Outline Construction Environmental Management Plan

Cairnmore Hill Wind Farm

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Contents

1 INTRODUCTION

1.1 This is an Outline Construction and Environment Management Plan (OCEMP) which is intended to show the principles which would be detailed in a CEMP, which would be agreed prior to construction commencing. This would be agreed with The Highland Council (THC) and relevant statutory consultees. The CEMP would, as a minimum, include details of:

- schedule of mitigation;
- construction methodologies;
- pollution prevention measures;
- public liaison provision;
- peat slide, erosion and compaction management;
- control of contamination/pollution prevention;
- drainage management;
- water quality monitoring;
- management of construction traffic;
- control of noise and vibration; and
- control of dust and other emissions to air.

2 GENERAL CONSTRUCTION MANAGEMENT PRINCIPLES

2.1 The Principal Contractor would be responsible for ensuring that a Construction Phase Plan is prepared and implemented on site. All work would be carried out in accordance with:

- The Health and Safety at Work etc. Act 1974;
- The Construction (Design and Management) Regulations 2015; and
- All applicable third party safety guidelines.

Environmental Management and Pollution Prevention

Pollution Prevention and Control

2.2 The CEMP would detail a number of measures to deal with pollution prevention, including procedures such as '*Environmental Requirements of Contractors*', '*Water Quality Monitoring Procedure*' and '*Procedure in the Event of a Contaminant Spill*'.

2.3 SEPA has produced *Guidance for Pollution Prevention* (GPP) for works and maintenance in or near water: GPP 5 (Version 1.2 February 2018) and PPG 6 for *Working at Construction and Demolition Sites* for civil engineering contractors (2012). The proposed wind farm would be constructed using best practice to conform with these requirements.

Contractors and sub-contractors would be required to follow the Pollution Prevention Guidance published by SEPA, and the following pollution control measures would be incorporated into the CEMP:

- equipment would be provided to contain and clean up any spills to minimise the risk of pollutants entering watercourses, waterbodies or flush areas;
- trenching or excavation activities in open land would be restricted during periods of intense rainfall and temporary landscaping would be provided as required to reduce the risk of oil or chemical spills to the natural drainage system;
- sulphate-resistant concrete would be used for the construction of foundations to withstand sulphate attack and limit the resultant alkaline leaching into groundwater;
- all refuelling would be undertaken at designated refuelling points. There would be no refuelling within catchments contributing to private water supply points;
- equipment, materials and chemicals would not be stored within or near a watercourse. At storage sites, fuels, lubricants and chemicals would be contained within an area bunded to

110%. All filling points would be within the bund or have secondary containment. Associated pipework would be located above ground and protected from accidental damage;

- any on-site concrete wash-out would occur in allocated bunded areas;
- drip trays would be placed under machinery left standing for prolonged periods;
- all solid and liquid waste materials would be properly disposed of at appropriate off-site facilities;
- routine maintenance of vehicles would be undertaken out with the site;
- there would be no unapproved discharge of foul or contaminated drainage from the proposed wind farm either to groundwater or any surface waters, whether direct or via soakaway;
- sanitary facilities would be provided and methods of disposal of all waste would be approved by SEPA;
- a programme of surface water quality monitoring would be undertaken during the construction phase to provide assurances as to the absence of water quality impacts; and
- no wind turbines, auxiliary and electrical equipment would contain askarels or Polychlorinated biphenyls (PCBs).

2.4 In the unlikely event of an environmental pollution incident, there would be an emergency response procedure to address any accidental pollution incident. For example, a procedure requiring the use of spill kits to contain the material and procedures to ensure that SEPA is notified immediately would be applied.

Contractor Requirements

2.5 A Principal Contractor would be appointed and they would ensure that all employees, subcontractors, suppliers and other visitors to the site are made aware of the content of the CEMP and its applicability to them. Accordingly, environmental specific induction training would be prepared and presented to all categories of personnel working on and visiting the site.

2.6 As a minimum, the following information would be provided to all inductees:

- Identification of specific environmental risks associated with the work to be undertaken on site by the inductee;
- Summary of the main environmental aspects of concern at the site as identified in the CEMP; and
- Environmental Incident and Emergency Response Procedures (including specific Environmental Communication Plan requirements).

2.7 A conveniently sized copy of an Environmental Risk Map or equivalent would be provided to all inductees showing all of the sensitive areas, exclusion zones and designated washout areas. The map would be updated and reissued as required. Any updates to the map would be communicated to all inductees through a toolbox talk given by specialist environmental personnel. Regular toolbox talks would be provided during construction to provide ongoing reinforcement and awareness of environmental issues.

General Drainage Design

2.8 Buffers to watercourses have taken into consideration, and the proposed wind farm's infrastructure has been designed in accordance with best practice guidance.

2.9 The potential impact of preferential routing of drainage and associated erosion and sediment wash-off within the sub-catchments draining the site would be mitigated through the following measures which would be incorporated into the SuDS Design:

- site track construction materials would be free draining, strong, durable and well graded;
- attenuation ponds and silt fences would be provided adjacent to the drains to prevent pollution and sedimentation of watercourses;
- direct drainage into existing watercourses would also be avoided to ensure that sediment and runoff from disturbed ground is not routed directly to the watercourses;
- appropriate scour prevention and energy dissipation structures would be constructed at each culvert outlet. Where appropriate, a shallow, lateral drainage swale would be installed at the toe of site track cuttings to intercept the natural runoff. This lateral drain would be piped under the track at regular intervals through correctly sized cross drains away from watercourses. Appropriate scour prevention and energy dissipation structures would be constructed at each culvert outlet;
- flow and sediment transport in any track drainage swales would be minimised by reducing concentrated flows, installing regular cross culverts and the use of checkdams placed at regular intervals within the trackside drainage swales;
- track drainage swales, where required, would discharge into attenuation ponds excavated on the downslope side, or silt fences. A shallow drainage swale would be cut directly downhill as a fan and at minimum slope until the bottom of the swale reaches the natural surface level. The discharge point of track drains would be constructed to minimise concentrated flows and ensure flows are dispersed over a large area with appropriate surface protection;
- the depth of individual drainage swales would be kept to the minimum necessary to allow free drainage of the tracks and swale lengths would be minimised to avoid disruption of natural drainage paths. Direct drainage into existing watercourses would be avoided to ensure that sediment and runoff from disturbed ground is not routed directly to the watercourses; and
- clay or peat plugs would be inserted within cable trenches at a frequency agreed with the Ecological Clerk of Works (ECoW) to suit the specific location to prevent gullying of trenches and preferential routing.

SuDS

2.10 A full SuDS solution would be developed prior to construction in consultation with SEPA.

2.11 A SuDS design would reduce the sediment/silt loads in construction and post construction runoff by providing a "treatment train" of pollutant removal to all surface water runoff, nominally by:

- ensuring that drainage swales are designed to convey flows at a low velocity by using a flatbottomed swale profile;
- encouraging vegetation growth in the base of all linear drainage to provide additional sediment removal from flows;
- providing settlement and filtration features in all linear drainage swales (stone check dams, filtration dams) to reduce flow velocity and encourage settlement of silts;
- installing temporary silt fencing to provide extra protection to waterways / environmentally sensitive areas during the construction phase;
- providing settlement ponds at turbine hard standing areas to manage sediment generated both during and post construction;
- ensuring that the final discharge points of the SuDS treatment train are located on stable, undisturbed, vegetated ground, allowing flow entrained sediment to drop out of flows. Providing silt fencing at outlets if required; and
- preventing discharge of construction runoff directly to existing watercourses or natural drainage channels. All discharges are to be via a SuDS feature to improve water quality prior to final discharge to the environment.

Runoff and Sediment Control Measures

2.12 The following measures would be used to mitigate any potential impacts on the water quality of the sub-catchments through peat erosion, stream acidification and metals leaching during construction. These will be incorporated into the CEMP:

- appropriate sediment control measures (silt fences, attenuation ponds, etc.) would be used in the vicinity of watercourses, springs or drains where natural features (e.g. hollows) do not provide adequate protection;
- sediment control measures (e.g. checkdams, silt fences etc.) would be employed within the existing artificial drainage network during construction. These would be regularly checked and maintained during construction and for an appropriate period following completion. Consideration would be given to the permanent infilling of any major drains;
- watercourses would be monitored throughout the construction period by the ECoW to identify any enhanced scouring of the catchment surface. If sediment from disturbed peat is excessively mobilised through the minor channels network these would be mitigated by temporary sediment control measures (e.g. geotextiles/straw/bales/brash);
- the extent of all excavations would be kept to a minimum and during construction activities surface water flows would be captured through a series of cut-off drains to prevent water entering excavations or eroding exposed surfaces. If dewatering of excavations is required,

pumped discharges would be passed through attenuation ponds and silt fences to capture sediments before release to the surrounding land;

- where there is a permanent relocation of peat, the ground would be reinstated with vegetation as soon as practicable;
- where practicable, vegetation over the width of the cable trenches would be lifted as turf and replaced after trenching operations to reduce disturbance.

Foul Water Management

2.13 Foul drainage would be provided in agreement with the relevant authorities and most likely involve the installation of a septic tank and soakaway.

Site Waste Management

2.14 A Site Waste management plan would be prepared designed to follow the principles of;

- Avoidance - select products and processes which remove the production of waste;
- Minimisation- minimise waste generated through specification of products and methods;
- Separable- any waste products generated should be easy to separate into distinct types for ease of handling and;
- Recyclable- where possible any waste generated should be suitable for re-use or recycling.

2.15 Any residual waste should then be handled, transferred and disposed of in line with best practice and current legislation.

Noise Management & Construction Working Hours

2.16 The sources of construction noise are temporary and vary in location, duration and level as the different elements of the wind farm are constructed. Construction noise arises primarily through the operation of large items of plant and equipment such as bulldozers, diesel generators, vibration plates, concrete mixer trucks, rollers etc. Noise also arises due to the temporary increase in construction traffic near the site.

2.17 BS 5228-1:2009 Noise control on construction and open sites; Part 1 - Noise is identified as being suitable for the purpose of giving guidance on appropriate methods for minimising noise from construction activities.

