due to their proximity to a watercourse. The risk is negligible due to shallow peat at the turbine however extra care should be taken to ensure best practice techniques during peat excavation and storage.*

The risk assessment reflects the probability of peat material entering the surface water course and being entrained to an offsite receptor without any mitigation. The wider geomorphological assessment and evidence from recorded peat depths would indicate that a large-scale translational mass movement of peat deposits is very unlikely.

6.1.2. Access Tracks

In addition to the turbine bases the sections of track have also been reviewed across the site. The areas of track with the deepest peat are around Turbines T2 and the section of track directly northwest of T2.

The following control measures are required at all areas of track identified as crossing medium-risk or high-risk areas of Figure A.10, in order to reduce the risk level to low:

- Cross track drainage which prevents any ponding or build-up of groundwater pressure within the peat upslope or beneath the access infrastructure. Where possible existing drainage systems should be utilised and maintained (including artificial drains);
- No stockpiling or surcharging of the peatland along specific access track sections identified as high or medium risk on Figure A.10.
- A system of ongoing monitoring throughout the construction phase should be in effect to monitor any movement in the peat. A rapid reaction strategy should be developed to ensure measures can be deployed to protect the watercourse in the event of any movement. This may include installation of downslope retaining systems to prevent peat material entering the watercourse and robust watercourse protection measures at the crossing point.
- Floating access track construction has been suggested for multiple sections of the track to leave the peat deposits in-situ, this generally reduces disturbance to the peat and the groundwater flow within the peat land.

6.2. Preliminary Geotechnical Risk Register

The preliminary risk register for development wide hazards is listed in Table 6.3 below. Key. Control measures for the hazards have also been identified. A geotechnical risk register should be utilised on an individual turbine basis throughout the construction phase and amended accordingly as new information is received.

Table 6.3: Preliminary Geotechnical Risk Register

Hazard	Cause	Location	Consequence
Peat Landslide / Bog Burst / Peat Flow	High rainfall, and increased surface water infiltration leading to build up of pore water pressure	**T1, T2, T3, T4** **Site Wide**	Instability of peat deposits and underlying superficial deposits around earthworks. Contamination of natural watercourses and damage to hydrological systems. Harm to personnel and damage to plant / equipment; Destruction of built infrastructure
Mitigation	Due consideration given to prevailing ground and weather condition when scheduling construction works. I.e. avoid opening new excavation during heavy precipitation and ensure sufficient drainage measures are in place to support construction activities. Ensure a contingency is in place to concentrate on more suitable construction activities during wet weather. The drainage design should be such that its construction is in sequence with providing necessary drainage to new areas of excavation and construction in advance of works. I.e. ensure cut-off ditches are in place prior to opening new excavation. The drainage design should as far as practicable preserve the natural hydrological regime and should not inundate areas with run-off which were previously not subjected to such affects. Monitoring weather forecast with site specific weather station; Monitoring (visual) regular site inspection to detect early indications of ground movement (tension cracks, groundwater issues).		
Peat Landslide / Bog Burst / Peat Flow	Concentrated loads placed at the top of slope system or on marginally stable peat deposits	**T1, T2, T3 , T4** **Site Wide**	Contamination of natural watercourses and damage to hydrological systems; Rapid ground movement and mobilisation of material down slope of construction operations; Harm to personnel, plant and equipment; Destruction of temporary or permanent construction works;
Mitigation	At these locations, robust and strict controls on the phasing and pace of construction must be in place. This would be most effectively managed through the CMS. Plant operatives should be briefed in detail regarding the side-casting and stockpiling of materials. Higher risk areas particularly at T06 and T08 should be demarked by high visibility ticker tape or similar as a warning not to stockpile any materials in the deeper peat areas. Ensure the peat depth contour mapping is available and has a high visibility during construction; A programme of frequent inspections should be implemented during excavation and access track construction works. This should be carried out by suitably experienced and qualified personnel. Where stockpiles are placed in suitable areas, these should be closely monitored through the use of high accuracy GPS level and visual survey.		
Peat Landslide / Bog Burst / Peat Flow	Increased subsurface groundwater flow and 'piping' failure beneath natural peat deposits, temporary and permanent earthworks	**T1, T2, T3, T4** **Site Wide**	Localised instability associated with temporary and permanent earthworks; Triggering of mass movement of peat material down slope causing harm to personnel, plant and equipment;
Mitigation	Ensure geotechnical design prevents blockages of groundwater flow. This may be achieved through the use of free draining fills and ensuring temporary and permanent earthworks do not cause the build-up of groundwater pressures. A programme of geotechnical inspections should be implemented throughout construction phase. Ensuring focus extends beyond immediate areas of construction, both up-slope and down-slope to detect any unforeseen effects on stability		
Bearing Capacity Failure (Peat Surface)	Increased loading of low shear strength deep peat deposits	**T2, T3, T4** **Site Wide**	Localised instability and settlement associated with temporary and permanent earthworks;

Hazard	Cause	Location	Consequence
			Triggering of mass movement of peat material down slope causing harm to personnel, plant and equipment; Contamination of natural watercourses and damage to hydrological systems from peat material mobilised down slope;
Mitigation	Due consideration given to the prevailing ground and weather conditions when scheduling site works Ensure detailed peat depth contour plan to be used in construction planning and design; Use of appropriate plant machinery (low ground pressure and long reach to avoid over loading peat deposits) A programme of geotechnical inspections will be implemented during excavation works Geotechnical monitoring post-construction		
Peat Failure	Mass movement of temporary storage mounds and bunds	**T2, T3, T4** **Access Track**	Localised instability and settlement associated with temporary and permanent earthworks Triggering of mass movement of peat material down slope causing harm to personnel, plant and equipment;
Mitigation	Storage site selection and stockpile design by a suitably qualified and experienced geotechnical engineer; Routine maintenance and inspection of peat storage mounds		
Creep, long term settlement of structures	Tracks or hardstand founded on peat and/or poor or variable foundation soils	**T1, T2, T3, T4** **Access Track**	Ongoing settlement and damage of infrastructure, e.g. damage to access track running surface.
Mitigation	Contingency of routine maintenance of infrastructure and drainage elements to ensure longer term issues do not cause a build-up of effects leading to higher level consequences e.g. larger scale instability		

Source: Natural Power

7. Conclusions

The peat depths across the site are variable, with the proposed infrastructure layout avoiding the deepest areas of peat. None of the turbines are within significant peat deposits that have the potential for peat sliding.

The following construction related factors to peat slide are highlighted for consideration:

- Movement can occur following over-loading of peat slopes, e.g. by placement of fill, stockpiling and end-tipping directly onto peat slopes;
- Suitability of drainage measures and the prevailing groundwater conditions are also key factors to consider during construction. Increasing pore water pressures within peat deposits decreases the stability of a slope;
- In extreme events, peat can act as a viscous fluid and travel over very shallow slopes. The re-working or excessive handling of peat can reduce the shear strength to residual levels and hence lead to ‘liquid’ peat behaviour;
- The rate of construction can have a major influence on the stability of peat land environments. Rapid loading and limited time for excess pore pressure dissipation can also decrease the stability state of peat slopes;
- Excavation across a side slope, a convex slope / break in slope can induce peat failure;
- Therefore, the most significant but highly unlikely impact is death or injury to site personnel. More likely is damage of the environment and disruption to the proposed infrastructure leading to time and cost impacts.

It should be noted that where peat probes indicate shallow depths 0.1m to 0.8m that the deposits are likely to be composed of a topsoil and mineral subsoil, thus the risk of peat sliding is none.

The mean un-drained shear strength determined across the Development is (26kPa). This indicates peat of low shear strength. A conservative characteristic value of 17kPa has been used in the slope stability modelling (representing the minimum recorded value).

The risk ranking produced in this report are a combination of the overall likelihood with the potential environmental/impact effect of a peat instability event. With increased proximity to watercourses exposure of such an event is vastly increased as watercourses act as a sensitive off-site receptor and can carry peat debris to further offsite receptors. In addition, where relevant the position of proposed internal site infrastructure and assets has been considered.

The initial risk rankings are based on the risk of peat failure occurring without appropriate mitigation and control measures in place during construction. It should be highlighted that through geotechnical risk management, strict construction management and implementation of relevant control measures, this shall reduce the risk of peat failure across the development to residual low levels.

The risk assessment should be reviewed prior to construction and further refined following intrusive ground investigation and detailed infrastructure design.

8. Recommendations

The peat slide risk assessment cites key control measures which are required to ensure the risk of peat slide remains at residual (low) levels. However, there should be wider consideration of these measures across all areas of the proposed development which may be influenced by the proposed construction. This is critical where infrastructure may impact terrain and slope conditions beyond the proposed working areas.

- Location specific mitigation has been described within Table 6.1. This includes restrictions on peat storage and stockpiling during the construction process, floating access track and drainage outfall design.
- A detailed intrusive ground investigation would be carried out (post-consent) and as part of the pre-construction phase of development. This investigation would seek to further characterise the peat deposits with emphasis on, in-situ shear strength testing and targeted undisturbed sampling and laboratory testing. All peat samples recovered should be classified in accordance with the Von Post system, (Hobbs, 1986) and current British and Eurocode standards for site investigation. Further investigation of the peat sub-soil interface would also be carried out.
- Groundwater level information would be collated as part of any future ground investigation;
- The results of a detailed ground investigation should be assessed with respect to refining the peat stability assessment at infrastructure locations where peat slide risk is elevated. All pertinent control measures and mitigation measures should be revised, and their implementation supervised following the results of the ground investigation and construction design phase of works;
- Continued assessment and monitoring throughout the construction phase of works and at suitable intervals post construction should be implemented to ensure the control measures are suitable and are providing adequate mitigation against peat instability;
- Construction practices should be managed through the Construction Method Statement (CMS) and within the wider context of the Construction Environmental Management Plan (CEMP). The CMS should be prepared by the appointed principal contractor and reviewed by a suitably experienced geotechnical engineer who has read and understood this report. The following general recommendations are provided in line with the, Good practice during wind farm construction, (2019) guidance:
  - Avoid peat arisings being placed as local concentrated loads on peat slopes without first establishing the stability condition of the ground and slope system. Stockpiling on areas of deep peat and in close proximity to steep slopes should be avoided.
  - Avoidance of uncontrolled and concentrated surface water discharge onto peat slopes as this may act as contributory factor to failure. All water discharged from excavations during construction phase should be directed away from all areas identified as susceptible to peat failure and should managed by a suitably designed site drainage management plan.
  - All excavations where required should be adequately supported to prevent collapse and the destabilising peat deposits adjacent to excavations.
  - A system of daily reporting should be established during construction and utilised to monitor the geotechnical performance of slopes including peat, sub-soil and bedrock. This should be implemented and undertaken by a suitable experienced and qualified geotechnical engineer. Post construction this monitoring procedure should be curtailed to allow for annual or ad-hoc inspection as required.

8.1. Floating Track Construction

MacCulloch, (2006) advises that a ‘floating’ type road construction which leaves the peat deposits in situ may be advantageous with respect to preventing peat failure. This method of construction has a lower impact on the internal groundwater flow within the peat land. However, there are cases where groundwater flow within the peat can be detrimentally affected. The following control measures should be implemented as part of the design and construction of ‘floating’ access track:

- Prevent the rupture of vegetation surface of the peat by avoiding the use of large sharp rock fill;
- Prevent the overloading and subsequent shearing of the peat throughout construction and use of the ‘floating’ track;
- Monitoring of the long-term settlement of the ‘floating’ track is necessary to predict the effects of reducing permeability within the peat and hence increasing groundwater pressures beneath the track construction. Through ongoing monitoring additional drainage relief measures can be implemented when conditions for peat failure are predicted;
- Do not position ‘floating’ access track on or adjacent to convex side slopes.

An additional control on the construction and use of ‘floating’ track is through the strict management of construction traffic loading. This may involve the timing between heavy traffic to be staggered to prevent the effect of cyclic loading over short time periods reducing the shear strength of the peat. In order to assess the maximum loading rate or timing between heavy construction traffic it may be necessary to monitor the vertical deformation of the ‘floating’ track sections following loading and recording the time taken for recovery of vertical deformation. The use of simple settlement plates and survey pegs can be used to achieve this. The frequency of trafficking for heavy loads must then be timed to allow deformation of the ‘floating’ road to recover its deformation.

MacCulloch (2006) generally advises that in order to prevent injury or an environmental incident, it is important that there is a robust procedure in place should it become apparent that a peat failure is imminent.

