Appendix 6.B
Peat Slide Risk Assessment

E.ON Climate & Renewables UK Developments Ltd

Enoch Hill Wind Farm

Peatslide Hazard and Risk Assessment

July 2015

Amec Foster Wheeler Environment
& Infrastructure UK Limited

Report for

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Doc Ref. 32965/C/Gos/i1r

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Document revisions

No.	Details	Date
i1	Draft for external review.	June 2015
i2	Draft for client comment.	July 2015
I3	Final	July 2015

Executive summary

Purpose of this report

The purpose of this report is to provide a Peatslide Hazard and Risk Assessment for the proposed Enoch Hill Wind Farm. As the wind farm will be within areas of peat on slopes greater than 2°, consideration of the potential peatslide risk is required within the Environmental Statement in support of the Section 36 Planning Application. The assessment of peatslide risk is based on peat depth surveys and an assessment of the hazards based on the principles of the Peatslide Hazard Rating System and infinite slope model.

Development Site Description & Location	Enoch Hill Wind Farm is situated adjacent to the south of the B741 approximately 5km to the south west of New Cumnock, East Ayrshire at approximate central Ordnance Survey National Grid reference 257360, 608630. The Development Site boundary covers an area totalling approximately 1,466 ha (hectares). The site comprises a large area of open moorland and grazing pasture containing numerous peat grips and drainage ditches. The surface cover of the Development Site is dominated by grassed cattle pasture, heather, tussock grass and moss peatland with some areas of exposed soils in areas of recent slope failure along the steep sided valleys. The area of Blood Moss south of Peat Hill is particularly boggy and unstable underfoot. The topography of the Development Site is steeply undulating, with a general southward rising trend towards the minor summits at Peat Hill, Rigg Hill and Blarene Hill. In the central area of the Development Site the topography levels out slightly before continuing to rise towards the highest points of the site on Enoch Hill, High Chang Hill and Benty Cowan Hill. The Development Site also contains a number of deeply incised burns including Crocradie Burn, Trough Burn, Connel Burn and the lower reaches of the Knockburnie Burn.
Desk Based Information	**Soils** Soil Survey of Scotland mapping reveals that the south and west of the Development Site are underlain by blanket peat. The remainder of the Development Site is underlain by gleyed podzols of the Ettrick Association. The SNH Carbon rich soil, deep peat and priority peatland habitats map of Scotland (March 2015) indicates the Development Site contains Categories 1, 2, 3 and 4. **Geology** BGS mapping reveals that Chang Hill, Barbeys Hill, High Chang Hill, Littlechang Hill, Benty Cowan Hill and the south facing slopes of Enoch Hill and Peat Hill are underlain by peat. The remainder of the Development Site is underlain by Glacial Till and thin or absent superficial deposits. The Development Site is underlain by the Southern Uplands Fault, to the south of which is underlain by greywackes and shales of Ordovician age. The underlying strata is shown to be highly inclined dipping in a general south-south-eastern direction. To the north west of the fault the Development Site is shown to be underlain by basalt and basic andesite. In the west the Development Site is also shown to be underlain by a felsite intrusion of the Midland Valley Felsite Sill as well as conglomerate and sandstone of Lower Old Red Sandstone. The Development Site also contains the Passage Group, Upper Limestone Group and the Limestone Coal Group. The far north of the Development Site is shown to be underlain by a further two faults including the Dalmellington Fault which strike in various directions but which all have their downthrow to the north. **Previous Investigations** A previous investigation was undertaken by AECOM which included a review of published information on site geology, a geophysical investigation of peat depths and an initial Peatslide Risk Assessment. In total 19.1km of ground penetrating radar readings were collected which revealed that peat depths were within the range of between approximately 0.2m and 5.2m with an average peat depth of 0.87m. Peat depths greater than 3m were only found in localised areas, particularly to the south of Peat Hill. Although AECOM considered peat to be a prevalent issue across the Development Site the overall peatslide risk assessment was considered to be negligible to medium in localised areas. The only area of the Development Site perceived to have a medium risk of peatslides was a small area to the north of Chang Hill. **Topography** Digital terrain (DTM) data reveals that the Development Site elevation ranges from 210m above Ordnance Datum (m AOD) to a maximum elevation of 569m AOD on Enoch Hill.

	The DTM, the Development Site walkover and Ordnance Survey mapping of the Development Site also shows that the Development Site contains a number of deeply incised streams flowing within flat bottomed very steep sided valleys along Catlock Burn, Littlechang Burn, Crocradie Burn, Knockburnie Glen, parts of Trough Burn and along the upper reaches of Connel Burn. The DTM reveals that slope angles across the Development Site are between 0 and 47 degrees with the steepest slopes encountered along the very steep sided incised stream valleys. The shallowest slopes are found in the west of the Development Site between Blood Moss and Knockburnie Burn, on Barbeys Hill, Chang Hill and to the east of High Chang Hill. **Private Water Supplies** Information from East Ayrshire Council reveals details of seventeen private water supplies located within 1km of the Development Site. **Designated Sites** Scottish Natural Heritage (SNH) data reveals that there are no designated ecologically or geologically important areas within the Development Site boundary or within 3km of the Development Site. The SEPA River Basin Management Plan (RBMP) Interactive Map reveals that the Knockburnie Burn is a Fresh Water Fish Directive Salmonid Water. The Development Site is also within an area designated as a Salmonid Water area under the Fresh Water Fish Directive. **Peatslide Inventory** The BGS GeoIndex reveals that there are no recorded landslides or peatslides within the vicinity of the Development Site. The assessments undertaken within the adjacent proposed South Kyle Wind Farm to the west of the Development Site revealed no peatslides there either. An online search for references to peat slides reveals one peatslide occurred at Grievehill Opencast Coal Site (OCCS) located approximately 10.5km north east of the Development Site. A review of Google Earth aerial photography reveals that there are no obvious existing areas of peatslides within the vicinity of the Development Site. A review of aerial photography for the Hare Hill Wind Farm approximately 6km east of the Development Site, which appears to be on similar ground at a similar altitude, reveals that there are no obvious peatslides present. The land owners were contacted to establish whether they are aware of any historical peatslides on the Development Site. None of the land owner are aware of any historical peatslides having occurred within the area of development.
Scope of Works	Design of the peat surveys at Enoch Hill Wind Farm have been developed in general accordance with the phased approach detailed in Scottish Natural Heritage (SNH) *et al* guidance on 'Developments on Peatlands: Site Surveys.' A Phase 1 peat depth survey based on a grid of points at 100m intervals was undertaken in general accordance with SNH *et al* guidance. The results of this survey were utilised during design of the Phase 2 peat survey. The Phase 2 detailed peat depth survey was undertaken on the design freeze layout of the proposed wind farm in general accordance with SNH *et al* guidance. The interpretation of peat depth data provided by the Phase 1 survey was used as the basis for deriving the required scope of works such that detailed information on peat depth was provided in sensitive areas where the depth was interpreted to be >1m.
Findings	**Peat Depth** A Phase 1 peat survey of the Development Site comprising 879 peat depth measurements revealed that peat depths generally ranged between 0.0m and 3.3m with a total of 378 (43%) recording 'true' peat depths that are equal or greater than 0.5m in depth. The Phase 2 peat survey comprised a total of 700 peat depth measurements, the findings of which reveals that peat depths ranged between 0 and 2.88m. In total 439 (62%) of the peat depth survey locations recorded 'true' peat depths >=0.5m. **Peat Profile** Russian core sampling during the Phase 1 revealed that the peat had a typical one or two layer peat profile with only five locations having a triple layer profile. In general moisture content values were found to be low and humification values were typically less than H5 with H values up to H8 or H9 encountered in the deepest and wettest peat with two or more layers. Peat depth and von Post data from the Phase 1 survey are presented in Appendix B. **Geomorphology** During the Phase 1 and 2 peat surveys, geomorphological features were identified, typically in areas of deeper peat with depths exceeding 1m. The most numerous features identified were man made peat grips and drainage ditches. A limited number of features associated with natural processes of drainage and erosion were identified with localised hagging and flushes. In addition, a limited number of peat pipes and pipe collapses were identified during the Phase 1 peat depth survey, these features were found at some distance from infrastructure locations.

	During the Phase 2 survey a relic peatslide and potential soil creep were identified approximately 135m northwest of T4 and in the general locality of T19, respectively. In addition, numerous translational mineral soils slides were identified along the steep side slopes of the Littlechang Burn, Catlock Burn, Knockburnie Burn, Crocradie Burn and the Trough Burn.
Peat Slide Risk Assessment	A qualitative peatslide risk assessment undertaken at Development Site infrastructure using the principles of the Peatslide Hazard Rating System reveals that none of the proposed infrastructure is within areas considered to be highly susceptible to peatslides. In addition, a quantitative slope stability assessment has been undertaken using the infinite slope model in general accordance with Scottish Government Best Practice. Peatslide risk assessment reveals that turbines T7, T8, T12, T15 and Borrow Pit (BP) C as well as a number of track changes are within areas of low to moderate peatslide risk where the peatslide risk assessment should be reconsidered during the post-consent ground investigation of the Development Site. The Risk Zoning Plan also shows that turbines T2, T17 and T19 and their connecting tracks are within areas that are considered to be moderately susceptible to peatslides. However, their micrositing within the micrositing allowance is likely to move these turbines to areas or shallower peat depths and lower peatslide risk. Although the PHRS scores at the substation, temporary compound and Borrow Pit BP-A indicate some localised areas that have a low to moderate and moderate susceptibility to peatslides, the general trend in peat depths at these locations is <0.5m. As such these areas are not considered to pose a risk of a peatslide on further consideration, though the post-consent ground investigation should aim to confirm that these areas are low risk.
Mitigation Measures	The peatslide risk assessment reveals that mitigation measures will be required at a number of turbines and track chainages. In general the construction practices that should be avoided, include: ▶ Stockpiling and side casting of excavated materials on, or at the top of marginally stable peat covered slopes; ▶ Removal of support at the toe of peat covered slopes; and, ▶ Poor drainage practices such as the draining of excavations, and placement of outfalls onto peat covered slopes or blocking of drainage channels. A detailed intrusive ground investigation should be undertaken following consent, to assist in detailed design of turbine and infrastructure foundations. The ground investigation should be used to confirm the peatslide hazard assessments and peat slope stability assessment based on site specific parameters. Furthermore detailed investigations should be undertaken at infrastructure where a moderate peatslide susceptibility has been identified. The ground investigation should aim to provide information on the geotechnical characteristics (e.g. shear strength and bulk density) of the peat and underlying mineral substrate. In addition, the results of the ground investigation should inform the development of a geotechnical risk register which should be reviewed and updated at each stage of the post-consent development of the wind farm. As there is potential evidence of slope creep within the vicinity of T19 monitoring of ground movements surrounding the turbine will be required for the duration of construction. During the construction phase a geotechnical clerk of works should be present on the Development Site to monitor sensitive slopes for movement and to manage any changes to the peatslide risk. Further detail on potential mitigations that will be required is provided in Section 6.

Contents

1. Introduction

E.ON Climate and Renewables UK Developments Ltd (E.ON) is proposing to develop a commercial scale wind farm on open moorland between the settlements of Dallmellington and New Cumnock in East Ayrshire. The Proposed Development is situated adjacent to the south of the B741 approximately 5km to the south west of New Cumnock, East Ayrshire at approximate central Ordnance Survey National Grid reference 257360, 608630. The Development Site boundary covers an area totalling approximately 1,466 ha (hectares). However, the proposed wind farm development is confined to the south and west of the site.

A site location plan is presented as Figure 1 in Appendix A.

Amec Foster Wheeler Environment & Infrastructure UK Limited (Amec Foster Wheeler) has been appointed by E.ON to provide an Environmental Statement (ES) in support of the Planning Application. As some of the proposed wind farm extension will be located within areas of peat greater than 0.5m in thickness and on slopes greater than 2° consideration of the potential peatslide risk is required within the ES.

1.1 Scope and Purpose Report

The following Peatslide Hazard and Risk Assessment (PHRA) provides factual desk based information and factual peat survey results relating to the Development Site. The site data has been used to assess the risk of peat instability using the methodologies outlined in Section 5. A description of the appropriate mitigation measures is also provided, where applicable.

The PHRA has been completed in general accordance with Scottish Government Best Practice guidance by providing a qualitative hazard assessment and geotechnically based quantitative assessment of peat slide risk. The assessment comprises the following scope of work:

- A review of published data including geological, soil, hydrological and hydrogeological data;
- A description of the peat survey works undertaken by Amec Foster Wheeler;
- A review and presentation of the data collected by Amec Foster Wheeler;
- Identification of salient geomorphological features related to processes of peat erosion, drainage and mass movement;
- PHRA using the principles of the Peatslide Hazard Rating System method developed by Nichol (2006); and
- Peat slope stability assessment using the Infinite Slope Model as detailed in Scottish Government Best Practice guidance (2006).

1.2 Enoch Hill Wind Farm

Following the iterative design process a total of nineteen turbines have been carried through to the final design freeze layout. The Proposed Development will include the following infrastructure:

- Nineteen wind turbines;
- One 25m x 50m crane hard standing at each turbine;
- Two permanent meteorological masts;
- 12.9km of internal access tracks, including 25 No. passing places, constructed as follows:
  - ~1.9 km of floating tracks over peat depths greater than 1m;
  - ~11 km of cut tracks where peat is less than 1m in thickness;

- Five watercourse crossings;
- One permanent wind farm control building and one Scottish Power Energy Networks (SPEN) substation compound;
- Three borrow pit (BP) search areas (herein referred to as BP-A, BP-B and BP-C); and
- One wind farm temporary construction compound.

The proposed layout of Enoch Hill Wind Farm is presented in Figure 2 in Appendix A.

1.3 Sources of Information

The sources of desk based information reviewed as part of these works are summarised below. In addition, literature sources of information have been referenced in Section 5. References are provided in Section 8.

- Enoch Hill Wind Farm, Geotechnical Desk Study, Amec Foster Wheeler, July 2014, document reference 32965/CGos/60/A;
- Ordnance Survey mapping;
- British Geological Survey (BGS) digital and published geological mapping;
- Macaulay Institute for Soil Research, Soil Survey of Scotland digital and published mapping;
- Scottish Environment Protection Agency (SEPA) website, including the River Basin Management Plan (RBMP) interactive map;
- SEPA Aquifer maps;
- Scottish Natural Heritage (SNH) website;
- Contemporary aerial photography;
- Digital Terrain Models (DTM);
- Meteorological Office website; and,
- East Ayrshire Council Private Water Supply data.

2. Desk Study Information

2.1 Site Description

The Development Site comprises a large area of open moorland and grazing pasture to the south of the B741 which runs along the north-western boundary of the Development Site. The Development Site is managed moorland, containing numerous peat grips and drainage ditches throughout the Development Site. The surface cover is dominated by grassed pasture, heather, tussock grass and moss peatland with some areas of exposed soils in areas of recent slope failure along the steep sided valleys. The area of Blood Moss south of Peat Hill was particularly boggy and soft underfoot.

The topography of the Development Site is steeply undulating, with a general southward rising trend towards the minor summits at Peat Hill, Rigg Hill and Blarene Hill. In the central area of the Development Site around Chang Hill, Barbeys Hill and to the south of Peat Hill the topography levels out slightly. The topography then continues to rise towards the highest points of the Development Site on Enoch Hill, High Chang Hill and Benty Cowan Hill, beyond which the topography then falls towards Carsphairn Forest which is adjacent to the west and south of the Development Site. The overall trend in the topography is interrupted in a number of places by deeply incised burns that flow in a general north and north-eastern direction towards the River Nith. In particular, Crocradie Burn, Trough Burn and the lower reaches of the Knockburnie Burn have very steep sided valleys with the meandering burn situated within the flat valley bottom.

Ordnance Survey (OS) maps indicate the elevation of the Development Site ranges between approximately 230m above Ordnance Datum (AOD) in the northeast to 570m AOD on the summit of Enoch Hill in the south west.

In numerous places along the steep sided valleys of the Knockburnie Burn, Trough Burn and the Crocradie Burn translational failures of the mineral soils were identified. The largest most recent failure is identified adjacent to the north of the Development Site on the western side of the Trough Burn valley near the confluence with the Crocradie Burn. These failures were typically caused by over steepening of the slope during high flows on the outside of a meander.

The Development Site is surrounded to the east and south by Carsphairn Forest (some of which has been felled) and to the north and east by farming land and opencast coal sites.

A series of photographs of the Development Site are presented as Target Notes (TN) in Appendix C.

2.2 Published Geology

Pedology

Soil Survey of Scotland mapping reveals that the majority of the turbines, tracks, and the borrow pit search areas to the east of T16 are underlain by blanket peat. The remainder of the Development Site is shown to be underlain by peaty gleyed podzols and peaty gleys of the Ettrick, Hindward and Craigdale Associations. These soils are likely to comprise <0.5m of peaty organic soils over a gleyed podzolised soil profile which may include ferrogeneous layering such as iron pans.

The soils shown at each of the major wind farm infrastructure locations are summarised in Table 2.1 below.

Table 2.1 Summary of Soil Type at Infrastructure Locations

Soil Type	Association	Series	Infrastructure
Blanket peat	Organic Soils	-	T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11, T13, T14, T15, T16, T17, T19, BP-C, southern part of BP-A, part of the substation compound and temporary construction compound and approximately 10.1km of access track
Peaty gleyed podzols	Ettrick	Dod	T12, T18 and approximately 900m of access track.
Gleys and peaty gleys	Craigdale	Maneight	The majority of the temporary construction compound, part of the substation and control building, the northern half of BP-B and approximately 1.1km of access track.
Brown earths with peaty gleyed podzols	Craigdale	Maneight	North-eastern half of BP-A and approximately 200m of access track.
Peaty gleys with blanket peat	Hindsward	-	Development Site entrance and approximately 200m of access track

The recently published SNH Carbon rich soil, deep peat and priority peatland habitats consultation map of Scotland (March 2015) provides further information on the likely distribution of peat. The carbon and peatland classes shown at each of the major wind farm infrastructure locations are summarised in Table 2.1 below and in Figure 3 in Appendix A.

Table 2.2 Summary of Carbon and Peatland Classes at Infrastructure Locations

Carbon and Peatland Class	Class Description	Infrastructure
Class 1	▶ All vegetation cover indicates priority peatland habitats. ▶ All soils are carbon rich soils and deep peat.	T5, T7, T8, T13, T16, T17, control building and substation, BP-B, BP-C and approximately 3.45km of access track.
Class 2	▶ Most of the vegetation cover indicates priority peatland habitats. ▶ All soils are carbon rich soil and deep peat.	BP-B and approximately 170m of access track.
Class 3	▶ Vegetation cover does not indicate priority peatland habitat but is associated with wet and acidic soil types. ▶ Most soils are carbon rich soils, with some areas of deep peat.	T1, T2, T3, T4, T6, T9, T10, T11, T12, T14, T15, T18, T19, BP-A, BP-C temporary compound and approximately 8.5km of access track.
Class 4	▶ Area unlikely to be associated with peatland habitats or wet and acidic soils. ▶ Area unlikely to include carbon rich soils.	Approximately 650m of access track and BP-A.
Class X	▶ Vegetation cover does not indicate peatland habitat. ▶ All soils are carbon rich soil and deep peat.	No infrastructure.

The SNH map reveals that the north of the Development Site is within an area of Class 4, the central and south of the Development Site contains areas of Class 3 and there is a small area of Class 2 to the south of Rigg Hill.

Superficial Deposits

BGS mapping reveals that the south and south west of the Development Site is dominated by peat which covers Chang Hill, Barbeys Hill, High Chang Hill, Littlechang Hill, Benty Cowan Hill and the south facing slopes of Enoch Hill and Peat Hill. In the north and north east of the Development Site, BGS mapping reveals that the Development Site is underlain by Glacial Till which typically comprises a heterogeneous mix of clay, silt, sand, gravels, cobbles and boulders of various lithologies. In addition, the Development Site is shown to contain many areas with thin or absent superficial deposits.

In general, the Soil Survey of Scotland and BGS mapping are in agreement with regard the extent of peat anticipated to be present on the Development Site.

The superficial geology of the Development Site is presented on Figure 4 in Appendix A.

Solid Geology

BGS mapping reveals that the Development Site is underlain by a number of bedrock geologies. In the north west of the Development Site the Southern Uplands Fault is shown to trend northeast to southwest through the west of the Development Site passing between the location of T1 and T16 and to the southeast of BP-B. The downthrow of the Southern Uplands Fault is shown to be on the north side of the fault, the throw distance is not given on geological mapping.

To the south of the Southern Uplands Fault the Development Site is underlain by greywackes and shales of Ordovician age. The underlying strata is shown to be highly inclined dipping in a general south-south-eastern direction at angles from 50^{o} to vertically inclined. Within the greywacke, subcropping beds of conglomerate, mudstone, cherts and igneous dykes are identified within the Development Site. The greywacke and shale is also shown to contain veins of lead adjacent to the north west and west of Benty Cowan Hill.

To the north west of the Southern Upland Fault, the Development Site is shown to be underlain by basalt and basic andesite which is shown to underlie the ground between T16, BP-B and the far north of the Development Site. The west of the Development Site is also shown to be underlain by a felsite intrusion of the Midland Valley Felsite Sill as well as conglomerate and sandstone of Lower Old Red Sandstone series.

The far northwest area adjacent to the Development Site boundary is shown to be underlain by Passage Group, Upper Limestone Group and the Limestone Coal Group, comprising sandstone and cyclical sequences of sandstone, siltstone, mudstone, limestone, thick coals and seatclays of Carboniferous age. The far north of the Development Site is shown to be underlain by a further two faults including the Dalmellington Fault which trend in various directions and both have their downthrow to the north.

In the far north east of the Development Site the Southern Upland Fault is shown to trend generally northeast to southwest adjacent to the north of Brockloch Farm. To the north of the Southern Uplands Fault the underlying geology is dominated by Carboniferous age Middle Coal Measures comprising cyclical sequences of sandstone, siltstone, mudstone, coals and seatclays. The far north west of the Development Site is shown to be underlain by two subcropping coal seams located within the Middle Coal Measures. These are the Upper Gas Coal and the Eight Foot Coal which trend generally parallel to the Southern Upland Fault. The far north west of the Development Site also contains a small area underlain by the Lower Coal Measures, the Upper Limestone Group and a dolerite igneous intrusion.

The solid geology of the Development Site is presented in Figure 5 in Appendix A.

2.3 Previous Ground Investigation

Feasibility Report

AECOM were commissioned by E.ON to complete a feasibility report for the Enoch Hill Wind Farm. This assessment included a review of published information on the Development Site geology and a geophysical investigation of peat depths. AECOM commissioned APEX Geoservices Ltd to complete an assessment of peat depths using ground penetrating radar (GPR).

In total 19.1km of GPR readings over 47 profiles were collected which revealed that in general, peat depths were within the range of between approximately 0.2m and 5.2m with an average peat depth of 0.87m. Peat depths greater than 3m were only found in localised areas, particularly to the south of Peat Hill.

South Kyle Wind Farm

The planning application for the South Kyle Wind Farm, situated within the Carsphairn Forest adjacent to the west and south of the Development Site, was submitted by Vattenfall Wind Power in August 2013. Although it is recognised that the land use (forestry) differs from Enoch Hill, given its proximity to the Development Site some of the information contained within the ES may still be relevant.

Peat depth investigations of South Kyle Wind Farm 561 peat depth measurements which revealed peat depths of between 0m and >4.40m (presumed to be the maximum measureable depth).

The previous investigations reveal that no relic peatslides or sub-profile drainage features were identified which is likely to be a consequence of the forestry land use. However, the forestry area was noted to be drained by numerous ditches.

In addition to peat depth measurements, investigations of the Development Site included the collection of 800 shear vane measurements at 250mm and 500mm depths. The results revealed an average value of 21kPa at both depths with more than 75% of the measurements recording shear vane values <30kPa and the lowest values associated with the wettest ground.

Where exposed at the surface, the superficial deposits were noted to comprise brown and grey brown, heterogeneous, silty, sandy and gravelly Glacial Till without evidence of humic staining or ferruginous layering according to the available examples.

2.4 Local Climate

The Meteorological (Met) Office website reveals that average annual rainfall within the western Scotland region ranges between 1,000mm over lower lying areas to over 3,500mm over higher ground. The Met Office Average Annual Rainfall map of West Scotland reveals that the Development Site is located within an area expected to receive between 1,300mm and 1,700mm per annum. In addition, the Met Office website reveals that Cumnock received an annual average rainfall of 1,390mm between 1981 and 2010.

The PHRA of the South Kyle Wind Farm reveals that an instrumented weather station at Moor (NS570036), approximately 2.6km south of T19, recorded an average annual rainfall of 1,715mm per annum between 1941 and 1970.

2.5 Aerial Photography & Development Site History

Historical Maps

Historical maps dating from 1850 to 1956 have been reviewed on the National Library of Scotland mapping service. The maps indicate that there has been little significant change during this time with the majority of the Development Site illustrated as open moorland crossed by a number of burns.

Historical mapping reveals that the Development Site contains a number of place names and mapped features of interest on the Development Site with regard peat and slope stability. In the northwest of the Development Site historical mapping identifies Peat Hill and Flood Moss (now Blood Moss) around the location of the proposed control building and substation. A number of potential slope failures are identified on historical mapping along the valley sides of the Trough Burn, Crocradie Burn and Knockburnie Burn. Further detail on these slope failures is detailed below.

Aerial Photography

Aerial photography with a 25cm resolution was obtained from Getmapping Plc (2010) and is presented as Figures 6.1 to 6.4 in Appendix A. Google Earth (© 2015 Google, © 2015 Getmapping plc) aerial imagery was also reviewed to supplement older mapping due to the steepest valley sides being in shadow. The resolution of these sources of aerial photography has allowed the identification potential geomorphological features such as peatslides, peat erosion, peat haggs, and gullies, peat cuttings, standing water, peat pipes, peat pipe collapses, flushes, drainage ditches and peat grips. In addition, mineral soil landslides are easily identifiable on aerial photography. These features have been interpreted from the size, shape, location and colour and in places have been encountered and ground truthed on site during the peat survey works.