2.18 For all activities, measures would be taken to reduce noise levels with due regard to practicality and cost as per the concept of 'best practicable means' as defined in Section 72 of the Control of Pollution Act 1974.

2.19 The following noise mitigation measures would be implemented where appropriate and in line with further guidance from BS 5228-1;

- Consideration would be given to noise emissions when selecting plant and equipment to be used on site. Where appropriate, quieter items of plant and equipment would be given preference.
- All equipment should be maintained in good working order and fitted with the appropriate silencers, mufflers or acoustic covers where applicable;
- Stationary noise sources would be sited as far as reasonably possible from residential properties and, where necessary and appropriate, acoustic barriers installed to further reduce the impact;
- The movement of vehicles to and from site would be controlled; and
- Employees would be instructed to ensure compliance with the noise control measures adopted.

2.20 Should it be considered necessary to further reduce noise levels, mitigation measures would be considered and appropriate measures would be undertaken.

2.21 There are many strategies that could be employed to reduce construction noise levels; BS 5228- 1 also states that the 'attitude to the contractor' is important in minimising the likelihood of complaints and therefore consultation with the local community should occur. Non-acoustic factors such as mud on roads and dust generation, which can also influence the overall level of complaints, would also be controlled as detailed elsewhere in the CEMP.

2.22 In the event that noise complaints are received, the complainant would be contacted and if required, the property visited to discuss the complaint and subjectively assess the noise levels. If the noise complaint is found to be merited, additional mitigation measures would be put in place.

2.23 In the event a resolution cannot be reached, the planning authority would be informed in order that they can carry out their own subjective assessment and if required agree any additional mitigation.

2.24 All noise complaints would be recorded along with actions taken to resolve the issue. These records would be available to the Council on request.

2.25 The normal hours of work for the construction phase would be restricted in time to Monday to Saturday from 7.00am to 7.00pm. There would be no working on a Sunday unless previously approved by the planning authority.

2.26 Out with these hours, development at the site would be limited to turbine delivery and erection, commissioning, maintenance and pouring of concrete foundations (provided that the Applicant notifies the planning authority of any such works within 24 hours if prior notification is not possible).

Dust Management

2.27 The potential issue of dust creation during the works would be weather and season dependant, therefore detailed dust management methods would be subject to the works programme and contractor working methods.

Dust management would be carried out at all times in accordance with industry best practice to ensure that any local sensitive receptors are not affected by nuisance levels of dust from the works.

The following methods of dust suppression would be implemented during the construction phase of the wind farm as required:

- Site tracks to be damped down using bowser or other suitable system;
- Road sweeper to be used to remove loose material from adjacent public roads during construction;
- Cleaning of vehicles, including provision of waterless wheel washing facilities, prior to exiting site onto the public road;
- Soil erosion control measures;
- Speed limits to be put in place to ensure low vehicle speeds;
- Vehicle loads to be covered;
- Damping of dry excavations and cutting activities which generate dust; and
- Sequencing of works to minimise the time that soils are exposed.

Peat Management Plan

2.28 A separate Draft Peat Management Plan is provided as EIA-Report Volume 4: Technical Appendix 2.2. This provides details of the predicted volumes of peat that would be excavated for the proposed wind farm, the characteristics of the peat that would be excavated, and how the excavated peat would be reused and managed. This document would be updated during the detailed design stage and agreed with SEPA prior to construction.

2.29 In line with best practice, the following order of preference would be used to relocate predominantly excess peat spoil:

- reinstatement locally around construction works - peat excavated for the construction compound and turbine foundations would be replaced on completion of the works as part of the reinstatement of the site to minimise movement of materials;
- along access tracks - floated tracks would incorporate stabilisation bunds to enhance stability. In addition, the peat would be stored in strips on one or both sides of the tracks as identified during detailed design. Design criteria would include consideration of peat thickness and strength, slope angle and effect of surcharge on stability and would include specification of maximum permitted mound heights;
- landscaping in and around the site infrastructure - any cut and/or fill sections of infrastructure would be landscaped using excess peat from excavations to reduce visual impact;
- any additional stockpile locations would be identified based on similar criteria to track-side storage; and
- at locations where relocation of excess material is required, the vegetation would be stripped, stored and replaced to re-establish growth and provide erosion protection as soon as reasonably practicable. All stockpiles, temporary and permanent, would be designed with appropriate drainage systems and include a monitoring plan to provide early warning of potential peat slide

events. A response plan would also be put in place to provide fast and effective action in the event of any peat movement.

Temporary Lighting

2.30 Temporary lighting would be required at the temporary construction compounds for security purposes and to ensure that a safe working environment is provided to construction staff. In addition, temporary lighting may be required to ensure safe working conditions at infrastructure locations during construction.

2.31 All temporary lighting installations would be downward facing and all lights would be switched off during daylight hours and out with working hours.

Peat Slide, Erosion and Compaction Management

2.32 Management of the risk of peat slides is now recognised in literature, and a range of measures have now become standard engineering practice for construction of roads over peat (EIA-Report Volume 4: Technical Appendix 2.3: Peat Landslide Hazard and Risk Assessment). These measures would be adopted, as appropriate, on site, ensuring that:

- concentrated loads, such as those arising from stockpiling of material from turbine foundation excavations, would not be placed on marginally or potentially marginally stable ground;
- concentrated water flows arising from any aspect of construction or operation of the proposed wind farm would not be directed onto peat slopes and unstable excavations;
- construction would be supervised on a full-time basis by engineers fully qualified and experienced in geotechnical matters;
- robust drainage plans would be developed;
- work practices would be reviewed, modified as necessary and adopted to ensure that existing stability is not compromised; and
- appropriate ground investigation and movement monitoring practices would be adopted.

2.33 The major contributory factor resulting in peat slide is heavy rain. Almost invariably, peat-slide events are preceded by unusual weather conditions typically characterised by a long dry summer that leads to desiccation cracking of the peat profile followed by a prolonged continuous rainfall including exceptionally heavy rainstorms.

2.34 The condition of the sliding surface at the base of the profile has a strong influence on potential mobility and depends on the regularity and smoothness or roughness of the underlying rockhead. According to the '*Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments*', peat slides tend to occur in shallow peat (less than 2 m deep) and where the slope is steeper, between 5° and 15°[1].

2.35 A separate Peat Landslide Hazard and Risk Assessment is provided in *ES Volume 4: Technical Appendix 2.3*. This document identifies that there is a "Low" or "Very Low" combined likelihood of peat landslide in association with proposed wind farm construction and it recommends the adoption

[1] Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments Second Edition, April 2017, Prepared for Energy Consents Unit Scottish Government

of a series of standard pre-construction, during construction and post-construction best practice mitigation measures to further reduce these risk levels.

Post Construction Restoration and Reinstatement

2.36 During construction of the infrastructure elements (detailed in Section 3), the vegetated layer would be stripped from the area of the excavation and stored locally with the growing side up. The remaining organic topsoil and subsoils would be excavated down to formation level, or a suitable stratum, and again would be stored local to the point of excavation but would remain segregated to avoid mixing of materials.

2.37 Temporary storage areas would take cognisance of all identified buffer areas and be stripped of vegetation prior to stockpiling in line with best working practices. As construction is progressed the effectiveness of the buffer zones would be reviewed and if necessary adjusted. Alternatively, the construction procedure may be reviewed and altered or additional control measures put in place.

2.38 Post-construction reinstatement would be undertaken as work progresses to minimise the period of time any organic material is stockpiled. Subsoils would be used in landscaping and backfilling around structures while the vegetated layer and/or topsoil would be used to reinstate storage and working areas, road verges, drainage swales and embankments. In addition, following the completion of the works, a final inspection of the wind farm site would be undertaken and in circumstances where reinstatement using vegetation and/or topsoil is unsuccessful alternative methods would be considered.

2.39 Upon completion of all construction works, the temporary construction compounds would be reinstated to their approximate pre-wind farm condition. All temporary structures and construction equipment would be removed and the granular material that forms the hardstands would be moved to areas agreed with the landowner or removed from site. Following this, the areas would be backfilled with material stripped and stored during the construction of the wind farm and reseeded as required.

2.40 In line with construction best practice and to suit the ground conditions anticipated on site, the track and hardstanding design has endeavoured to minimise spoil generated during construction.

Traffic Management

2.41 As detailed in Chapter 9: Access, Traffic and Transport, a Construction Traffic Management Plan (CTMP) would be developed to ensure road safety for all users during transit of development loads. The CTMP would outline measures for managing the convoy and would set out procedures for liaising with the emergency services to ensure that police, fire and ambulance vehicles are not impeded by the loads. The CTMP would be developed in consultation with THC, Police Scotland, highways authorities and the local community and agreed before deliveries to the proposed wind farm commence.

Environmental

2.42 An Ecological Management Plan (EMP) would be prepared and implemented through the CEMP to set out the measures required to protect and enhance ecology and hydrology at the proposed wind farm during the construction phase, including pre-construction surveys, habitat management, water quality and biodiversity enhancement. The detail of the EMP would be prepared and agreed with SNH prior to commencement of construction.

2.43 An ECoW would be appointed and would be present during the construction and restoration period to ensure that ecological and hydrological impacts are appropriately mitigated in accordance with the EMP.

2.44 It would be the duty of the ECoW to check the status of the protected species and associated protected features immediately prior to construction activity progressing across the proposed development and to continue spot checks during construction for any new protected species features in the vicinity of the construction works.

2.45 Arrangements for pre-construction ecological monitoring would be conducted within 6 months of construction commencement. A species protection plan designed to increase the protection levels and reduce general disturbance of protected species and associated protected features from the proposed development is detailed in EIA-Report Volume 4: Technical Appendix 7.2: Protected Species Survey Report.

Archaeological

2.46 Mitigation measures as detailed in EIA-Report Volume 2 Chapter 6 include marking out a small number of heritage assets which lie in close proximity to the proposed infrastructure and incorporation of some heritage enhancements. All staff involved in intrusive works would be briefed on the potential to uncover features or items of archaeological interest. The site induction would contain details of how in the unlikely event of uncovering something, work would be stopped and matters escalated as appropriate.