8.2. Cut/Fill Track Construction

Across the main area of Development not affected by deep peat; the construction of proposed access tracks should be considered by excavation and replacement method, MacCulloch, (2006). Excavated peat is removed and targeted for suitable re-use. Aggregate would be used to form the subgrade and running surface of the track.

For ‘Cut/Fill’ track construction the risk of peat failure is therefore focussed on the peat deposits adjacent to the access track, and the placement of peat arisings. In these areas the following control measures are listed by MacCulloch, (2006):

- Careful excavation of peat deposits by appropriate machine excavator to limit localised peat failures which can occur on the edge of the track excavation. This is in order to prevent a minor failure triggering retrogressive peat failure affecting a larger area of peat adjacent to the track;
- Temporary drainage systems followed by establishment of a permanent drainage network. Silt traps and small retaining structures may be required especially in proximity to water crossings to prevent siltation and blockage of watercourses;
- Ongoing monitoring and on demand maintenance when silt traps require emptying and temporary drainage reinstated if blocking occurs. This will assist in maintaining hydrology baseline conditions;
- The permanent drainage system must direct surface water flow away from the ‘cut’ track to prevent peat failure within the track bunds;

8.3. General Earthworks

It has been identified that there is a requirement for the excavation of peat soils and superficial deposits during construction of the wind farm. Initially the vegetated peat layer and any topsoil should be stripped and temporarily stockpiled away from areas of deep peat and instability risk. The design of this stockpile must be agreed by a suitably qualified geotechnical engineer. When working in areas of deep peat (i.e. >0.5m) no peat or overburden should be stored on such deposits as this may lead to instability. The following options for peat storage may be considered:

- Dedicated peat storage areas designed under the advisement of a suitable qualified geotechnical engineer and conform to up-to-date regulations and waste directives.
- Re-use of peat in dressing-off of batters on access tracks, finishing of cable trenching works, the landscaping of turbine bases. Peat must be re-used to ensure stability and its long terms sustainability i.e. the prevention of drying of desiccation.
- Excavated glacial till and weathered rock may be used as backfill to turbine bases should material be deemed geotechnically suitable. All related works must be carried out in accordance with an agreed CEMP and conform to site restoration plans.
- For in-situ and undisturbed peat; site vehicle movements must be minimised across such areas, throughout construction and post construction. Observation and monitoring for settlement, deformation, or signs of failure along access tracks and critical working areas must be implemented. This may be achieved with a network of settlement plates and survey markers which can be periodically re-surveyed, and any differential movements identified. It is recommended that all earthworks are designed in accordance with current national standards. Such measures would be focused on zones of deep peat and areas at elevated peat slide risk.

The following risk mitigation is recommended with regards to peat storage:

- Storage site selection and stockpile design would be undertaken by a suitably qualified and experienced engineer;
- Temporary storage of peat in a single dedicated area shall be avoided;
- Peat storage on areas of low / negligible peat slide risk only
- Peat storage height shall not exceed 0.5m without dedicated stability assessment; and
- Routine maintenance and inspection of peat storage areas would be undertaken.

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A. Maps

Figure A. 1: Site Layout

Figure A. 2: Site Location

Figure A. 3: Aerial Imagery

Figure A. 4: Site Topography

Figure A. 5: Major Geomorphological Features

Figure A. 6: Terrain Slope Angle

Figure A. 7: Superficial Geology Map

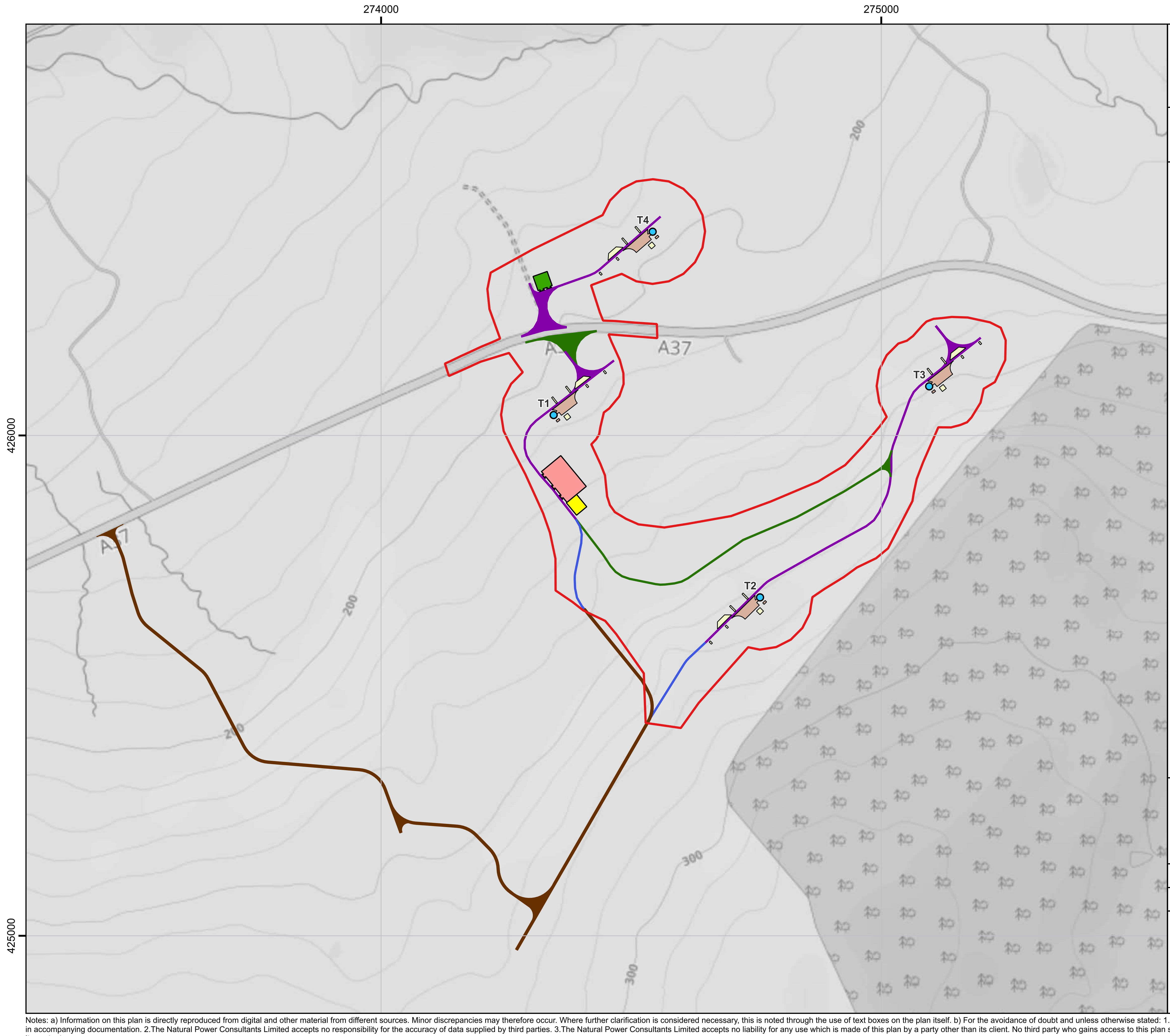
Figure A. 8: Peat Depth Map

Figure A. 9: Solid Geology Map

Figure A. 10: Peat Stability Risk Ranking

Figure A. 11: Environmental Impact Zones

Figure A. 12: Factor of Safety Map



Project:

Dunbeg South Extension, Co. Londonderry

Title:

Site Layout

Key

- Site boundary
- Proposed turbine
- Proposed permanent hardstanding
- Proposed temporary hardstanding
- Proposed new track
- Proposed new track (Option 1)
- Proposed new track (Option 2)
- Existing access via Dunbeg South wind farm
- Temporary construction compound
- Small construction compound
- Proposed substation

Scale @ A3:1:7,500

Coordinate System: TM65 Irish National Grid

0 100 200 300 400 m

N

Date: 19-07-24	Prepared by: DH	Checked by: EE
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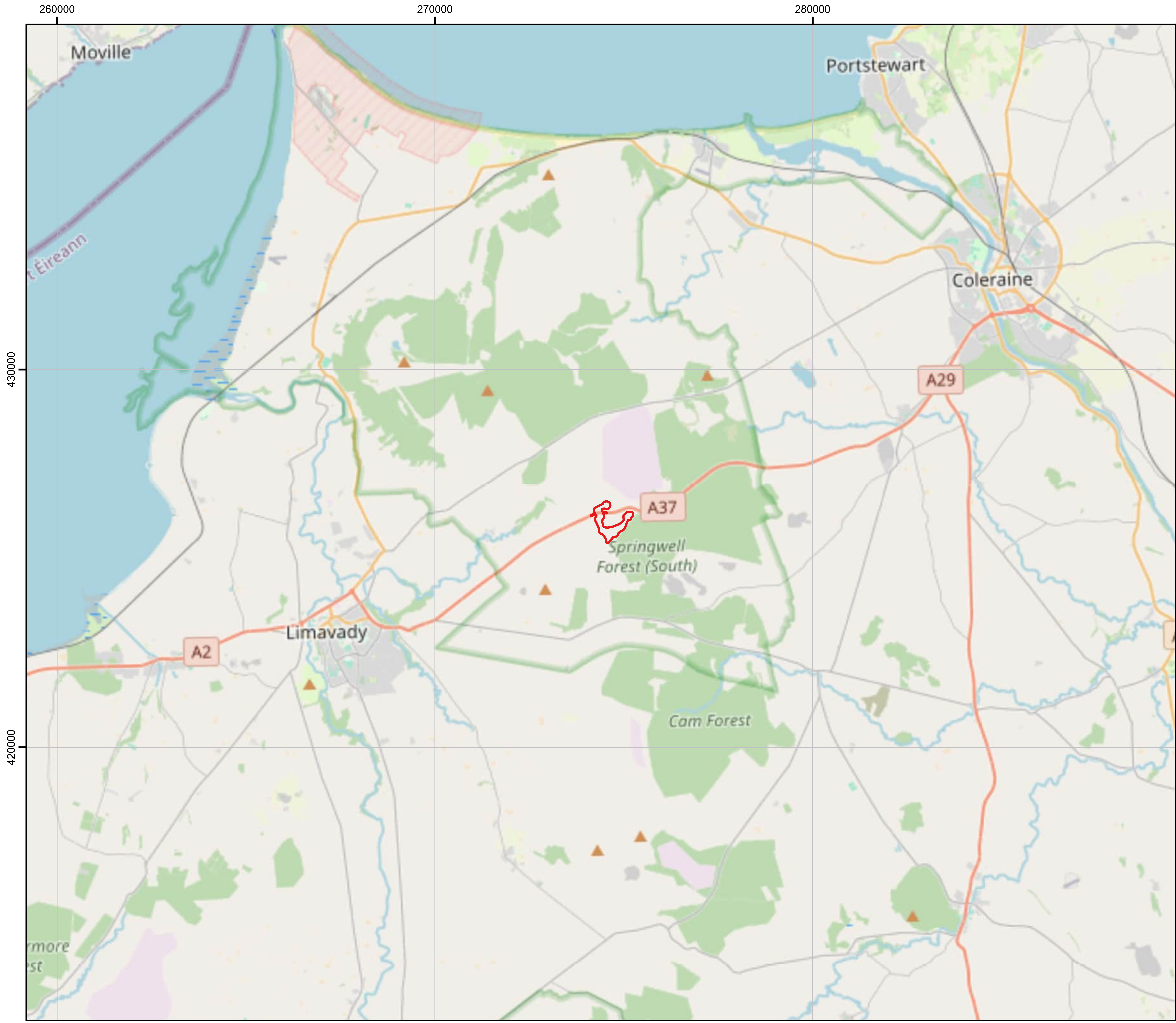

Project:

Dunbeg South Extension, Co. Londonderry

Title:

Site Location

Key

Site boundary

© Thunderforest, © OpenStreetMap contributors.