Historical aerial photography held by the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) ranging in date from 1946 to 1988 was reviewed. However, the available photography is at a small scale (1:24,000) and as such only the larger translational mineral soil slides along the steep sided valleys are visible.

A review of contemporary aerial photography (Getmapping Plc, 2010) reveals that the Development Site contains no obvious relic or incipient peatslide features such as indications of backscars, peatslide rafts or run-outs. However, aerial photography reveals that there are numerous mineral soil translational failures along the steep sided valleys of Knockburnie Burn, Crocradie Burn, Catlock Burn and Littlechang Burn. These failures have potentially been caused by over steepening of the slopes by erosion on the outside of stream meanders. These features generally appear as a pronounced arcuate headscarp with downslope run-out of the mineral soils. In addition, bedrock or mineral superficial deposits are visible and the slide has been of sufficient magnitude to have altered the course of the stream in some cases. During the peat surveys a number of the mineral slides were identified on the Development Site, examples of the feature identified are presented in TN 021, 022 and 025 in Appendix C.

In the vicinity of T19, aerial photography appears to indicate that the ground surface may be uneven and potentially terraced. A walkover of this area during the peat surveys revealed that this area may have experienced slope creep.

The only peat erosion features identified in aerial photography are small areas of hagging located around the source of Littlechang Burn to the west and southwest of T5. In addition areas of flushing and hagging are also identified between T6 and T7, between T10 and T13 and at the Development Site boundary to the south of T3. The aerial photography reveals that the Development Site also has numerous areas where the ground has been drained by gripping of the peaty soils. In general most gripping is low intensity with spacing's typically in the range of less than 15m to 30m or more. The grips are typically aligned down or diagonally along the slope. There are two areas of the Development Site that are intensely gripped with spacing's less than 15m and that often criss-cross wider spaced grips running perpendicular to them. The areas of intense peat gripping are located in the vicinity of turbines T2 and T17 and within the north west of BP-A.

Figure 7 in Appendix A presents the locations of key geomorphological features within the Development Site. Target notes are presented in Appendix C.

2.6 Topography

The Ordnance Survey Terrain 5 Digital Terrain Model (DTM) with a 5m resolution was obtained for the Development Site. The DTM reveals that the lowest elevation is approximately 210m above Ordnance Datum (m AOD) adjacent to the B741. The overall topographic trend is rising moderately steeply from north to south reaching a maximum elevation of 569m AOD on Enoch Hill.

The DTM, the site walkover and Ordnance Survey mapping of the Development Site also shows that the Development Site contains a number of deeply incised streams flowing within flat bottomed very steep sided valleys, TN 021, 023 and 050. These very steep sided valleys are found along the route of Catlock Burn, Littlechang Burn, Crocradie Burn, Knockburnie Glen, parts of Trough Burn and along the upper reaches of Connel Burn in the far south of the Development Site.

The DTM reveals that slope angles across the Development Site are between 0° and 47° with the steepest slopes encountered along the very steep sided incised stream valleys. The shallowest slopes are found within the west of the Development Site between Blood Moss and Knockburnie Burn, on Barbeys Hill, Chang Hill and to the east of High Chang Hill.

The OS Terrain data is presented within Figure 8 in Appendix A.

2.7 Hydrology

Ordnance Survey mapping reveals that the Development Site is within the catchment of the River Nith which is located approximately 2.3km to the north. Onsite, Ordnance Survey mapping shows that the Development Site forms the watersheds for a number of named burns that include Spout Burn, Knockburnie Burn, Polmath Burn, Crocradie Burn, Redhall Burn, Blarene Burn and the Connel Burn that all flow generally northward to the River Nith. In addition, these burns are fed by named and unnamed burns including Littlechang Burn, Catlock Burn, Trough Burn, Polga Burn and the Straid Burn. The Strathwiggan Burn and Bitch Burn are located on the south side of Enoch Hill and High Chang Hill and flow southward to the Water of Deugh.

The locations of watercourses draining the Development Site are shown in Figure 2 presented in Appendix A

The SEPA River Basin Management Plan (RBMP) website reveals that only the Knockburnie Burn is classified by SEPA under the Water Framework Directive. This stream is classified as having an overall status of Good and an overall chemical status of Pass.

Further information on the hydrology of the Development Site and its surroundings is referenced in Chapter 13: Geology, Hydrology and Hydrogeology within the ES.

There are no designated surface water Drinking Protected Areas within the Development Site.

2.8 Hydrogeology

The Superficial Aquifer Map of Scotland reveals that the far north and north east of the Development Site is underlain by deposits with a high productivity where flow is dominated by intergranular flow. The remainder of the Development Site is shown to be underlain by low productivity superficial deposits where flow is dominated by intergranular flow.

The Bedrock Aquifer Map of Scotland indicates that the Development Site is underlain by a low productivity bedrock where flow is dominated by intergranular and fracture flow.

The SEPA RBMP Interactive Map indicates that the Development Site is underlain by the New Cumnock bedrock and localised sand and gravel aquifer. This is classified by SEPA under the Water Framework Directive as having an overall status of Poor, with an overall quality status of Poor but with a Good quantity status.

The Development Site is shown to be within a Drinking Water Protected Area for groundwater.

2.9 Private Water Supplies

East Ayrshire Council has provided details of private water supplies (PWSs) located within 3km of the Development Site. Table 2.3 below and Figure 2 in Appendix A summarise the locations of the PWSs identified within the vicinity of the Development Site.

Table 2.3 Private Water Supplies Located within 1km of the Development Site Boundary

Supply Name	**Easting**	**Northing**	**Supply Source**	**Distance from Development Site Boundary**
Meikle Hill	252969	609059	spring	1.9km west
Nith Lodge	253070	609554	spring/near surface water	1.5km west
Knockenlee	253620	609169	borehole	1.2km west
Maneight Farm	254300	609200	spring	550m west
Craighouse Cottage	254892	610295	spring	Onsite in northwest

Supply Name	Easting	Northing	Supply Source	Distance from Development Site Boundary
Lanehead Farm	255600	610200	spring	Onsite in north.
Knockburnie Farm	256024	610242	spring	Onsite in north.
Brockloch Farm	259213	609952	spring	Onsite in northeast.
Laglaff Farm	260500	609900	spring	520m east.
Brockloch Farm	258950	609700	spring	Onsite in northeast.

Notes
Coordinates for PWS's that have not had their source location recorded according to East Ayrshire Council record are assumed to be at or near the property they supply.

In addition to the above sources, East Ayrshire Council has also identified the locations of PWS infrastructure including tanks and pipelines within the Development Site.

Although East Ayrshire Council has identified ten PWS within 3km of the Development Site the supplies for Laglaff Farm, Meikle Hill, Nith Lodge and Maneight Farm are not considered to be at risk from potential peatslides from the Development Site. This is due to their location being well beyond the area of Proposed Development or on the opposite side of a valley from the Development Site. The remaining PWS are potentially at risk of adverse effects from potential peatslides due to their location downslope or downstream of the proposed area of development.

2.10 Designated Sites

SNH Natural Spaces data reveals that there are no designated ecologically or geologically important areas within the Development Site boundary or within 3km of the Development Site.

The SEPA RBMP Interactive Map reveals that the Knockburnie Burn is a Fresh Water Fish Directive Salmonid Water for the River Nith that is located approximately 2.3km north of the Development Site boundary. The Development Site is also within an area designated as a Salmonid Water area under the Fresh Water Fish Directive.

2.11 Peatslide Inventory

The BGS GeoIndex reveals that there are no recorded landslides or peatslides within the vicinity of the Development Site. The assessments undertaken within the adjacent proposed South Kyle Wind Farm to the north of the Development Site revealed that there are no peatslides within Carsphairn Forest.

An online search for references to peat slides within the area of New Cumnock was conducted. This search reveals one article published in the Herald Scotland which relates to a peatslide at Grievehill Opencast Coal Site (OCCS) located approximately 10.5km northeast of the Development Site. According to the article, planning conditions to prevent a collapse of the bog were imposed, however it was alleged that none of the conditions were met, resulting in a bog burst on the south side of the opencast.

A review of Google Earth aerial photography reveals that there are no obvious peatslides within the vicinity of the Development Site. A review of aerial photography for the Hare Hill Wind Farm approximately 6km east of the Development Site, which appears to be on similar ground at a similar altitude, reveals that there are no obvious peatslides present.

The land owners were contacted to establish whether they are aware of any historical peatslides on the Development Site and they confirmed that they are not aware of any historical peatslides within the area of development.

3. Field Investigations

3.1 Design of Investigation

Design of the peat surveys at Enoch Hill Wind Farm was developed in general accordance with the phased approach detailed in SNH, Scottish Government and James Hutton Institute guidance on 'Developments on Peatlands: Site Surveys,'(herein described as the SNH guidance).

As desk based information reveals the presence of peat and peaty soils onsite, a Phase 1 peat depth survey was undertaken on the whole development area and an access corridor in the north west of the Development Site. In accordance with SNH guidance this survey was undertaken using a 100m x 100m grid of points which resulted in a total of 879 peat depth measurements. The results of this survey were utilised during the iterative design of the wind farm layout, such that areas of deep peat could be avoided wherever practical.

Following design freeze of the wind farm layouts, a Phase 2 detailed peat depth survey was undertaken. This targeted the location of proposed wind farm infrastructure and was conducted in general accordance with SNH guidance. The interpolation of the Phase 1 peat depth data was used as the basis for deriving the required scope of works such that detailed information on peat depth and salient peatslide features was provided in sensitive areas where the depth was interpreted to be >1m in thickness.

The design of the Phase 2 survey works along access tracks comprised a single point at 50m intervals along all access tracks. Within or close to areas where peat was interpreted to be >1m in depth the central point was supplemented by an offset point 10m perpendicular to either side of the proposed route.

At turbine and met mast locations, where peat was interpreted to be <1m deep, survey points were placed at the central turbine location and at four locations at the edge of the micro-siting allowance (50m). Where the turbine is within or close to an area with an interpreted peat depth >1m a grid of points at 25m intervals was placed within the micro-siting allowance (13 points). This design allowed for additional information on peat depth to be collected within the micro-siting allowance and resulted in additional points at T2, T7, T8, T15, T17 and T19. The locations of points were subsequently optimally orientated, i.e. to combine track and turbine survey points wherever possible.

Following design of the survey to cover the turbines and tracks, additional points were placed on the crane pads where required to allow for a minimum of one point per crane pad. The substation and temporary construction compound were surveyed on grid of points at 20m intervals. The three borrow pit search areas were surveyed on a grid of points at 50m intervals.

Where peat depths of >1m were unexpectedly encountered, additional peat depth measurements were taken in accordance with the methodology detailed above.

3.2 Methodology

Peat Depth Survey

The Phase 1 peat depth survey was undertaken by Russian core sampling. This was conducted by initially using a 1m long peat probe to establish whether the soft deposits (which include peat) were greater than 0.5m in thickness. Where soft deposits were greater than 0.5m in thickness the sampler was used to physically measure the depth of peat and to recover samples for inspection and von Post classification at all locations where required. The sampler was manually driven into the ground at 0.5m vertical intervals, extracting a sample at each interval until it refused on a solid obstruction. There were no survey locations where the practical limit of the equipment was reached during the Phase 1 peat depth survey.

Recovered peat samples were subject to a modified von Post classification (Hobbs, 1986). Although this classification scheme allows many characteristics to be described, only those which could be determined on site were recorded. These included the degree of humification (H), water content (B), fine fibres content (F), coarse fibres content (R), wood remnant content, (W), smell (A) and the possibility of plasticity index testing

(P). The characteristics that were not determined on site included, plant type, organic content, pH and tensile strength.

The Phase 2 survey of the proposed infrastructure was conducted by peat probing using an extendable fibre glass peat utility probe extendable up to 5m in length. As the Phase 1 survey provided sufficient information on the characteristics of the peat across the whole Development Site, no further Russian core sampling or logging of peat was conducted during the Phase 2 peat depth survey.

During the Phase 1 and 2 surveys the results at each survey location were recorded using a hand held Trimble Juno 3B Personal Digital Assistant (PDA) with GPS positioning and mobile GIS capabilities. The accuracy of the Trimble Juno 3B generally ranged between 1m and 3m which is considered sufficiently accurate for the purposes of a peat survey. The following parameters were recorded on ESRI ArcPad at each location, some were only collected during the Phase 1 survey:

- Date;
- Peat depth;
- Peat layer depth ranges (Phase 1 only);
- von Post classifications (Phase 1 only); and
- Peat Hazard Rating System (PHRS) descriptions.

During both surveys Peat Hazard Rating System (PHRS) descriptions included the presence of water on the slope, slope angle and regularity, geomorphology and peatslide history, in accordance with Nichol (2006).

Peat survey data was exported from the Trimble Juno PDAs to ESRI ArcGIS for data processing.

Peat Geomorphology Survey

A visual geomorphological walkover of the Development Site was carried out at and between each probe location while conducting peat survey works in order to inform the Peatslide Hazard Rating System (PHRS). The geomorphological walkover sought to map the following features:

- Relic peatslides;
- Tension features (e.g. tension cracks);
- Compression features (e.g. compression ridges & peat thrusts);
- Sub-profile drainage features (e.g. peat pipes and pipe collapses);
- Peat creep features (e.g. closed peat grips);
- Erosion features (e.g. exposed peat faces, peat haggs and gullies);
- Surface drainage features (e.g. flushes); and,
- Humification of the mineral substrate was also noted in exposures.

The geomorphological features identified were captured on the Trimble Juno 3B PDA. The target notes presented in Appendix C provide examples of the geomorphological features identified on the Development Site.

3.3 Laboratory & In-situ Testing

Due to the inherent material variability, the difficulty in obtaining representative samples of peat and thus obtaining sensible and reproducible geotechnical parameters, samples were not recovered during the Phase 1 or 2 peat investigation and no laboratory or in-situ testing was scheduled or undertaken. The collection of samples is not considered critical for peatslide risk assessment at the Planning Application stage as these parameters should be determined during the post consent ground investigation.

4. Peat Survey Findings

4.1 Introduction

The Phase 1 peat depth survey was undertaken between 7th and 18th July 2014 and on the 8th and 9th September 2014 during periods of relatively dry weather with intermittent showers.

The Phase 2 peat survey was undertaken between 1st and 5th June 2015. Very heavy rainfall was experienced on the 1st June, followed by dry windy weather with intermittent light rain for the remainder of the survey.

4.2 Peat Depth & Profile

The Phase 1 and 2 peat depths surveys comprised a total of 1,581 peat depth measurements. In general peat depths ranged between 0.0m and 3.3m with a total of 764 (48%) recording 'true' peat depths >=0.5m. The calculated true peat mean depth for the Development Site is 1.02m and the most frequently recorded peat depth was 0.5m (10%).

At proposed wind farm infrastructure a total of 700 peat depth measurements were taken with peat depths ranging between 0 and 2.88m. In total, 439 (62%) of the peat depth survey locations recorded 'true' peat depths >=0.5m. The calculated true peat mean depth of at the proposed infrastructure is 0.79m and the most frequently recorded peat depth was 0.9m (5%).

Peat depth data is summarised in Figure 9.1 to 9.6 in Appendix A.

A peat depth contour plan showing the interpolated distribution of peat depths is presented as Figure 10. This is based on both the Phase 1 and Phase 2 peat depth measurement and therefore provides the highest degree of accuracy at the proposed wind farm infrastructure. The interpolated peat depth map was generated using ESRI ArcGIS Spatial Analyst tools to interpolate the peat depths between survey points using the Natural Neighbour method (default settings), this being the simplest interpolation of the peat depths between survey points. In Figure 10 a threshold of 0.5m has been applied to highlight areas of 'true' peat, i.e. organic soils >0.5m in depth, as opposed to soils with organic surface horizons <0.5m which would be classified as peaty gleys and peaty podzols for example. The interpolated peat depth map reveals that peat depths >0.5m roughly correspond with the areas of peat shown in BGS mapping of the Development Site.

During the Phase 1 survey a total of 321 Russian cores samples were inspected which revealed that the peat had a typical one or two layer peat profile with only five locations having a triple layer profile. In general moisture content values were found to be low (i.e. von Post class B2) and humification values were typically less than H5 with H values up to H8 or H9 encountered in the deepest and wettest peat with two or more layers. Based on the modified von Post classification system the following characterisation of the peat profile applies:

Where a one layer profile was encountered the von Post classification was typically:

H_5 B_2 F_2 R_1 W_0 A_1 P_1

Where two layers of material were encountered the von Post classification was typically:

Upper layer – H_7 B_2 F_2 R_2 W_0 A_1 P_1
Lower layer - H_7 B_2 F_1 R_1 W_1 A_1 P_1

It should be noted that the above is a general characterisation of the peat layers and as such localised variations in this were noted across the Development Site during the Phase 1 investigation.

4.3 Peat Substrate

The phase 1 and 2 peat surveys revealed that there are numerous exposures of the underlying peat substrate, particularly along the steep sided valleys of the water courses that drain the Development Site. There were very few peat substrate exposures in areas of deeper peat or on the upper slopes and flatter ground.

Where exposed by translational slides, the underlying substrate was noted to comprise a brown or grey clayey very gravelly sand with a high cobble and boulder content. In a number of places throughout the Development Site, particularly where there is shallow peat, numerous cobbles and boulders were noted to protrude the peat at the surface. In some exposures the underlying substrate was noted to comprise sandy gravelly weathered bedrock. Bedrock was also noted to be close to the surface at a number of locations where it has been exposed by translational slope failures. Where exposed, the bedrock was noted to be rough and irregular as shown in TN 004, 021, 022, 026, 027 and 039.

In addition to exposures, a small sample of the peat substrate was often extracted in the Russian core samples. In general this was found to comprise a gleyed sandy clay as shown in TN 031 and 043.

4.4 Geomorphology

During the Phase 1 and 2 peat surveys geomorphological features were identified, typically in areas of deeper peat with depths exceeding 1m, examples of the features identified are presented in TN 030, 047 and 057 in Appendix C.

The most numerous features identified were man made peat grips and drainage ditches which correspond with the findings of a review of aerial photography (see Section 2.5) and were found across most parts of the Development Site. Although features associated with natural processes of drainage and erosion were identified, these were limited in number and typically comprised local hagging and flushes, see TN 009, 019, 036, 038, 037, 040 and 055. In addition, a limited number of peat pipes were identified during the Phase 1 peat depth survey, such as to the northwest of T1 and potential peat pipe collapses to the north of T2 and at the source of the Polga Burn, see TN 013, 028, 045, 048 and 049.

During the Phase 2 survey the only indication of a relic peatslide feature was encountered on the north face of Enoch Hill approximately 135m northwest of T4. The relic peatslide comprises an area of slumped peat on the moderately steep slope with a visible backscar and a peat grip at the toe of the slide, see TN-058. A review of aerial photography in the area of the slide reveals that there may also be a similar feature approximately 50m to the north east. Further potential slope movement by slope creep was identified on the south side of Enoch Hill in the general location of T19. TN-034 shows potential tension cracks and micro terracing of the slope where peat depths range from <0.5m to >2m in thickness.

Along the steep side slopes of the Littlechang Burn, Catlock Burn, Knockburnie Burn, Crocradie Burn and the Trough Burn numerous translational mineral soils slides were identified. These features generally accord with the aerial photography and typically comprise an arcuate scar on the valley side with rafts of topsoil and exposed superficial deposits and/or bedrock, see TN 021, 022 and 025.

5. Peatslide Risk Assessment

5.1 Introduction

The results of the desk based research reveal that the Development Site presents conditions which may be susceptible to peatslides in certain areas. In particular, desk based information and site surveys indicate that the Development Site contains areas of blanket peat with peat depths up to 3.3m. Furthermore the DTM for the Development Site indicate that slope angles within the Development Site are typically >2°, ranging up to around 47°. On this basis a peatslide risk assessment is considered necessary to identify areas at risk of a peatslide and to target mitigation measures and monitoring of slope movement.

The following assessment of peatslide risk has been undertaken in general accordance with Scottish Government guidance in providing a qualitative and quantitative assessment of peatslide risk.

5.2 Qualitative Peatslide Risk Assessment

Methodology

A qualitative peatslide risk assessment has been undertaken using the principles of the Peatslide Hazard Rating System (PHRS) as developed by Nichol (2006), modified for the specific Development Site conditions. The PHRS is a variation of the method outlined in Scottish Government Best Practice Guidance and comprises ten categories with criteria scores applied to each hazard corresponding to logical stages of associated increasing risk. The scores for each hazard category are derived from an exponential scale which provides a rapid increase in score to distinguish the increasing severity of the hazard. The scores for each type of hazard can range from 0 (lowest hazard) to 100 (highest hazard), the method allows the assessor some flexibility in evaluating the impact of hazardous conditions.

When evaluated and combined, the PHRS scores generate a single value that allows for the identification and differentiation of localities from low to high risk. In general, localities with higher scores present the highest risk of a peatslide occurring.

The key criteria contained within the PHRS and their relating scores are included in Table 5.1. To ensure that the methodology is appropriate for assessing each different site, the scores for each PHRS criterion are checked to ensure that they are suitably site-specific, further explanation on the PHRS scorings for each factor is given below.

Table 5.1 Peatslide Hazard Rating System

Category	Rating Criteria and Score			
	Points 3	Points 9	Points 27	Points 81
Rainfall and climate	Low to moderate precipitation	Moderate precipitation	High precipitation	Very high precipitation
Presence of water on slope	No water on slope; Few water bodies	Intermittent water on slope; Occasional water bodies	Continual water on slope; Many water bodies	Continual water on slope; Major water bodies
Rockhead or subsoil	Rough and irregular rockhead or granular subsoil of sand and gravel	Undulating rockhead or granular subsoil	Planar and regular rockhead or cohesive subsoil	Smooth, polished and regular rockhead or cohesive subsoil of clay

Category	Rating Criteria and Score			
	Points 3	Points 9	Points 27	Points 81
Peat profile and depth	Single layer profile < 1m deep	Double layer profile < 2m deep	Triple layer profile > 2m deep	Complex profile. > 4m deep
Peat strength (vane shear test)	40 kPa	30 kPa	20 kPa	10 kPa
Slope and slope regularity	2˚; even	5˚; uneven	10˚; irregular	15˚; very irregular
Geomorphology and site history	Few differential erosion features	Occasional erosion features	Many erosion features	Major erosion features
Sub-profile drainage	Few pipes	Occasional pipes	Many pipes	Many pipes and sinkholes
Peatslide history	Few slides	Occasional slides	Many slides	Major peatslide events
Potential peatslide severity	Few consequences: small impacted area	Minor consequences: minor impacted area	Many consequences: large impacted area	Major consequences: large impacted area

During the Phase 2 detailed peat survey the locations were assessed using the categories in Table 5.1 above to provide information required for the PHRS assessment. This excluded the Potential Peatslide Severity Factor which has been determined separately as discussed below. The information collected by the surveyors was stored on the Trimble PDA and scoring of the points conducted using this data and site knowledge to attribute the appropriate scores to the individual points.

A summary of the methodology for scoring each of the ten hazard criteria used in this assessment is given in the following sections.

Rainfall & Climate

The amount and intensity of rainfall a peat body receives is an important contributory factor in initiating peat slides. In many peatslide studies the occurrence of a slide has been attributed to heavy rainfall delivered during high intensity events (Carling, 1986, Acreman, 1991), high rainfall over longer periods (Wilson and Hegarty, 1993; Hendrick, 1990) or rainfall and snow melt combined (Warburton *et al*, 2003).

As detailed in the desk based information an instrumented weather station within the vicinity of the Development Site measured an average annual rainfall of 1,715mm per annum between 1941 and 1970. In addition, Met Office information reveals that average annual rainfall in the Cumnock area is in the order of 1,390mm per annum.

The method of assessing the rainfall hazard applies scores to average annual rainfall within the range of 800 to 1,800mm per annum as derived by the exponential scale detailed within the methodology. Where the average annual rainfall exceeds this range the maximum score of 100 is applied. On the basis of climatic information a score of 91 has been applied to all points due to the potential for lower average annual rainfall.

Presence of Water on Slopes

The hydrogeology of peat is complex and differing hydrogeological conditions within the acrotelm and catotelm are demonstrated in a number of studies (Warburton *et al*, 2004). In general, surface water flows over peat are concentrated through the upper more fibrous acrotelm with flow depths up to 0.2m below ground level reported (Warburton *et al*, 2004). Catotelmic (amorphous peat beneath the fibrous acrotelm) hydrogeology appears to be dominated by vertical seepage and concentration of flows along peat pipes (considered separately).

The resulting surface features of a blanket bog's hydrogeology include the presence of seeps, flushes and bog pools of varying scale. The presence of these features may give rise to increased vertical migration of surface water through the catotelm leading to increased basal moistening or liquefaction of basal peat (Evans & Warburton, 2010) and decreased shear strength. In addition, increasing moisture content and waterlogging of the peat will also increase the loading on the slope and basal/substrate pore water pressures.

In terms of surface drainage, Mills (2002) attributes the presence of drainage features such as flushes discharging to the top of the slide as being a contributory factor in several reported peatslides or bursts.

As a possible consequence of the density of drainage ditches and peat depth, very few parts of the Development Site where infrastructure is proposed were noted to have standing water or wet boggy ground. The only features that were identified within the location of proposed infrastructure were peat flushes, some localised wet ground and some very small pools. The scoring of survey points for the Development Site was attributed as follows:

- 3 points – ground without standing water or locations with a peat depth of 0m;
- 9 points – intermittently wet ground, occasional ponds, pools and minor streams;
- 27 points – continual wet ground on the slope, large streams, small flushes and gullies, many small ponds and pools; and
- 81 points – continually saturated ground on the slope, rivers, large gullies and drainage ditches, large ponds, pools and flushes.