Community Liaison

2.47 During the construction period, a community liaison group would be set up to disseminate information and take feedback and the project website would be regularly updated to provide the latest information relating to traffic movements associated with vehicles accessing the site. This would be agreed with THC as the Local Roads Authority. An Outdoor Access Management Plan is provided in EIA-Report Volume 4: Technical Appendix 2.7 and sets out public access arrangements that would be put in place during the construction period.

3 DESIGN PHILOSOPHY AND CONSTRUCTION METHODS

Site Entrance and Public Road Upgrades

3.1 A new site entrance shall be constructed off of the A836 to gain access to the site. Wheel cleaning facilities would be set up at the site entrance to remove mud from the wheels of vehicles leaving the site. Public roads would be inspected daily and the road swept to remove any mud or debris transferred onto the roads from site activities.

General Construction Method

3.2 The site entrance will be designed to allow Abnormal Indivisible Loads (AIL) access based on the current candidate turbine.

Temporary Construction Compounds, Temporary Enabling Works Compound, Site Tracks and Crane Hardstands

Temporary Construction Compound

3.3 A temporary construction compound would be required for the provision of site offices, welfare facilities and storage arrangements for materials, plant and equipment.

3.4 The temporary construction compound would be the main compound for the site with welfare facilities at this location.

3.5 An area would be assigned for the storage of fuels and chemicals, ensuring any spillage is captured and appropriately dealt with.

3.6 The temporary construction compound would be reinstated following completion of the construction process.

3.7 The temporary construction compound would be constructed at the location indicated on the Infrastructure Layout drawing (EIA-Report Volume 3a: Figure 2.1).

Temporary Enabling Works Compound

3.8 In addition to the temporary construction compound, one temporary enabling works compound would be established to control vehicle movements.

3.9 The temporary enabling works compound would be built to provide a security point and to control movements on site along with the provision of car parking for personnel working on the wind farm.

3.10 Details of this compound are shown on (EIA-Report Volume 3a: Figure 2.10) and the location is indicated on the Infrastructure Layout drawing (EIA-Report Volume 3a: Figure 2.1).

3.11 The temporary enabling works compound would be reinstated following completion of the construction process.

Site Tracks

3.12 The running width of the tracks would be typically 4.5 m on straight sections, increasing at corners and passing places to accommodate the swept path of wind turbine generator delivery vehicles. The track working area would be kept to the minimum required allowing for working area, safe access, drainage and electrical works.

3.13 Where existing tracks are to be adopted they shall be widened to the same parameters as new site tracks

3.14 Site tracks would consist of a compacted stone structure and a number of track designs may be utilised on site which would be determined during detailed design, dependent on the ground conditions encountered on site and include:

- Excavated track; and
- Floating track.

3.15 Track drainage would be incorporated within the design in accordance with sustainable drainage design principles. Where the road alignment crosses existing drainage channels, crossings appropriate to the location would be designed in accordance with the relevant guidelines.

3.16 A buffer zone in accordance with the relevant guidance from SEPA[2] would be maintained around watercourses. Site personnel would be made aware of the buffer zones through the site induction and specific toolbox talks.

Excavated Track

3.17 Excavated track construction would be used in areas identified where the thickness of soft soils is low, and the underlying layer has adequate load bearing properties. This track system would likely consist of a suitable capping layer and then a suitable running layer.

Floating Track

3.18 Floating track construction would be adopted where the ground conditions require. This track system involves installing geosynthetic reinforcement directly onto the organic or exposed soil layer and placing layers of suitable stone and additional geosynthetic reinforcement (as required) above until the track design level is achieved.

3.19 Floating track would also be adopted where it would be appropriate to minimise effects on ecology and existing water paths by minimising impacts on shallow sub-surface flow paths.

Crane Hardstands

3.20 The main crane hardstand area is anticipated to be up to 55m x 35m. There may be additional temporary hardstand areas required for the erection of the main crane, lay down of materials and turbine components.

3.21 The main crane hardstand area would be left uncovered for the operational lifetime of the wind farm in line with good practice outlined in the Scottish National Heritage guidance Good Practice during Windfarm Construction. Temporary crane hardstand elements would be reinstated post construction.

[2] Land Use Planning System. SEPA Guidance Note 4: Planning Guidance on On-Shore Windfarm Developments, September 2017.

3.22 All crane hardstands would consist of one or a combination of the following:

- A compacted stone structure bearing directly on a suitable formation strata;
- A compacted stone structure bearing on a formation strata strengthened through ground improvement techniques; or
- A compacted stone structure bearing on a strengthened soil mass created by the installation of multiple stone or concrete columns.

General Construction Method

3.23 Where competent soils exist close to the existing ground surface the following construction method would typically be followed;

- Track alignments would be established from the construction drawings and marked out with ranging rods, timber posts or steel pins;
- Track corridors would be pegged out 500m - 1000m in advance of operations;
- Where possible, upgraded tracks would re-use the structure of the existing track to reduce construction requirements; and
- Material would be excavated and stored;
- Excavated track construction would be used where soils are identified as being shallow. This track system would likely consist of a suitable layer of crushed aggregate, either spread by a dozer or placed by an excavator, prior to being compacted in layers by vibratory rollers. If ground conditions dictate a geotextile membrane would be applied;
- Floating track construction may be adopted where the ground conditions dictate. This system involves installing a geosynthetic reinforcement directly onto the organic vegetated layer and placing layers of suitable stone and additional geosynthetic reinforcement (if required by the design) above. If ground conditions require a geotextile membrane may be applied also;
- Drainage swales would be excavated adjacent to the tracks where required. Surface water runoff would not be allowed to discharge directly into existing watercourses but would be routed through a Sustainable Drainage System (SuDS);
- A surface water cut off ditch may be installed on the slope above the earthworks footprint where achievable given the topography. Where the road alignment crosses existing drainage channels, crossings appropriate to the location would be designed in accordance with the relevant guidelines;
- Depending on depth and type of material, cut slopes are anticipated to be between 1:1 to 1:3;
- Post construction reinstatement shall be in line with the details of section 2.38.

Should the load bearing properties of the underlying soils be determined to be insufficient, ground stabilisation may be carried out to provide adequate bearing capacity of the formation level. Due to the variable nature of the ground at the site, specific construction methods shall be selected at detailed design stage in consultation with specialist contractors. Such methods may consist of:

- Compaction of the existing in situ soils;
- Lime/cement stabilisation of the existing in situ soils; or
- Installation of stone or concrete columns to provide adequate support.

Turbine Foundations

3.24 Wind turbine generator foundations would be designed in accordance with the relevant design standards. Due account would be taken of guidance provided in appropriate codes and standards such as Eurocodes, British Standards and other specialist design documents.

3.25 Due to the anticipated load bearing capacity of the near surface soils, gravity base turbine foundations are expected to be used to support the wind turbine.

3.26 The foundations would be designed as a reinforced concrete slab. The foundation geotechnical design would be based on the information contained in the site investigation reports, yet to be carried out.

Gravity Base Turbine Foundation Construction Method

3.27 The gravity base turbine foundation construction method would generally be as follows:

- The topsoil would be excavated and stored to one side for reuse during the landscaping round the finished turbine;
- Excavation would be undertaken to competent material. Excavated subsoil material may be stockpiled temporarily adjacent to the excavation for later use as backfill or stored elsewhere on site. Temporary and permanent drainage shall be installed at the same time as the excavation works;
- In the case where competent material is lower than the required formation level the foundation would likely be over-excavated to competent material and compacted engineering fill placed to the required formation level;
- Where excavation is required to extend below the water table or in material which does not drain freely, appropriate pumping would be employed to keep the excavation dry. Water pumped from an excavation shall not be discharged directly to any watercourse;
- A layer of concrete blinding would be laid directly on top of the newly exposed formation, finished to ensure a flat and level working surface;
- Steel reinforcement, the turbine anchorage system and cable ducts would be fixed in place and formwork erected around the steel cage;
- Concrete would be placed using a crane, pump or other suitable lifting device and compacted using vibrating pokers;
- The foundation would be backfilled with suitable material, and landscaped using the vegetated soil layer set aside during the initial excavation; and
- A gravel path would be built leading from the access track or crane hardstanding to the turbine door or access steps and around the turbine for maintenance.

Turbines and Turbine Transformers

Turbines

3.28 The turbine would be supplied with a light grey semi-matt finish (RAL colour 7035) unless otherwise approved by THC.

3.29 The turbines would not carry any symbols, logos or other lettering except where required under other legislation. However, turbine numbers would be added to the base of each tower to aid service engineers during the operational phase of the wind farm.

3.30 In line with health and safety best practice, turbine manufacturers have indicated a preference to locate a passive infra-red (PIR) detector and light above each turbine door. It should be noted that this lamp would not be permanently lit and would only be switched on by the PIR when personnel approach a particular turbine.

Turbine Transformers

3.31 Turbine transformers would be placed internally within the turbine.

3.32 Oil or air cooled transformers would be supplied on site. The transformers would be sealed and would be inspected for any damage prior to offloading. Oil cooled transformers would be supplied full of oil and do not require topping up on site. Air cooled transformers do not require cooling oil. The transformers would be located within the turbines which shall be locked, accessible by trained and authorised personnel only, and displaying appropriate warning signs.

General Turbine Erection Method

The following general steps would be undertaken in order to erect the turbines on site:

- Some turbine components would be pre-delivered in sections to the site and offloaded at the crane hardstands;
- The remaining turbine components would be delivered on a just-in-time basis and be lifted directly from vehicle trailers;
- Turbine components would be lifted by adequately sized cranes (one main crane and one smaller assist crane) and positioned on the foundations / other turbine sections until the entire turbine is erected;
- Upon completion of the erection all fasteners would be tightened and the internal fit out of the turbine undertaken;
- The turbines would then be connected to the wind farm substation; and
- Turbine testing and commissioning would be undertaken before the turbines would be handed over as complete

Control Building and Substation Compound (including Energy Storage)

3.33 Cables would export power from the wind turbines to the control building and substation compound (including energy storage) before being transferred to the local distribution network. The location of the control building and substation compound (including energy storage) is shown in EIA-Report Volume 2 Figure 2.1.