Scale @ A3: 1:100,000

Coordinate System: TM65 Irish National Grid

0 1 2 3 4 km

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Project:

Dunbeg South Extension, Co. Londonderry

Title:

Aerial Imagery & Site Layout

Key

- Site boundary
- Proposed turbine
- Proposed permanent hardstanding
- Proposed temporary hardstanding
- Proposed new track
- Proposed new track (Option 1)
- Proposed new track (Option 2)
- Existing access via Dunbeg South wind farm
- Temporary construction compound
- Small construction compound
- Control building

Scale @ A3: 1:7,500

Coordinate System: TM65 Irish National Grid

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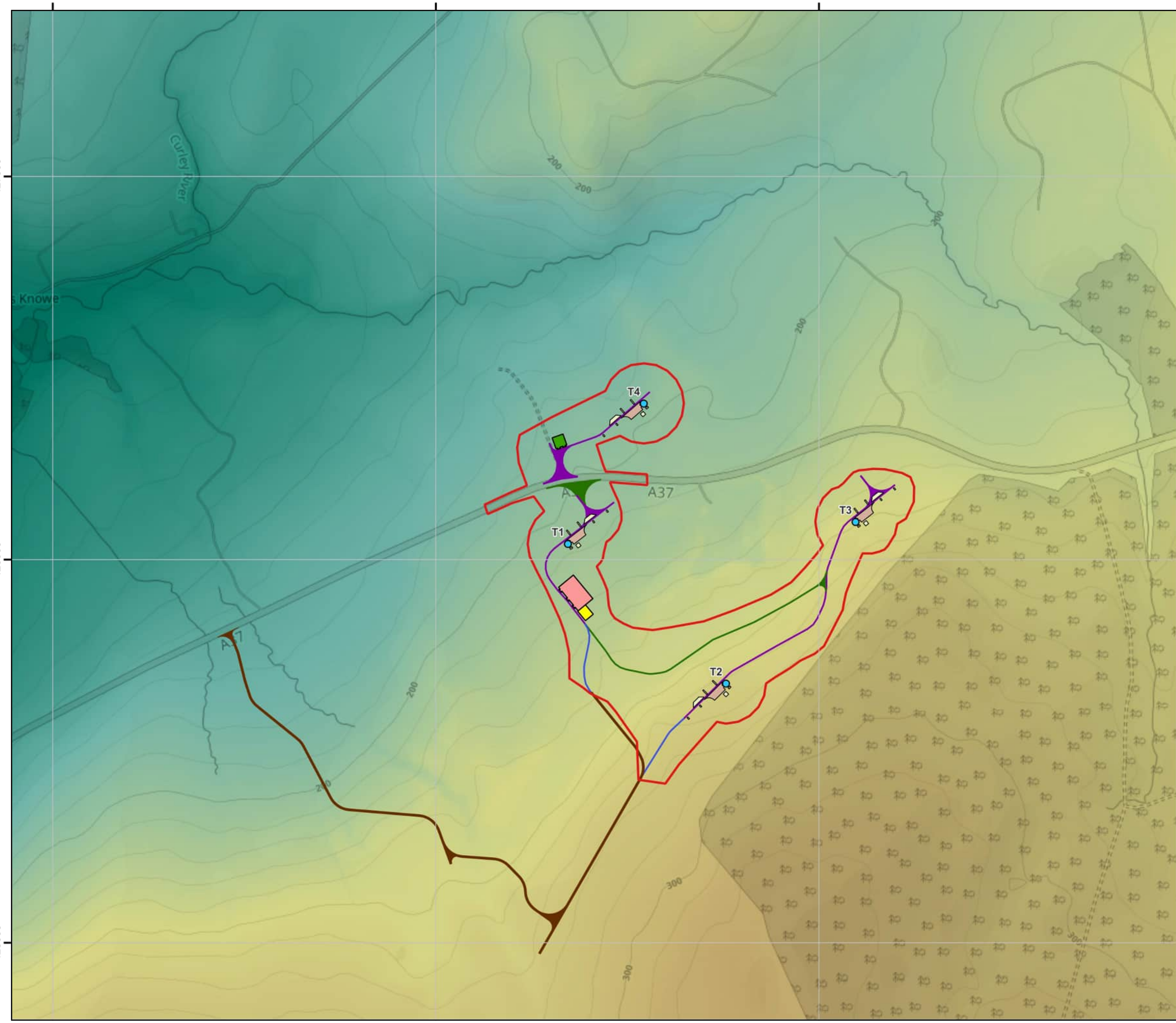

Project:

Dunbeg South Extension, Co. Londonderry

Title:

Site Topography

Key

- Site boundary
- Proposed turbine
- Proposed permanent hardstanding
- Proposed temporary hardstanding
- Proposed new track
- Proposed new track (Option 1)
- Proposed new track (Option 2)
- Existing access via Dunbeg South wind farm
- Temporary construction compound
- Small construction compound
- Control building

Height above MSL (m)

400

100

Scale @ A3: 1:10,000

Coordinate System: TM65 Irish National Grid

0 100 200 300 400 m

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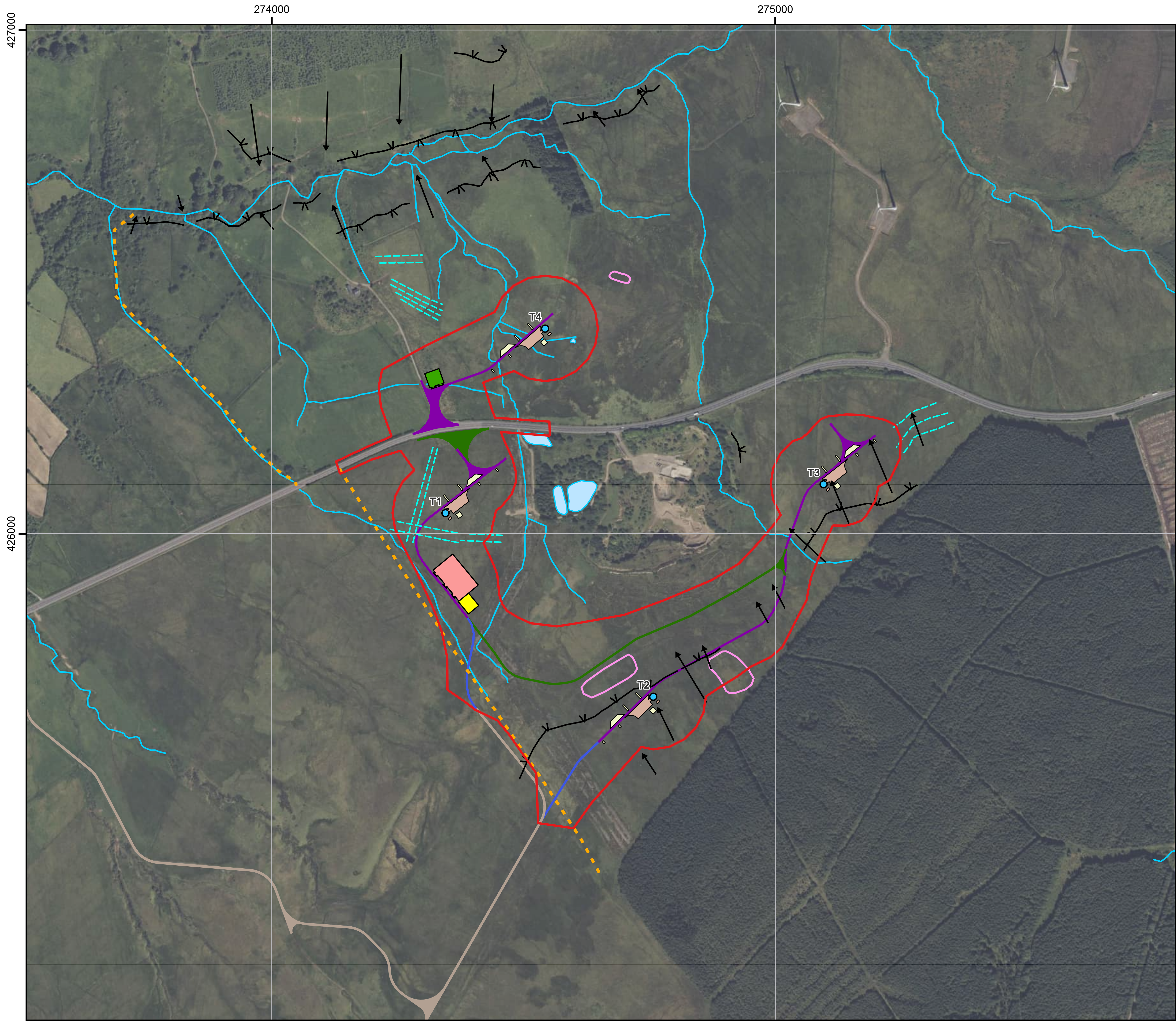

Project:
Dunbeg South Extension, Co. Londonderry

Title:
Geomorphological Features

Key
- Site boundary
- Proposed turbine
- Proposed permanent hardstanding
- Proposed temporary hardstanding
- Proposed new track
- Proposed new track (Option 1)
- Proposed new track (Option 2)
- Existing access via Dunbeg South wind farm
- Temporary construction compound
- Small construction compound
- Control building

Geomorphological Features
- Historic area of peat cutting
- Natural watercourse
- Water body
- Relic drainage feature
- Footpath
- Break in slope
- Slope direction

Scale @ A3: 1:7,500
Coordinate System: TM65 Irish National Grid

0 100 200 300 400 m

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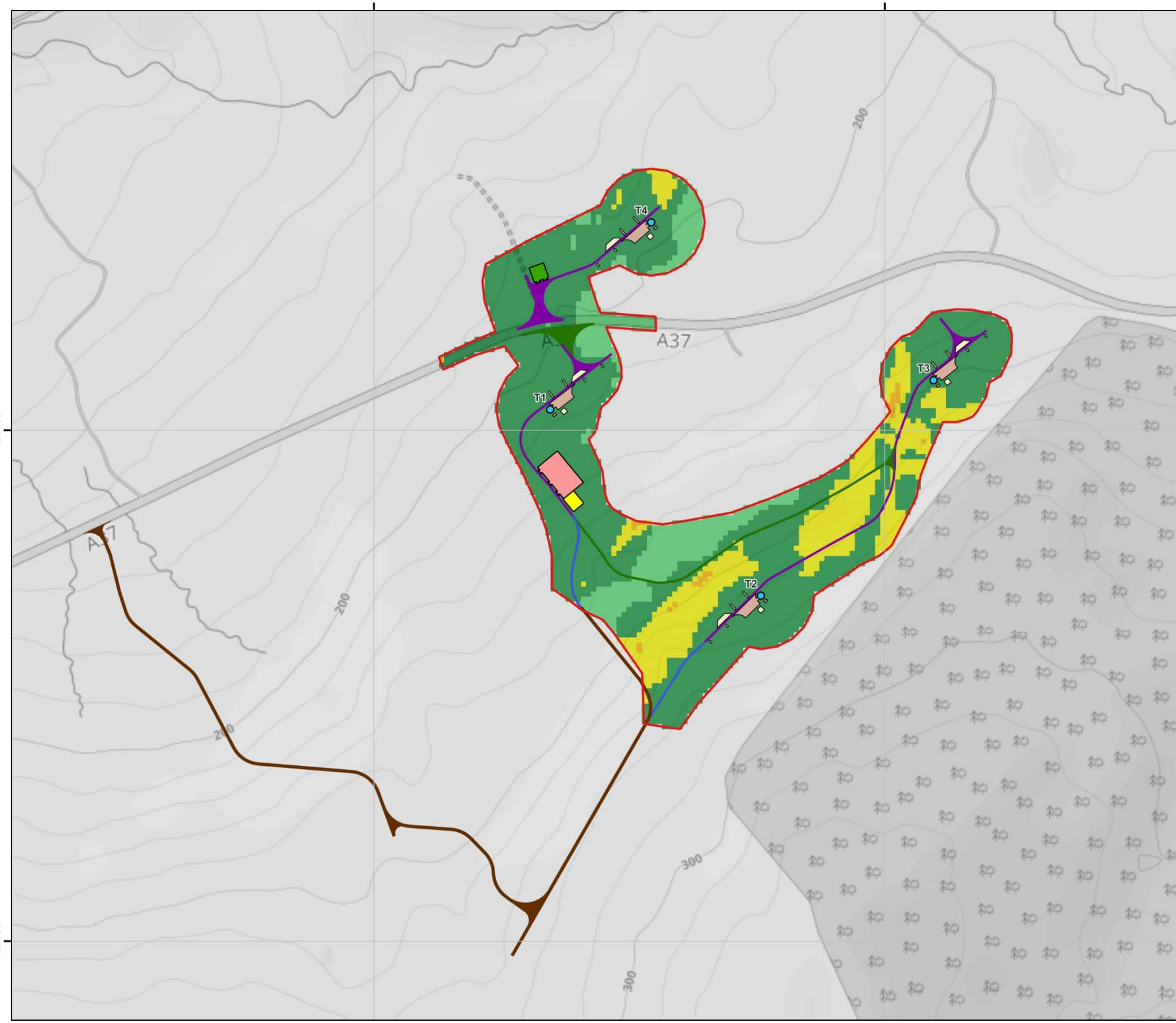

Project:

Dunbeg South Extension, Co. Londonderry

Title:

Slope Angle

Key

- Site boundary
- Proposed turbine
- Proposed permanent hardstanding
- Proposed temporary hardstanding
- Proposed new track
- Proposed new track (Option 1)
- Proposed new track (Option 2)
- Existing access via Dunbeg South wind farm
- Temporary construction compound
- Small construction compound
- Proposed substation

Slope angle (degrees) *

- 0° - ≤ 3°
- 3° - ≤ 9°
- 9° - ≤ 15°
- 15° - ≤ 20°
- > 20°

* Slope calculated using OSNI 10 m DTM.