Rockhead or Subsoil

The rockhead/subsoil category relates to the potential for the peat to move down slope relative to the rockhead or granular and/or cohesive substrate surface. In a number of peatslides described in the literature the substrate characteristics of the slopes have been considered a possible contributory factor in making the slope prone to a peatslide failure. The presence of particular substrate features such as an iron pan within the soil profile below the peat was reported at three peat slides by Acreman (1991, p. 175). In other studies, Glacial Till deposits were reported at peatslides described by Crisp *et al* (1964), Tomlinson and Gardiner (1982) and Carling (1986) in the Pennines and County Antrim and basalt derived regolith and 'rubble' was noted in the study by Wilson and Hegarty (1993). Nichol (2009) noted patches of smooth rockhead at the head of a peatslide within the Scottish Highlands.

For underlying superficial deposits, the category distinguishes between cohesive and granular strata. In addition the category also allows for the presence of impervious clay or rock at the peat/substrate interface which have been previously linked to failure by creating perched water tables at the interface.

The scoring of points was determined by site observations and desk based information. Although there were some exposures of the substrate at ground level, there is insufficient data to accurately map the distribution and composition of the peat substrate. Where exposed, the substrate was found to comprise clayey very gravelly sand without any indications of humic staining or ferrogeneous layering (i.e. iron pans). Further indications of a clayey substrate were also identified within the base of a number of the Russian sampler core holes, where soft clay was encountered. In other exposures, the substrate was found to comprise possible weathered bedrock comprising sandy gravels and cobbles.

In the absence of detailed ground investigation information and on the basis of the observed substrate exposures, PHRS scores have been based on geological mapping. In areas where BGS mapping indicates thin or absent deposits a PHRS score of 3 has been applied to the survey points. In these areas it is considered likely that there will be granular deposits or a rough and irregular/undulating bedrock substrate interface. Where BGS mapping indicates that Glacial Till and peat are present a PHRS score of 18 has been applied as these areas are likely to contain variable deposits that may be dominated by clayey, very gravelly sand with cobbles and boulders.

Peat Profile & Depth

The peat depth and profile are both equally key factors associated with peatslide events. In literature, peat depths at slide locations vary with typical depth values reported to be between 0.5m and 3.0m depth (Warburton *et al*, 2004). Evans and Warburton (2010) indicate that peatslides are most frequent in peat depths between 1.0m and 1.5m.

The scores assigned to the peat depths in this assessment are obtained as per the PHRS methodology (Table 5.1). However, the system requires consideration be given to other peat factors so as not to overestimate the importance of peat depths. As such, the number of layers within the peat, the level of humification, moisture content, and fibrosity has also been taken into account when attributing scores to the locations. As per the methodology, PHRS scores for peat with multiple layers, high humification values, high water content and low fibrosity have been attributed higher peat depth and profile scores to take account of the increased hazard these conditions pose. For areas without 'true' peat (<0.5m) a score of 0 is attributed. In addition, as the depth of peat will affect the likelihood of other features such as peat pipes being present, where peat depth is 0 other factors such as sub-surface drainage, geomorphology and site history are also given a PHRS score of 0.

Russian peat sampling and description of the peat in general accordance with the modified von Post classification (Hobbs 1986) was undertaken during the phase 1 peat depth survey of the Development Site. In order to consider the peat profile in the PHRS score, the nearest Russian peat sample results are considered in the scoring.

Peat Strength

It is generally recognised that the shear strength of the peat is an important contributory factor in not only assessing peatslide susceptibility but also in the initiation of peatslides (Boylan *et al*, 2008). However, it is also recognised that it is difficult to apply traditional methods for measuring shear strength in mineral soils due to the presence and inherent variability in the fabric and stratification of peat deposits (Dykes, 2008) and the presence of fibres. However, notwithstanding the inherent limitations, *in situ* hand shear vane testing provides a sufficient estimation of the shear strength of peat. Hanrahan (1994) suggests that hand shear vane testing remains a useful simple method of evaluating hard and soft layers within the peat profile. In addition, widespread use of *in situ* shear vane testing is common in many of the literature sources, and studies of other wind farms. As such, the shear strength of the peat cannot be ignored in the PHRS assessment.

As detailed in Section 4.3 there were very few peat exposures available for *in-situ* hand shear vane testing during the phase 1 and 2 peat surveys. Where exposures were encountered these were typically found to be dry and often desiccated, resulting in test results that would have been unacceptably unreliable and as such no hand shear vane results are available for the Development Site.

However, shear strength data is available for the adjacent proposed South Kyle Wind Farm. These readings were taken from a depth of 250mm and 500mm below ground level. Although it is recognised that the land use and drainage of the proposed South Kyle Wind Farm differs to Enoch Hill, the average measured peat strength (21kPa) at the proposed South Kyle Wind Farm has been used as the basis of the PHRS assessment at all Phase 2 survey points. In accordance with the PHRS methodology this results in a score of 23 which has been attributed to all points where true peat was encountered. In places where true peat was not encountered (i.e. peat depths <0.5m) a score of 3 has been applied as peat of this depth is likely to have more shear strength owing to the likely influence of increased fibrosity and lower moisture content.

Slope Angle and Form

Peat resting on a slope has potential energy and as such poses a much greater peatslide hazard than peat resting on level ground. In general, literature sources suggest that peat failures dominated by bog bursts can occur on slopes as low as 2˚ and up to 8˚ degrees with the majority of peatslide failures between 5º and 20º (Evan and Warburton, 2010).

Although bog burst failure may occur on the lowest slopes, the Proposed Development area is not considered to have a bog burst morphology. These types of failure tend to occur mainly on deeper peat depths (typically >1.5m and up to 6m) while peat depths at peatslides are typically between 1m and 1.5m. In addition, bog bursts are typical of peat stratigraphies consisting of less humified peat over an equally thick layer of wet, well humified peat (Evan and Warburton, 2010). As bog burst conditions are not considered prevalent at the Development Site it is considered that the PHRS scores derived by Nichol (2006) are appropriate for use at this Development Site and provide a sufficient reflection of increasing peatslide hazard with increasing slope angle.

The method to attribute PHRS scores to each of assessed locations was as follows:

- Slope angle data has been derived from the available DTM. This data is considered to be of sufficient detail to provide information on the overall topography of the Development Site for the purpose of peatslide risk assessment;
- Slope regularity was noted during the detailed peat survey.

The PHRS methodology makes allowance for the point scores to be adjusted by a maximum of 10 points to take account of slope regularity, outcrops of rock and the presence of tracks. In this regard, point scores for steep, even slopes have been attributed initial high scores that are lowered by regularity of the slope.

Geomorphology and Development Site History

Nichol (2006) considers the presence of natural erosion features such as haggs, mounds, ridges, pools, incised streams and disruption of the surface by land management activities such as grazing, burning, forestry, drainage ditches, tracks and cuttings of peat.

The current land use of the Development Site comprises managed grazing land which has numerous man made, typically moss filled drainage ditches and peat grips at varying intervals that often intersect natural flush features. It has been demonstrated that the presence of drainage ditches have contributed to peatslides in studies by authors such as Carling (1986). A common phenomenon in relation to man-made peat drainage is the desiccation of peat below the base of drainage channels cut into the peat. The Phase 2 peat survey identified desiccation of the peat in a number of exposures. The desiccation of peat generally occurs during prolonged periods of dry weather and is particularly hazardous in the summer months when long periods of dry weather are followed by torrential rainfall. Warburton, Holden and Mills (2004) indicate that in these instances rainwater is rapidly transferred down to the substrate/peat interface where lubrication and increased pore water pressures at the interface can trigger peatslides. This was also noted as a contributory factor in studies of the Derrybrien Wind Farm peatslide on the summit of Cashlaundrumlahan, County Galway, Ireland (Lindsay and Bragg, 2004). Where the peat grip is filled with moss (which is the majority of the grips at the Development Site), the peat below the grip is likely to be protected from longer dry periods and desiccation by the presence of water-holding moss and slower flows.

In most instances, peat grips on the Development Site were found to be filled with wet moss, however in the interest of providing a conservative assessment the peat grips have been considered in the peatslide hazard assessment as follows:

- Survey points within areas of intensely gripped peat, with grip spacing of <15m have been given a score of 27;
- Survey points within areas of low intensity peat gripping, with spacing >15m have been given a score of 9.

The Phase 2 detailed peat survey revealed that the Development Site does not contain significant natural erosion features such as fields of peat haggs, bare peat and large peat erosion features. In addition, the wind farm layout has been specifically designed to avoid the hagged areas. In particularly the tracks linking T3 to T5 and T17 have been designed to pass between or around areas of hagged peat.

The PHRS scoring for the remainder of the Development Site where there are few or no erosional features has been given a PHRS score of 3 in accordance with the PHRS methodology.

Sub-surface Drainage

The natural sub-surface drainage of peat is typically dominated by lateral, concentrated flow through conduits within or at the base of the peat profile. These conduits are commonly referred to as peat pipes and are a ubiquitous feature of blanket peat bogs throughout the UK (Holden 2005). Peat pipes are reported to range in scale from a few centimetres to meters (Evans & Warburton, 2010) in diameter and can form complicated patterns of sub-surface peat drainage. The presence of peat pipes have been found to be a contributory factor in a number of peatslides by supplying rainwater to the slide site (Warbuton *et al*, 2003). An account of a peatslide in the Scottish Highlands (Nichol, 2009) identified a peat pipe outfalling at the head of the slide which was considered to be a contributory factor in initiating the slide.

Although very few peat pipes were identified within the Development Site, literature evidence suggests that artificial peat drainage is an important influence on the prevalence of peat pipes; there are more peat pipes where there is artificial land drainage (Holden, 2004). As the Development Site is managed and there are numerous peat grips and drainage ditches throughout the Development Site, a PHRS score of 9 has been attributed to all survey locations to account for the possibility that more peat pipes are present than were identified. However, where the peat depth is recorded as <0.5m the frequency of peat piping is likely to be much lower (Holden, 2005) and as such a score of 0 has been applied to locations where the peat depth is <0.5m.

Peatslide History

The presence of pre-failure indicators, or evidence of relic failures, provides site specific information on the predisposition of a peat covered slope to failure. As such, the identification of features including relic peatslides, tension cracks, compressive, thrust and creep features forms an important element of peatslide hazard and risk assessment. The identification of these features by the trained eye allows the assessor to determine which slopes are likely to have marginal stability or are conducive to future peat instability.

During the Phase 2 detailed peat survey there were two relic or incipient peatslide features identified, including a potential relic slide approximately 130m northwest of T4 and an area of potential peat slope creep around the location of T19. In the most part the locations of proposed infrastructure are at sufficient distance from the translational slides that they are unlikely to affect the stability of wind farm infrastructure. The infrastructure that may be affected by mineral slope failures are borrow pit BP-B and crossings of the Catlock Burn and Littlechang Burn. The likelihood that wind farm construction activities will affect the stability of marginally stable steep slopes at distance from construction activities should be assessed in the post consent design ground investigation, particularly if blasting will be required.

At the location of T19, a PHRS score of 27 has been attributed to the survey locations, given the presence of indications of slope creep. As the remainder of the Development Site contains no features indicative of an imminent or relic peatslide a PHRS score of 3 has been attributed to the whole Development Site.

Peatslide Severity

The assessment of peatslide severity is a non-technical and subjective assessment of the consequences of a peat slide comparable to the exposure factor used in Scottish Government Best Practice. The peatslide severity factor directs the assessor to consider the consequences of a slide (at a point under assessment) on key physical and environmental receptors such as:

- Ecology (stream & terrestrial);
- Cultural and Heritage sites;
- Visual impact;
- Surface water quality;
- Development infrastructure;
- Commercial impacts (e.g. impacts on estates activities); and
- Other infrastructure (i.e. highways, bridges & railway lines).

In addition to considering the immediate impacts, the potential size of a peatslide and longer term impacts such as the cost and time taken for recovery of ecosystems and revegetation are also taken into account within the PHRS scores.

In order to score the survey points, areas of the Development Site have been scored on the basis of the peat depth, the size of areas of deep peat (>1m) and slope angle, which are likely to influence the magnitude and route of a peatslide. The severity of a slide from these areas has then been determined by the distance to receptors and the potential consequences a slide would have on the receptors downslope or along the likely run-out zones. The Phase 2 survey locations have then been attributed the highest score of the area within which they are situated. Figure 11 in Appendix A presents the scored Peatslide Severity areas within the Development Site.

Designated Ecological and Geological Receptors

Desk study information reveals that there are no sensitive or designated ecologically important receptors on the Development Site.

Hydrological assessments of the Development Site, detailed in Chapter 13 of the ES reveal that there are four Groundwater Dependent Terrestrial Ecological systems (GWDTEs). The consequences of a peatslide on a GWDTE include the destruction of the ecosystem which would take a number of years to regenerate or would have to be recreated artificially. In general, the potential GWDTEs correspond with surface water courses which have already been considered as detailed above. To provide a peatslide severity score for the assessed GWDTEs, their location and the upslope area above which a potential slide may impact them have been given a PHRS score of 9. The remainder of the Development Site has been given a score of 1 where there is no risk to a ‘designated’ ecological receptor.

Highways and Property Receptors

The north-western boundary of the Development Site is formed by the B741 which is the main road between the settlements of New Cumnock and Dalmellington. The consequences to the highway are considered to include blocking of the highway, financial losses (by business and the public) and transport disruption (although other routes are available) and the potential for injury or loss of life. As such, the score for areas of deeper peat that may result in a significant impact to the highway have been given a score of 81 to account for the potential significance of the impacts/consequences, the worst being injury or loss of life. Where peat is shallow <1.0m a score of 9 has been attributed to the area. Where a peatslide is not likely to have a direct impact on the highway a score of 3 has been attributed to area, regardless of peat depth.

There are no properties directly downslope of areas of deep peat that could be affected by a peatslide. The Development Site has therefore been given a PHRS score of 3.

Surface Water Receptors

The Knockburnie Burn is the only sensitive onsite watercourse according to the SEPA RBMP website and is shown to flow into the River Nith which is a Fresh Water Fish Directive Salmonid Water. However, the Development Site is within an area designated by SEPA to be a Salmonid Waters area under the Fresh Water Fish Directive and as such all watercourses draining the Development Site may also be sensitive. The peatslide severity scores for surface water receptor have been derived through a review of peat depths upslope of the watercourse. In order to provide a conservative PHRS score for the surface water receptors it is assumed that any peatslide will eventually reach the waterbody downslope of a failure point and they have been scored as follows:

- Peat depths <0.5m have been given a score of 3 as slides of this magnitude are unlikely to have a measureable impact on surface water quality or ecology downstream of the Development Site;
- Peat depths >0.5m but <1.5m have been given a score of 9 as a slides of this magnitude may have a measurable impact for a short duration and distance downstream of the Development Site;
- Peat depths >1.5m but <2.5m have been given a score of 27 as a slide of this magnitude is likely to have a significant measurable impact on surface water quality and ecology downstream of the Development Site;

- Peat depth >2.5m have been given a score of 81 as a slide of this magnitude is likely to have a significant and far reaching impact on surface water quality and ecology;
- Areas where a peatslide will not impact a surface water body have been given a score of 1.

Water Supply Receptors

East Ayrshire Council data reveals that there are six PWS that may be impacted by an onsite peatslide. The consequence of a peatslide affecting a PWS are that it could not be used as a water supply for the properties it serves. However, in comparison to other receptors, the consequences are much less significant as an alternative relatively low cost water supply could be provided until the water supply is reinstated. As such, the areas up slope of the PWS that may be impacted by a slide have been given a score of 9 to reflect the relative insignificance of the consequence. The PWS at risk from a peatslide originating at proposed Development Site infrastructure include those supplying Knockburnie Farm and Lanehead Farm in the north west of the Development Site. The remainder of the Development Site has been given a PHRS score of 3.

Cultural and Heritage

The Development Site does not contain any designated or significantly important archaeological sites. Although, archaeological features are present in places (e.g. sheepfolds and mining features) these are generally only of local importance and as such a PHRS score of 3 has been applied to the whole Development Site.

Peatslide Risk Assessment

The PHRS scores are intended to be an assessment of the perceived hazards associated with the various characteristics of the blanket peat. The combination of PHRS scores represent the assessment of peatslide risk and is a means of identifying areas of the Development Site where there is a risk of peatslides occurring in order that preventative measures may be prioritised at an early stage of the Proposed Development.

Nichol (2006) recommends that as a rule of thumb, cumulated ratings of less than 200 should be assigned low priority (or low risk) and values over 400 should be assigned as high priority (or high risk). In the methodology Nichol (2006) bases the rule of thumb ratings on the retrospective hazard assessment of well-known peatslides at Derrybrien (Fleming, 2003), Morsgail (Bowes, 1960) and Hart Hope (Warburton *et al*, 2003). It is considered prudent to measure the moderate and high risk cut-off scores against an existing relic slide such that cut-off scores are made more site specific. However, given that there are no suitable peatslides examples within the Development Site it is not possible to adjust the cut-off scorings, therefore the rule of thumb cut-off scores have been used to identify areas of low (<200), moderate (200-400) and high (>400) peatslide susceptibility (or risk) for the Development Site.

In addition to highlighting areas of moderate or high peatslide susceptibility, areas of marginal susceptibility, or areas of 'low to moderate risk,' have been identified as having PHRS scores between 170 and 200. These areas have been identified as they represent locations where changes in the PHRS scoring of either (a) shear strength, or (b) water at the surface (due to seasonality), for example, may result in a total PHRS score of >200, i.e. the locality would become moderate risk.

In areas of low to moderate peatslide susceptibility, development may continue, although further investigation, assessment and mitigation measures will be required to reduce the risk of a peatslide occurring. In areas of moderate risk, relocation of the infrastructure should be considered and where this is not possible further detailed investigation and mitigation measures to reduce the risk of a peatslide will be required. In areas deemed to be highly susceptible, wind farm development is discouraged.

The results of the PHRS assessment using the cut-off points for the four levels of risk as proposed above are summarised in Table 5.2 and Plate 1 below. The locations of low, moderate and high scores are presented within Figure 12.1 to 12.5 in Appendix A.

Table 5.2 Summary of PHRS Scores for the Whole Development Site

Level of Risk	PHRS Score	No. of Points
Low	0 – 170	342 (49%)
Low to Moderate	171 – 200	280 (40%)
Moderate	201 – 400	78 (11%)
High	401 - 600	0 (0%)

As detailed in Table 5.2, 78 No. phase 2 survey points have PHRS scores that are considered to represent areas that are moderately susceptible to peatslides. In general areas of moderate risk correspond with areas of deeper peat where peat depths are up to 2m or more, such as the locations of turbines T2, T7, T17 and T19 in the west and south west of the Development Site. In addition, PHRS scorings reveal that 280 of the 700 phase 2 survey locations are considered to have a low to moderate peatslide susceptibility. Although approximately 40% of the Development Site is considered to have a low to moderate or moderate susceptibility to peatslides, a review of the PHRS scorings reveals that a significant proportion of all the total PHRS scores are driven by the climate score which is 91 due to the relatively high average rainfalls that are anticipated.

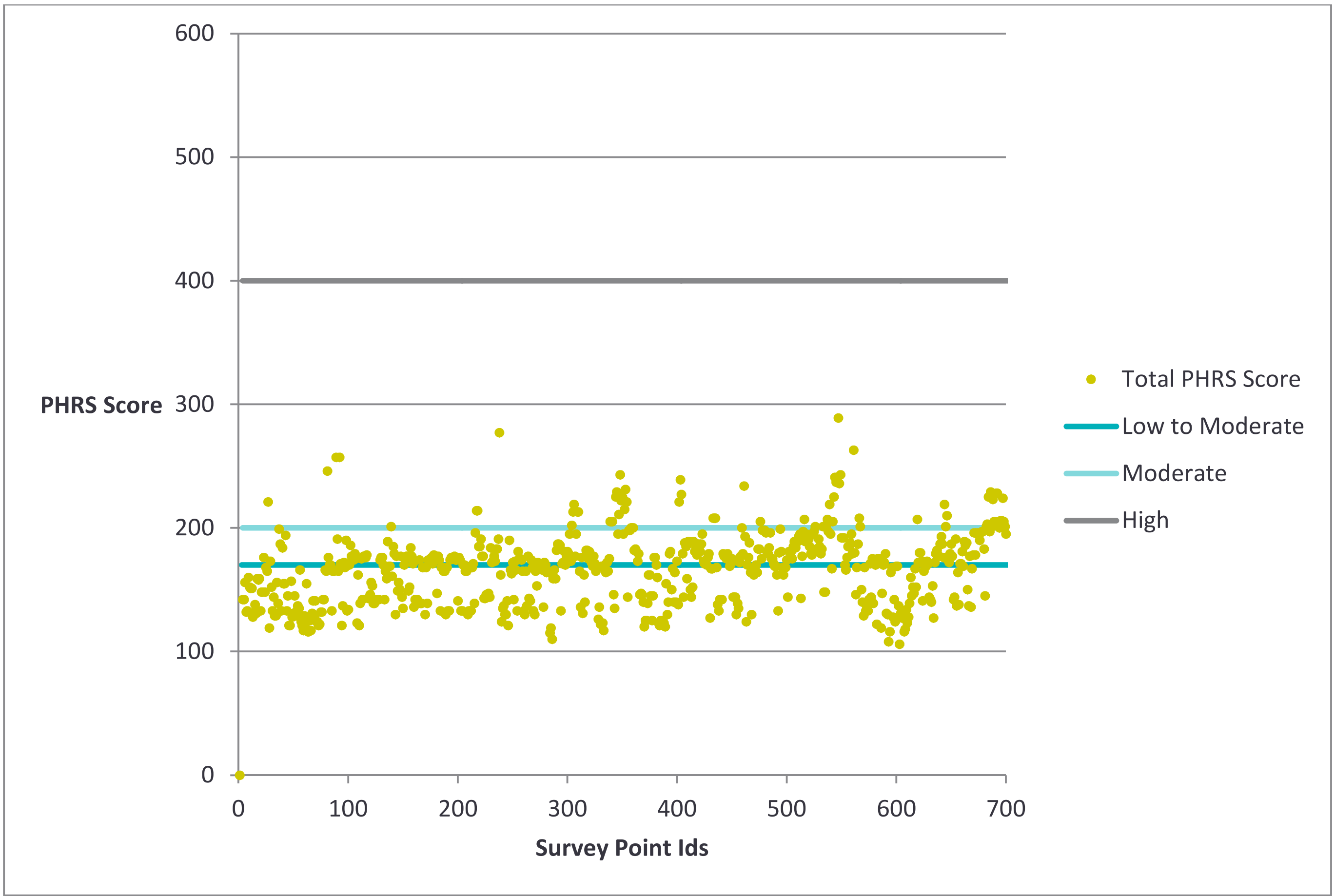

Plate 1: Peat Hazard Rating System Scores

Turbines, Met Masts, Temporary Compound, Control Building Compound and Borrow Pit Search Areas

At each of the proposed turbines, met masts, site for the control building and SPEN substation, borrow pit search areas and temporary construction compound locations, the average score based on the survey points within the micrositing allowance (50m) or their extent has been calculated to provide a summary of the peatslide risk at each location. The peatslide risk at each crane pad is considered to be the same as the turbine given that they are within the micrositing allowance. The average scores are summarised in Table 5.3 below.

Table 5.3 Summary of PHRS Scores at Infrastructure Locations (Values Rounded)

PHRS Factor	T01	T02	T03	T04	T05	T06	T07	T08	T09	T10	T11
Rainfall and climate	91	91	91	91	91	91	91	91	91	91	91
Presence of water on slope	3	3	3	3	3	3	4	3	3	3	3
Rockhead or subsoil	18	18	18	3	18	16	18	18	18	18	18
Peat profile and depth	3	16	3	4	5	3	11	5	2	3	3
Peat strength (vane shear test)	10	22	20	11	23	14	22	20	10	5	13
Slope and slope regularity	18	11	3	19	5	15	12	8	7	14	15
Geomorphology and Site history	3	26	6	3	3	3	3	6	2	3	4
Sub-profile drainage	3	9	7	4	9	6	9	8	4	1	5
Peatslide history	3	3	3	3	3	3	3	3	2	3	3
Potential peatslide severity	5	25	9	5	7	7	17	9	6	3	5
Total PHRS Score	**157**	**224**	**163**	**146**	**167**	**161**	**190**	**171**	**145**	**144**	**160**

Notes

(light teal)	Low Risk (<170)
(dark teal)	Low to Moderate Risk (170 – 200)
(yellow)	Moderate Risk (200 – 400)

PHRS Factor	T12	T13	T14	T15	T16	T17	T18	T19	Met Mast 01	Met Mast 02	Temporary Compound	Substation	Borrow Pit A	Borrow Pit B	Borrow Pit C
Rainfall and climate	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91
Presence of water on slope	3	3	3	4	14	3	3	4	5	3	3	3	3	3	3
Rockhead or subsoil	18	18	13	18	18	18	8	18	18	3	18	18	13	14	18
Peat profile and depth	5	4	3	5	4	17	3	17	10	3	3	3	3	2	6
Peat strength (vane shear test)	15	21	10	15	20	23	3	23	23	3	12	15	9	8	22
Slope and slope regularity	38	8	9	17	4	8	35	24	14	35	9	6	16	8	20
Geomorphology and Site history	3	3	3	9	6	18	4	3	3	3	8	6	5	2	5
Sub-profile drainage	6	8	3	6	8	9	0	9	8	0	4	5	3	3	9
Peatslide history	3	3	3	3	3	3	3	27	3	3	3	3	2	2	3
Potential peatslide severity	7	9	9	7	8	21	3	13	20	3	5	7	10	5	10
Total PHRS Score	**189**	**168**	**147**	**175**	**176**	**211**	**153**	**229**	**195**	**147**	**156**	**160**	**155**	**138**	**186**

Notes

(light teal)	Low Risk (<170)
(dark teal)	Low to Moderate Risk (170 – 200)
(yellow)	Moderate Risk (200 – 400)

The results of the PHRS assessment at the turbines, temporary construction compound, wind farm control building/substation compound and the borrow pit search areas reveals that none of the proposed infrastructure is within an area considered to be highly susceptible to peatslides.