3.34 The energy storage infrastructure is required to help smooth over peaks and troughs in electricity supply and is able to respond at short notice to requests from National Grid to generate, such as periods when renewable sources are not generating or fossil fuel plants are unexpectedly offline.

There is a clear requirement to balance the peaks and troughs associated with electricity supply and demand to manage the strain on distribution networks and ensure there are no power blackouts.

3.35 The wind farm substation and control buildings (including energy storage) have been designed, sized and positioned to be minimise visual impact. The control buildings would be constructed using steel portal frames sheds, clad in a visually recessive colour, with major openings positioned away from major view to minimise visual clutter.

3.36 The detailed design of the foundations for the control buildings would be based on the site investigation reports and building requirements, and would ensure loads associated with the building are transferred to the appropriate bearing layer in the sub-stratum.

3.37 Foul drainage would be provided in accordance with Building Control requirements and in agreement with SEPA.

General Construction Method

The control building and substation compound would generally be constructed in accordance with the following:

- The plan area of the control building and substation compound would be set out and the topsoil stripped and removed to a temporary stockpile;
- The building foundations would be excavated and concrete poured;
- The steel building units would be erected;
- The internal fit out of the building including installation of services would be completed.

Cabling Works

3.38 All electricity and other service cables between the turbines and the control building and substation compound would be placed underground. Small collector cabinets may be required to minimise the number of cables buried and hence the area of ground disturbed.

3.39 The detailed construction and trenching specifications would depend on the ground conditions encountered but typically cables would be directly buried inside a trench, except at road crossings where cables would be ducted.

General Construction Method

The following construction method would typically be used (EIA-Report Volume 3a: Figure 2.11):

- Trenches would be excavated and a suitable bedding material placed for which to lay the cables upon. The ground is trenched typically using a mechanical digging machine;
- The cables shall be laid directly onto the bedding material;
- The trench would then be backfilled and compacted with suitable material up to the required level and finished with a layer of topsoil to aid in the trench reinstatement;
- A suitable marking tape is installed between the cables and the surface; and
- The cables are terminated on the switchgear at each turbine and at the control building and substation compound.

4 DECOMISSIONING AND RESTORATION PLAN

4.1 At the end of the operational life of the wind farm a decision would be made as to whether to refurbish, remove, or replace the turbines. If refurbishment or replacement were to be chosen, relevant planning applications would be made.

4.2 If a decision were to be taken to decommission the wind farm a draft Decommissioning and Restoration Plan (DRP) would be reviewed (no later than three years prior to final decommissioning of the wind farm) and, if required, revised to a detailed DRP. The DRP would be submitted to and approved in writing by THC in consultation with SNH and SEPA no later than twelve months prior to the final decommissioning of the wind farm.

4.3 The detailed DRP would be implemented within eighteen months of the final decommissioning of the development unless otherwise approved in writing with the planning authority.

Site Track & Hardstand Areas

4.4 New site tracks, existing site tracks and hardstand areas constructed during development of the wind farm would be reinstated to the approximate pre-wind farm condition, unless otherwise agreed with the Landowner and/or THC. Areas to be reinstated would be treated in the following way:

- The material used to construct the tracks would be taken up and removed to areas identified in the site restoration scheme;
- The areas would be backfilled with suitable fill material, covered with topsoil and reseeded as required;
- Backfilling of access tracks would be carefully planned in advance to avoid having to unnecessarily move plant and equipment on freshly reinstated land; and
- Any tracks which were upgraded during the development of the wind farm would be left unchanged from the conditions used during the operation phase of the wind farm.

Wind Turbine Generators

The decommissioning of the wind turbine generators would be the reverse of the erection process involving similar lifting plant and equipment:

- Wind turbine generators would be disconnected from the cabling and internal components stripped and taken off site;
- It is anticipated that the nacelle would then be taken down and loaded straight onto the back of transport vehicles and removed from site for reconditioning or scrap; and
- The towers and blades would be taken down and either transported directly off site or broken down into smaller components if required.

Wind Turbine Foundations

It is widely accepted that there is no appreciable effect on the local environment from buried reinforced concrete structures left in-situ due to the inert state of concrete. Therefore, the foundations would be reinstated as follows:

- Following the removal of the wind turbine, topsoil and subsoil would be excavated to expose the top of the foundation and set aside for reuse;
- The reinforced concrete foundation would then be broken out to an agreed depth below existing the ground level and the material would be taken up and removed; and
- The excavation would be then backfilled with suitable fill material, covered with topsoil and reseeded as required.

Control Building, Energy Storage and Substation Compound

4.5 The control building, energy storage infrastructure and substation compound would be decommissioned by disconnecting and dismantling all the surface plant. Solid structures such as the buildings and equipment plinths would be demolished and the foundation would be removed to an agreed depth below ground level. Ducting and cabling that is within the depth to be cleared would be removed.

4.6 The fence surrounding the compound would be removed and the area covered with topsoil and reseeded as required.

Electrical Equipment

4.7 The electrical equipment would be decommissioned in the reverse of the installation method involving similar plant. The equipment would be dismantled, removed from site and disposed of in an appropriate manner.

Cabling

4.8 Cables would remain in-situ to avoid any effect to the local environment through their removal.

5 RECORDS

Records, as-built drawings, specifications, operational maintenance manuals and residual risks would be collated and filed in the project health and safety file based upon the requirements of the Construction (Design and Management) Regulations 2015.

Annex 1: Drawings

EIA-R Figure	Drawing Name	Drawing Number
1.1	Location Plan	03022-RES-LAY-DR-LE-001
2.1	Infrastructure Layout	03022-RES-LAY-DR-PE-001
2.2	Typical Wind Turbine Elevation	03022D2304
2.3	Typical Wind Turbine Gravity Base Foundation	03022D2303
2.4	Typical Crane Hardstand	03022D2302
2.5	Typical Access Track Details	03022D2402
2.6	Typical Water Crossing Detail	03022D2305
2.7	Substation, Control Building & Energy Storage Unit Layout	03022D2219
2.8	Typical Substation, Control Building & Energy Storage Unit Elevation	03022D2301
2.9	Typical Construction Compound Layout	03022D2217
2.10	Typical Temporary Enabling Works Compound Layout	03022D2216
2.11	Typical Cable Trench Details	03022D2307
2.12	Typical Energy Storage Unit Layout	03022D2215
2.13	Indicative Grid Connection	03022-RES-GRD-DR-CE-001
2.14	Typical Rock Anchor Foundation	03022-RES-FOU-DE-CE-001
2.15	Site Entrance	03022-RES-ACC-DR-LO-003
2.16	General Storage Design	03022-RES-BAT-DR-EE-001

Annex 2: Safety & Environmental Requirements of Contractors

Safety & Environmental Requirements for Contractors on all activities (RSWP 005)

Document Nº: **01059R00038**

Revision History

Issue	Date	Nature and Location of Change
1-13		Previous revision histories to this document can be found in revision 13
14	12/09/15	Document completely redrafted as part of lean review / FFF process, to incorporate previous departmental 'Safety Requirements' versions and Environmental Requirements of Contractors document. Reviewed extensively by all the UK Geographic Business Units during this process and this document now replaces; RSWP 011 Safety Requirements of Contractors Construction (Eire) 01059R00039 RSWP 022 Responsibilities of Contractors Working on RES Offices 01059-000095 RSWP 027 Safety Requirements of Contractors Generation 01059-000654 RSWP 031 Safety Requirements of Contractors Development 01059-001264 Environmental Requirements of Contractors 01226R00016
15	19/08/16	Document title changed by removing RSWP 005 from start and putting at end; Safety & Environmental Requirements for Contractors on all activities (RSWP 005)

CONTENTS

1 PURPOSE

The purpose of this document is to promote; Health, Safety, Environment, Safety Leadership and Sustainability of our Contractors, Consultants, RES employees and the general public by setting out the minimum expectations when working on RES managed contracts.

This document shall be supplied to all Contractors and Consultants tendering for any contracts relating to works or services on any RES site or office, it shall be read carefully and its receipt acknowledged in writing in connection with a specific Contract. No variation shall be permitted without the express permission of the appropriate RES Manager responsible for the works / services; eg. Project Manager, Construction Site Manager, Asset / Site Manager or Office / Facilities Manager, etc.

This document shall be read in conjunction with the relevant Health and Safety (& Environmental – where applicable) Plan for the location of the works.

2 SCOPE

It should be noted that this document and the References quoted below **do not** cover all possible site activities and it therefore remains the Contractor's / Consultant's responsibility to ensure that their works are carried out in a safe and environmentally responsible manner which complies with **ALL relevant legislation current at that time.** All work activities with significant risks are to be covered by an appropriate written risk assessment and work instruction / method statement that has been reviewed by the appropriate RES Manager prior to works commencing.

3 RESPONSIBILITIES & REQUIREMENTS

Contractors & Consultants shall comply with all relevant requirements appertaining to their contracted works. Throughout this document any references to Contractor(s) shall also apply equally to Consultant(s) and whilst RES are not typically identified, this does not absolve RES employees from following the same site rules and requirements as our Contractors or Consultants. Where specific training requirements or qualifications are required, Contractors may provide evidence of alternative training subject to it being equivalent to / better than, the RES defined minimum requirements.

4 RES RESPONSIBILITIES

4.1 Controlling Documentation

RES shall provide the Health, Safety & Environmental Plan (Pre-tender and construction phase), Project Quality Plan and Site Waste Management Plan. RES shall review all Safe Systems of Work for **all significant risk** activities; including Risk Assessments, Method Statements and Permits to Work - **work will not be permitted without these being in place.** HV Electrical cable and system isolations and documentation shall be controlled through RES Senior Authorised Person (SAP) or RES nominated SAP.

RES **shall** audit all aspects of the management of health, safety, quality and environment on site and may carry out appropriate surveys, inspections, tours and sampling at any time. RES may carry out their own accident investigation if deemed necessary to ensure that correct preventative measures are put in place.