Scale @ A3:1:7,500

Coordinate System: TM65 Irish National Grid

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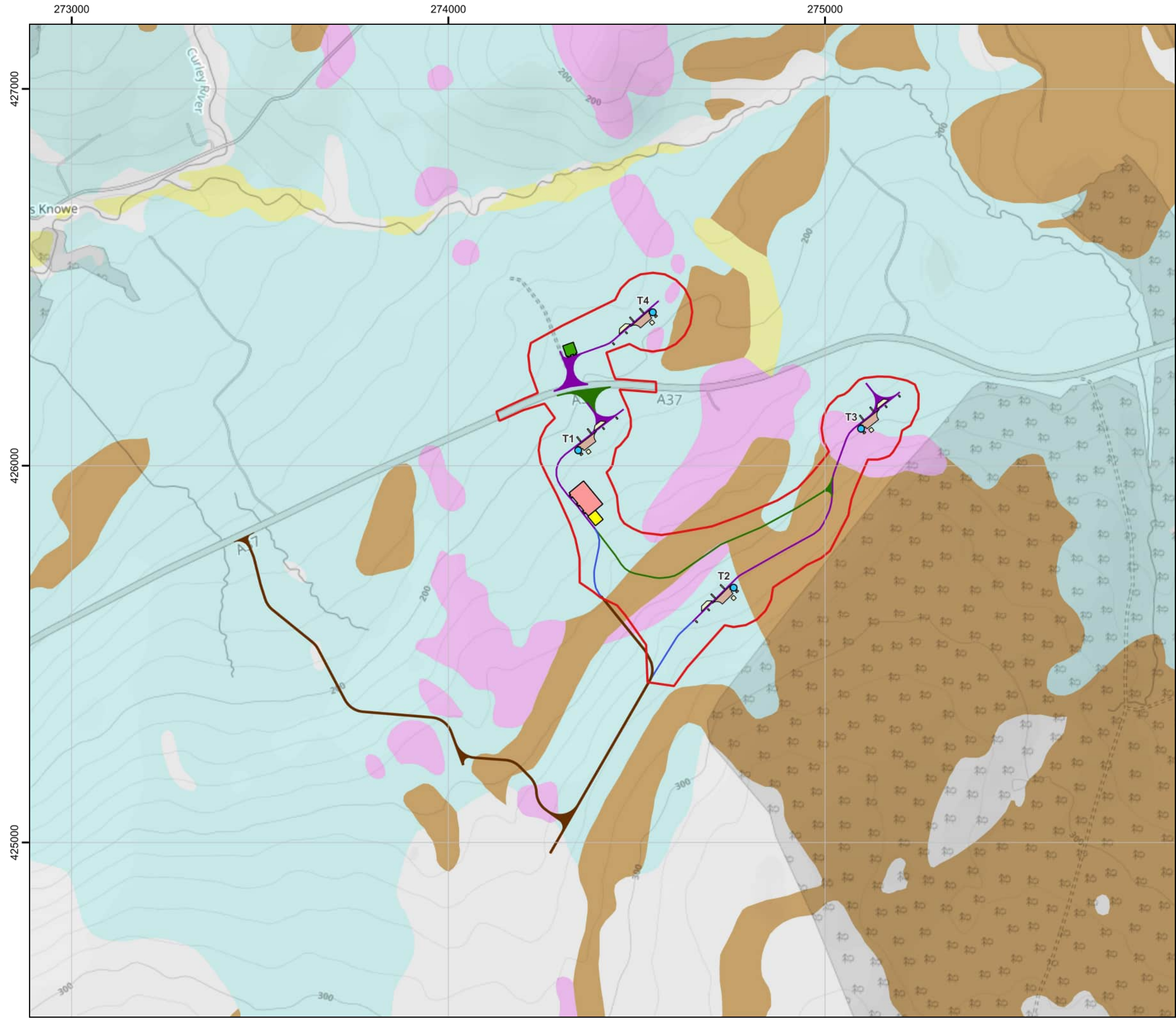

Project:

Dunbeg South Extension, Co. Londonderry

Title:

Superficial Geology

Key

- Site boundary
- Proposed turbine
- Proposed permanent hardstanding
- Proposed temporary hardstanding
- Proposed new track
- Proposed new track (Option 1)
- Proposed new track (Option 2)
- Existing access via Dunbeg South wind farm
- Temporary construction compound
- Small construction compound
- Control building

Superficial Deposits

- Alluvium - Silt, Sand and Gravel
- Glaciofluvial Deposits - Gravel, Sand and Silt
- Till, Devensian - Diamicton
- Peat

Scale @ A3: 1:10,000

Coordinate System: TM65 Irish National Grid

0 100 200 300 400 m

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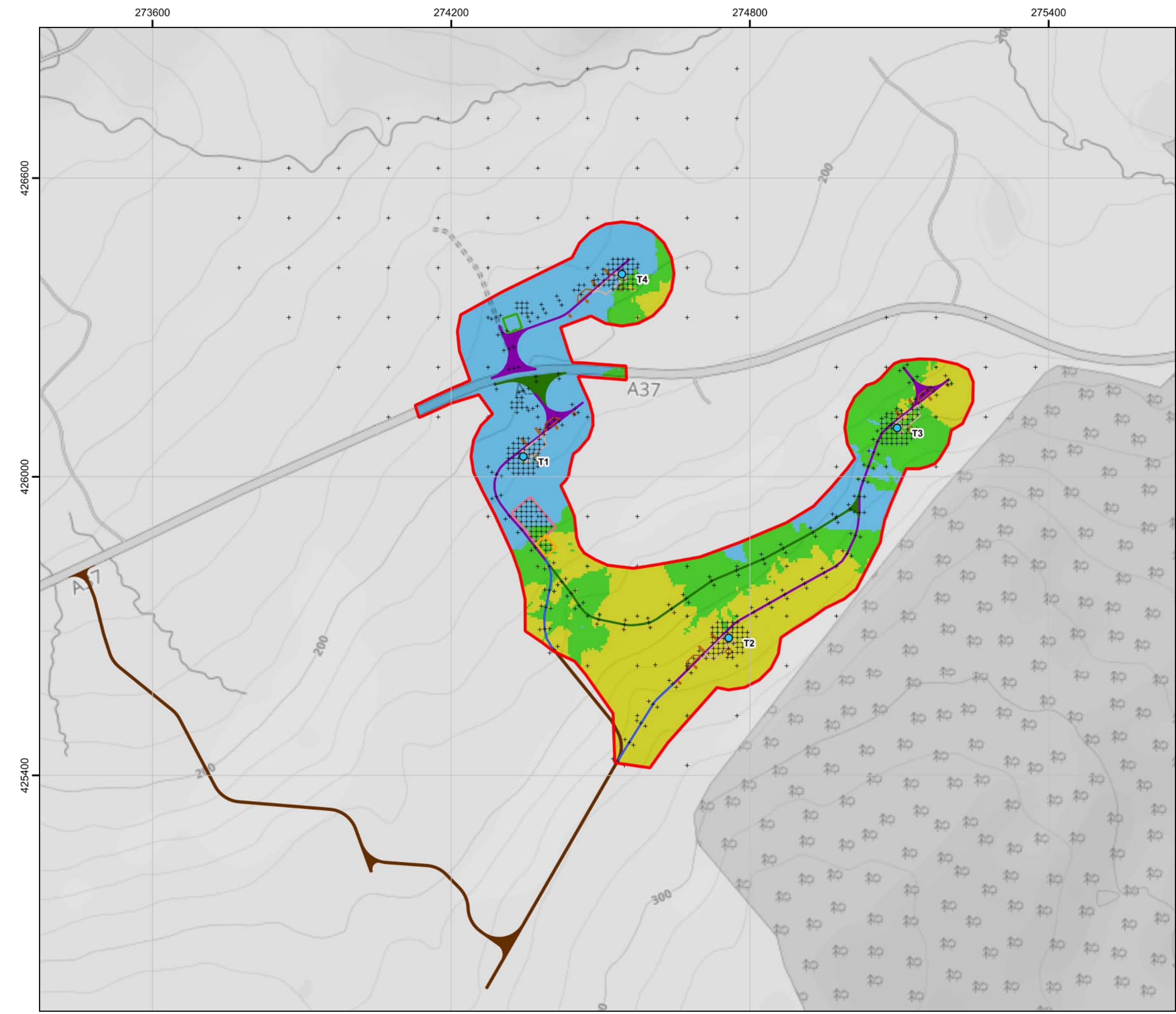

Project:

Dunbeg South Extension, Co. Londonderry

Title:

Interpolated Peat Depth (Page 1 of 3)

Key

- Site boundary
- Proposed turbine
- Proposed permanent hardstanding
- Proposed temporary hardstanding
- Proposed new track
- Proposed new track (Option 1)
- Proposed new track (Option 2)
- Existing access via Dunbeg South wind farm
- Proposed substation
- Proposed temporary construction compound
- Proposed small construction compound
- Peat probe

Interpolated peat depth (m) *

- <= 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- > 3

* Peat depth interpolated using the Kriging method

Scale @ A3:1:7,500

Coordinate System: TM65 Irish National Grid

0 100 200 300 400 m

N

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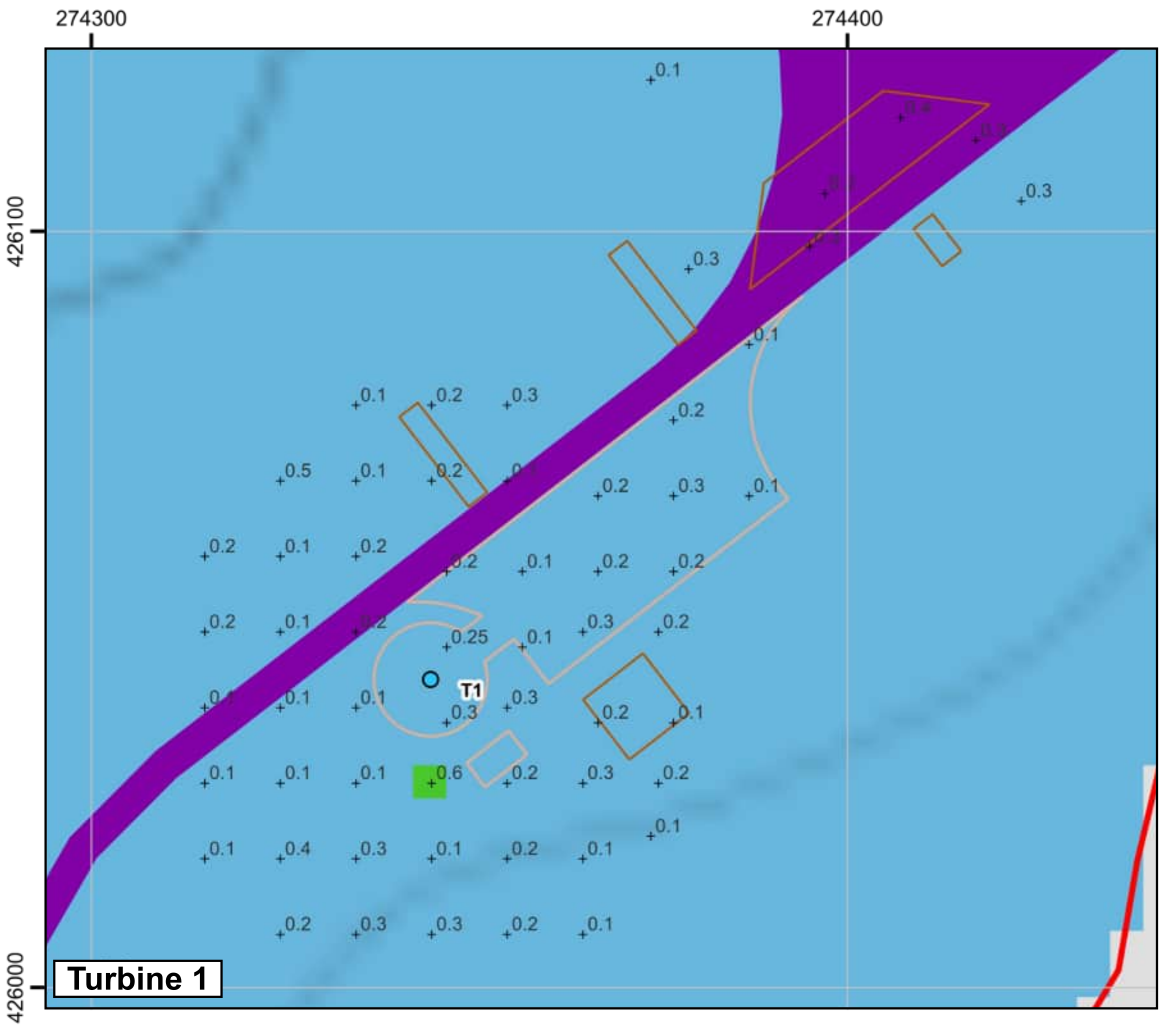