The PHRS scores at turbines T2, T17 and T19 are revealed to be moderately susceptible to peatslides. Turbines T2 and T19 are particularly of note due to the presence of deeper peat at T2 and indications of slope creep at T19. Although moderately susceptible to peatslide, development in these areas may continue provided that there is further pre-construction detailed ground investigation and confirmation of the slope stability assessment and design of mitigation measures where required. Alternatively micrositing of T17 and T19 within the 50m micrositing allowance would be sufficient to move the turbines outside the area of deep peat and slope creep, respectively.

At turbines T7, T8, T12, T15, T16, Met Mast 01 and BP-C the PHRS scores are within the low to moderate susceptibility range. However, a review of the peat depths and 'Peat profile and depth' PHRS scores reveals that peat depths at T12, T15 and T16 are 0.7m or less. As most peatslides are within the range of 1.0m to 1.5m (Evans & Warburton, 2010) the risk of a peatslide occurring in peat depths <0.7m is more likely to be low.

On the basis of the PHRS scores, it would prudent to conduct detailed post-consent investigation and to implement mitigation measures to minimise the risk of a peatslide at turbines T2, T17 and T19. Given the assessment of Low to Moderate Risk, post-consent confirmation of the peatslide risk assessment should also be undertaken at T7, T12, T15, T16, Met Mast 01 and Borrow Pit BP-C and mitigation measures implemented where necessary. It is assumed that the requirement for detailed post-consent investigation and implementation of mitigation measures to minimise the risk of a peatslide would form part of the planning conditions for the Proposed Development.

Internal Access Tracks

In order to summarise the assessment of the internal access tracks they have been divided into chainages of up to 250m, turbine spur roads and the cross roads on High Chang Hill as shown on Figure 2 in Appendix A. The results of the average PHRS scores between the chainage points are presented in Table 5.4 below.

Table 5.4 Summary of PHRS Scores for the Internal Tracks

Chainage	Average PHRS	Chainage	Average PHRS
B741 (entrance) - 000	**149**	Spur MM01	**186**
000 - 250	**144**	3250 – T17/000	**162**
250 – 500	**149**	T3 - 3500	**155**
500 – 750	**127**	T17/000 – T17/250	**181**
750 – 1000	**165**	T17/250 – T17	**204**
1000 – 1250	**181**	3500 – 3750	**185**
1250 – 1500	**157**	3750 – 4000	**165**
1500 – 1750	**149**	Spur T5	**164**
1750 - 2000	**154**	4000 - 4250	**182**

Chainage	Average PHRS	Chainage	Average PHRS
2000 – 2250	**167**	4250 - 4500	**185**
2250 – 2500	**173**	Spur T8	**162**
2500 - 2750	**185**	4500 – 4750	**180**
Spur T2	**196**	4750 – 5000	**175**
2750 – 3000	**176**	T9 Crossroads	**141**
3000 - 3250	**164**	T12/000 – T12/250	**179**
T12/250 – T12/500	**146**	T19/1500 – T19/1750	**188**
T12/500 – T12/750	**144**	T19/1750 – T19	**216**
T12/750 – T12	**186**	T4 – T7/000	**119**
T10 – T15/000	**167**	T7/000 – T7/250	**155**
T15/000 – T15/250	**166**	T7/250 – T7	**177**
T15/250 – T15/500	**180**	T18/000 – T18/250	**172**
T15/500 – T15	**183**	T18/250 – T18/500	**160**
T19/000 – T19/250	**174**	Spur T14	**157**
T19/250 – T19/500	**151**	T18/500 – T14/750	**190**
T19/500 – T19/750	**150**	T18/750 – T18/1000	**165**
T19/750 – T19/1000	**128**	T18/1000 – T18	**173**
T19/1000 – T19/1250	**141**	1750 – BP-B/250	**151**
T19/1250 – T19/1500	**152**	BP-B/250 – BP-B/500	**164**
Spur MM02	**142**		

Notes

(light blue)	Low Risk (<170)
(teal)	Low to Moderate Risk (170 – 200)
(yellow)	Moderate Risk (200 – 400)

The results of the PHRS peatslide risk assessment reveals that low to moderate PHRS scores at twenty two track chainages situated throughout the Development Site. In addition, track chainages T17/250 – T17 and T19/1750 – T19 are revealed to have average PHRS scores marginally within the moderate peatslide susceptibility range. Development in these areas may continue provided that there is detailed ground investigation carried out post-consent to confirm the peat slope stability. This information should be used to determine the requirement for mitigation measures, which might include some of those outlined in Section 6.3. Alternatively micrositing of the turbine(s) and/or access track may be sufficient to avoid areas of deeper peat and moderate peatslide susceptibility.

A review of the peat depth and PHRS scores at the chainages listed below reveals that peat depths are generally <0.7m and as such the potential for a peatslide is more likely to be low at:

- 2250 – 2500;
- 4500 – 4750;
- 4750 – 5000;
- T18/1000 – T18; and
- T12/750 – T12.

On the basis of the PHRS scores, pre-construction detailed ground investigation should be undertaken at chainages T17/250 – T17 and T19/1750 – T19. This would provide further geotechnical information on the peat, confirm the peatslide risk assessment, enable the design of preventative mitigation measures and to determine the need for micrositing of the track. In addition, confirmation of the peatslide risk assessment should also be undertaken at low to moderately susceptible track chainages and preventative mitigation measures implemented where necessary.

Peatslide Hazard Assessment Summary

The results of the Phase 2 peat survey and PHRS assessment reveals that the Development Site has a mean PHRS score of 165 which is within the low risk range. However, on the basis of the site specific PHRS scores at proposed Development Site infrastructure further investigation and mitigation measures should be implemented at the following locations:

- Turbines T2, T17, T19; and
- Track chainages T17/250 to T17, and T19/1750 to T19.

Depending on the outcome of detailed pre-construction ground investigations that would be carried out post-consent, elements identified as being in areas of moderate peat slide risk will be located as far as possible from these areas (within the constraints of the micro-siting allowances). For example the micrositing of T19 within the west or north west to locate it upslope of the deeper peat and outside the area of potential slope instability.

In addition to the above, at areas of low to moderate susceptibility the peatslide assessment would be confirmed post-consent through detailed investigation of the Development Site and mitigation identified and implemented as necessary. This information should be used to design preventative mitigation measures and determine the need for micrositing of infrastructure.

5.3 Quantitative Peatslide Risk Assessment

Methodology

A quantitative peat slope stability assessment has been undertaken in accordance with the methodology detailed within Scottish Government Best Practice (2006) which presents an alternative geotechnical engineering based assessment of peat slope stability. Best Practice Guidance states that the 'Infinite Slope' method of analysis, after Skempton and DeLory (1957), is the most well established and commonly applied method for the assessment of peat slope stability. Therefore, this methodology forms the basis of the assessment.

The guidance describes the infinite slope analysis as follows:

'The infinite slope model assumes a planar translational failure, where the shear surface is parallel to the ground surface, and the length of the slope is large in comparison to the failure depth.'

The factor of safety of a given slope is calculated by comparing the sum of the resisting forces with those of the destabilising/acting forces, given by the following equation:

$$\mathbf{F} = \frac{Shear\ Resistance}{Shear\ Forces} = \frac{c' + (\gamma - m.\gamma w).z.cos^2\beta.tan\phi'}{\gamma.z.sin\beta.cos\beta}$$

Where:

F	=	Factor of Safety
c'	=	Effective cohesion
γ	=	Bulk unit weight of saturated peat
γ*w*	=	Unit weight of water
m	=	Height of water table as a fraction of the peat depth
z	=	Peat depth in the direction of normal stress
β	=	Angle of the slope to the horizontal
ϕ'	=	Effective angle of internal friction

Given the variability of peat, an onerous number of samples would be required to sufficiently characterise the geotechnical parameters and as such samples for geotechnical testing were not collected. However, geotechnical parameters are not considered critical in providing a generic preliminary assessment to highlight areas with potential peatslide risks.

As no site specific geotechnical parameters have been derived from geotechnical testing the parameters for the assessment have been established from a series of literature values for blanket peat of both acrotelmic and catotelmic conditions. A summary of literature values used to inform the factor of safety parameters are presented in Table 5.5 below.

Table 5.5 Literature Values for the Geotechnical Parameters of Peat

Reference	Effective cohesion *c'* (kPa)	Effective angle of friction *φ'* (°)	Unit weight ɣ (kN/m³)	Comments
Hanrahan *et al* (1967)	5.5 – 6.1	36.6 – 43.5	-	Remoulded H_4 *Sphagnum* peat
Hollingshead and Raymond (1972)	4.0	34	-	-
Landva and La Rochelle (1983)	2.4 – 4.7	27.1-35.4	-	*Sphagnum* peat (H_3, mainly fibrous)
Carling (1986)	6.52	0	10	-
Kirk (2001)	2.7 – 8.2	26.1 – 30.4		Ombrotrophic blanket peat
Warburton *et al* (2003)	5.0	23	9.68	Basal Peat
Warburton *et al* (2003)	8.74	21.6	9.68	Fibrous Peat
Dykes and Kirk (2006)	3.2	30.4	9.61	Acrotelm

Reference	Effective cohesion c' (kPa)	Effective angle of friction φ' (°)	Unit weight γ (kN/m^3)	Comments
Dykes and Kirk (2006)	4.0	28.8	9.71	Catotelm
Risk Assessment Design Values	**4.0**	**27**	**10**	-

The risk assessment design values given in Table 5.5 have been adopted on a site wide basis. Although unlikely due to the drained nature of the Development Site, the water table level is assumed to be at ground level (m = 1) to provide a conservative assessment based on flooded conditions (i.e. worst case).

The Factor of Safety (FoS) **F** values for the whole Development Site have been calculated using ESRI ArcGIS Spatial Analyst Raster Calculator to derive the **F** from the interpolated peat depth map (Figure 10), DTM (Figure 8) and the constant values detailed in Table 5.5.

The Factor of Safety results are summarised in Figure 13 in Appendix A.

In accordance with the Best Practice method, **F** values of < 1.0 indicate slopes that have experienced failure under current conditions and as such are considered areas of high risk. In accordance with the methodology detailed in Boylan *et al* (2008), a relatively high value of **F** >1.4 typically suggests that slopes are stable. In order to identify areas of marginal stability which may be affected by loading, values of between **F**=1 and **F**=1.4 are used to indicate slopes that may be susceptible to failure given that a change in ground conditions or loadings may result in **F** values lowering below **F**=1.

The results of the infinite slope model reveal that under the modelled conditions, there is no infrastructure located within an area with **F** values <1. The only proposed infrastructure within an area with an **F** value 1<**F**<1.4 is a short section of the track approximately 40m east of chainage 2,750, the far south east of Borrow Pit BP-B and a small area of ground adjacent to the west of T19. The area with FoS values <1.4 adjacent to Borrow Pit BP-B is revealed to be an area of steeply sloping ground along the valley of Littlechang Burn where the interpolated peat depth map indicates peat depths up to 1.7m deep. However, peat depths within the search area of the Borrow Pit BP-B are revealed to be typically <1.0m resulting in **F** values >1.4, therefore in reality the **F** is likely to be >1.4.

The results of the **F** assessment are consistent with the absence of any peatslides within the location of proposed infrastructure. In addition, areas of **F** values 1<**F**<1.4 are consistent with areas that have obvious translational mineral soil failures such as to the east of T12 and potential slope creep at T19.

Sensitivity Analysis

A sensitivity analysis has been undertaken on the FoS analyses at the Phase 2 survey locations in order to determine the influence of variance in the selected parameters, particularly as variable values are reported in the literature and will be present across the Development Site. A sensitivity analysis on the bulk unit weight parameter (γ) is not considered necessary due to the consistency of literature values detailed in Table 5.5.

The parameters that are considered to vary the most are cohesion (c') and angle of friction (φ'). On this basis the sensitivity analysis has been conducted using the extreme lowest and greatest values for cohesion and effective angle of internal friction. Where a study has presented a range of values the lowest of the values has been selected from that study (e.g. Hanrahan *et al*, 1967) to provide a conservative assessment. The following parameters derived from literature sources and summarised in Table 5.5 were used in the sensitivity analysis:

- Maximum cohesion ($c'_{max} = 8$) and minimum angle of friction ($\varphi'_{min} = 0°$);
- Minimum cohesion ($c'_{min} = 2.4$) and maximum angle of friction ($\varphi'_{max} = 36°$);
- Minimum cohesion (c'_{min}) and minimum angle of friction (φ'_{min});
- Maximum cohesion (c'_{max}) and maximum angle of friction (φ'_{max});

The above models represent the potential current loadings of the peat (unloaded condition). In order to determine the effect of loading (loaded condition) on the peat by machinery and side casting of peat, the infinite slope model has been used to apply an additional loading of 55kPa which approximately represents a 40 tonne excavator. This has been added to the ɣ value of the shear force parameters.

As the additional loadings are considered a destabilising effect the above loadings have been added to the shear forces and such there are a number of important limitations and assumptions in calculating **F** values under the loaded scenario, these include:

- The model assumes instantaneous application of the total load;
- Only short term effects are modelled and it assumes that no compaction and dissipation of pore water pressures will occur;
- The model does not consider the stabilising effects of additional loading. Over the long term, with increasing load and compaction increasing cohesion would be expected as pore water is drained and interactions between peat fibres increases. The loaded maximum cohesion scenarios are therefore considered to most likely reflect long term conditions.

The number of point locations susceptible to failure for each sensitivity analysis are summarised in Table 5.6.

Table 5.6 Sensitivity Analysis Results

Analysis		Number of Points, F < 1	Number of Points, 1 > F < 1.4	Number of Points, F > 1.4
Unloaded Model		0	4	696
Loaded Model		0	1	699
Unloaded	c'min / φ'min	12	48	640
	c'min / φ'max	9	31	660
	c'max / φ'min	0	0	700
	c'max / φ'max	0	0	700
Loaded	c'min / φ'min	455	94	301
	c'min / φ'max	450	90	152
	c'max / φ'min	131	96	473
	c'max / φ'max	122	100	478

The sensitivity analysis suggests that the effective cohesion of the peat has the most influence on the risk of a peatslide with the lowest c' values producing the greatest number of locations experiencing marginal or potential failure conditions.

The results of the analysis reveals that under unloaded conditions with variable geotechnical conditions the majority of the Development Site has **F** values >1.4. The results show that localised areas of potentially unstable ground would be anticipated on the steeper slopes under the minimum cohesion conditions. (*c*' =

2.4 kPa), including within the micrositing allowance of T2, T7 and T19. The maximum cohesion analysis reveals that under unloaded conditions the entire Development Site is shown to be stable, with **F** values >1.4. On the basis of the results of the unloaded analysis, and the absence of any large failures the c'min models are unlikely to be representative of the Development Site conditions as many more failures would be expected on the Development Site where the **F** values are <1.

The results of the loaded scenario reveals that much more of the Development Site may be susceptible to peatslide failure if loaded. Under the c'min and φ'min conditions the majority of the site would have the potential to fail, even where the shallowest peat depths <0.5m are anticipated. As such, these conditions are considered to be overly conservative and are not likely to be representative of actual Development Site conditions. The results of the loaded analysis under c'max and φ'max conditions reveals that approximately a third of the survey locations may be susceptible to peatslide failure. In particular turbines T2, T4, T7, T12, T17, T19 and met mast 1 and the tracks to these locations are shown to be within areas of potential peatslide susceptibility under loaded conditions. In addition, the following track sections are shown to pass through areas potentially susceptible to failure:

- 2500 to T2;
- 4250 to 4500;
- 4500 to 5000;
- T19-1500 to T19;
- T7/250 to T7;
- Near T19/250;
- North of T12/250;
- T15/250 to T15;
- T18/250 to T18.

The results of the above sensitivity analysis reveals that the effective cohesion of the peat has potentially the greatest influence on the likelihood of a peatslide and that establishing site-specific values of peat cohesion should be an important aim of further ground investigation of the Development Site. It is recommended that site specific geotechnical parameters (particularly cohesion and angle of internal friction) of the peat in critical areas (floating roads and crane pads) should be obtained and the slope stability analysis confirmed during the post-consent ground investigation of the Development Site. Where confirmation of the slope stability analysis indicates FoS **F** values are <1.4 detailed preventative mitigation measures should be implemented or the risks avoided by micrositing. The results of this work will inform the nature of any mitigation measures necessary to reduce the risk of peat slide (See Section 6 for potential measures).

5.4 Peatslide Risk Assessment & Risk Zoning Plan

A combination of the Development Site assessments using the PHRS and infinite slope methods have been used to derive a Peatslide Risk Zoning Plan presented as Figure 14 in Appendix A. The Peatslide Risk Zoning Plan has been derived through consideration of the extents of the following:

- Low to Moderate and Moderate PHRS scores; and
- Factor of safety values (loaded model using c'max / φ'max).

In addition to the above, the extents of potential run-out routes have also been included in determining the extent of the low to moderate and moderate risk areas. The figure does not attempt to second guess the run-out distance as this is difficult to predict particularly on a site without an obvious peatslide history or examples nearby. Instead, the peatslide run-out route has been taken to be in a downslope direction until a physical barrier that might stop the slide is encountered (e.g. valley bottom).

As shown in Figure 14 turbines T7, T8, T12, T15 and Borrow Pit BP-C as well as a number of track changes are within areas of low to moderate peatslide risk where the peatslide risk assessment should be confirmed during the post-consent ground investigation of the Development Site. The Risk Zoning Plan also shows that turbines T2, T17 and T19 and their connecting tracks are within areas that are considered to be moderately susceptible to peatslides. In these areas detailed ground investigation and confirmation of the peatslide risk assessment using site specific geotechnical parameters should be undertaken during the post-consent ground investigation in order to design appropriate preventative mitigation measure and establish the need for micrositing of infrastructure. The results of this work will inform the nature of any mitigation measures necessary to reduce the risk of peat slide (See Section 6 for potential measures).

Although the PHRS scores at the substation, temporary compound and Borrow Pit BP-A indicate some localised areas that have a low to moderate and moderate susceptibility to peatslides, the general trend in peat depths at these locations is <0.5m. As such these areas are not considered to pose a risk of a peatslide on further consideration, though the post-consent ground investigation should aim to confirm that these areas are low risk.

6. Mitigation Measures

The potential construction practices that may increase a slope's susceptibility to a peatslide during construction and operation of the wind farm, and which should be avoided, include:

- Stockpiling and side casting of excavated materials on, or at the top of marginally stable peat covered slopes;
- Loading of susceptible peat by floating roads without further ground investigation and assessment of peat slope stability;
- Removal of support at the toe of peat covered slopes; and,
- Poor drainage practices such as the draining of excavations, and placement of outfalls on to peat covered slopes or blocking of drainage channels.

Further discussion on specific mitigation measures is provided in the following sections.

6.1 General Considerations

A detailed intrusive ground investigation should be undertaken following consent, to assist in detailed design of turbine and infrastructure foundations. It is assumed that this would form part of the planning conditions for the Proposed Development. This is also considered the best opportunity to confirm the peatslide hazard assessments and peat slope stability assessment based on site specific parameters. Although the peat slope stability should be confirmed throughout sensitive areas (peat depths >1m and where making slope cuts) the investigations should also pay attention to infrastructure within areas of low to moderate peatslide susceptibility. Furthermore detailed investigations should be undertaken at infrastructure where a moderate peatslide susceptibility has been identified to update/confirm the peatslide risk assessment using site specific geotechnical parameters and to target mitigation measures or micrositing.

In addition to the above, detailed ground investigation of the Development Site should determine the slope stability of mineral soils where infrastructure will be placed close to steep slopes or where blasting of bedrock is proposed.

The ground investigation should aim to provide information on the geotechnical characteristics (e.g. shear strength and bulk density) of the peat and underlying mineral substrate. In addition, although peat survey works did not identify any obvious peat pipes these are ubiquitous and hard to identify sub-surface features common in the upland blanket peats of the UK. It is therefore recommended that intrusive investigations are complemented by non-intrusive investigations (e.g. ground penetrating radar), particularly where floating road construction is proposed, in order to target mitigation measures such as those detailed in Section 6.3.

The results of the ground investigation will inform the development of a geotechnical risk register which should be reviewed and updated at each stage of the post-consent development of the wind farm.

At turbine locations where there are low peat depths and no peat gripping or widely spaced grips, mitigation measures to avoid causing a peat slide will not be required and therefore normal construction methods may be employed. This applies at turbines T01, T03, T06, T08, T10, T11, T14 and T18.

Where turbines will be within areas of low to moderate or moderate peatslide susceptibility and where there are peat grips, mitigation measures should be implemented, generally to maintain current drainage routes. These mitigation measures shall include the following:

- Stockpiling and side casting sites of excavated material on slopes considered to be low to moderately susceptible to peatslides or with peat depths >0.5m should be avoided;
- Discharge of water from excavations on to peat, particularly to the head of peat covered slopes, should be avoided. Wherever possible water should be extracted and discharged to purpose-built, reinforced, drainage channels;

- Crane pads should be constructed in a manner that allows the hydrogeology of the peat to be maintained by allowing throughflow and continuity of peat pipes where the crane pad will be floating;
- Upslope of the turbine excavation/base and crane pads, peat grips and drainage ditches may be constructed to divert flows to a purpose built drainage network in order to maintain flows and prevent upslope ponding;
- Adequate drainage should be designed to cater for expected heavy rainfall events such that there is no possibility of water ponding upslope.

  As there is potential evidence of slope creep within the vicinity of T19, precautionary monitoring of ground movements surrounding the turbine is recommended prior to and for the duration of construction. During the construction phase a geotechnical clerk of works should be present on the Development Site to monitor sensitive slopes for movement and to manage any changes to the peatslide risk.

In addition to the above, micrositing of T2, T17 and T19 should be considered for the following reasons:

- Micrositing T2 within the extreme west of the allowance would move the turbine from an area of deep peat and intense gripping to an area with peat depths up to 1.0m with low intensity gripping. This would reduce the impacts on the peat and lower the peatslide susceptibility for this turbine to within the low to moderate susceptibility range;
- Micrositing of T17 within the south east of the micrositing allowance is recommended to move the turbine out of the area of deeper peat;
- Micrositing of T19 within the west or north west of the micrositing allowance is recommended in order to move the turbine outside the area of slope creep and to an area of lower peat depths. This is likely to results in a reduction in peatslide susceptibility at T19.

6.2 Tracks

Cut/Excavated Tracks

Cut tracks, where the foundation of the track will be on the underlying bedrock or superficial deposits, are proposed for areas with peat depths <1m. On the basis of available peat depth data, most access tracks will be of cut construction. Where a cut track is required, peatslide mitigation measures should aim to maintain or divert water away from slopes in order to avoid surface water ponding and where peat covered slopes will be undercut measures must be included to ensure that the peat is supported. These measures may include the following:

- Adequate drainage should be designed to intercept surface water from flushes, peat exposures, peat grips and drainage ditches. This water will be transferred down slope along an engineered drainage network. This network should be capable of transferring flows during expected heavy or prolonged rainfall events;
- Where upslope ponding occurs, measures should be taken to drain the area to an engineered drainage network. Drainage outfalls on to peat should be avoided. Where an outfall will drain to a surface water channel, measures should be installed to avoid erosion and headward gully formation (e.g. gabion outfall weirs);
- Outfalls from wind farm drainage networks should avoid discharging large flows to existing peat grips and drainage ditches as this may accelerate peat and soil erosion. If this is necessary, existing grips and drainage ditches may need to be upgraded and reinforced.

In addition to avoid water ponding upslope of the track, storage locations for excavated spoil, rock and peat should be carefully selected to avoid loading moderately stable slopes or slopes with peat depths >0.5m.

Floating Roads

In total, approximately 1.9 km of floating roads are proposed for the Proposed Development. Best practice guidance on the design and construction of floating roads on peat is well documented[1] and the guidance and methods presented therein should be implemented during design and construction of floating tracks.

Where floating roads are required, the route should be subject to detailed ground investigation including an assessment of the bearing capacity of the peat in relation to the maximum loads it may experience, loading rates and slope stability. In addition, detailed information on the location of peat grips, drainage ditches, peat pipes and flushes crossing the proposed routes should be collected in order to target mitigation measures which will aim to maintain these drainage routes. This may require non-intrusive methods of ground investigation to identify as many of the sub-surface features as possible.

In addition to the above, further mitigation measures that may be required include:

- Surface vegetation and acrotelmic peat should be left *in situ* to provide additional strength and support;
- Floating road construction should be conducted at a rate which allows sufficient time for the peat to 'rebound' and regain strength. This may involve applying aggregates in a number of layers and monitoring of settlement;
- Construction of the floating roads should be conducted outward from the starting point so as to limit loadings directly onto peat by construction traffic;
- Measures to limit the weight of delivery vehicles may be required to reduce loading onto the peat during construction;
- Targeted monitoring of slope stability and ground movement will be required throughout construction and a detailed monitoring programme will be developed pre-construction.

The above mitigation measures will also be required at locations where a floating crane pad is required.

6.3 Borrow Pits

At borrow pit locations detailed ground investigation should be undertaken to determine the slope stability of the upslope area which will be undercut by the excavation. If required, mitigation measures should include monitoring of the upslope areas of the borrow pit and, if required, formation of a catch mound formed of stone founded on bedrock or a catch fence upslope of the excavation.

6.4 Control Building/Substation Compound & Temporary Compound

Given that the temporary compound and the control building and SPEN substation are considered to be within an area of low peatslide susceptibility, mitigation measures are unlikely to be required. However, this should be confirmed in detail during the post consent ground investigation.

If mitigation measures are required for the temporary construction compound and the substations, they should be similar to those for cut track construction. Construction of this infrastructure should consider measures to avoid ponding of surface water upslope.

6.5 Side Casting & Stockpiling of Subsoils

A peat management plan detailing the measures for handling and storage of peat and the design and selection of peat and subsoil storage areas has been prepared and is appended to the ES. The recommendations of this should be followed throughout the construction of the wind farm and storage areas

[1] SNH and FCS (2010) Floating Roads on Peat.

should be confirmed through detailed ground investigation and confirmation of the peatslide risks at the stockpiling areas.