4.2 On Site Responsibilities

Safety requirements & rules shall be displayed on site and readily available for all employees to see. RES shall provide the RES site induction or RES on-line induction (to be advised by RES) prior to visiting, starting works & at refresher intervals and provide support to those who have difficulty with the English language to ensure that all site attendees can demonstrate that they understand the site rules & instructions.

RES shall provide prompt information that could affect health & safety of workers, and/or other 3rd parties, members of the public, ensuring adequate steps to prevent harm to livestock on site, maintenance of site fencing, boundaries & keeping gates closed.

RES shall facilitate agreements on interface responsibilities between other parties – within procedures and appropriate documentation controls, including regular meetings / liaison with RES staff, employees and other contractors to identify and discuss hazards with work activities and how they could affect others.

Unaccompanied site visits will be at the discretion of the RES Site Manager. First Aid facilities and provision of first aid is the responsibility of the contractor unless agreed otherwise, RES facilities will be available for use in case of emergency.

4.3 Wildlife

RES Site Manager shall inform Contractors of any constraints or work time restrictions due to the protection of wild life, i.e. nesting sites, habitat issues. If unexpected wildlife is encountered during work activities, i.e. bird nest / badger sett etc, work is to be temporarily suspended and the Site Manager informed. No work shall take place until clearance has been given by RES to resume.

5 CONTRACTOR / CONSULTANT RESPONSIBILITIES & REQUIREMENTS

5.1 Controlling Documentation

Contractors shall provide the Health & Safety management & site controls applicable to employees, visitors, third parties, Quality management & associated documentation for services, equipment, materials, products, Environmental management & associated documentation for services, equipment, materials, products. Contractors shall conform to the Project; Health, Safety (& Environmental) Plan, Quality Plan and Site Waste Management Plan. Contractors shall provide the Inspection & Test Plan appropriate for their works and any associated documentation required to support conformance to contract specification.

Safe Systems of Work for **all significant risk** activities shall be provided, including; Risk Assessments, Method Statements and Permits to Work - **work will not be permitted without these being in place.**

5.2 On Site Responsibilities

Safety requirements & rules shall be displayed on site and be readily available for all employees to see, with delivery of toolbox talk records provided to RES. Contractors shall ensure that all site attendees complete a RES site induction or have undertaken a RES on-line induction (to be advised by RES) prior to visiting, starting works & at refresher intervals – including provision of support to those who have difficulty with the English language;

everyone attending site must demonstrate that they understand the site rules & instructions. Contractors shall provide safety training & skills competency records (nationally recognised training bodies) – including matrix of training requirements and supporting certificates, CITB cards etc for all employees.

Contractors shall provide communication devices for contact and emergencies; to suit site requirements (mobile phone signals may not work), provision of prompt information that could affect health & safety of workers, and/or other 3rd parties, members of the public. Implementing adequate steps to prevent harm to livestock on site, maintenance of site fencing, boundaries & keeping gates closed. A fencing & gates / gated scheme **shall** be developed and agreed with the landowner, including location, temporary or permanent. Agreeing interface responsibilities between other parties, defining within procedures and appropriate documentation controls.

Undertake regular meetings / liaison with RES staff, employees and other contractors to identify and discuss hazards with work activities and how they could affect others. Agreement to start works on site is through the consent of the RES Site Manager. When required, work instructions and risk assessments are to be provided to all employees undertaking the work who fully understand and agree with the requirements. Keep adequate records for site works including nature of work, duration, etc and making available to RES as required.

Visitors to be accompanied on site **at all times** by a fully inducted employee, (visitors shall receive a full induction if visiting site more than once and unaccompanied site visits shall be at the discretion of the Site Manager).

Contractors shall appoint a Competent Safety Representative (responsible for all safety issues for their company inc. electrical safety rules if applicable) and Site Supervisor(s) normally (black coloured hard hat required on construction sites) trained to nationally recognised standards, E.g. SSSTS, IOSH Managing Safely, Black / Gold CITB Card.

5.3 Site Accommodation

Temporary electrical systems are to be designed, inspected & tested by the Contractor, who shall provide the forms of Completion, Inspection & Testing required by the Wiring Regulations BS7671. Housekeeping relating to accommodation, storage and vehicles is to be of a high standard including regular cleaning. Areas for storage of plant, equipment, materials along with rules for use and access are to be in agreement with / designated on site by the RES Site Manager – Contractor shall provide all details of site requirements and what is being used on site (including any reinstatement of area after use).

All access tracks and entry routes are to be kept free of obstacles and well maintained – this includes controlling dust. Petrol or diesel engine plant is not to be used within buildings unless exhaust gases are piped to open air or an alternative approved. LPG is only to be used in accordance with legislation.

5.4 Site Security

Contractors **shall** use designated means of access and egress on the site, daily site records of employees **shall** be collected to aid security in the event of a fire or other emergency. Where security is used on site it **shall** be the duty of the gate / guard person to ensure vehicles and people are logged and have undergone induction.

5.5 Safety Audit(s)

Contractors shall make available all information and records as required by an auditor in the undertaking of their activities. The Contractor **shall** co-operate at all times in the undertaking of such health, safety, quality or environmental related audits and follow up actions. The Contractor **shall** undertake their own audits and inspections as agreed by both parties. Any actions identified from the audits shall be planned, communicated and agreed to rectify the issue(s).

5.6 Alcohol, Drugs & Smoking

The supply and consumption of alcohol & drugs is **prohibited** on site. Any misbehaviour at work such as; being under the influence of alcohol or drugs, shall be classed as gross industrial misconduct. Accident investigation on site may require the need for alcohol or drug tests to be undertaken by the employer.

Any person prescribed medication by their GP must be fit for work. The Site Manager needs to be informed of such instances and arrangements made for storage of their medication on site. A record of their capability for work may also be required.

5.7 First Aid

First aid facilities and provision of first aid is the responsibility of the contractor unless agreed otherwise. All First Aid treatments must be reported and logged, no matter how small. Notification of first aid arrangements **shall** be displayed and employees and other 3rd parties **shall** be informed of the arrangements.

5.8 Accident Reporting & Investigation

All accidents **shall** be reported and recorded in their company and the RES site accident book / recording system. The RES Site Manager **shall** be informed of all accidents, incident and near misses. The RES accident procedure shall be followed. Any notifiable accidents, specified injuries or conditions, or dangerous occurrences which are reported by the contractor under RIDDOR regulations, **shall** be reported without delay to the RES Site Manager.

The Contractor **must** encourage near miss incident and hazard reporting, active recognition and reporting is a key function in Safety Leadership and a mandatory responsibility of everyone on site. The Contractor's Health and Safety Advisor is to carry out a full investigation of all accidents and issue a report to RES.

5.9 Lone Working

A risk assessment **shall** be produced to determine the risks of lone working and to mitigate any risks – lone working should be avoided where possible. Where persons are required to work alone, i.e. surveys, a lone working procedure shall be in place and communicated to all parties. The procedure shall be agreed with the Site / Project Manager.

5.10 Excavations, Barriers & Existing Underground Services

No mechanical excavation work shall take place within one metre of live High Voltage Cables, nor within 500mm of any known live utility services. Contractors shall provide early notice of their intended work near live services, confirming location of underground services and preparing safety document controls, barriers around all opening, trenches, excavations to prevent access into the areas.

Permission to remove / open mesh, coverings, gratings shall be obtained and removed items are to be replaced as soon as possible. Report any broken or damaged gratings etc and put in place controls to prevent any risk of injury etc. Provide all shoring and support to excavations to prevent collapse as per HSG 150.

Excavated materials not suitable for backfill are to be disposed of in accordance with the Site Spoil Management Plan. Drilling, spikes or posts are to not to be driven into the ground without a permit to break ground as issued by the Site Manager.

There must be no alterations to any RES supplied barriers, screens or notices. Warning lights and reflective surfaces **shall** be placed on barriers around excavation works. Inspection reports are to be undertaken prior to entry of excavations, upon completion of shuttering and after additional works, alterations or dismantling as per HSE CIS 47. Weekly inspections are required and evidence submitted to RES. Excavation tags to be positioned at all access/egress points to all excavations and be updated at each inspection.

Segregation of plant and pedestrians shall be maintained; barriers are to be installed at access points and within excavation, along with appropriate signage. Stop blocks to be used with reversing of vehicles up to an excavation.

Pumps to be used to remove water from excavations shall be regularly inspected for stability; pumped water, whether ground or rain is not to be pumped into a watercourse or drain, water is to be managed in accordance with the site drainage plan (typically settlement lagoons).

5.11 Lifting Operations - Mobile cranes or similar type of equipment & lifting accessories

All lifting operations shall be managed in accordance with BS 7121; which shall include preparation of: risk assessment, method statement and lifting plan; and shall be agreed by all parties prior to works taking place. The lifting plan shall cover crane mobilisation, assembly and travel on site as well as any unloading and lifting activities. All crane movements on site are subject to 'Permit for Movement of Heavy Plant'.

All lifting equipment shall be fully certified and in date; copies of all certification and inspection reports shall be provided to RES prior to the works taking place. Safe Working Load (SWL) shall be clearly marked on **all** lifting equipment and ancillaries, along with test date. Structural steelwork shall not be used for lifting point or anchorage without agreement of RES (only permitted in exceptional circumstance and has been subject to structural review - Structural Engineer report required).

All temporary points for attachment to be load tested prior to use and record of test provided to RES, method of testing to be agreed. All testing shall be undertaken by an approved Test Engineer to British standards; approved on Lifting Equipment Engineers Association (LEEA) or similar organisation. Persons are not allowed to ride on a hoist unless it has been designed to carry passengers and fitted with interlock gates / safety devices. All persons operating hoists are to be fully trained and have recorded evidence of training to a national recognised standard.

RES lifting operations checklist shall be used unless contractor has their own approved requirements. All crane lifts shall be planned by a competent Appointed Person (AP), an approved Crane Supervisor **MUST** be on site if the AP is not able to monitor the lifting. Lifting plans including method statement / risk assessment shall be reviewed by RES.