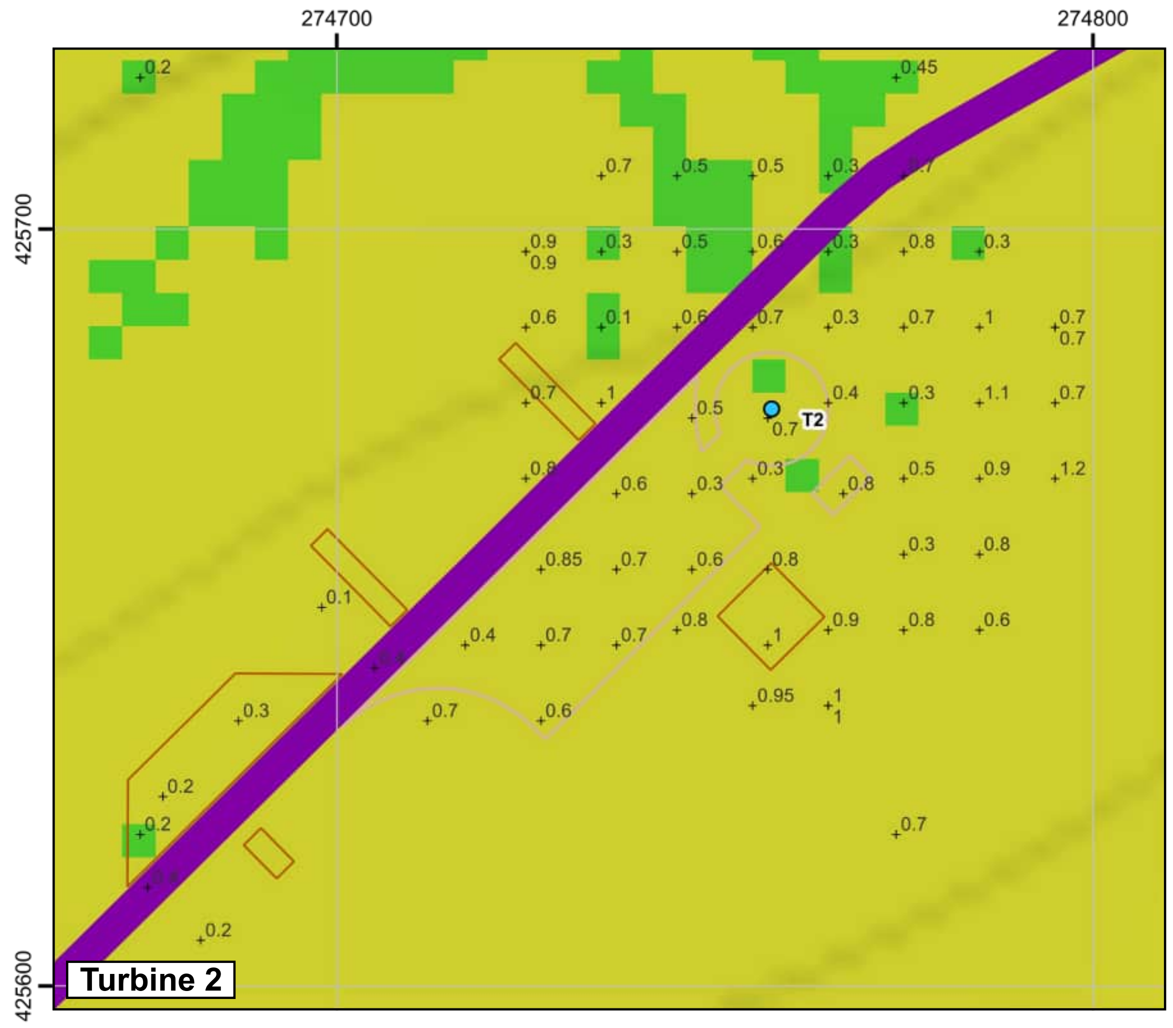

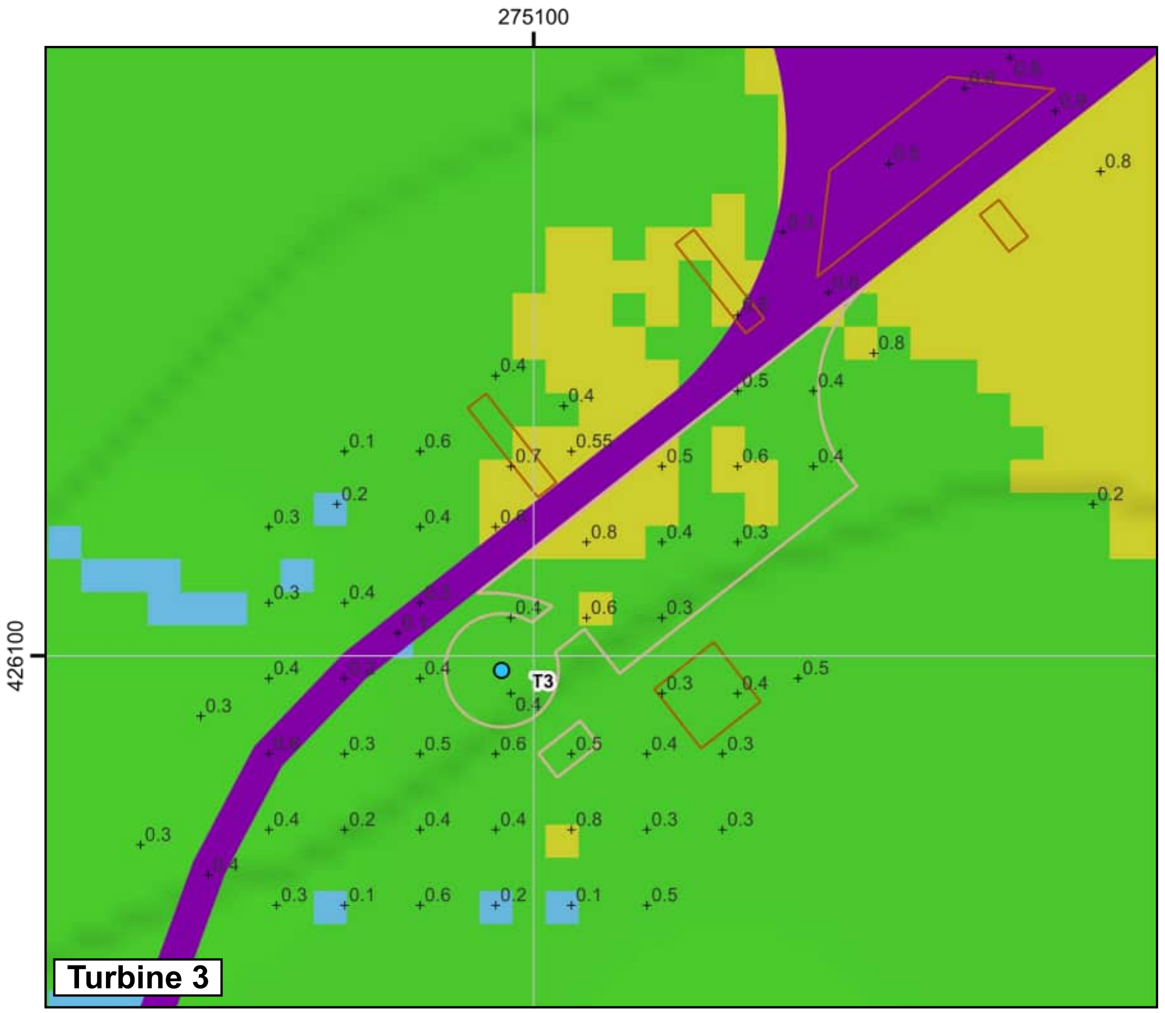

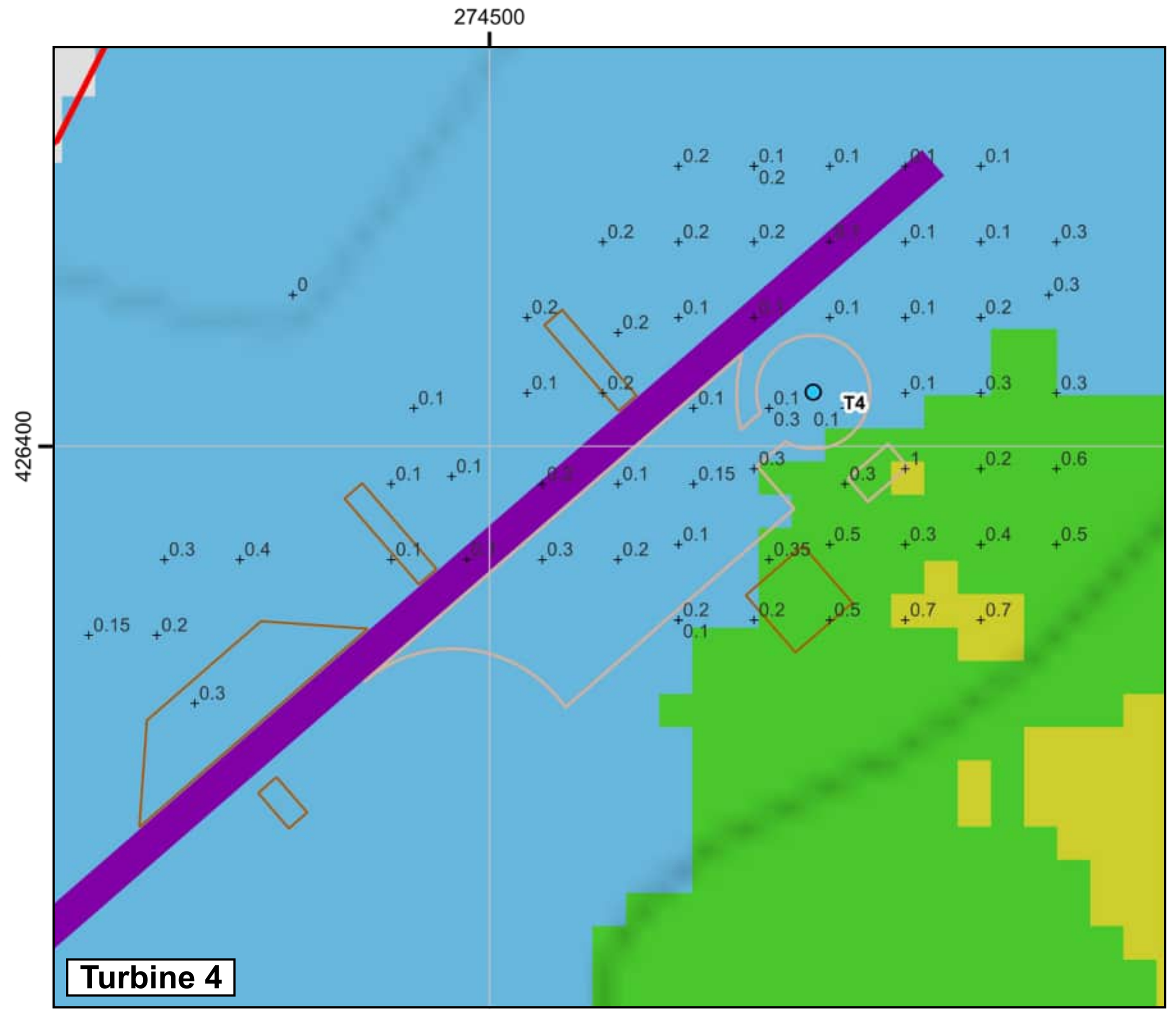

Project:

Dunbeg South Extension, Co. Londonderry

Title:

Interpolated Peat Depth (Page 2 of 3)

Key

- Proposed turbine
- Proposed permanent hardstanding
- Proposed temporary hardstanding
- Proposed new track
- Peat probe