The application of excavated material onto peat covered slopes should be avoided. Storage of excavated materials on slopes with peat depths >1m and areas with low to moderate or moderate susceptibility of instability should be avoided.

Where storing of materials in these areas is unavoidable, a detailed assessment of their stability should be undertaken during the post consent ground investigation of the Development Site and mitigation measures similar to those for floating and cut tracks should be employed accordingly.

7. Conclusions & Recommendations

7.1 Conclusions

Published Soil Survey of Scotland and BGS mapping revealed that the majority of the Development Site is underlain by blanket peat, particularly in the central, south and western areas of the Development Site. The remainder of the site was revealed to be underlain by soils comprising peaty gleyed podzols and peat gleys and superficial deposits that are either thin or absent or composed of Glacial Till.

A Phase 1 peat survey of the Development Site revealed that peat depths generally ranged between 0.0m and 3.3m. A Phase 2 peat survey undertaken at the proposed wind farm infrastructure reveals that peat depths ranged between 0 and 2.88m.

A qualitative peatslide risk assessment undertaken at the Development Site infrastructure locations using the principles of the PHRS reveals that none of the Development Site is considered to be highly susceptible to peatslides. However, the assessment reveals that PHRS scores at T7, T12, T15, T16, Met Mast 01, Borrow Pit BP-C and along approximately 5.5km of the track have scores that indicate low to moderate peatslide susceptibility conditions. In addition, PHRS scores at T2, T17 and T19 are revealed to be in the moderate susceptibility range. Further investigation and mitigation measures should therefore be implemented to minimise the risk of a peatslide at the locations identified within the Peatslide Risk Zoning Plan (Figure 14).

A quantitative assessment of the peat slope stability based on the infinite slope model reveals that under unloaded conditions using the typical parameters derived from literature sources, factor of safety values are generally in excess of **F**=1.4.

A sensitivity analysis reveals that the effective cohesion of the peat has the greatest influence on the likelihood of a peat slope failure. The maximum effective cohesion scenarios are considered to most likely represent the peat conditions and long term effects of loading. The results of the loaded analysis using maximum cohesion scenarios reveals that only those slopes with peat depths typically >1m on slopes >5^{o} may experience failure.

7.2 Recommendations

A post-consent detailed ground investigation is recommended to assist in detailed assessment of peat slope stability in the most sensitive areas. The ground investigation should also aim to establish the nature and geotechnical parameters of the peat and peat substrate interface. It is recommended that ground investigation information is used to confirm the slope stability assessments herein, particularly in the sensitive areas identified in the Risk Zoning Plan.

In areas where floating roads are proposed, the ground investigations should also include non-intrusive methods in order to identify sub-surface features such as peat pipes. This information should be used to inform a detailed assessment of slope stability and to target mitigation measures, including cross track continuity of the peat drainage.

An intrusive investigation of the Development Site should include the excavation of trial pits and boreholes to determine the nature of subsurface mineral substrates and the installation of groundwater monitoring wells to establish the groundwater level within the peat and substrate. In addition, more intensive peat probing should be undertaken in sensitive areas to provide further information on peat depths for further assessment and design of mitigation measures.

In a number of areas, mitigation measures will be required, particularly where crossing peat pipes, flushes, peat grips and drainage ditches. These mitigation measures should aim to maintain the current drainage of the peat and avoid ponding of surface water upslope of Development Site infrastructure. While micro-siting T19 to the north west and upslope of the deeper peat would take it outside the area of potential slope instability and geotechnical monitoring in this vicinity may be required for the duration of the construction works as a precautionary measure to provide an early warning of slope movement. Further monitoring may also be required where a detailed ground investigation of the proposed infrastructure confirms that sensitive slopes may be moderately susceptible to peatslides.

In conjunction with the above, a geotechnical risk register should be developed and maintained by a Geotechnical Engineer through the life of the development of the proposed wind farm. During construction, a Geotechnical Clerk of works should also be present on the Development Site to monitor sensitive slopes for movement and to manage any changes to the peatslide risks.

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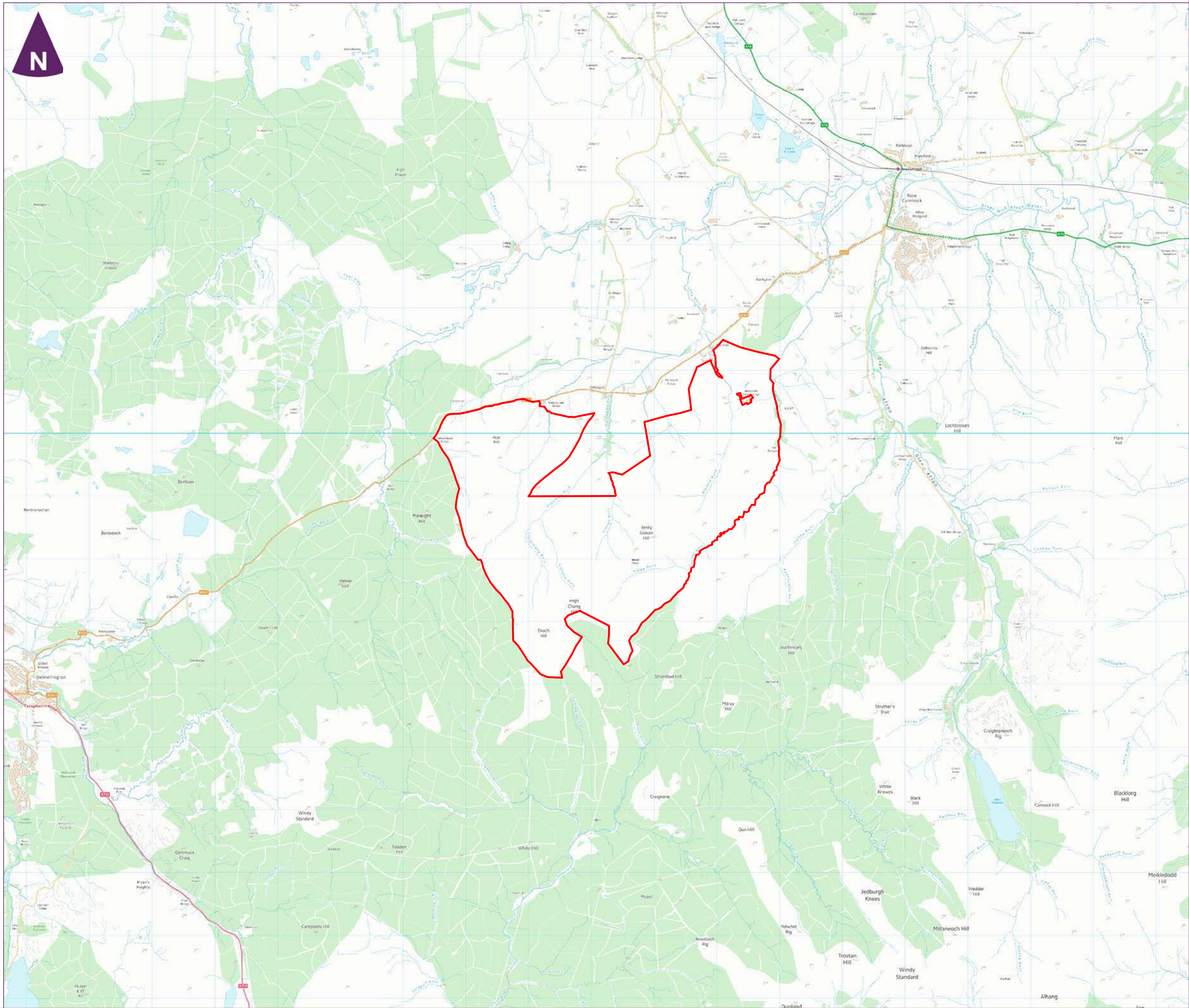
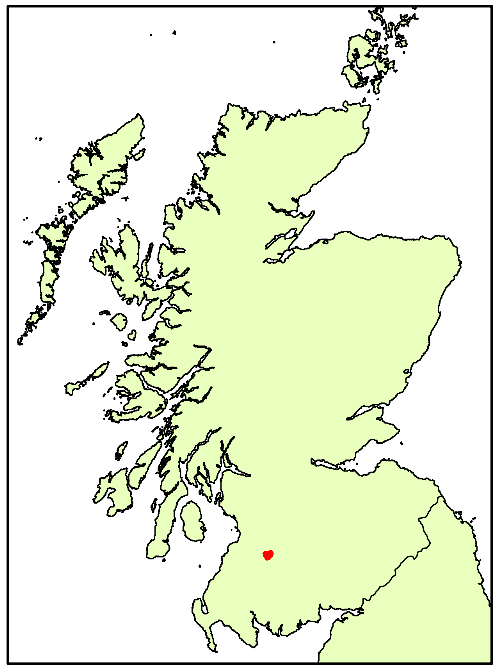
Appendix A Figures

Drawing Number	Drawing Title
Gla351	Figure 1 – Site Location Plan
Gla352	Figure 2 – Site Layout Plan
Gla355	Figure 3 - SNH Carbon rich soil, deep peat and priority peatland habitats map (in consultation)
Gla356	Figure 4 – BGS Superficial Geology
Gla357	Figure 5 – BGS Bedrock Geology
Gla308	Figure 6.1 – 6.4 – Aerial Photography
Gla371	Figure 7 – Geomorphology Map
Gla359	Figure 8 – OS Terrain 5 Digital Terrain Model
Gla360	Figure 9.1 – 9.5 – Peat Depth Survey Data
Gla361	Figure 10 – Interpolated Peat Depth Map (by Natural Neighbour)
Gla368	Figure 11 – PHRS Peatslide Severity Scores
Gla369	Figure 12.1 – 12.5 – PHRS Scores
Gla370	Figure 13 – Infinite Slope Analysis Results Unloaded Model Parameters
Gla364	Figure 14 – PHRS Risk Zoning Plan



Key

Application Boundary



0 0.45 0.9 1.8 2.7 3.6 km

Scale at A3: 1:60,000

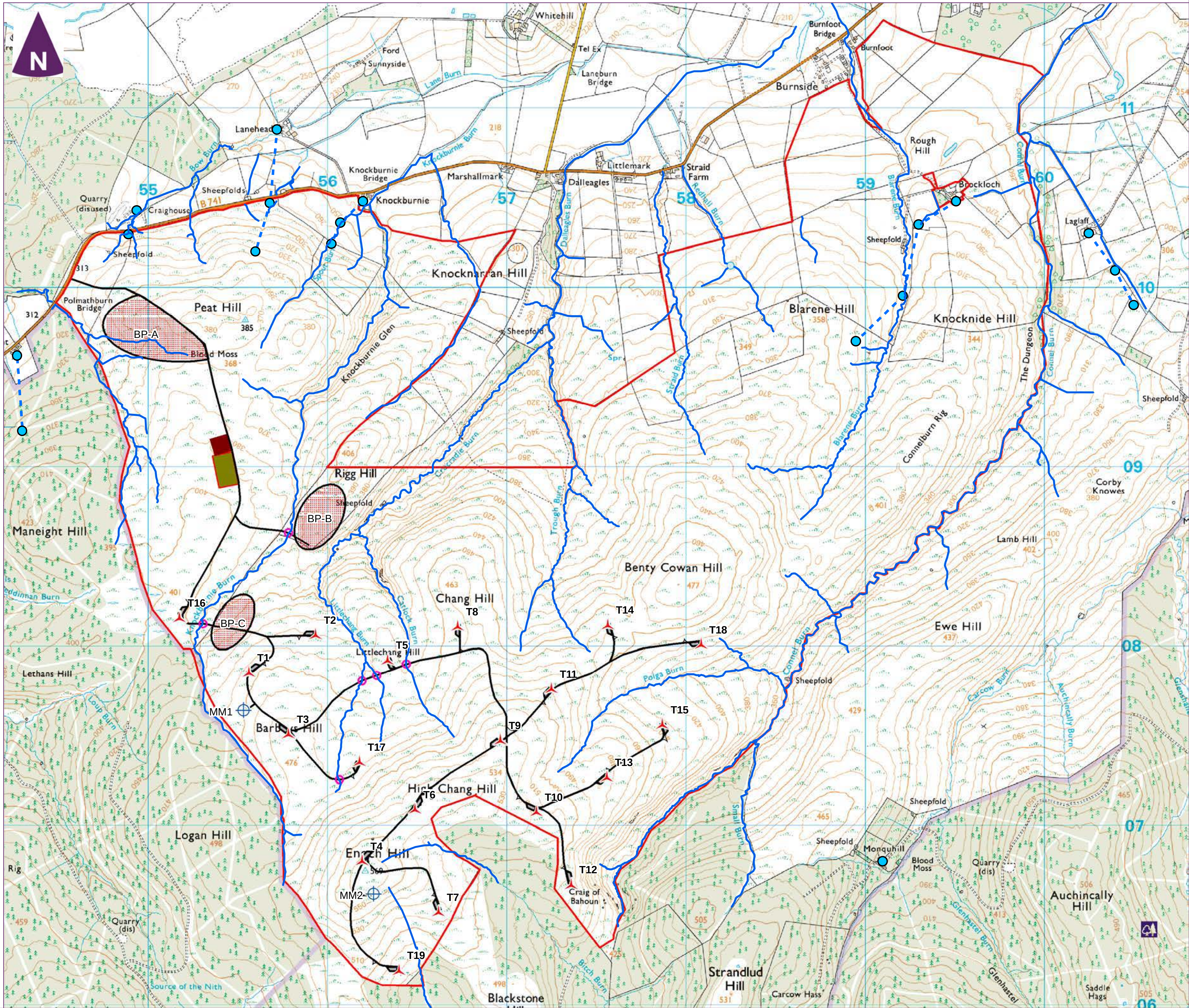
Client

Enoch Hill Wind Farm
Peatslide Hazard and Risk Assessment

amec foster wheeler

Figure 1
Site Location

June 2015 32965-Gla351.mxd tudoa



Key

- Application Boundary
- Turbine locations
- Watercourse crossings
- Permanent meteorological masts
- Proposed on site tracks
- Turning Heads
- Temporary Construction Compound
- SPEN & EON Substation compound
- Borrow pit seach areas
- Crane pads
- Surface Water Courses
- Private Water Supplies
- PWS_Pipelines

0 0.15 0.3 0.6 0.9 1.2 km

Scale at A3: 1:21,000

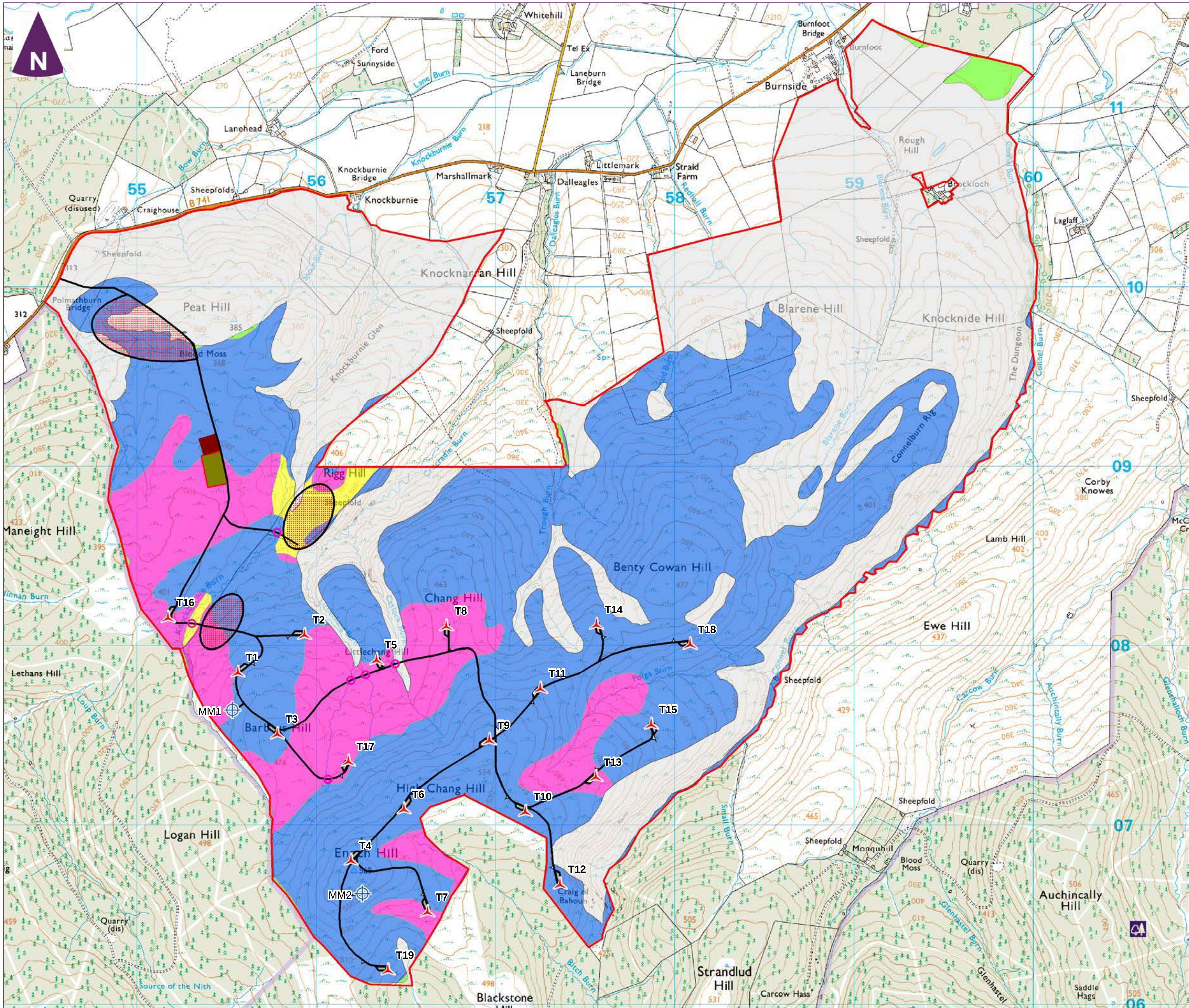
Client

Enoch Hill Wind Farm Peatslide Hazard and Risk Assessment

amec foster wheeler

Figure 2
Site Layout

July 2015 32965-Gla352.mxd tudoa



Key

- Application Boundary
- Turbine locations
- Watercourse crossings
- Permanent meteorological masts
- Proposed on site tracks
- Borrow pit seach areas
- Turning Heads
- Temporary Construction Compound
- SPEN & EON Substation compound
- Crane pads

SNH Carbon Rich Soil Category

- 1
- 2
- 3
- 4
- X

0 0.15 0.3 0.6 0.9 1.2 km

Scale at A3: 1:21,000

Client

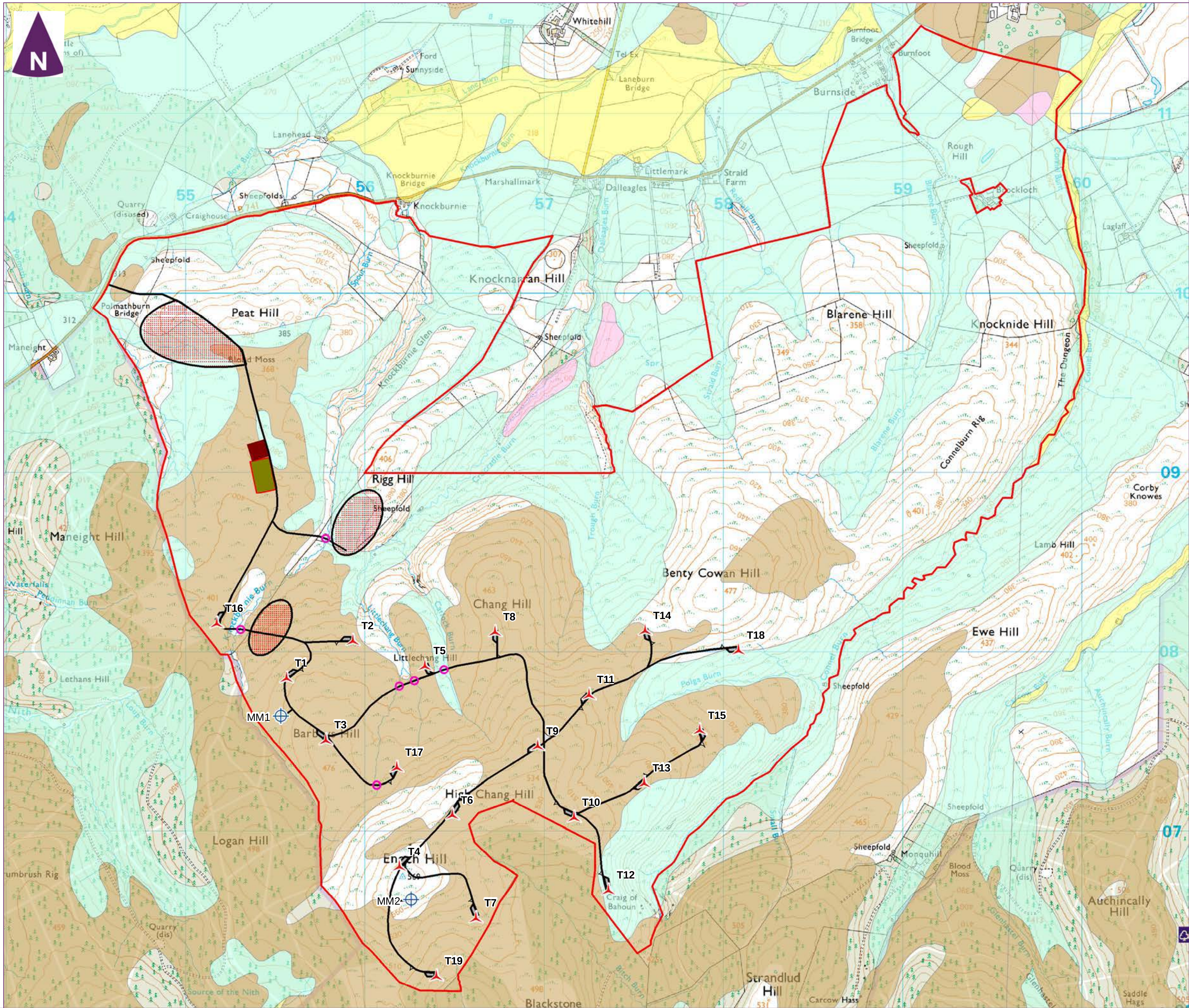
Enoch Hill Wind Farm
Peatslide Hazard and Risk Assessment

amec foster wheeler

Figure 3
SNH Carbon rich soil, deep peat and priority peatland habitats map (in consultation)

July 2015 32965-Gla355.mxd tudoa

file: \\gos-fs14\shared\GWM\DATA\PROJECT\32965 Enoch Hill Wind Farm EIA SUB\D040 Design\ARC\Peat\PSRA\32965-Gla355.mxd



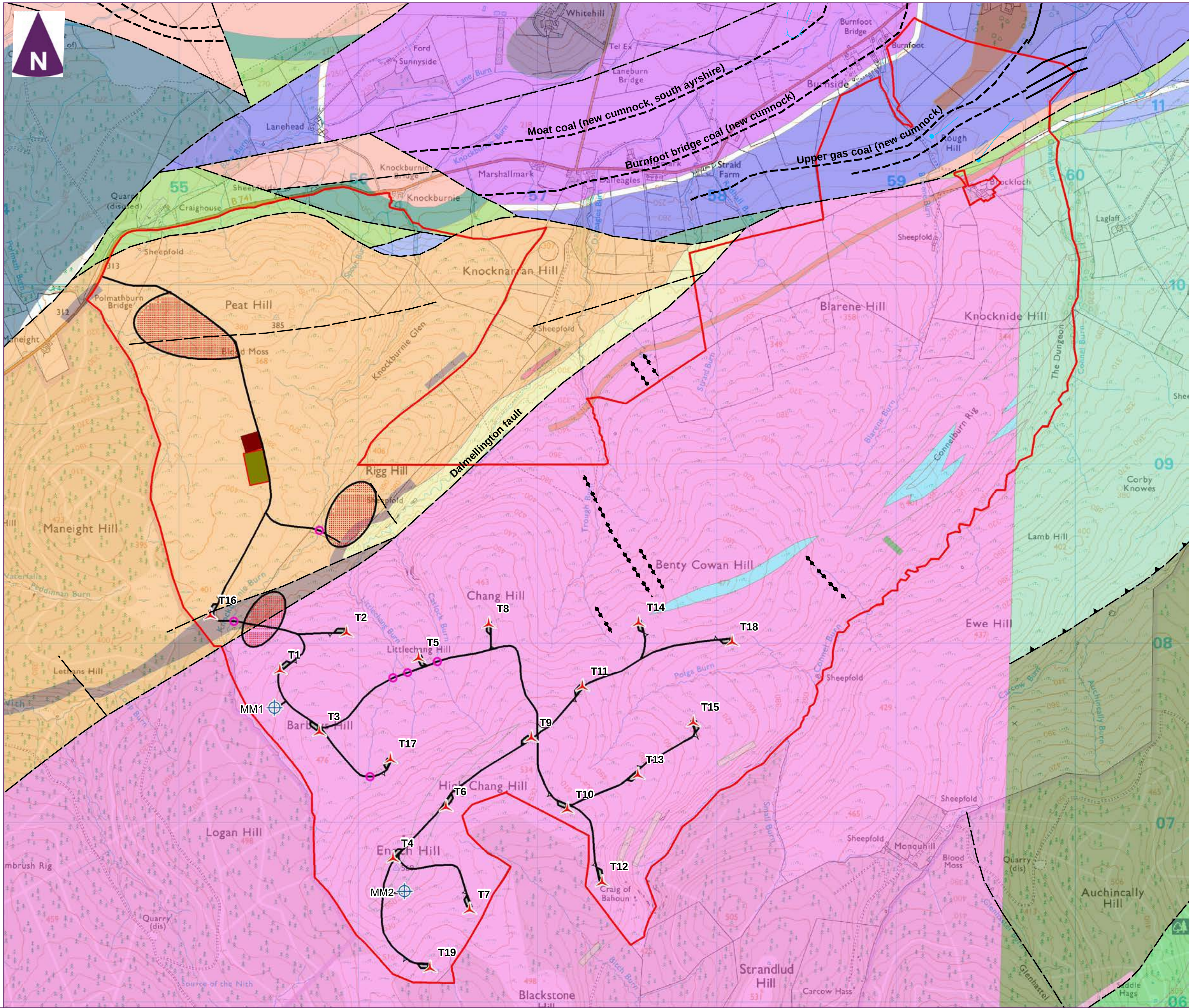
Client

Enoch Hill Wind Farm
Peatslide Hazard and Risk Assessment

amec foster wheeler

Figure 4
BGS Superficial Geology

July 2015 32965-Gla356.mxd tudoa



Key

BGS Bedrock Geology

- Ayrshire Basanitic and Foiditic Plugs and Vents
- Blackcraig Formation
- Carrick Volcanic Formation
- Crawford Formation
- Cumbrae-Stevenston Dyke
- Kirkholm Formation
- Lanark Group
- Leadhills Formation
- Limestone Coal Formation
- Limestone Coal Formation and Upper Limestone Formation (Undifferentiated)
- Marchburn Formation
- North Britain Siluro-Devonian Calc-Alkaline Dyke Suite
- Passage Formation
- Scottish Lower Coal Measures Formation
- Scottish Middle Coal Measures Formation
- Scottish Upper Coal Measures Formation
- Southern Midland Valley Felsite Sills
- Unamed Igneous Intrusion of unknown age
- Upper Limestone Formation
- Western Midland Valley Westphalian to early Permian Sills
- Coal seam, inferred
- Coal seam, observed
- Drumlin, form line at base
- Fault, inferred, displacement unknown
- Reverse or thrust fault, inferred, barbs on hanging wall side, throw in metres
- Glacial meltwater channel centre line, undifferentiated
- Mineral vein, inferred