5.12 Scaffolding / Ladders

Only competent and fully trained persons **shall** be used to erect, dismantle and modify/alter and inspect scaffolding (CISRS – tube & clip, PASMA – system). All scaffolding **must** display an in date SCAFFTAG or similar signage tag at point of access detailing scaffold status. All scaffolding **shall** be designed, erected, maintained, examined and recorded for the type of scaffold used – where necessary scaffold should be earthed.

All trained scaffold erectors **shall** wear securely attached safety harnesses connected to suitably tested fixed points as appropriate to risk assessment requirements. Scaffold boards **shall** be clamped into place wherever possible; any gaps in scaffold boards **shall** be covered with an appropriate secured material strong enough for the application and activity. Scaffolding **shall** be redesigned for all work activities, adjusted and inspected prior to use for each phase of work, scaffolding is not to be used until it has been cleared for the work activity.

Permission to use a scaffold erected by others must be obtained from the Site Manager and only after an inspection has been carried out. Incomplete and unsafe scaffolding **must** not be used and appropriate measures shall be put in place to prevent usage and when site is unattended access routes to scaffold to be removed to stop persons climbing scaffold.

All ladders used on site **shall** be in good condition and have a system of regular inspection; register to be kept on site. Metal ladders **shall** not be used in the vicinity of electrical equipment or scaffold.

Scaffold inspections **shall** be carried out by a competent person before use and then weekly (7 Days). Inspections will also need to be carried out following any modification or alteration to scaffolding; reports to be provided to RES weekly.

5.13 Work at Height

Any work at height or below ground level activity, **shall** require a method statement & risk assessment and be reviewed by RES prior to starting the work. A safe access & safe work place **shall** be provided via use of crawling boards, ladders, barriers, handrails, toe boards, edge protection as applicable. All materials **shall** be prevented from falling. Warning notices shall be displayed, along with exclusion zones at all levels, access routes etc.

The Work at Height hierarchy; Avoid, Prevent, Minimise should be implemented; ‘collective’ protection methods shall take priority to individual personal protection, with fall arrest equipment only being used if all other forms of protection cannot be achieved.

If Fall Arrest is to be used, persons must be fully trained in its use; it shall be inspected before / during use and have appropriate tested attachments; relevant records of equipment tests / dates to be provided. 100% attachment of the equipment is required during working at height, including double lanyards or other fall arrest equipment if collective measures are not implemented, method statement shall include Emergency Plans to rescue a suspended casualty. The Contractor shall inspect all equipment to ensure compatibility between each item being used.

MEWPS, mobile scaffold, podium steps **shall** be used where possible, ladders shall only be used for short duration low risk work, for no more than 30 minutes and only where stability can be achieved.

5.14 Risk & Environmental Controls

Contractors shall identify all potential environmental risks and report to the Site Manager, inform all employees of the site environmental rules and inform RES of environmental incident or potential incident as soon as practicable. Provision of information to RES for carbon counting / sustainability targets and records, typically: vehicles on site, mileage covered, fuel used (site equipment), materials used, visitors and travel details, etc.

5.15 Environmental Plan

Contractors will be required to provide relevant documentation for inclusion into the RES Environmental Plan when applicable, all contractors are to comply with the RES Environmental Plan at all times.

5.16 Existing Features (Sites)

Any disturbance, remediation or disposal of contaminated land shall only be carried out under the direction of RES and in accordance with the Health, Safety (and Environmental) Plan, areas of contaminated land **shall** be fenced off and all persons made aware of its location and hazardous nature. Where any unexpected or potential hazardous obstacles are encountered, work **shall** cease until specialist advice has been obtained.

Underground services **shall** be identified in the site Health, Safety (and Environmental) Plan and controls put in place for the works to be undertaken, i.e. permit to work, risk assessment, etc. If poor conditions of underground services are found after exposure, this is to be reported to RES and the relevant authority.

Any old containers found on site should be checked and emptied by a licensed waste carrier before removal. Pollution is often caused through vandalism, theft or fly tipping – the site or working area **shall** be protected by fencing and locked access to discourage unauthorised access. Any instances of tipping on site **shall** be reported to the Site Manager.

5.17 Discharges to Water

All employees **shall** be made aware of the following:

- Rules about discharges to drains from spillage
- Refuelling / storage controls to be in place & location to be away from surface drains (minimum 10m distance)
- Use of bunded areas / bunds, double skinned bowsers for storing of fuels, liquids etc – to be checked weekly
- Management of any / all spills, spill kits, informing Site Manager etc (included in risk assessment)
- Discharge of any fuel, chemicals, silt, etc to a drain or water course is forbidden. Ensure that a suitable method for containing any surface water is provided when working near to a watercourse
- Surface water drains should only carry uncontaminated rain water and shall be protected from any other contaminants

Methods for prevention of pollution to water courses shall be regularly checked and maintained – failing of systems should be reported immediately to RES.

5.18 Hazardous Substances (COSHH)

Contractor shall provide a list of substances, liquids, gases, etc to be used on site or with their work activities, along with quantities to be stored in secure storage containers, clearly labelled with legible warning signs and content details. MSDS & COSHH Risk Assessment & register and controls in place, including emergency plans.

As defined by COSHH Risk Assessment, spill kits are to be located near any hazardous liquids or substances either at point of use or storage area. Emergency procedures and associated equipment shall be provided – 'Kelp' bio-remediation solution shall be provided for early treatment of any spills after initial clean up.

Generators **shall** be provided with an internal bund and external fuel tank with fuel cut off float switch, the refuelling area shall be kept empty of water (covered area or inceptor/full retention separator).

Bowsers are to be stored to minimise risk of collision, run-away and vandalism, with a flexible pipe, tap or valve provided with an appropriate lock for security when not in use. Flexibly delivery pipes for use with refuelling must be fitted with manually operated pumps or a valve that closes automatically when not in use (delivery end).

Fuel type and capacity shall be displayed, along with no smoking signs and close valve when not in use signs, etc. A responsible person **shall** supervise deliveries, check tank quantities and emptying of tank and residues for safe disposal elsewhere.

Switch gear containing SF6 (Sulphur Hexafloride) **shall** be labelled on the equipment and substation door, along with contractor details and any leak **shall** be reported to the Site Manager and acted upon following the emergency contamination spill procedure.

5.19 Waste Management

Waste management **shall** follow the waste hierarchy of: Prevent, Reduce, Re-use, Re-cycle, Other recovery before disposal, all wastes shall be stored and segregated at designated disposal points away from watercourses and potential risk areas (cleared from work area as it is accumulated).

All personnel are to prevent litter from being blown around the site by disposing of rubbish responsibly. Skips must be covered to prevent refuse blowing away and rainwater accumulation. Skips to be replaced when full and disposal shall be in accordance with statutory requirements and RES Site Waste Management Plan, Contractors shall provide appropriate waste documentation.

5.20 Earthworks

Contractors shall work to the site drainage / SuDS design statement for the site. Appropriate drainage / SuDS management methods shall be agreed with the Site Manager where no Construction Method Statement is present.

Contractors shall make best endeavours to prevent water becoming contaminated at the place of work, activity area and to prevent build up of silt; shall use methods of work that eliminate or reduce workings in channels and do not contaminate surface water. Water containing silt **shall** not be discharged directly into rivers, streams or surface water drains. If silty water does occur and present a hazard, suitable treatment will be required – details of controls to be presented to the Site Manager.

Contractor shall prevent water from entering excavations, any cut-off ditches, well point de-watering or pumping shall be in accordance with the site drainage plan. Disturbance to flora and fauna whilst carrying out works **shall** be kept to the minimum and agreed with the Site Manager.

Topsoil and vegetation (not part of subsoil) **shall** be retained and stored in accordance with the Site Spoil Management Plan and reinstated on all areas of stripped ground as soon as possible to prevent erosion and leaching.

Where wet and marshy ground occurs, excavated materials may need to be stored on a geotextile. Turf shall be reinstated wherever possible to maintain the original species mix. Exposed ground and stockpiles / storage shall be kept to the minimum to prevent silt and dust build up, whilst long term storage shall be controlled and stockpiles seeded with recovered seed, covered and silt fences constructed from geotextile where required. In dry weather dust suppression controls will be required to eliminate at source, e.g. watering.

Environmental Agency guidance shall be used as guidance in control measure for works and maintenance in or near water.

5.21 Road Cleanliness

Site roads to be brushed or scraped as required to minimise mud and dust deposits, especially at site entrances and watercourse crossings; mechanical suction brush may be necessary. Wheel wash stations may be required to mitigate debris going onto public highways, private roads or accesses. Used water shall be collected and passed through a silt trap before disposal.

5.22 Drip Trays

Where practicable, drip trays shall be used to contain absorbent granules, sheets or fibres and disposed of to site rules. Once used, drip trays shall be cleaned using appropriate materials and disposed of in accordance with COSHH regulations. Regular checks and cleaning of drip trays to be carried out.

5.23 Concrete

All concrete disposal shall be as set out in the Site Waste Management Plan (SWMP) when in place or responsibly and in accordance with legislation when no SWMP in place. Cement and wash out water is not to enter any watercourse or aquifer; wash out of cement vehicles **shall** only be permitted in a designated and suitable prepared wash out area(s), clearly signed and to the satisfaction of the RES Site Manager.

Tools, equipment or materials shall not be washed in watercourses, mortar mixing and storage shall be clear of any watercourses. Any concrete works near to a watercourse shall be approved by the appropriate agency and the RES Site Manager.

5.24 Wildlife

Wildlife **shall** be protected from entering and becoming trapped in any part of the works on site. For excavations this may mean provision of fences, crossing or escape routes. Due consideration shall be given to hazards presented to personnel from wildlife; adders, wild boar, buzzards, wasps etc.

5.25 Emergencies

Environmental emergencies such as spills **shall** be dealt with in accordance with the Environmental Emergency Response Plan – familiarisation with this plan is required before commencement of any works. Any spill kit provided **shall** be made accessible at all times to all site staff.

5.26 Environmental Assessment

Contractor shall provide an assessment of the likely environmental impacts of their activities (if applicable), along with controls to minimise impact and any corrective measures and actions.

6 APPENDICES

Appendix 1 – References
Appendix 2 – Issue / Receipt for Safety and Environmental Requirements for Contractors on all activities

Appendix 1 – RES References

The following documents may contain useful references.