Interpolated peat depth (m) *

- <= 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- > 3

* Peat depth interpolated using the Kriging method

Scale @ A3: 1:1,000

Coordinate System: TM65 Irish National Grid

0 10 20 30 40 m

N

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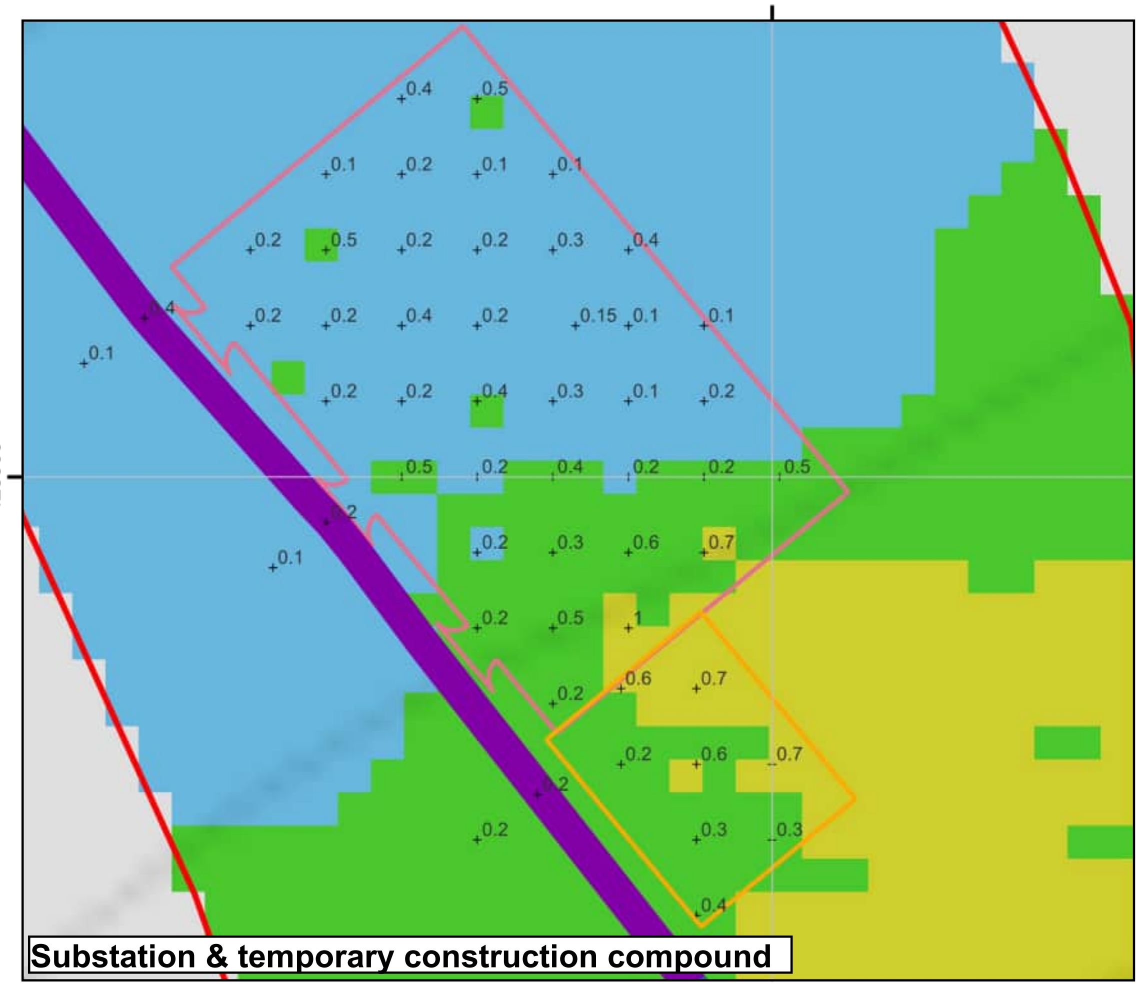

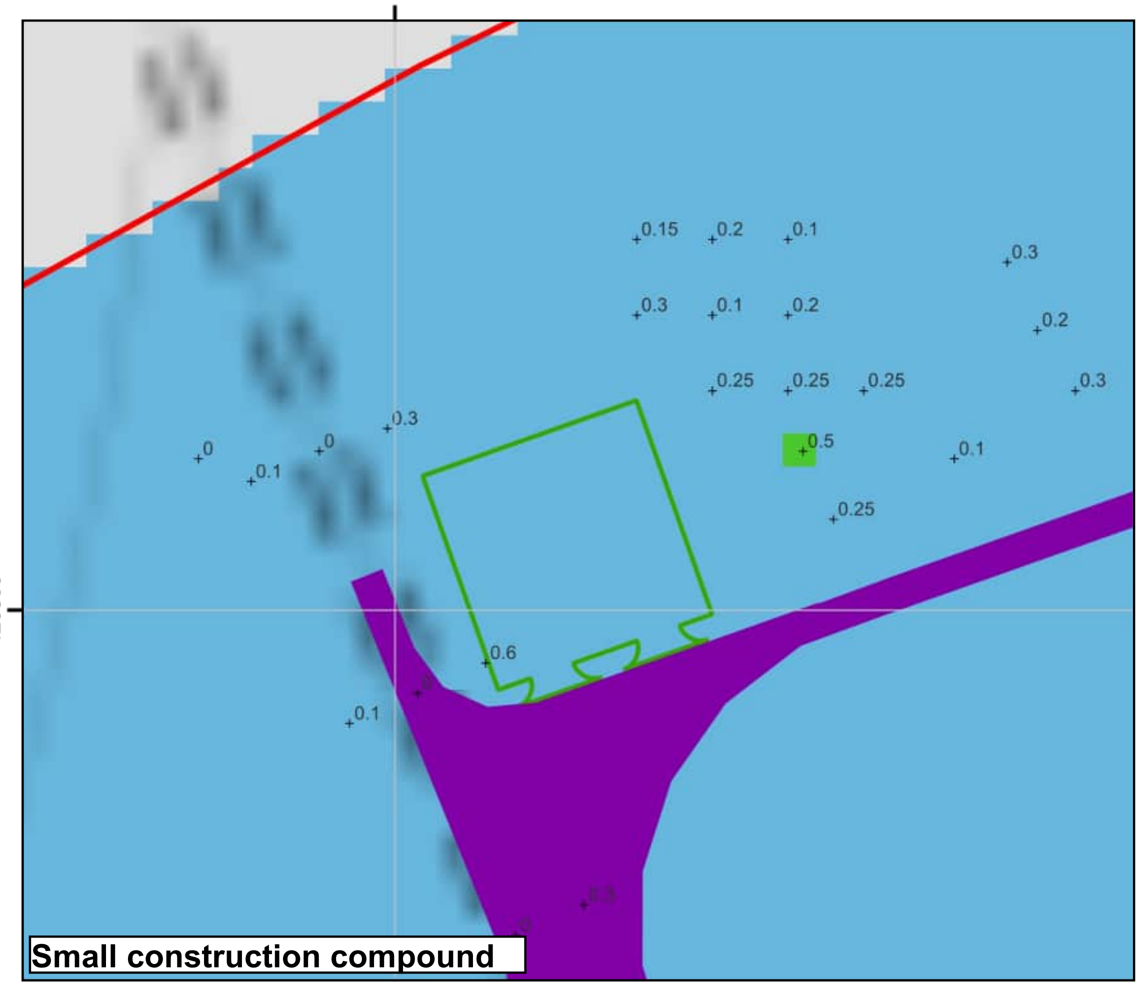

Project:

Dunbeg South Extension, Co. Londonderry

Title:

Interpolated Peat Depth (Page 3 of 3)

Key

- Site boundary
- Proposed new track
- Proposed substation
- Proposed temporary construction compound
- Proposed small construction compound
- \+ Peat probe

Interpolated peat depth (m) *

- <= 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- \> 3

* Peat depth interpolated using the Kriging method

Scale @ A3:1:1,000

Coordinate System: TM65 Irish National Grid

0 10 20 30 40 m

N

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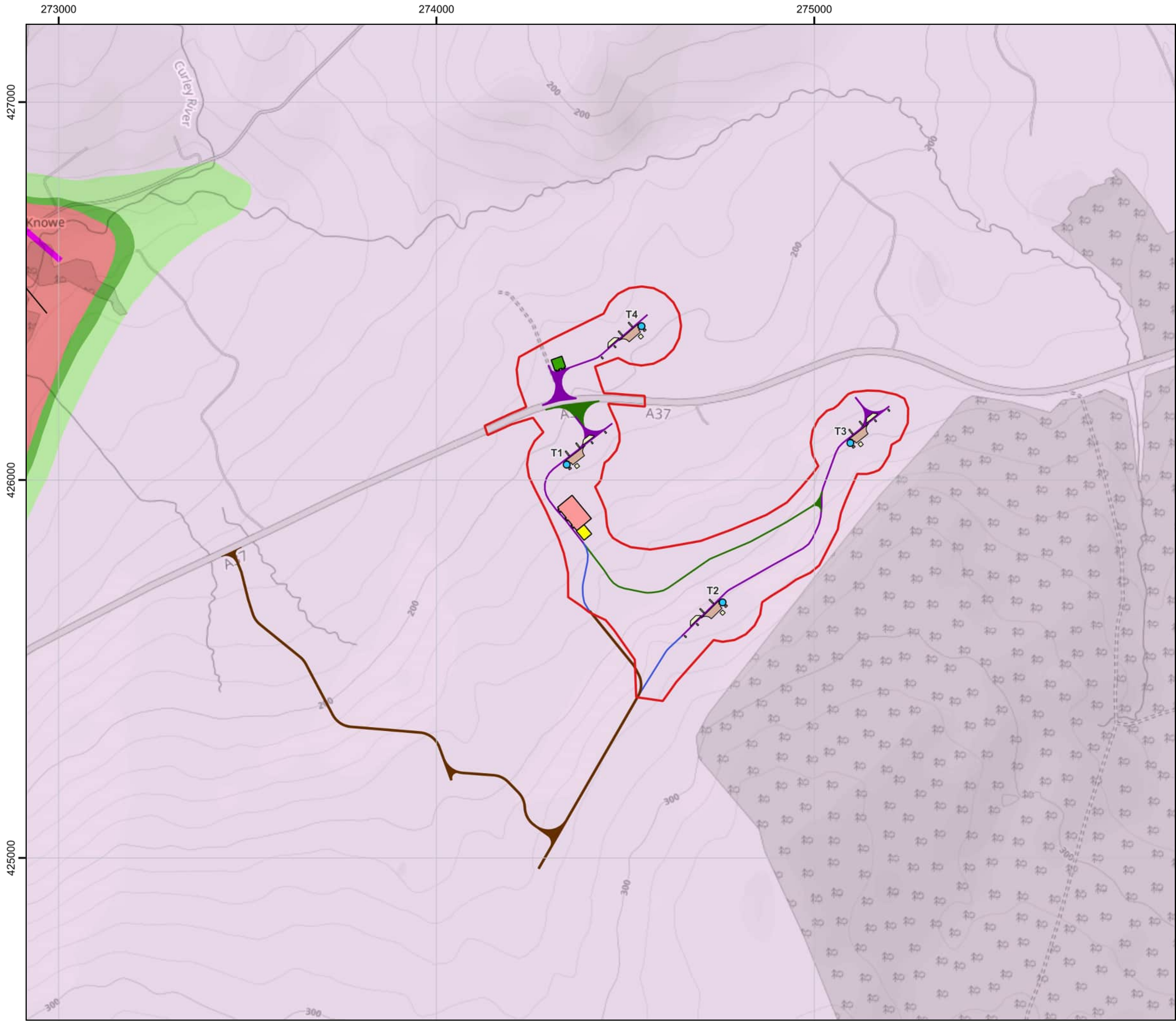

Project:

Dunbeg South Extension, Co. Londonderry

Title:

Bedrock Geology

Key

- Site boundary
- Proposed turbine
- Proposed permanent hardstanding
- Proposed temporary hardstanding
- Proposed new track
- Proposed new track (Option 1)
- Proposed new track (Option 2)
- Existing access via Dunbeg South wind farm
- Temporary construction compound
- Small construction compound
- Control building

Bedrock Geology

- Upper Basalt Formation - Basalt
- Ulster White Limestone - Chalk
- Hibernian Greensands Group - Sandstone, glauconitic
- Mercia Mudstone Group - Mudstone
- Unnamed Dyke, Palaeogene - Microgabbro
- Fault, observed

Scale @ A3:1:10,000

Coordinate System: TM65 Irish National Grid

0 100 200 300 400 m

N

Date: 19-07-24	Prepared by: DH	Checked by: EE
Ref: IE200135_M_021_A	Layout: 030524_4t_A	