0 0.15 0.3 0.6 0.9 1.2 km

Scale at A3: 1:21,000

Client

Enoch Hill Wind Farm
Peatslide Hazard and Risk Assessment

amec foster wheeler

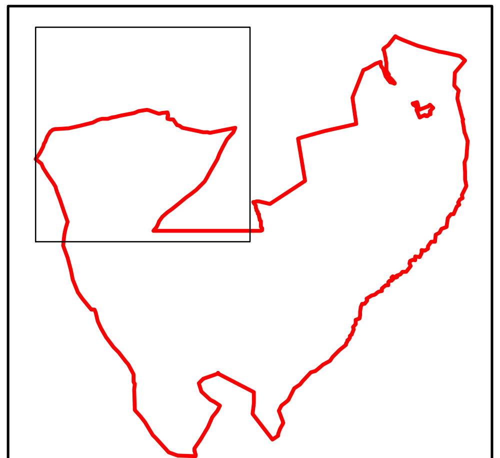
Figure 5
BGS Bedrock Geology

July 2015 32965-Gla357.mxd tudoa

file: \\gos-fs14\shared\GWM\DATA\PROJECT\32965 Enoch Hill Wind Farm EIA SUB\D040 Design\ARC\Peat\PSRA\32965-Gla357.mxd

Key

(red outline)	Application Boundary
(red symbol)	Turbine locations
(blue symbol)	Permanent meteorological masts



0 0.075 0.15 0.3 0.45 0.6 km

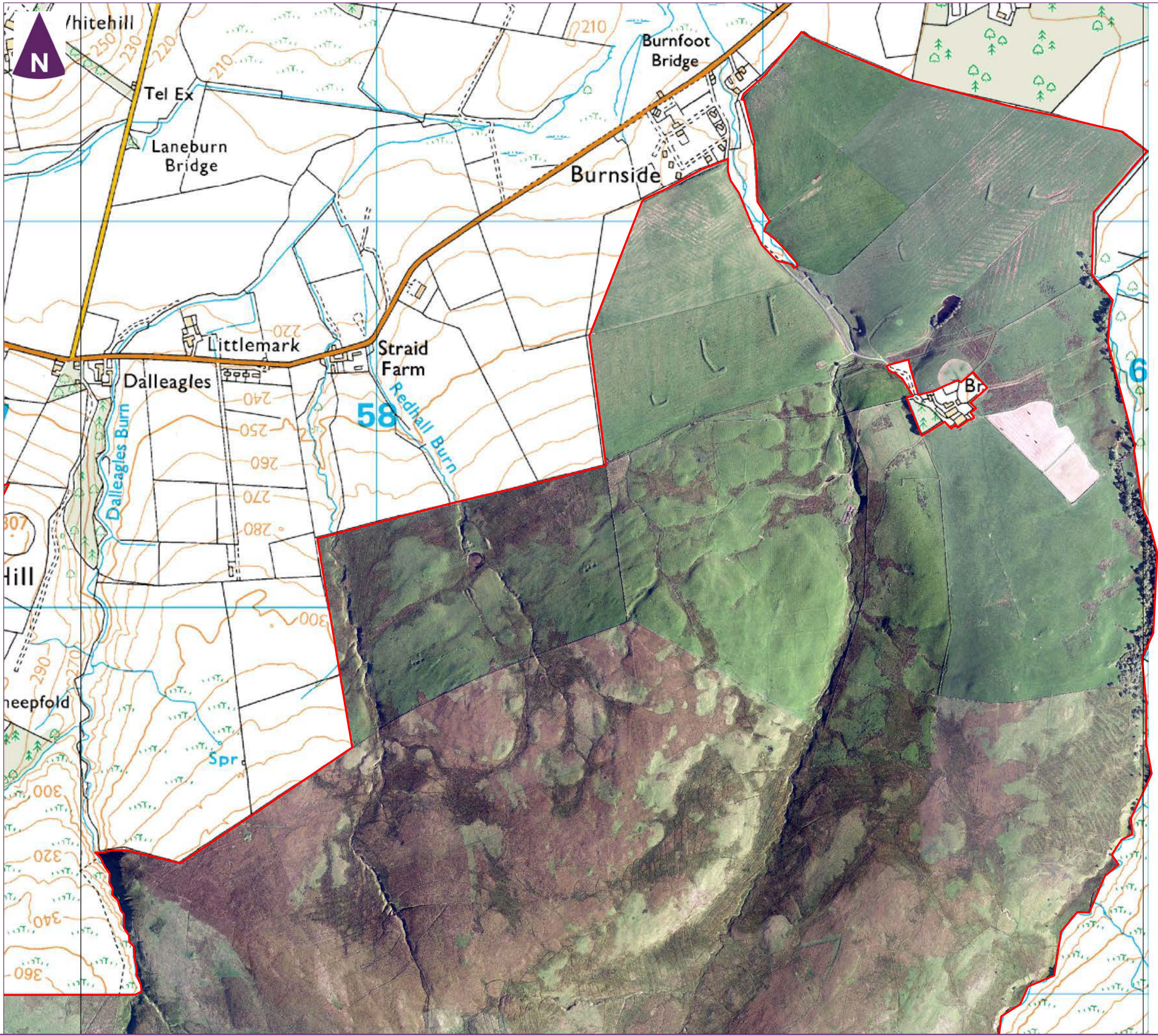
Scale at A3: 1:10,000

Client

Enoch Hill Wind Farm
Peatslide Hazard and Risk Assessment

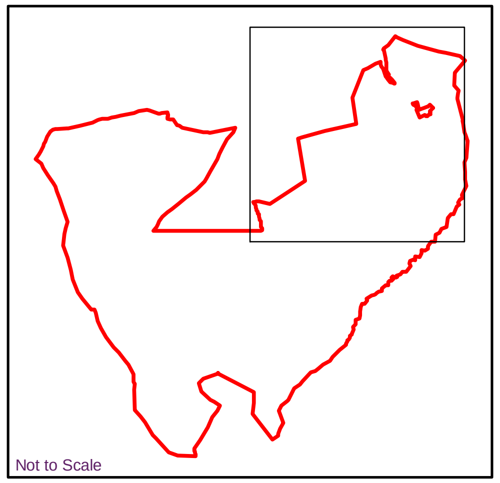
amec foster wheeler

Figure 6.1
Aerial Photography



Key

- Application Boundary
- Turbine locations
- Permanent meteorological masts



0 0.075 0.15 0.3 0.45 0.6 km

Scale at A3: 1:10,000

Client

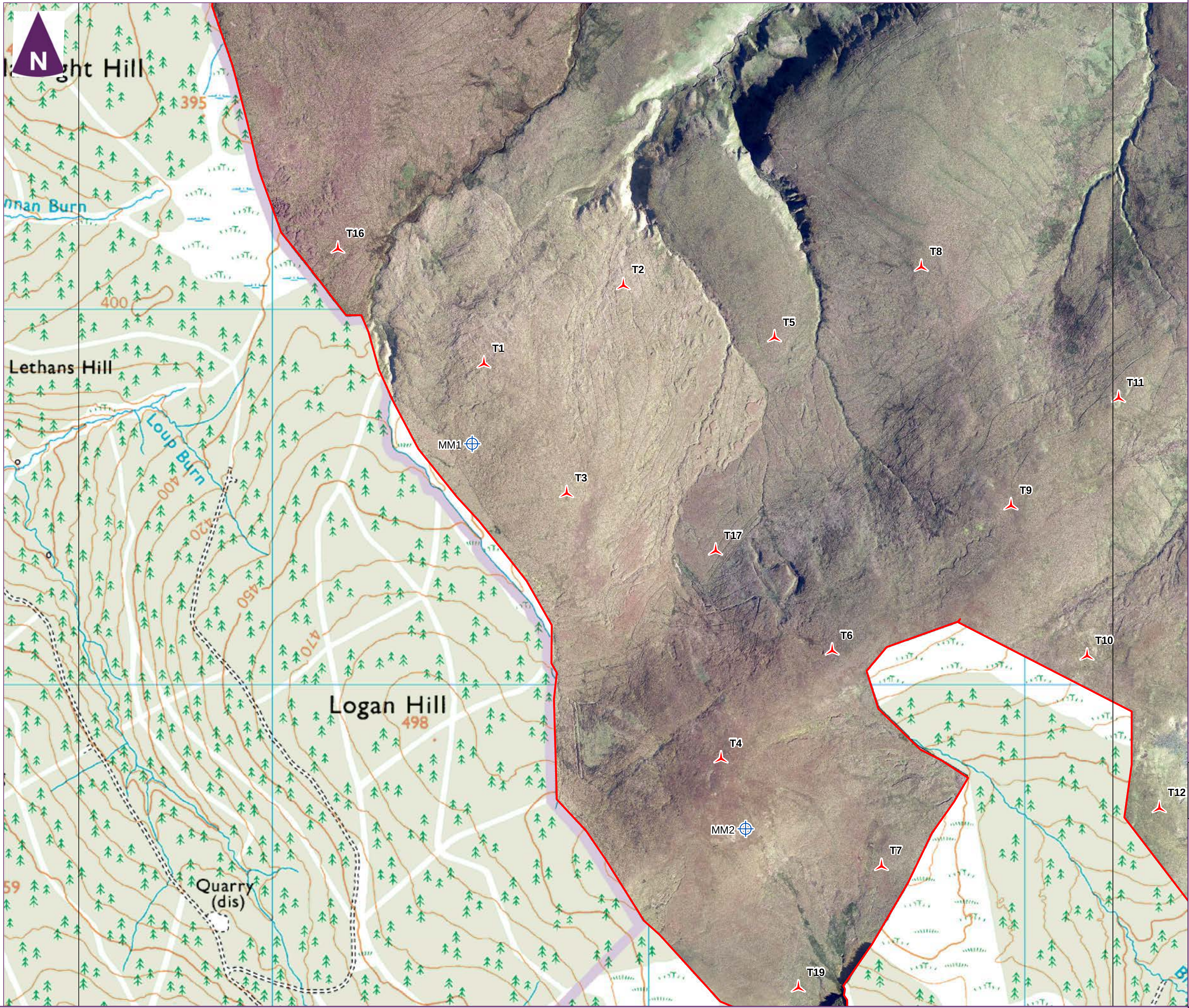
Enoch Hill Wind Farm
Peatslide Hazard and Risk Assessment

amec foster wheeler

Figure 6.2
Aerial Photography

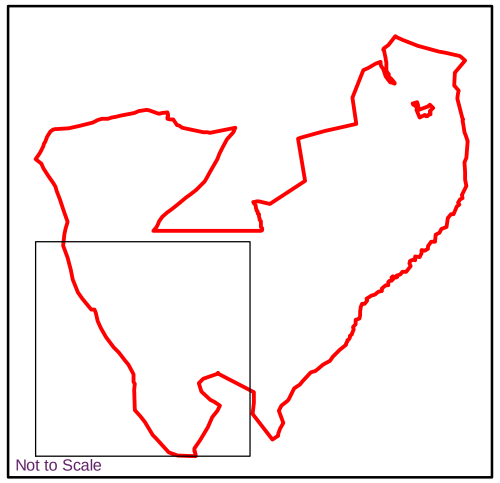
June 2015 32965-Gla308.mxd amaib

file: \\gos-fs14\shared\GWM\DATA\PROJECT\32965 Enoch Hill Wind Farm EIA SUB\D040 Design\ARC\Peat\PSRA\32965-Gla308.mxd



Key

- Application Boundary
- Turbine locations
- Permanent meteorological masts



0 0.075 0.15 0.3 0.45 0.6 km

Scale at A3: 1:10,000

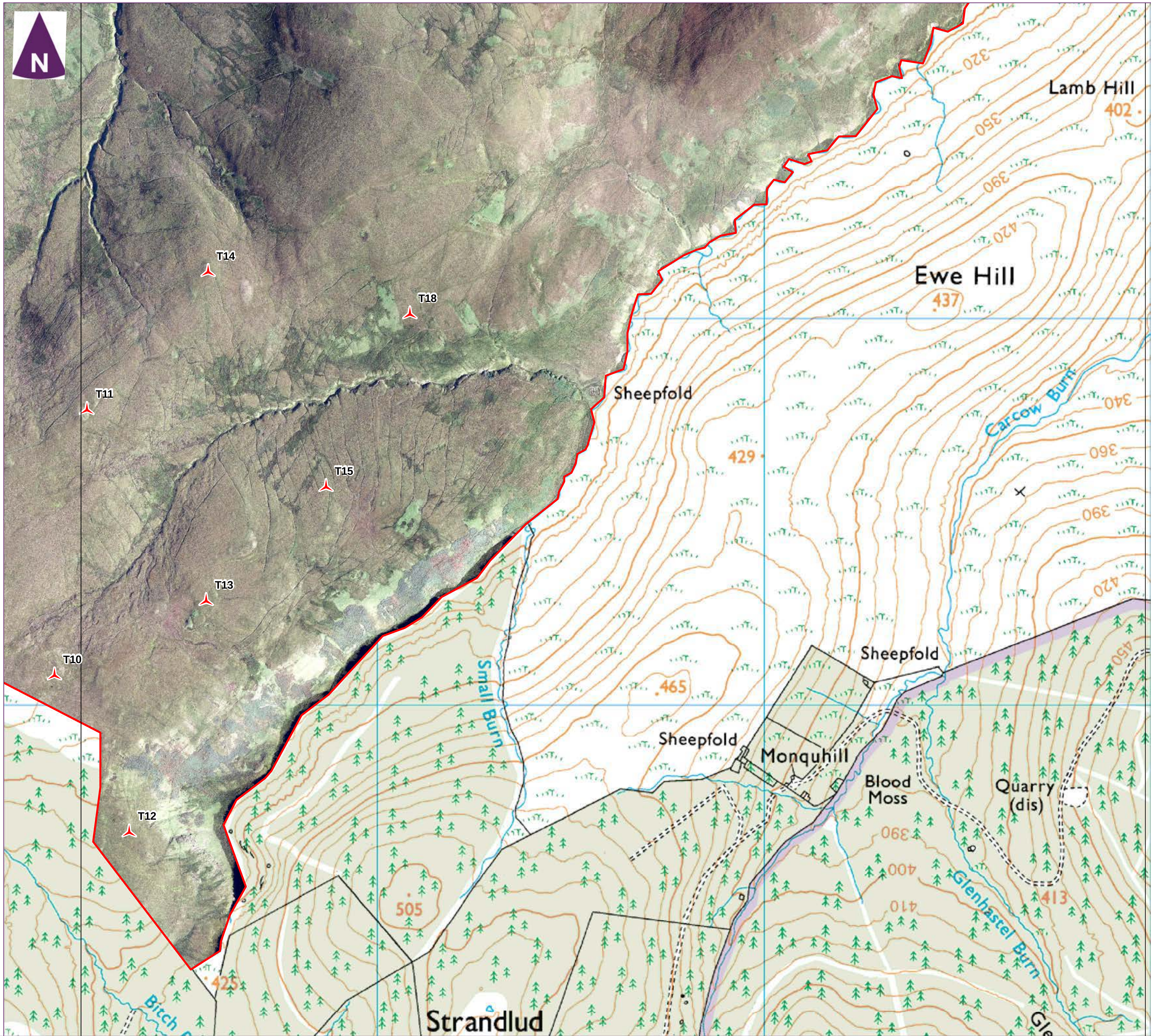
Client

Enoch Hill Wind Farm
Peatslide Hazard and Risk Assessment

amec foster wheeler

Figure 6.3
Aerial Photography

June 2015 32965-Gla308.mxd amaib

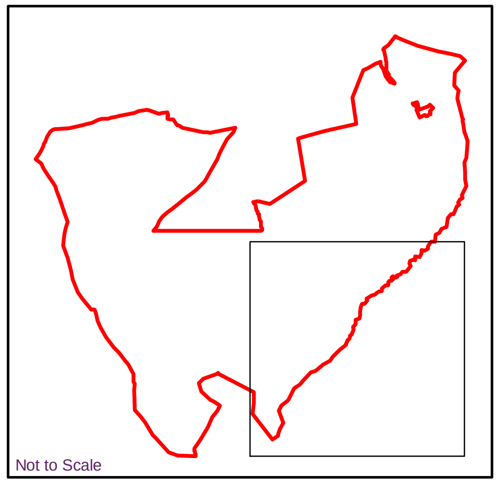


Key

Application Boundary

Turbine locations

Permanent meteorological masts



0 0.075 0.15 0.3 0.45 0.6 km

Scale at A3: 1:10,000

Client

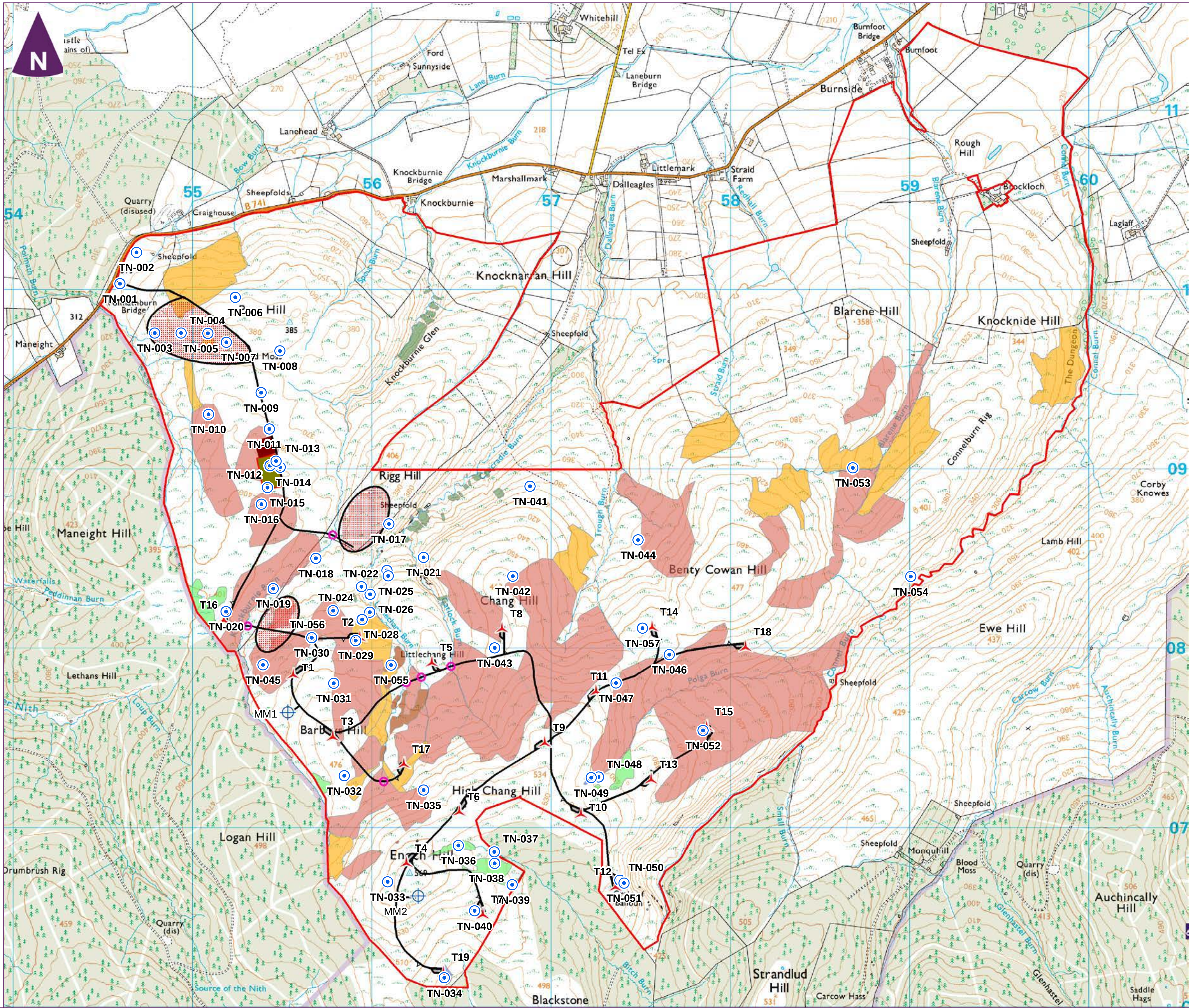
Enoch Hill Wind Farm
Peatslide Hazard and Risk Assessment

amec foster wheeler

Figure 6.4
Aerial Photography

June 2015 32965-Gla308.mxd amaib

file: \\gos-fs14\shared\GWM\DATA\PROJECT\32965 Enoch Hill Wind Farm EIA SUB\D040 Design\ARC\Peat\PSRA\32965-Gla308.mxd



Key

Geomorphology Features

- Flushes
- Flushes and Hagging
- Gripping (high intensity)
- Gripping (low intensity)
- Hagging
- Peatslide
- Slope Creep
- Tranlational Mineral Soil Slide
- Target Notes (see Appendix C)

0 0.15 0.3 0.6 0.9 1.2 km

Scale at A3: 1:21,000

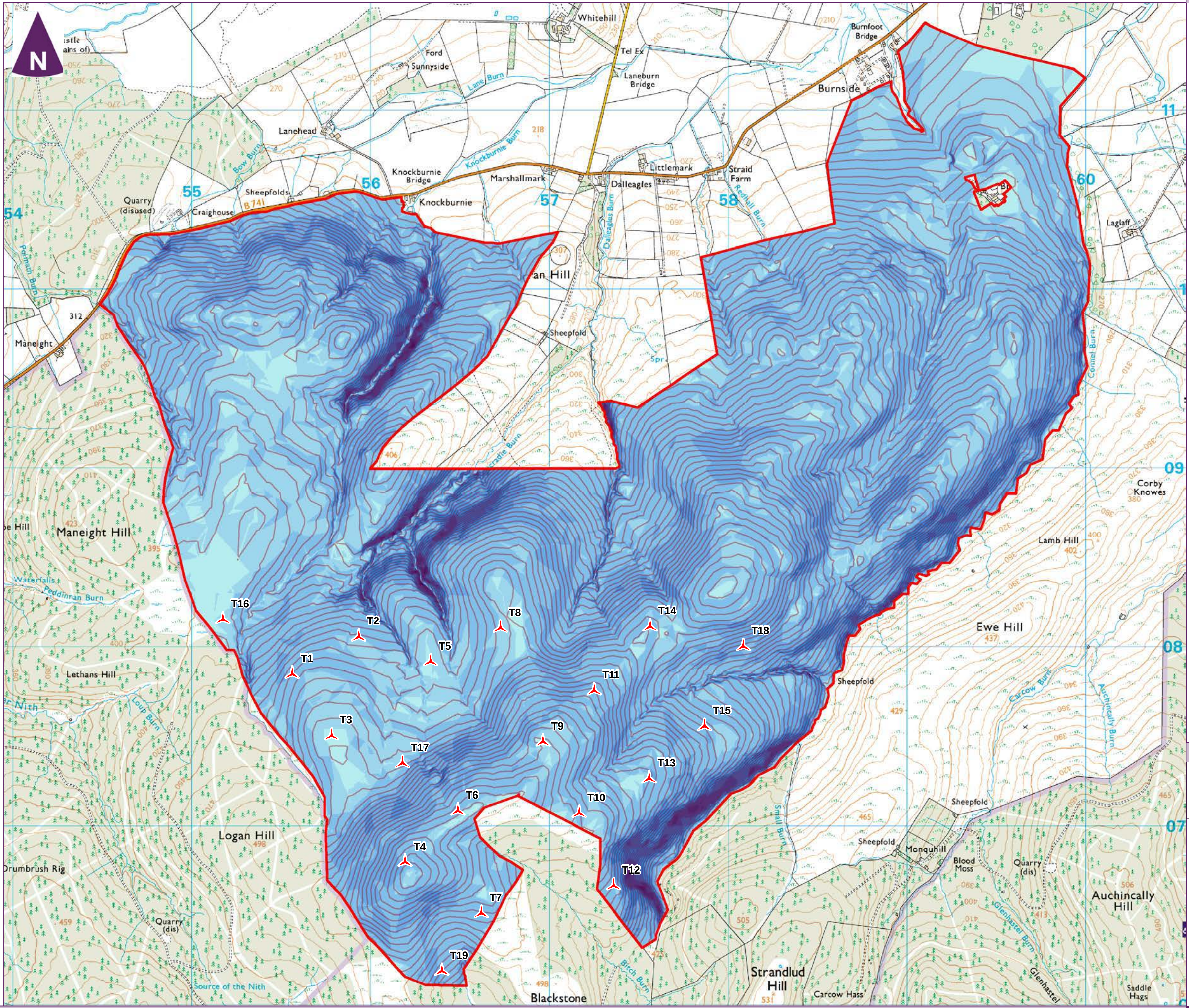
Client

Enoch Hill Wind Farm
Peatslide Hazard and Risk Assessment

amec foster wheeler

Figure 7
Geomorphology Map

July 2015 32965-Gla371.mxd amaib



Key

Application Boundary

Turbine Locations

OS Terrain 5 DTM Slope Angle (degrees)