App 1.1 RES Documents

- *i) RES Health, Safety, Quality & Environmental Management Systems, and associated documentation including all IMS, **Safety Procedures**, RAWP and documents and templates*

App 1.2 Project Specific Documents

- *i) The Health, Safety & Environment Plan (Pre-tender and construction phase)*
- *ii) Health & Safety Plan*
- *iii) Quality Plan*
- *iv) Environmental Plan*
- *v) Inspection and Test Plan*
- *vi) Site Waste Management Plan*

Appendix 2 – Issue / Receipt for Issue / Receipt for Safety and Environmental Requirements for Contractors on all activities

SAFETY & ENVIRONMENTAL REQUIREMENTS FOR ALL CONTRACTORS

ISSUE DOCUMENT

Issued to ....

Contract Number and Description ....

...

...

Location ....

The person named below is the Company Project Manager responsible for overall management of the contract.

Project Manager .... Telephone ....

The person named below is the Company Site / Facilities Manager responsible for local management of the contract, who shall be permanently on Location.

Site Manager .... Mobile ....

Other Site Telephones ....

The Site Manager shall always be the first point of contact, if for any reason, he is not available you shall contact the Company Project Manager.

The Company Integrated Management System and Site Rules are available / displayed at:

...

SAFETY & ENVIRONMENTAL REQUIREMENTS FOR ALL CONTRACTORS

RECEIPT DOCUMENT

RENEWABLE ENERGY SYSTEMS COPY

(To be detached and retained by the Site Manager when this document is issued to a Contractor on site)

I acknowledge receipt of the safe works procedure - Safety & Environmental Requirements for All Contractors.

Contract Number and Description ....

...

..

Location ....

Signed ....

Contracting Company ....

Date ....

Contracting Company Head Office Telephone ....

Local / site Telephone Number ....

Cairnmore Hill Wind Farm
Draft Peat Management Plan
Technical Appendix 2.2

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Document Quality Record

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1.0	Internal Approval	David H. MacArthur	16/05/2022
1.1	Minor Updates	Jenni Cunningham	07/06/2022
2.0	Internal Approval	David H. MacArthur	20/06/2022

CONTENTS

LIST OF FIGURES

1 INTRODUCTION

MacArthur Green was commissioned by RES Ltd, the 'Applicant', to produce a Draft Peat Management Plan (DPMP) for the proposed Cairnmore Hill Wind Farm (hereafter referred to as the 'Proposed Development'). The Proposed Development is located approximately 4.5 km west of Thurso, on the north coast of Caithness in the Scottish Highlands and consists of five wind turbines and associated infrastructure and covers an area of approximately 3.58 km^2.

This report has been produced by MacArthur Green in accordance with current guidelines. All staff contributing to this DPMP have undergraduate and/or postgraduate degrees in relevant subjects and hold professional membership of a relevant institution (e.g., Chartered Institute of Ecology and Environmental Management (CIEEM) or Association of Geographic Information (AGI)).

This report was previously submitted in support of the Environmental Impact Assessment (EIA) for Cairnmore Hill Wind Farm original planning application (2019). This report has been updated to reflect the new layout and include the additional peat depth data that was collected in 2022. In summary, the reduction in turbines from eight to five and reduced length of access tracks from 7,508 m to 2,277 m has led to 1,382.62 m^3 less (reduction of 14.18%) of peat requiring excavation.

The site in which the Proposed Development lies extends across a section of heavily grazed heathland where there is moderate coverage of relatively shallow peat (see Technical Appendix 2.4: Phase 1 and 2 Peat Depth & Coring Survey Report). The vegetation within the site is typical of heavily grazed upland habitats and the botanical species present reflect this (see Technical Appendix 7.1: NVC and Habitats Survey Report for a full description of the habitats within the site).

Phase 1 and Phase 2 peat depth surveys were undertaken at the site from 2016 to 2019 and 2022. A total of 1,262 peat depth probes were collected within the site and the results of these surveys are reported within Technical Appendix 2.4: Phase 1 and 2 Peat Depth & Coring Survey Report. The results from the Phase 1 and Phase 2 peat surveys have been used to inform the DPMP.

The DPMP is completed in accordance with the relevant advice in: 'Developments on Peatlands, Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste' (Scottish Renewables (SR) & SEPA, 2012), from herein referred to as SR & SEPA (2012). In accordance with this reference document, a final Peat Management Plan (PMP) will be prepared post-consent and in advance of construction commencing, when a finalised post consent layout has been agreed and the infrastructure contractor has been appointed. The final PMP will be informed by further ground investigation surveys and detailed construction plans.

2 STRUCTURE OF THE PEAT MANAGEMENT PLAN

While there are no defined requirements for the layout or content of a PMP, SR & SEPA (2012) provides advice to what should be considered when preparing a PMP. This has been used to inform the structure within this DPMP as noted below:

- Section 3: Aims & Objectives
- Section 4: Details to Inform the DPMP:
    - Section 4.1: Peat conditions at the Proposed Development; and
    - Section 4.2: Excavation and reuse volume estimates and reuse requirements for peat.
- Section 4.3: Classification of excavated peat;
- Section 4.4: Handling excavated peat;
- Section 4.5: Temporary peat storage; and
- Section 4.6: Is there a requirement for a Waste Management Plan for the Site?

3 AIMS & OBJECTIVES

The key aim is to demonstrate, "*how, through site investigation and iterative design, the Proposed Development has been structured and designed to minimise, so far as reasonably practicable, the quantity of peat which will be excavated*" (SR & SEPA, 2012). The iterative design process that has been followed to achieve this aim is detailed within Chapter 2: Development Description and Chapter 3: Design Evolution and Alternatives. The key element of the design that reduces excavation of peat on the site is, where possible, locating infrastructure in areas of shallower peat.

This DPMP addresses the peat that is expected to be excavated during the construction of the Proposed Development, which has been specifically designed to minimise the excavation of peat.

The aim of this DPMP is to: **Establish how peat excavated during the construction of the Proposed Development would be managed to allow valid reuse of peat and to avoid, or minimise, the generation of waste peat.**

This aim is achieved through the following objectives:

- Objective 1: Detail the peat conditions at the Proposed Development.
- Objective 2: Detail expected volumes of peat to be excavated and reused.
- Objective 3: Consider the likely physical nature of the material and confirm it will be suitable for the reuses proposed.
- Objective 4: Consider the validity of the use of peat in temporary SEA restoration.
- Objective 5: Describe how excavated peat will be handled to ensure suitability for reuse.
- Objective 6: Describe if temporary storage of peat will be required during construction and how this will be done to ensure suitability for reuse.
- Objective 7: Consider whether any peat will not be suitable for reuse and whether there is a requirement for a Waste Management Plan for the Proposed Development.

4 DETAILS TO INFORM THE PEAT MANAGEMENT PLAN

The following sections detail the information available to inform the DPMP.

4.1 Peat Conditions at the Proposed Development (Objective 1)

Technical Appendix 2.4: Phase 1 and 2 Peat Depth & Coring Survey Report details the peat depth surveys at the site.

During Phase 1 peat depth surveys of the site a total of 240 peat depth probes were taken. These data were interpolated in ARC GIS using Inverse Distance Weighted (IDW) to produce an initial peat depth contour map of the peat study area. This map was then used to help inform the infrastructure layout, aiming to minimise impacts on peatland and avoid the deepest areas of peat.

The previous layout was then subject to further detailed Phase 2 peat depth probing surveys, for instance at 50 m intervals along new tracks and 10 m intervals around wind turbine locations. The Phase 2 probing collected a further 703 peat depth samples around the site. Following the redesign for the new submission, additional Phase 2 peat probing was carried out to complete coverage of the Proposed Development layout.

This data was added to the previously collected Phase 1 and Phase 2 data to create a combined peat data set of 1,262 peat depth probes within the site (see EIA Report Volume 4: **Figure 2.4.1**). Based on this data, revised peat depth maps and an interpolated contour map were created to juxtapose the Proposed Development layout against peat depth (see EIA Report Volume 4: **Figure 2.4.2** and **Figure 2.4.3**).

The results of the surveys revealed a dominance of shallow peat throughout the peat study area, with only two distinct pockets of deeper peat recorded. The only deep pocket within the site boundary was recorded at 333 cm depth. The site itself exists on a plateau, free from complex topography, with steeper contours to the north and west of the site beyond the proposed Turbine 4 buffer.

The peat depths around the site show a large degree of consistency, with shallow peat dominating across the peat study area. The peat depths are generally predictable and consistent throughout the site due to the generally homogenous, low gradient topography and land use.

4.2 Excavation and Reuse Volume Estimates and Reuse Requirements for Peat (Objective 2)

Table 4.2.1 and **Table 4.2.2** below detail the construction activities (excluding the temporary facilities to be provided) that would generate excavated peat and the expected volumes of peat arising from these activities. These estimates are based on the dimensions of infrastructure as described within Chapter 2: Development Description. The estimates are generated in GIS and based on the peat depth information provided in Technical Appendix 2.4: Phase 1 and 2 Peat Depth & Coring Survey Report and the infrastructure layout, as illustrated in **Figure 2.2.1**. **Table 4.2.1** details the predicted excavation volumes for each individual infrastructure element, including the control building and substation, and turbine bases and associated hardstandings.

The estimation of peat excavation and reuse volumes relies on several design assumptions that may vary on a small scale according to discrete changes in topography and peat depth. Taken together, these estimated peat excavation and reuse volumes describe whether the Proposed Development has a positive, negative or neutral peat balance.

Cabling would follow the line of onsite tracks, which may require dedicated excavations to be undertaken. However, cable trenches would be incorporated, as much as possible, into the restored peat verges (if these are required) along the access tracks in order to reduce the requirement to excavate undisturbed ground. Any peat arising from specific cable trench excavations would be backfilled using the same peat and reinstated in the correct order. Backfilling would be on an 'as-you-go' basis in order to minimise time between excavation of the cable trench and peat reinstatement. Equivalent volumes of peat are excavated and restored for cabling works, which effectively ensures no net surplus of peat is generated. As a result, the peat volumes associated with the cabling are not included within the peat reuse calculations and cabling is not considered further in this DPMP.