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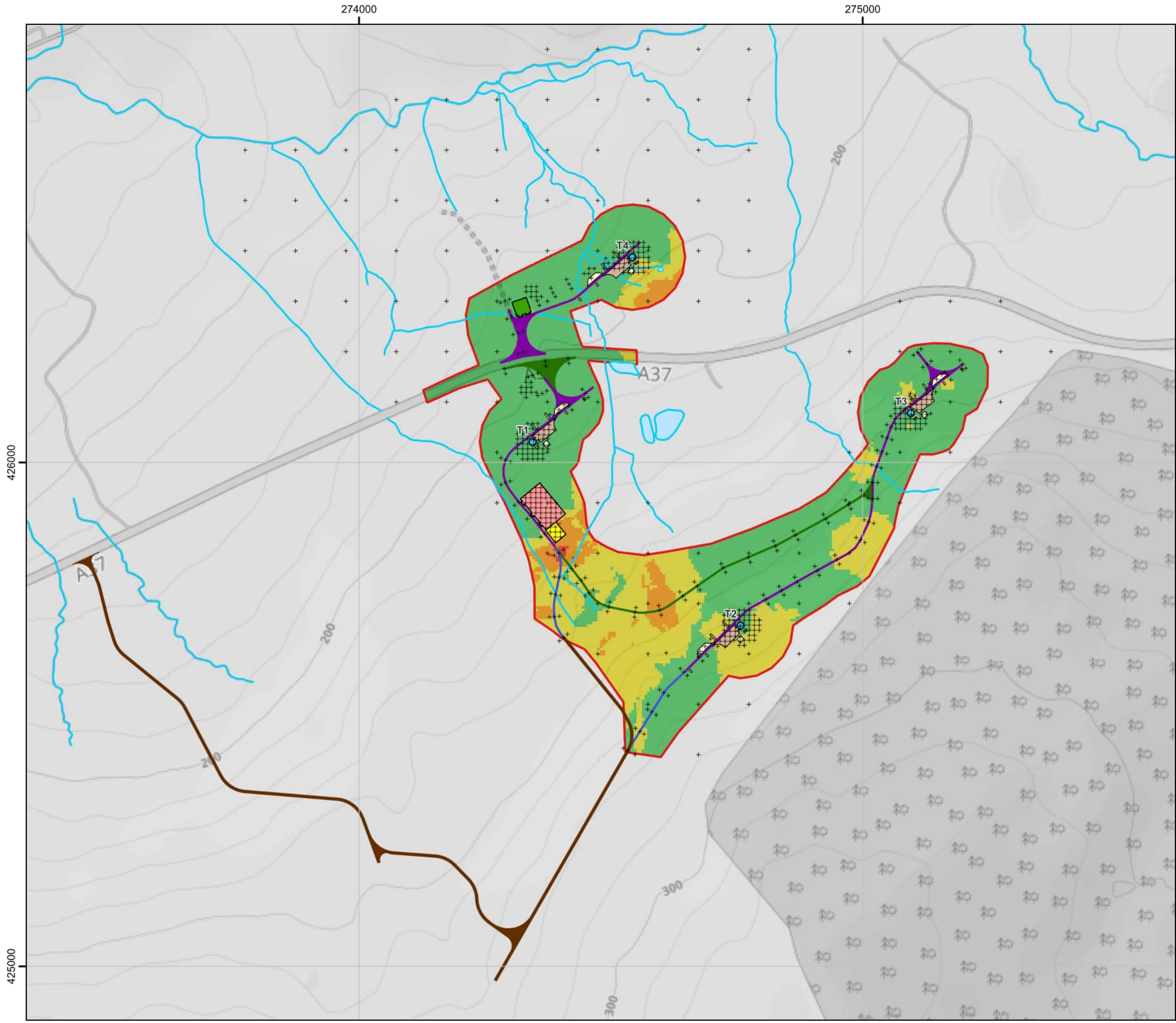

Project:

Dunbeg South Extension, Co. Londonderry

Title:

Peat Stability Risk Ranking

Key

- Site boundary
- Proposed turbine
- Proposed permanent hardstanding
- Proposed temporary hardstanding
- Proposed new track
- Proposed new track (Option 1)
- Proposed new track (Option 2)
- Existing access via Dunbeg South wind farm
- Temporary construction compound
- Small construction compound
- Proposed substation
- Watercourse
- Water body
- Peat probe

Peat Stability Risk Ranking (PSRR) *

- 1 ≤ 4 Negligible**
- 5 ≤ 10 Low
- 11 ≤ 16 Medium
- > 16 High

* Peat Slide Risk Zones = (Peat depth + Slope) x Proximity to watercourse

** Exception: where peat depth is 0.5m or below, PSRR is deemed negligible, regardless of other factors.

Scale @ A3:1:7,500

Coordinate System: TM65 Irish National Grid

0 100 200 300 400 m

N

Date: 19-07-24	Prepared by: DH	Checked by: EE
Ref: IE200135_M_014_B		

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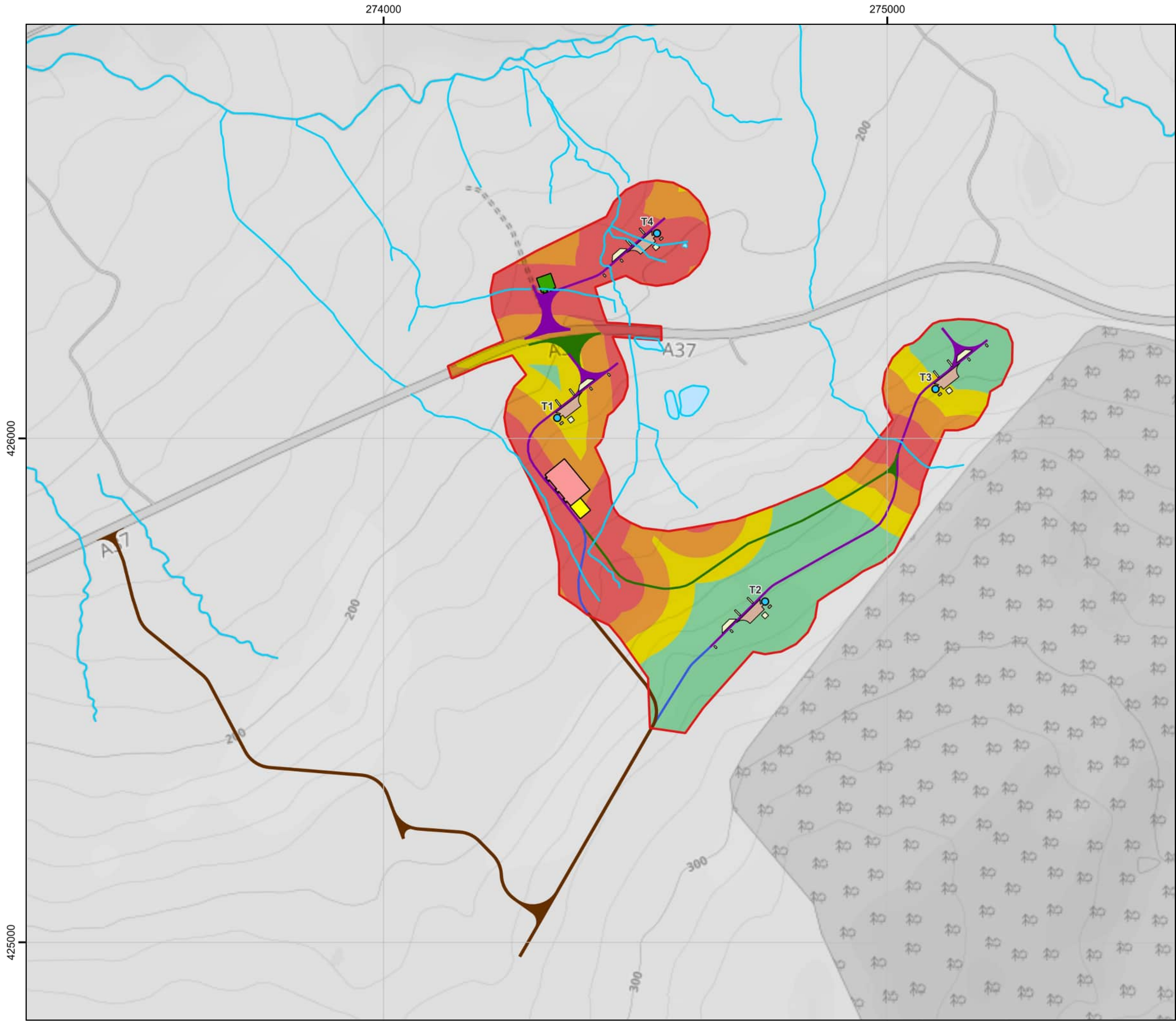

Project:

Dunbeg South Extension, Co. Londonderry

Title:

Environmental Impact Zones

Key

- Site boundary
- Proposed turbine
- Proposed permanent hardstanding
- Proposed temporary hardstanding
- Proposed new track
- Proposed new track (Option 1)
- Proposed new track (Option 2)
- Existing access via Dunbeg South wind farm
- Temporary construction compound
- Small construction compound
- Proposed substation
- Watercourse
- Water body

Environmental Impact Zones

- High (< 50 m from watercourse/water body)
- Medium (50 - 100 m from watercourse/water body)
- Low (100 - 150 m from watercourse/water body)
- Negligible (> 150 m from watercourse/water body)

Scale @ A3:1:7,500

Coordinate System: TM65 Irish National Grid

0 100 200 300 400 m

N

Date: 19-07-24	Prepared by: DH	Checked by: EE
Ref: IE200135_M_013_B	Layout: 030524_4t_A	