- 0 - 2
- 2 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50

5m Elevation Contours

0 0.15 0.3 0.6 0.9 1.2 km

Scale at A3: 1:21,000

Client

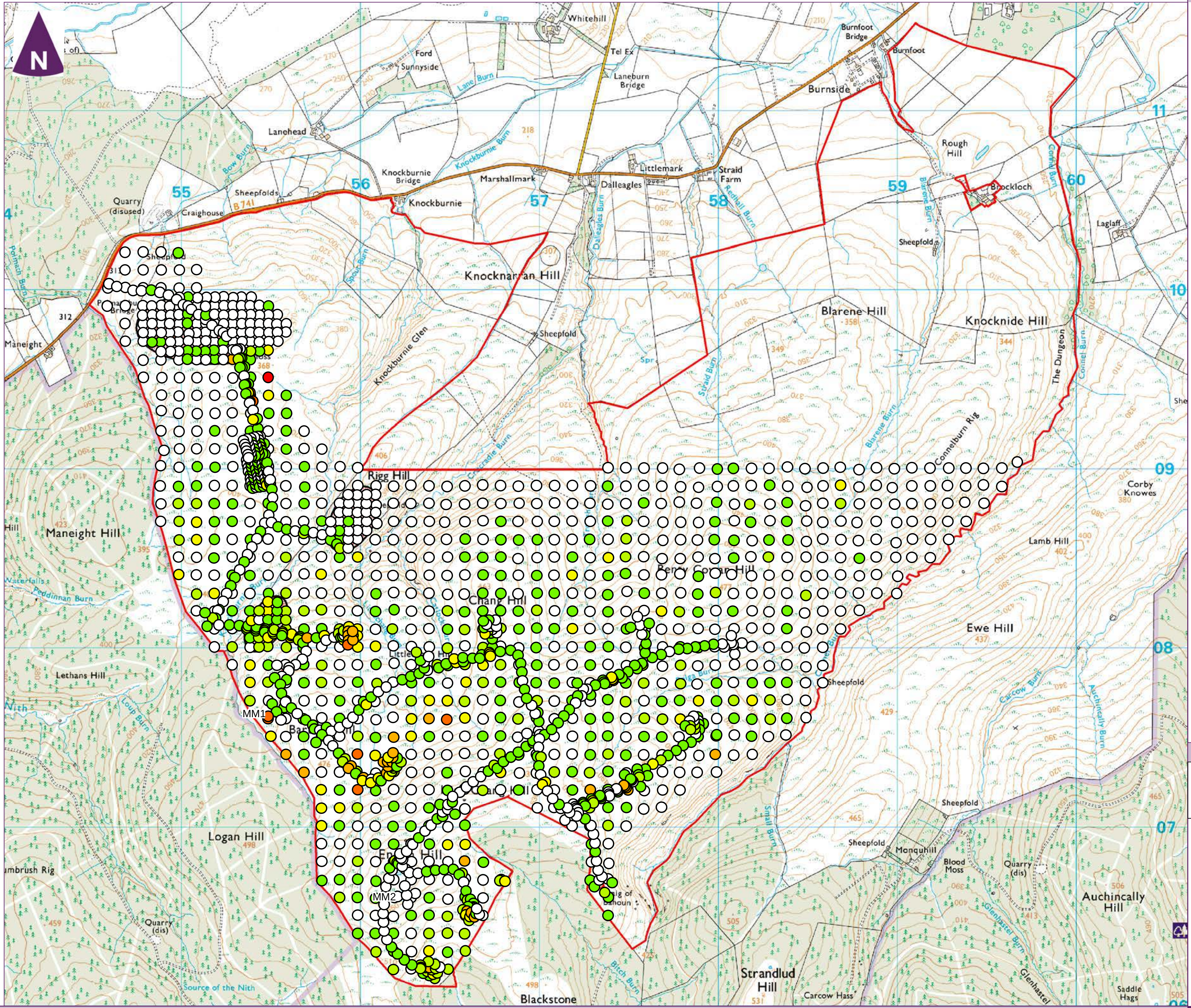
Enoch Hill Wind Farm
Peatslide Hazard and Risk Assessment

amec foster wheeler

Figure 8
OS Terrain 5 Digitial Terrain Model

June 2015 32965-Gla359.mxd amaib

file: \\gos-fs14\shared\GWM\DATA\PROJECT\32965 Enoch Hill Wind Farm EIA SUB\D040 Design\ARC\Peat\PSRA\32965-Gla359.mxd



Key

Application Boundary

Turbine locations

Watercourse crossings

Permanent meteorological masts

Proposed on site tracks

Borrow pit seach areas

Turning Heads

Temporary Construction Compound

SPEN & EON Substation compound

Crane pads

Phase 1 and 2 Peat Depth Data (m)

0.00 - 0.50

0.50 - 1.00

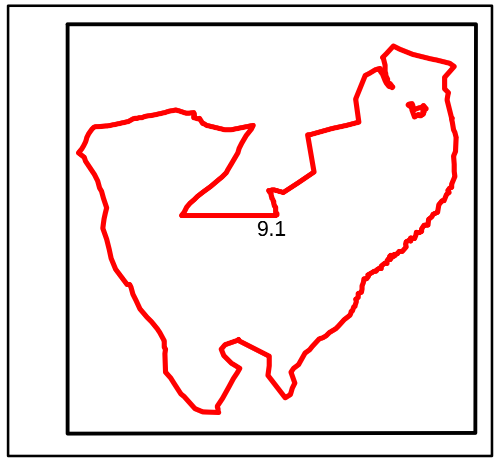
1.00 - 1.50

1.50 - 2.00

2.00 - 2.50

2.50 - 3.00

3.00 - 3.50



0 0.15 0.3 0.6 0.9 1.2 km

Scale at A3: 1:21,000

Client

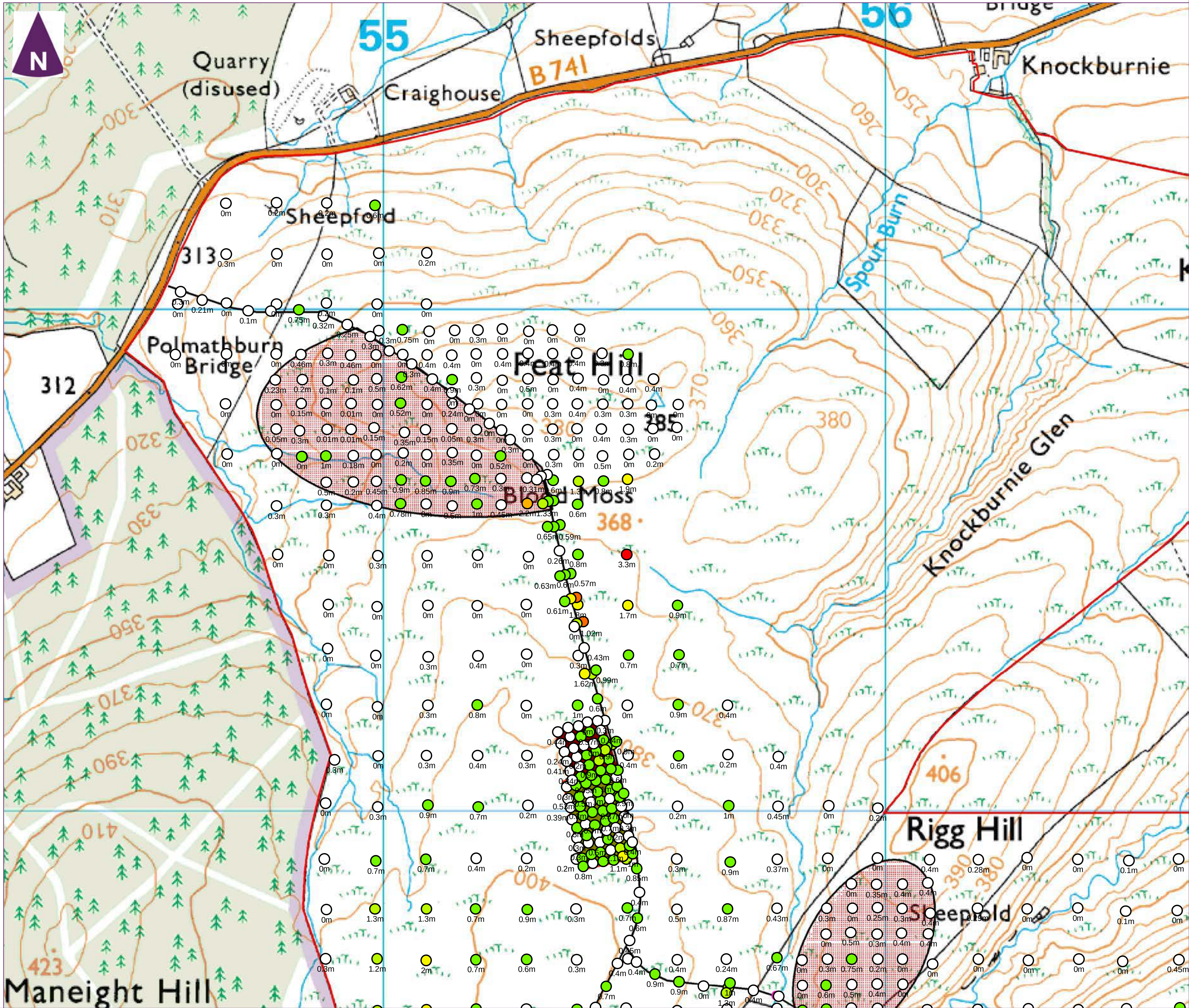
Enoch Hill Wind Farm
Peatslide Hazard and Risk Assessment

amec foster wheeler

Figure 9.1
Peat Depth Survey Data

July 2015 32965-Gla360.mxd tudoa

file: \\gos-fs14\shared\GWM\DATA\PROJECT\32965 Enoch Hill Wind Farm EIA SUB\D040 Design\ARC\Peat\PSRA\32965-Gla360.mxd

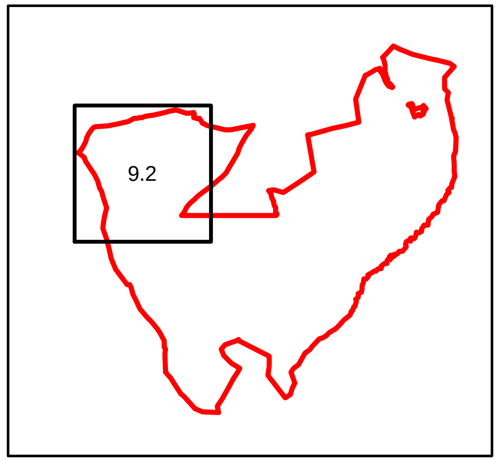


Key

	Application Boundary
	Turbine locations
	Watercourse crossings
	Permanent meteorological masts
	Proposed on site tracks
	Borrow pit seach areas
	Turning Heads
	Temporary Construction Compound
	SPEN & EON Substation compound
	Crane pads

Phase 1 and 2 Peat Depth Data (m)

- 0.00 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- 3.00 - 3.50



0 0.05 0.1 0.2 0.3 0.4 km

Scale at A3: 1:7,500

Client

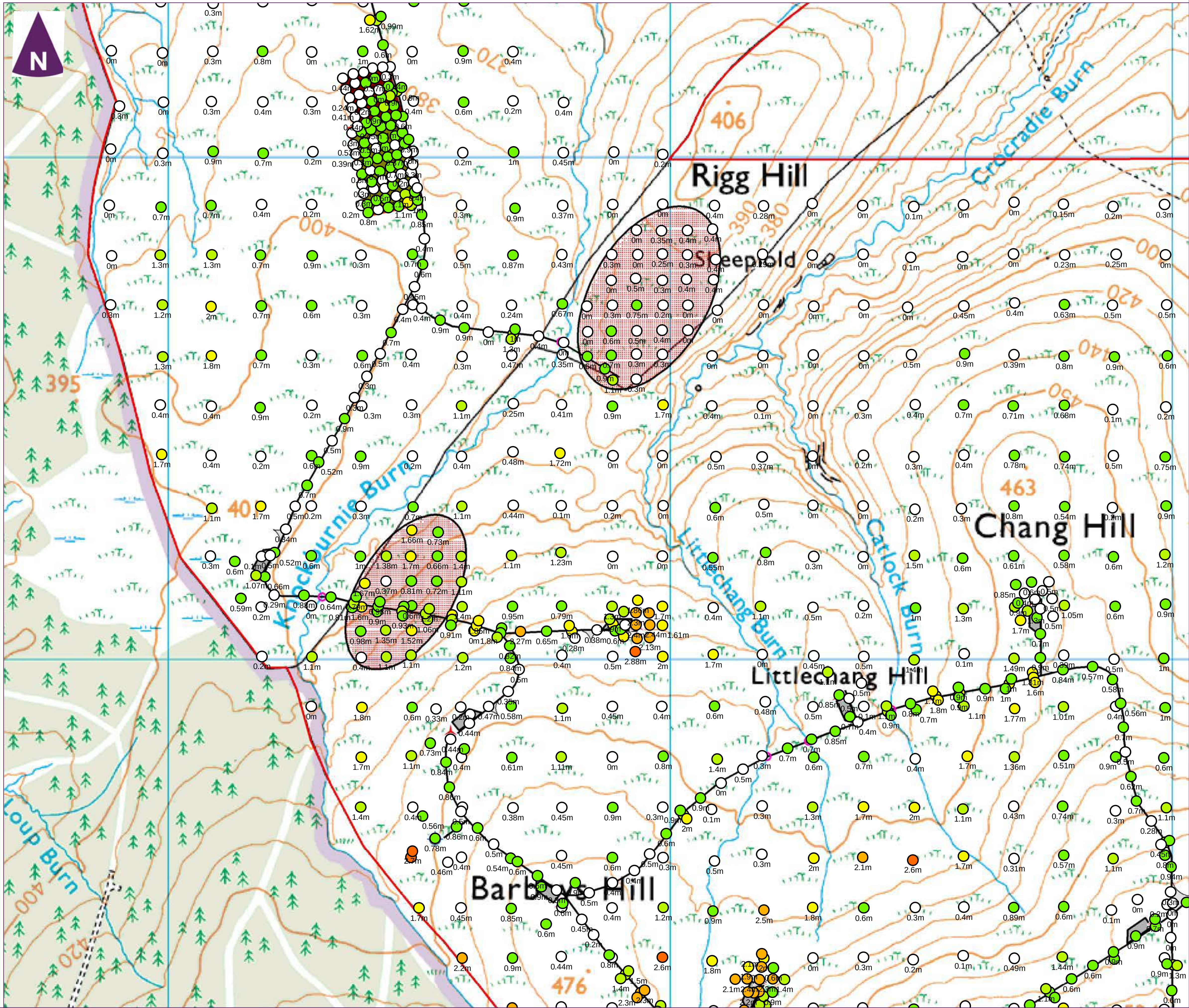
Enoch Hill Wind Farm
Peatslide Hazard and Risk Assessment

amec foster wheeler

Figure 9.2
Peat Depth Survey Data

July 2015 32965-Gla360.mxd tudoa

file: \\gos-fs14\shared\GWM\DATA\PROJECT\32965 Enoch Hill Wind Farm EIA SUB\D040 Design\ARC\Peat\PSRA\32965-Gla360.mxd

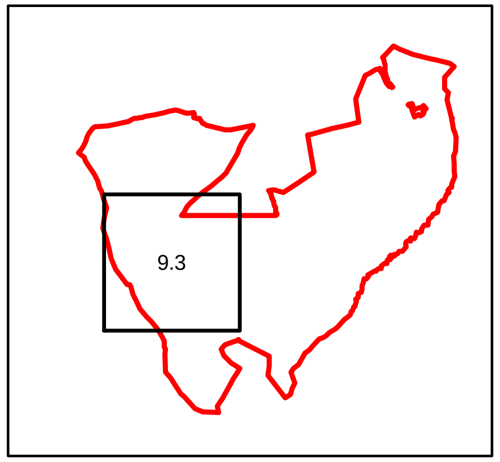


Key

- Application Boundary
- Turbine locations
- Watercourse crossings
- Permanent meteorological masts
- Proposed on site tracks
- Borrow pit seach areas
- Turning Heads
- Temporary Construction Compound
- SPEN & EON Substation compound
- Crane pads

Phase 1 and 2 Peat Depth Data (m)

- 0.00 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- 3.00 - 3.50



0 0.05 0.1 0.2 0.3 0.4 km

Scale at A3: 1:7,500

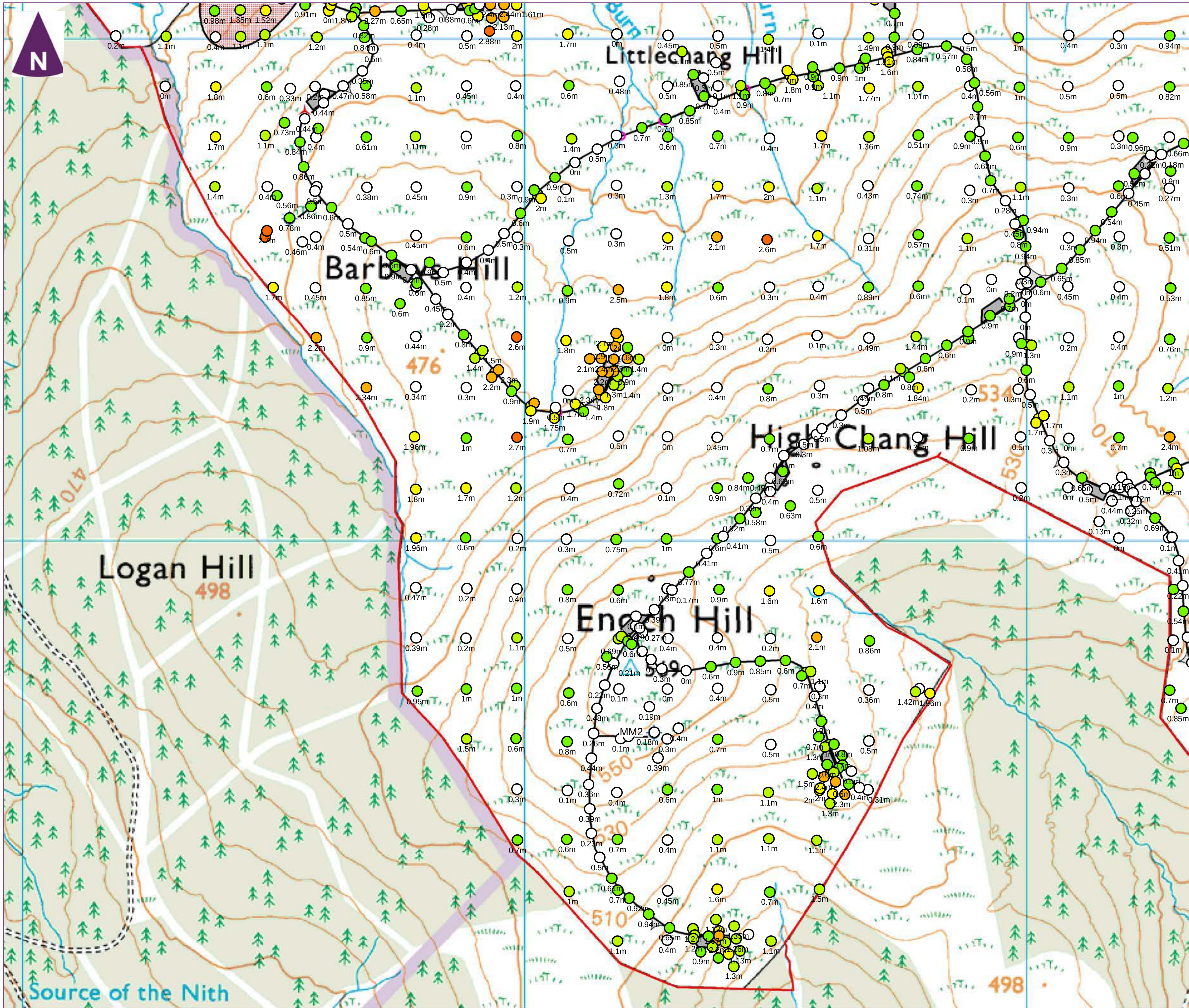
Client

Enoch Hill Wind Farm
Peatslide Hazard and Risk Assessment

amec foster wheeler

Figure 9.3
Peat Depth Survey Data

July 2015 32965-Gla360.mxd tudoa

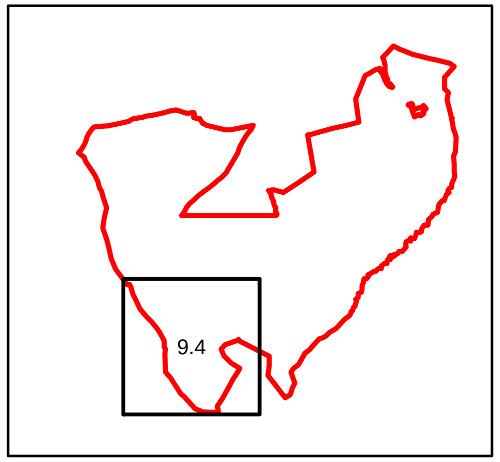


Key

- Application Boundary
- Turbine locations
- Watercourse crossings
- Permanent meteorological masts
- Proposed on site tracks
- Borrow pit seach areas
- Turning Heads
- Temporary Construction Compound
- SPEN & EON Substation compound
- Crane pads

Phase 1 and 2 Peat Depth Data (m)

- 0.00 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- 3.00 - 3.50



0 0.05 0.1 0.2 0.3 0.4 km

Scale at A3: 1:7,500

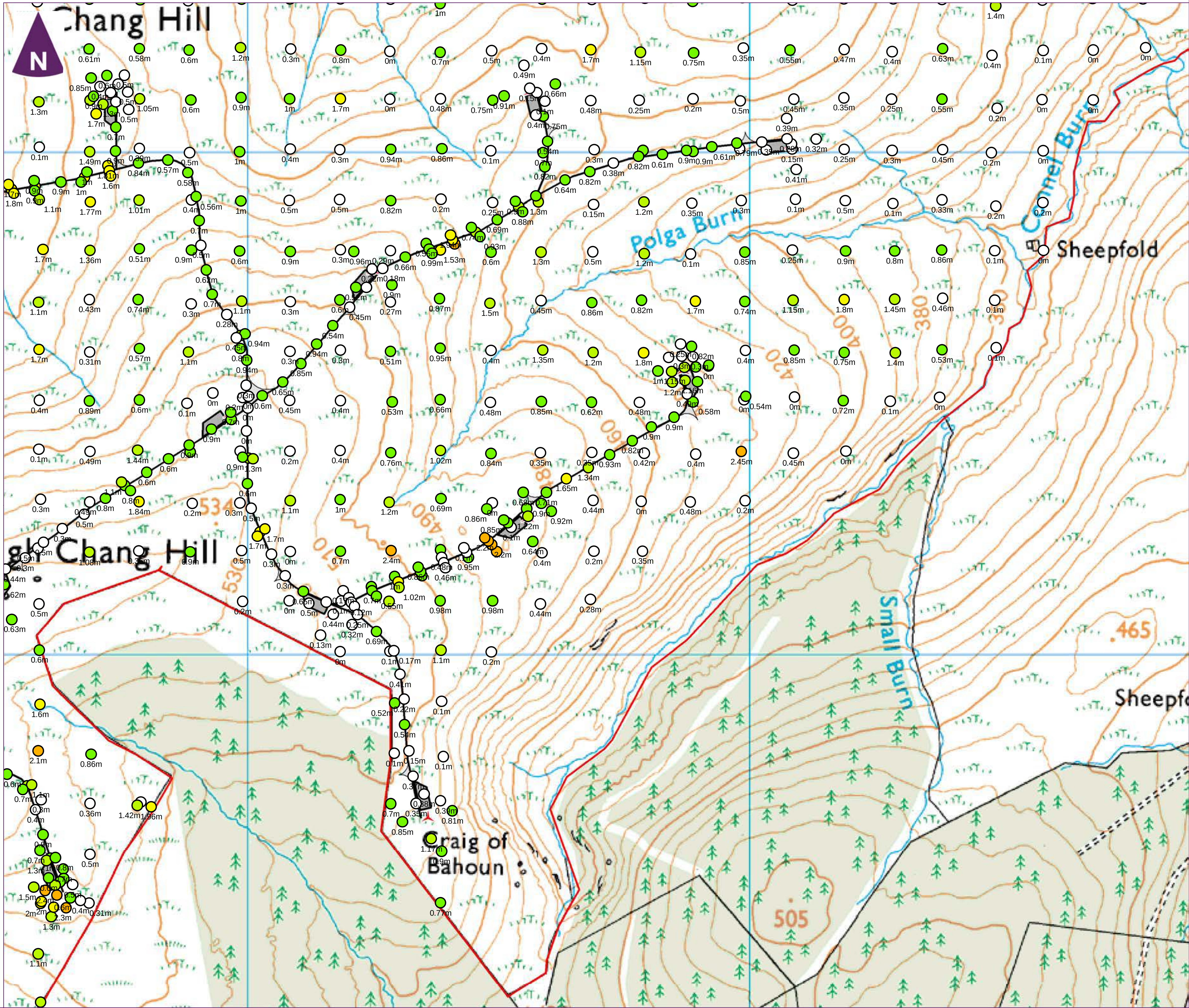
Client

Enoch Hill Wind Farm
Peatslide Hazard and Risk Assessment

amec foster wheeler

Figure 9.4
Peat Depth Survey Data

July 2015 32965-Gla360.mxd tudoa

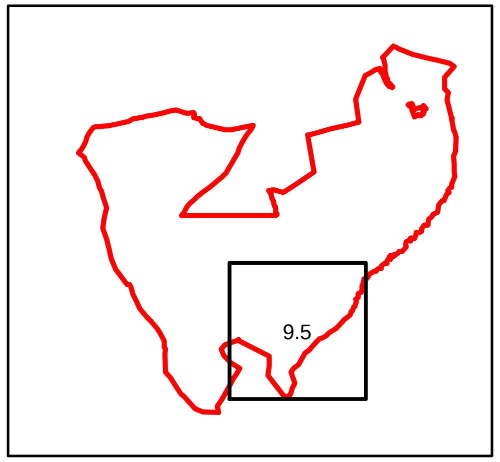


Key

- Application Boundary
- Turbine locations
- Watercourse crossings
- Permanent meteorological masts
- Proposed on site tracks
- Borrow pit seach areas
- Turning Heads
- Temporary Construction Compound
- SPEN & EON Substation compound
- Crane pads