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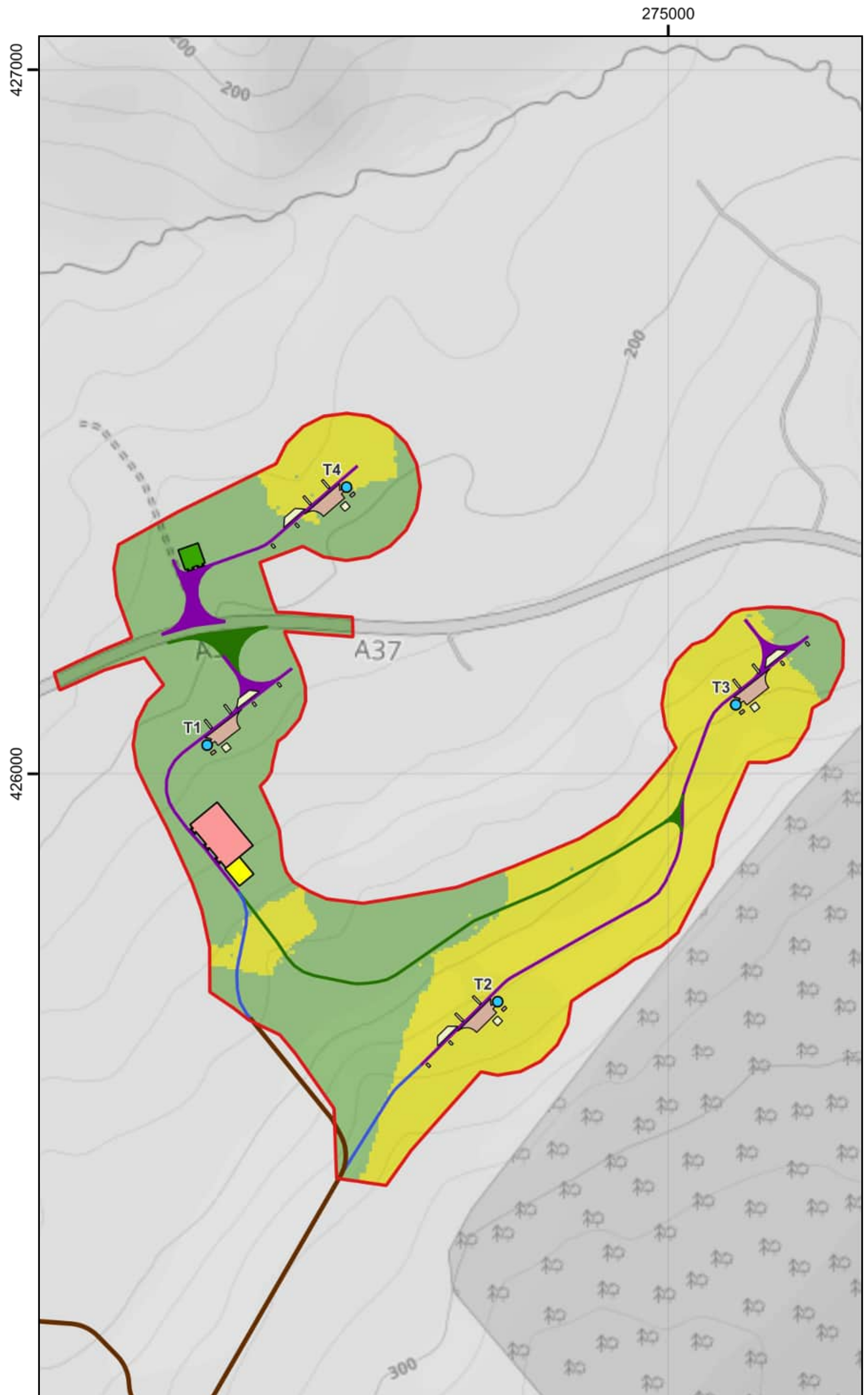
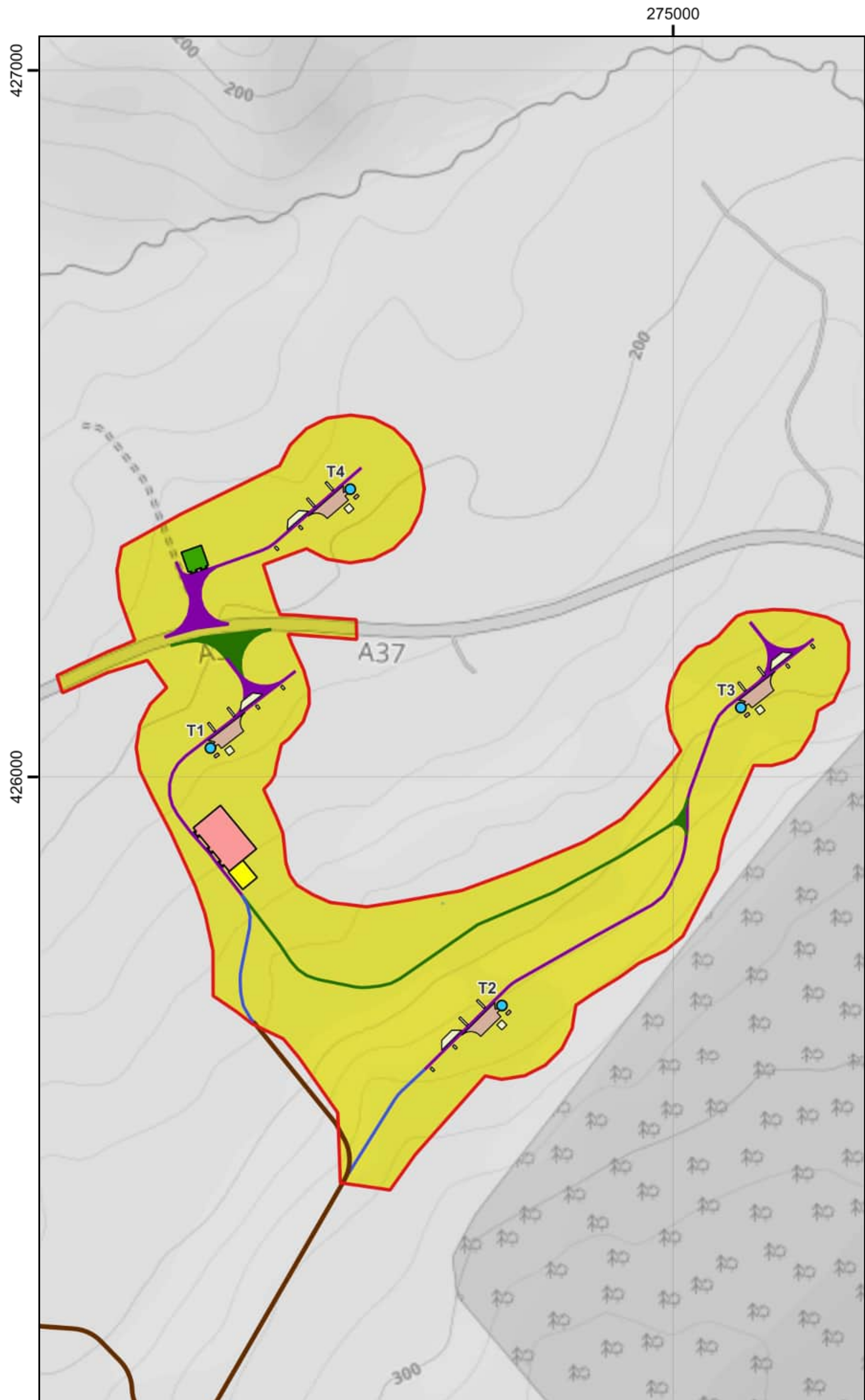


Infinite Slope Analysis

Equation:

FoS = 'Peak Shear Strength' / ('Peat Density' x 'Peat Depth') x Sin('Slope angle') x Cos('Slope angle')



Infinite Slope Analysis with 20kPa Surcharge

Equation:

FoS = 'Peak Shear Strength' / ('Peat Density' x 'Peat Depth') + Surcharge) x Sin('Slope angle') x Cos('Slope angle')

Project:

Dunbeg South Extension, Co. Londonderry

Title:

Slope Stability Factor of Safety

Key

- Site boundary
- Proposed turbine
- Proposed permanent hardstanding
- Proposed temporary hardstanding
- Proposed new track
- Proposed new track (Option 1)
- Proposed new track (Option 2)
- Existing access via Dunbeg South wind farm
- Temporary construction compound
- Small construction compound
- Proposed substation

Factor of Safety (FoS) *

- 1.0 - 1.3
- > 1.3 - 2.0
- > 2.0 - 10.0
- > 10.0 - 30.0
- > 30.0

*F = Cu / (y*z* sinβ * cosβ)
Where:
F = Factor of Safety (FoS)
Cu = Undrained shear strength of the peat (kPa) - 10 kPa
y = Bulk unit weight of saturated peat (kN/m³) - assumed value 10 kN/m³
z = Peat depth in direction of normal stress
β = Slope angle to the horizontal and hence assumed angle of sliding plane (degrees)

Scale @ A3: 1:8,000

Coordinate System: TM65 Irish National Grid

0 100 200 300 400 m

N

Date: 19-07-24	Prepared by: DH	Checked by: EE
Ref: IE200135_M_015_B		

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B. Site Photographs, In-situ Testing, Lab Testing and Peat Coring

Figure B. 1: View South of site

Figure B. 2: View West of site.

Figure B. 3: View East of site, showing woodland.

Figure B. 4: View to the North of site, showing Dunbeg Windfarm Phase I.

Figure B. 5: Peat core photograph from peat probe position 108 showing firm dark brown plastic pseudo fibrous peat (H7/B2)

Figure B. 6: Peak undrained shear strength against depth across the site. *A, denotes previous turbine locations.

C. Reporting and ECU Checking

As part of the Section 36 Application, The Energy Consents Unit (ECU) commissioned Ironside Farrar Ltd. (IFL) to provide a checking report for the initial peat slide risk reporting.

The following checking report has been reviewed as part of this latest revision of the Peat Slide Risk Assessment:

Dunbeg South Extension Wind Farm, Stage 1 Checking Report (Ref:63085) issued by Ironside Farrar and dated June 2022.

This Section highlights where updated report information is provided and aims to address each IFL recommendation.

Table 8.1 below provides a summary of the Stage 1 checking responses.

It should be noted that following the IFL Stage 1 Checking Report, there have been significant changes to the proposed windfarm layout, a summary of the changes to the turbine locations is included within Table 8.2 and includes details on amendments to the peat slide risk assessment.

Table 9.1: ECU Checking Report Summary

ID	Stage 1 Checking Report Recommendation (Ironside Farrar Ltd)	Natural Power Response
1	Justification on why Phase 1 probing grid does not cover entire RLB.	The peat surveys follow the principles of the Peatland Survey Guidance, SNH, SEPA (2017). The central guidance being to target the peat surveys across areas of greatest potential impact. Detailed peat survey further targets proposed infrastructure including turbine foundations and adjacent hardstands. The report incorporates several key receptors into the assessment which directly correspond to each key infrastructure location. The risk of impacting these receptors has been assessed in part based on the proximity of downstream watercourses. This is inherent to the risk assessment. The interceding peat depth (between source and receptor) is not a primary factor. The peat depth at the infrastructure location is given priority in the risk assessment scoring. This methodology provides a robust risk classification for the proposed infrastructure locations and examines risks to downstream receptors. The risk zonation mapping of the site provides relevant further information. In this case, Natural Power concludes that expanding the 100m grid probing would not materially improve the confidence in the risk assessment at this pre-planning stage. The report highlights future requirement for survey and investigation which should be conducted and used to refine the risk assessment part of the pre-construction phase of development.
2	Comment on why Phase 2 probing has not been conducted in line with SNH 2017 guidance on spacing.	Detailed Probing (targeted) has been undertaken to the following specification: • 50 m intervals along the centre line of the access tracks with 10 m offsets to either side. • Probes have been taken at 20 m spacing at the turbine centre locations and at 20 m grid intervals on the hardstands and ancillary infrastructure. Forestry across much of the proposed infrastructure locations made probing at a 10m grid density difficult. The Peat Slide Risk Assessment Government Guidance provides specific reference to the assessment of geotechnical risk associated

ID	Stage 1 Checking Report Recommendation (Ironside Farrar Ltd)	Natural Power Response
		with peat. This guidance clearly allows for the scope of detailed peat probing work to be determined by engineering judgement which is informed by primary data sources, GIS and site reconnaissance analysis. Following this regime the targeting of peat probing can be such that it focuses on pertinent aspects of the site.
3	Confirmation / justification on the risk scoring in relation to forestry and artificial drainage.	Artificial drainage ditches present across this site are all associated with commercial forestry operations. The author has applied a subjective judgement to not score these features twice. In doing so would over-estimate the risk factor at these locations. The presence of the ditches in this instance is concluded to be sufficiently accounted for within the land management scoring.
4	Confirmation on whether the substation should have an environmental risk score of 3, rather than 2, and update the assessment if required.	Sub-station is located across both environmental zones. Updated to environmental factor value of '3' within the assessment and suggested a micro-site west to move away from the watercourse.
5	Confirmation on whether Table 4.7/8 have been omitted in error and provide these if so.	Incorrect reference to Table 4.7/4.8, this has been updated within the report to state Table 6.1 where a qualitative assessment is made on the impact to infrastructure.
6	Provide additional comment on very soft clay encountered and associated risk	Added the following note to superficial geology: "The glacial till will most likely form a substrate and sub-soil to the peat deposits. The heterogenous nature of this material will give rise to a wide range of geotechnical behaviours. Topography across the development is relatively complex and coupled with the probable heterogeneous nature of the underlying glacial subsoils a large-scale mass movement is considered unlikely to be generated. In this assessment, peat slide has been assessed based on sliding within or at the base of the peat layer, and not within the underlying soil substrate. Loose poorly consolidated granular soil deposits can also create marginally stable terrain. These issues would be investigated in detail by a future phase of intrusive geotechnical investigation."
7	Confirmation that GWDTEs, dwellings, PWS and drinking water catchment receptors have been considered.	Although considered within each specific mitigation in Table 6.1, Have also added Section 3.6 "Designated Sites and Receptors" detailing the identified receptors across the proposed development.
8	Update the risk rankings to follow the methodology exactly as set out	The methodology has been followed as set out in the report and the risk rankings updated to accommodate this along with the updated turbine layout.
9	Confirmation on the peat depth and risk rankings for the turbines with peat depth discrepancies.	Peat depths have been updated throughout the report in line with the updated peat probe data collected during the additional Phase II surveys and tied in with the PMP.
10	Confirmation on whether all areas of track passing though medium / high risk areas will be subject to specific mitigation	Yes, this is now stated within the report to refer to Figure A.8 for all medium to high-risk areas of access track, which will all require mitigation to reduce the residual risk levels to low.

Source: Natural Power

Updates to the turbine locations have occurred after the issuing of the ECU Checking report, these are shown within the table below. The access tracks associated with these locations have also been updated, the updated figures show the current site layout in all instances.

Table 9.2: Changes to Site Layout

Turbine ID	Original Location (BNG)	Updated Location (BNG)	Notes
T1	E209480, N570658	E209550, N570713	95m NE
T2	E209002, N572057	E209120, N572194	180m NE
T3	E209230, N571655	E209344, N571767	160m NE
T4	E209628, N571366	E209713, N571366	85m E

Source: Natural Power

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For full details on our ISO and other certifications, please visit our website.