Phase 1 and 2 Peat Depth Data (m)

- 0.00 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- 3.00 - 3.50



0 0.05 0.1 0.2 0.3 0.4 km

Scale at A3: 1:7,500

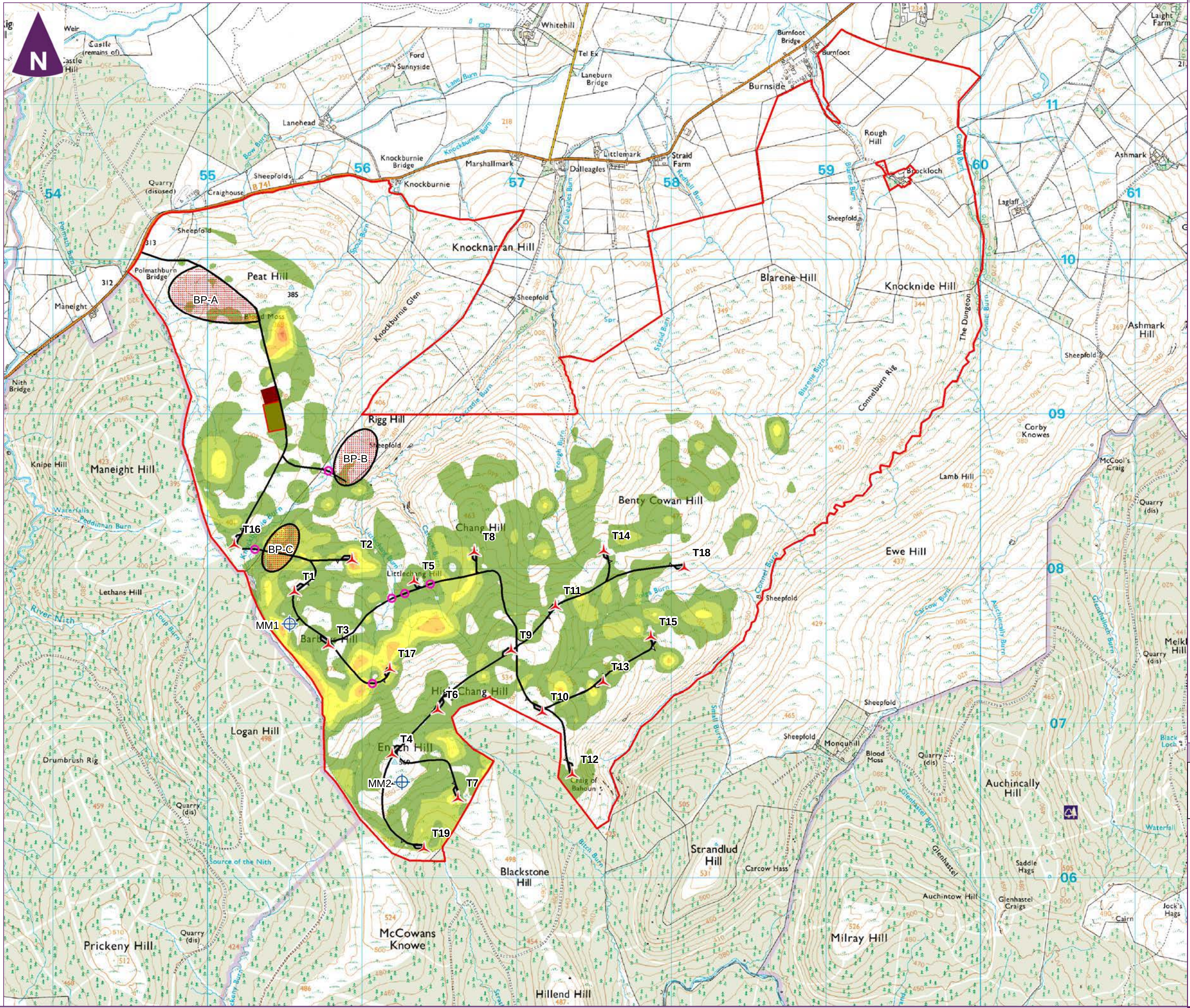
Client

Enoch Hill Wind Farm
Peatslide Hazard and Risk Assessment

amec foster wheeler

Figure 9.5
Peat Depth Survey Data

July 2015 32965-Gla360.mxd tudoa



Key

- Application Boundary
- Turbine locations
- Watercourse crossings
- Permanent meteorological masts
- Proposed on site tracks
- Borrow pit seach areas
- Turning Heads
- Temporary Construction Compound
- SPEN & EON Substation compound
- Crane pads

Interpolated Peat Depth (m)

- 0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5

0 0.175 0.35 0.7 1.05 1.4 km

Scale at A3: 1:24,363

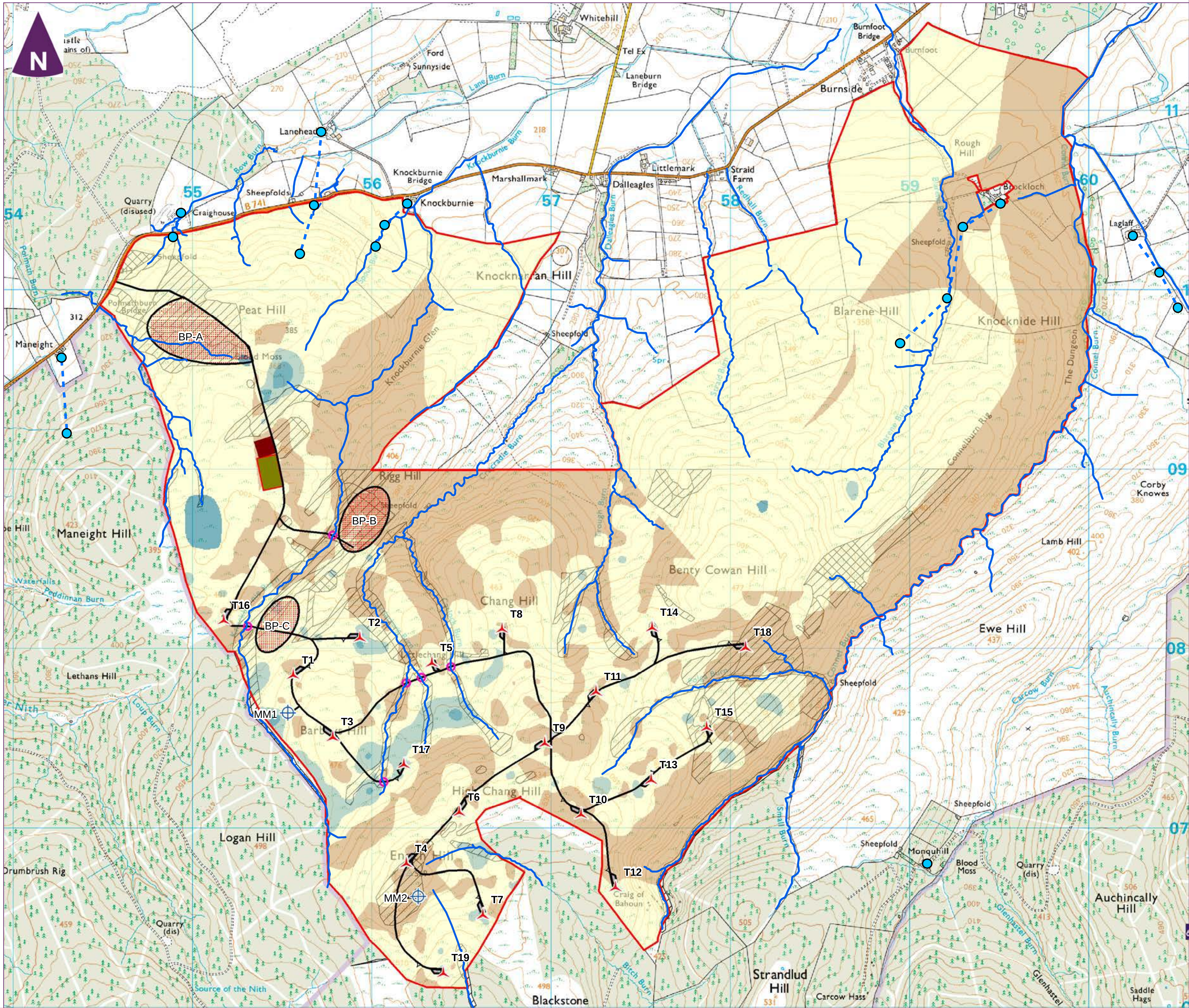
Client

Enoch Hill Wind Farm
Peatslide Hazard and Risk Assessment

amec foster wheeler

Figure 10
Interpolated Peat Depth Map (by Natural Neighbour)

July 2015 32965-Gla361.mxd tudoa



Key

- Application Boundary
- Turbine locations
- Watercourse crossings
- Permanent meteorological masts
- Proposed on site tracks
- Borrow pit seach areas
- Turning Heads
- Temporary Construction Compound
- SPEN & EON Substation compound
- Crane pads

PHRS Scores

- 1
- 3
- 9
- 27
- 81
- Private Water Supplies
- Surface Watercourses
- PWS_Pipelines
- Actual GWDTEs
- Potential GWDTEs

0 0.15 0.3 0.6 0.9 1.2 km

Scale at A3: 1:21,000

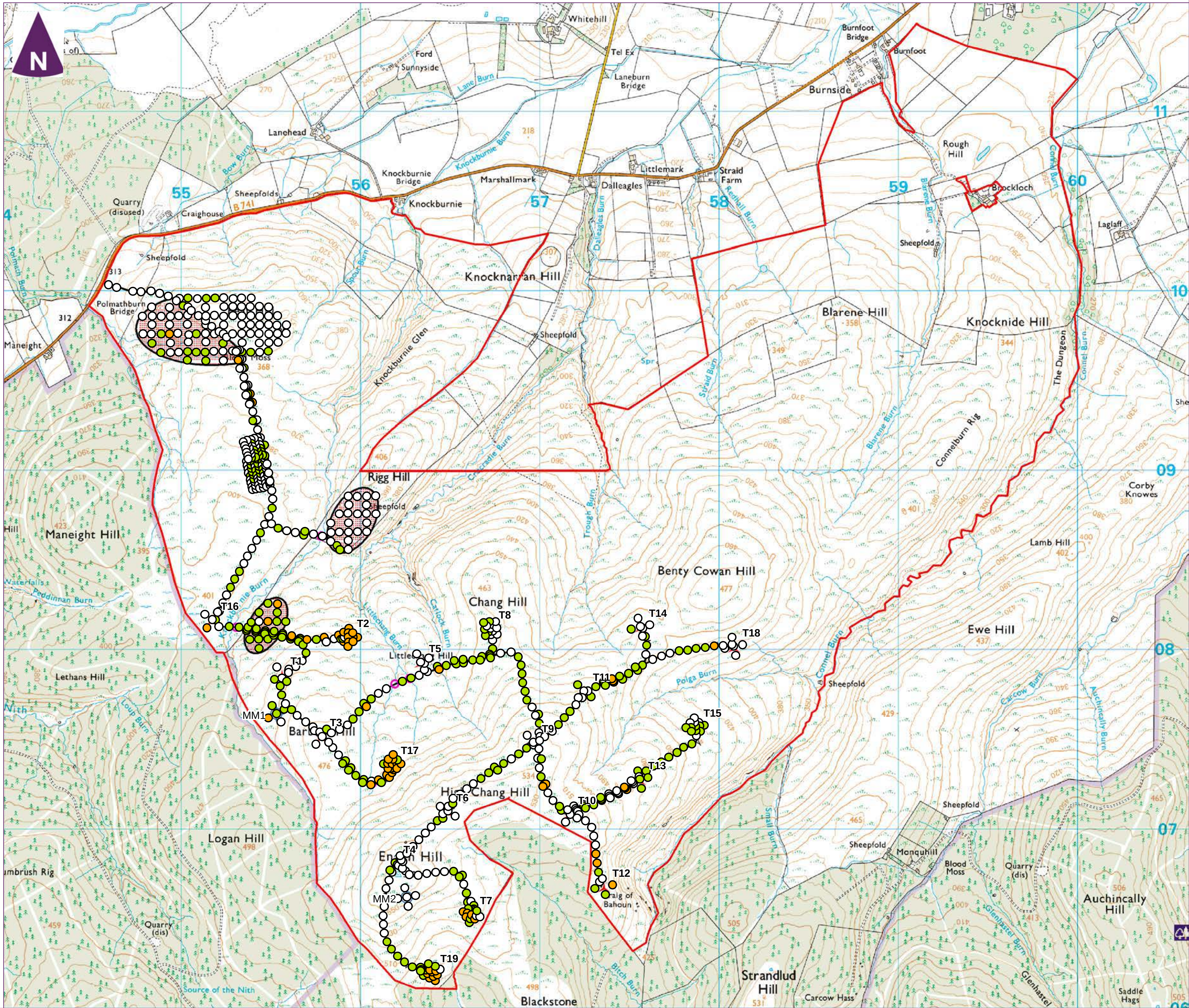
Client

Enoch Hill Wind Farm
Peatslide Hazard and Risk Assessment

amec foster wheeler

Figure 11
PHRS Peatslide Severity Scores

July 2015 32965-Gla368.mxd amaib

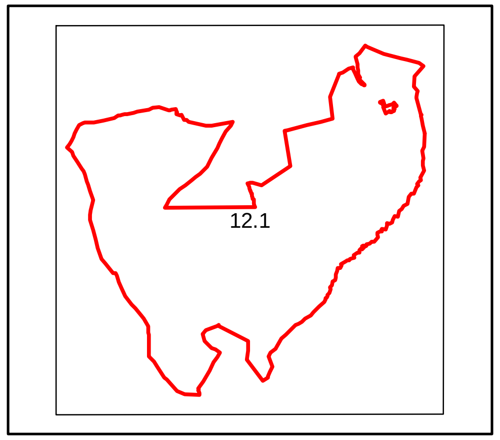


Key

- Application Boundary
- Turbine locations
- Watercourse crossings
- Permanent meteorological masts
- Proposed on site tracks
- Borrow pit seach areas
- Turning Heads
- Temporary Construction Compound
- SPEN & EON Substation compound
- Crane pads

PHRS Scores

- 0 - 170
- 171 - 200
- 201 - 400
- 401 - 600



0 0.15 0.3 0.6 0.9 1.2 km

Scale at A3: 1:21,000

Client

Enoch Hill Wind Farm
Peatslide Hazard and Risk Assessment

amec foster wheeler

Figure 12.1
PHRS Scores

July 2015 32965-Gla369.mxd amaib

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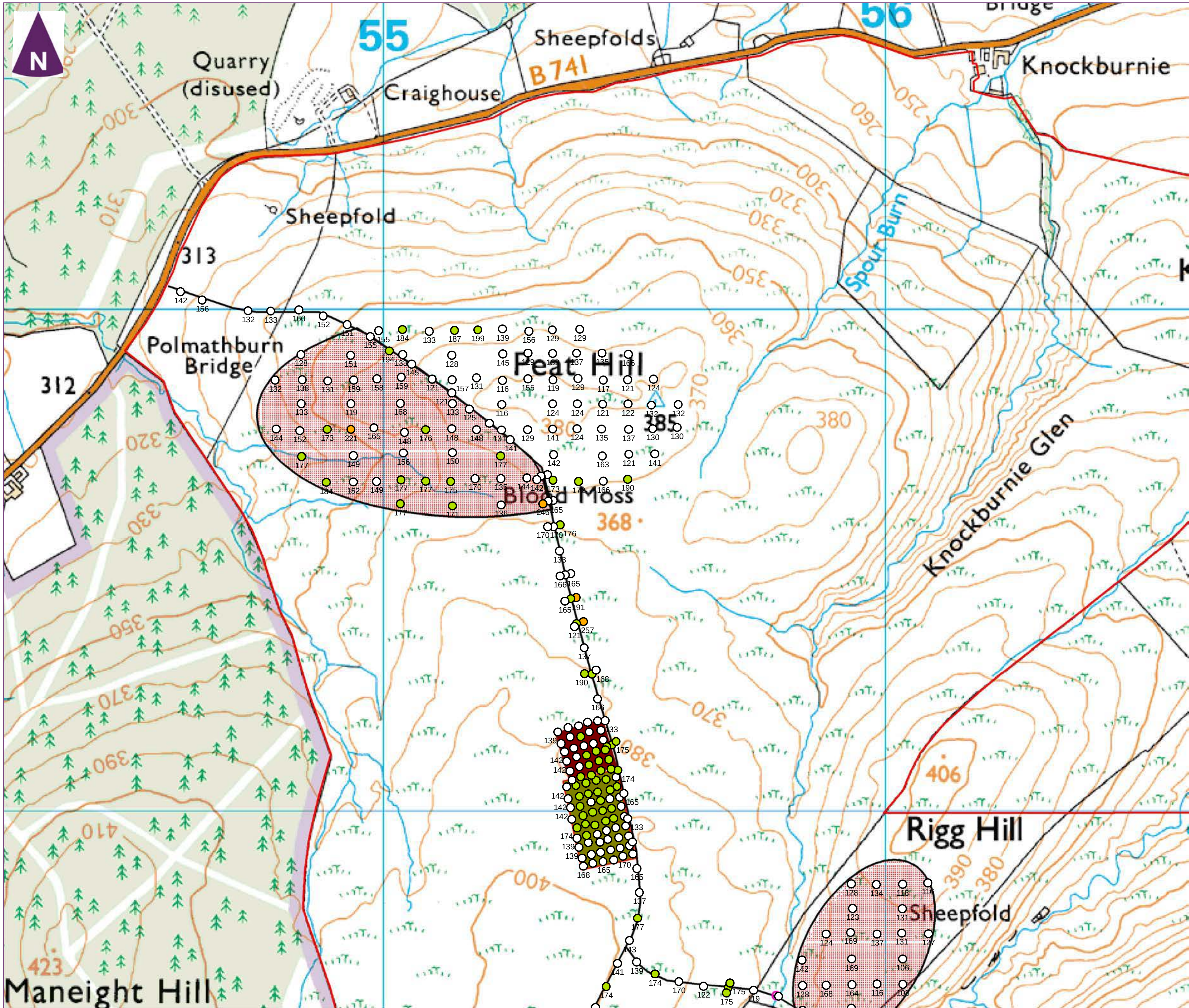
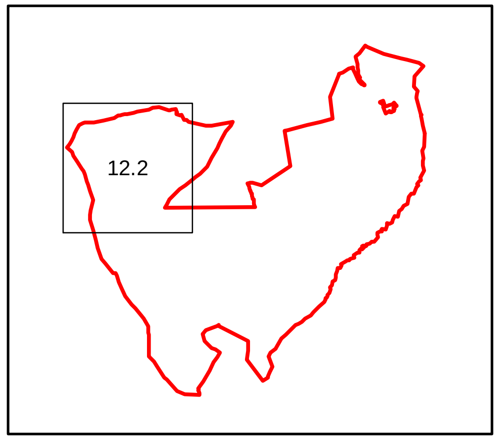


Key

- Application Boundary
- Turbine locations
- Watercourse crossings
- Permanent meteorological masts
- Proposed on site tracks
- Borrow pit seach areas
- Turning Heads
- Temporary Construction Compound
- SPEN & EON Substation compound
- Crane pads

PHRS Scores

- 0 - 170
- 171 - 200
- 201 - 400
- 401 - 600



0 0.05 0.1 0.2 0.3 0.4 km

Scale at A3: 1:7,500

Client

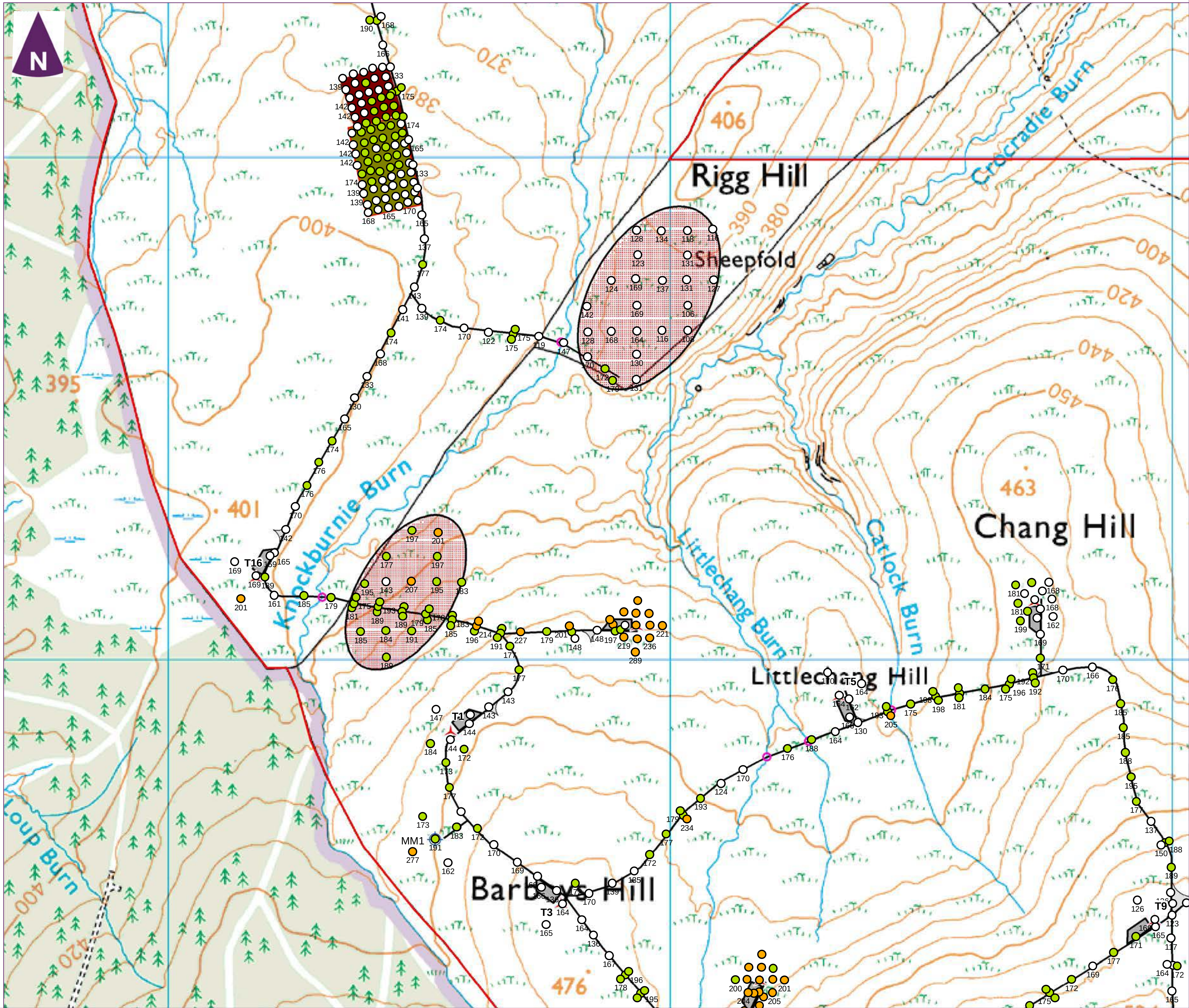
Enoch Hill Wind Farm
Peatslide Hazard and Risk Assessment

amec foster wheeler

Figure 12.2
PHRS Scores

July 2015 32965-Gla369.mxd amaib

file: \\gos-fs14\shared\GWM\DATA\PROJECTS\32965 Enoch Hill Wind Farm EIA SUB\D040 Design\ARC\Peat\PSRA\32965-Gla369.mxd

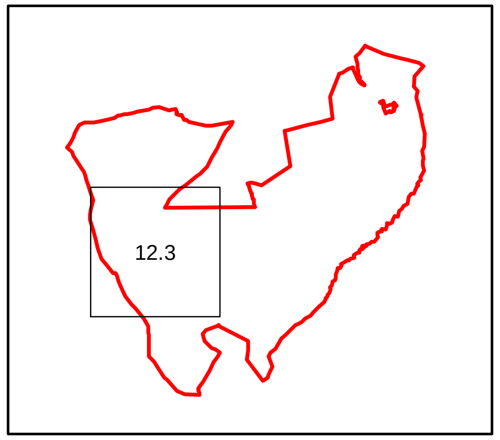


Key

	Application Boundary
	Turbine locations
	Watercourse crossings
	Permanent meteorological masts
	Proposed on site tracks
	Borrow pit seach areas
	Turning Heads
	Temporary Construction Compound
	SPEN & EON Substation compound
	Crane pads

PHRS Scores

- 0 - 170
- 171 - 200
- 201 - 400
- 401 - 600



0 0.05 0.1 0.2 0.3 0.4 km

Scale at A3: 1:7,500

Client

Enoch Hill Wind Farm
Peatslide Hazard and Risk Assessment

amec foster wheeler

Figure 12.3
PHRS Scores

July 2015 32965-Gla369.mxd amaib