The formation of temporary infrastructure, such as the temporary construction compound and temporary enabling works compound would also generate excavated peat, however, this peat would be stored adjacent to the works and reinstated once the temporary structure has been removed (as per Chapter 2: Development Description). There would not be any requirement to reuse this peat elsewhere within the site. Peat excavated for temporary infrastructure would be handled and stored in line with the principles outlined within this DPMP (**Section 4.5**). The excavation and subsequent restoration of this peat would create no net surplus of peat, as a result the peat volumes associated with the temporary construction compound/enabling works compound areas are not included within the peat excavation calculations in **Table 4.2.1** or **Table 4.2.2**.

Table 4.2.1 Peat Excavation by Infrastructure Element – Potential Peat Generated

Infrastructure	Estimated Peat Volume to be Excavated (m^3)
Control Building & Substation Compound	1,140.12
New Site Tracks (Site Entrance)	0.00
New Site Tracks (Main Site)	4,517.99
T1: Crane Hardstanding Area (Includes Octagonal Turbine foundation)	589.00
T1: Turbine excavation	102.88
T2: Crane Hardstanding Area (Includes Octagonal Turbine foundation)	693.78
T2: Turbine excavation	161.55
T3: Crane Hardstanding Area (Includes Octagonal Turbine foundation)	282.36
T3: Turbine excavation	41.67
T4: Crane Hardstanding Area (Includes Octagonal Turbine foundation)	719.21
T4: Turbine excavation	116.38
T5: Crane Hardstanding Area (Includes Octagonal Turbine foundation)	0.00
T5: Turbine excavation	0.00
Total	**8,364.94**

Table 4.2.2 Peat Excavation by Construction Category – Peat Supply

Infrastructure	Estimated Peat Volume to be Excavated (m^3)
New Tracks	4,517.99
Control Building & Substation	1,140.12
Wind Turbine Foundations x 4[1] (Excavated)	422.46
Crane Hardstandings	2,284.37
Total	**8,364.94**

Table 4.2.3 below provides details on the reinstatement requirements of the Proposed Development and, in particular, the anticipated demand for peat from the various reinstatement sources.

[1] Excavation of peat at Turbines 1 to 4 only, no peat recorded at Turbine 5.

Table 4.2.3 Reinstatement Requirements & Estimated Peat Volume Requirement – Peat Demand

Reinstatement Requirements	Restoration Area (m^2)	Average Depth of Restoration (m^2)	Total Demand Estimate (m^3)
Turbine Foundations Finished Ground Level	2,194.00	0.20	438.79
Turbine Foundations Compacted Backfill	1,178.00	2.85	2,356.20
Crane Hardstanding Verges	720.00	1.50	1,440.00
Control Building & Substation Compound Verges	301.00	1.40	602.00
Excavated Access Track Verges	4,555.00	1.50	3,529.77
Total			**8,366.76**

Table 4.2.4 below summarises the figures for total supply and demand for peat the Proposed Development as calculated from the above estimates.

Table 4.2.4 Total Demand, Supply and Balance of Peat

Peat Demand/Supply	Volume (m^3)
Total Peat Supply (from excavation)	8,364.94
Total Peat Demand (from reinstatement)	8,366.76
Surplus (+) or Deficit (-) [Supply-Demand]	**-1.82**

A number of design assumptions were made when considering the reuse of excavated peat at the proposed development, as detailed in **Table 4.2.3**, including:

- The area for construction of the wind turbine foundations has been estimated to be a maximum 30 m diameter excavation to allow for an excavated working area around the concrete foundation (see Chapter 2: Development Description). A circular/octagonal concrete foundation slab of approximately 20 m diameter will sit on the underlying rock or suitable substratum with a founding depth of approximately 3 m to 5 m subject to prevailing ground conditions. With regard to backfilling at these foundations, it has been assumed that an area of the 'compacted backfill between foundation and excavation face', as indicatively shown in **Figure 2.3**, will be partially comprised of peat. Peat would not be used to backfill the excavation void over the 20 m diameter plan footprint of the foundation due to its potential low strength; instead, rockfill, sands, or gravel will be required to backfill here. However, peat could be used as backfill outside the foundation footprint. Therefore, the area available for peat backfill is the area of the 30 m diameter excavation minus the area of the 20 m typical foundation slab. This DPMP further assumes based on development figures that only 75% of this area would be available for peat backfill due to the juxtaposition and partial overlap with crane hardstanding areas. Consequently, the area of potential peat backfill equates to 294.52 m^2 per wind turbine. As above, the founding depth will be up to 3 m to 5 m, however with the majority of the site containing relatively shallow peat, a depth of 2m has been used as an approximation to backfill excavations to ground level. As per **Table 4.2.3**, it has been predicted that a significant volume of peat may feasibly be reused during the compacted backfill of the foundations.
- With respect to the finished ground level around wind turbine foundations, as per **Figure 2.3**, once the turbines have been installed, the surface of the immediate construction area around the bases would be restored using retained peat, soils, or turf to within approximately 5 m of the tower bases (due to a 5 m wide maintenance track/path around the base of each turbine). As per **Figure 2.3** this reinstated finished ground level will be approximately 0.2 m in depth. The corresponding area for surface reinstatement at each turbine base has been calculated as 548.49 m^2 (calculated as the area of a 30m diameter excavation minus the area of the 14.2 m diameter tower base and maintenance track/path). The peat demand at a depth of 0.2 m depth for four wind turbines is therefore 548.49 m^3 as per **Table 4.2.3**.
- A 55 m x 35 m crane hardstanding will be required at each wind turbine location, these will be maintained during the operational phase of the Proposed Development. **Table 4.2.3** assumes that one length and one width of each hardstanding is available for reinstatement during construction, with verges 2 m in width.
- A 64.5 m x 43 m Control Building and Substation Compound is required. **Table 4.2.3** assumes that one length and two widths are available for verge reinstatement, with verges assumed to be 2 m in width.
- New access tracks will be flanked by low angle landscaped verges that will seek to provide visual continuity and topographical tie-in between the access tracks and the surrounding peatland, as per guidance (FCE & SNH, 2010). In general, the verges used for finishing and landscaping of the new access tracks will be extended to 2 m either side of the full track width (e.g., running width and track shoulders). It has been assumed that peat will only be used in verges where the surrounding ground is peatland (i.e., peat would not be used to create verges within the improved fields by the site entrance).

With regards to peat reuse as detailed in **Table 4.2.3** above, the following guiding principles and assumptions are also made, including, in combination with other guidelines and principles described within this DPMP, the following:

- During the excavation and reuse of peat deposits, where any layered structuring within the peat exists, namely the 'acrotelm' and underlying 'catotelm', these layers would be preserved as far as is practicable. This approach would aid in the successful re-vegetation and prevent drying and desiccation of the peat;
- Any underlying substrate material removed as part of the excavation should also be stored separately (not mixed with the peat material) and used as backfill over the plan area of foundation bases (if suitable);
- Peat would be stored suitably close and reused as close to its source location as far as practicable;
- Where feasible, reinstatement and restoration would be carried out concurrently with construction rather than at its conclusion;
- Verges at the track margins and around infrastructure will be tapered as necessary to provide a suitable landscape and topographical tie-in and be in such a manner as to prevent the ponding of water on tracks or hardstanding surfaces;
- Verges along tracks will be 'wedge-shaped' with the deepest section adjacent the track before tapering down; verge edges will not sit above the level of the track;
- Limiting the width of the peat verges to 2 m width, as detailed above, will minimise unnecessary smothering of intact vegetation adjacent to infrastructure; and
- All peat reuse and landscaping activities should be agreed in advance with the onsite Ecological Clerk of Works (ECoW), and suitably qualified engineer if required. In the unlikely event that there is a surplus of

peat on the site, there may be extra reuse capacity in turbine backfill areas; up to a maximum depth of 2 m.

It can be concluded from **Table 4.2.4** above that the reasonable demand for peat for reinstatement purposes is greater than the supply of peat arising from excavation. It is also apparent that there is also spare reuse capacity in the event more peat is excavated than predicted, or other reuse areas cannot accommodate the predicted amounts. As such, it is predicted the Proposed Development will not generate surplus peat.

4.3 Classification of Excavated Peat (Objective 3)

Peat was characterised for the five peat core sub-samples from four sample locations (as detailed in Technical Appendix 2.4: Phase 1 and 2 Peat Depth & Coring Survey Report, **Figure 2.4.1**). Furthermore, Technical Appendix 2.4: Phase 1 and 2 Peat Depth & Coring Survey Report details the physical properties recorded from the five peat core sub-samples taken at the site.

The key measures of peat condition, which are important to establishing the appropriate type of reuse, are noted in **Table 4.3.1** below. Overall, the sample results suggest that the acrotelm layer is variable in depth and it is recommended that the upper 0.5 m should be reused as part of the reinstatement programme, where this depth of material is available. Excavation of 0.5 m ensures that the acrotelm remains as intact as possible and captures much of the underlying seed bank material which would aid vegetation regeneration. With regards to the catotelm material within the Proposed Development site, the results indicate that all material is fibrous; no intermediate or amorphous peat was recorded.

Table 4.3.1 Peat Condition

Acrotelm / Catotelm	Measure of Peat Condition	Consideration (Refer to Technical Appendix 2. for detail)
Acrotelm	Depth	The depth of the acrotelm was measured at four sample point locations, which ranged from 0 to 9 cm, with a mean depth of 5.75 cm. Due to the difficulties of excavating a thin layer of acrotelm, without causing significant damage to it, it is recommended that 0.5 m of surface peat is excavated (where possible) for reuse as acrotelm material.
Acrotelm/Catotelm	Degree of Humification	100% of 0.5 m sub-samples (n=5) were fibrous in nature.
	Fibrous Content (fine and coarse fibres)	Fine fibres were assessed as low in all samples. Coarse samples were variable, with one sample assessed as moderate, one sample low-moderate, and two samples as low coarse fibre content.
	Water Content	The five sub-samples ranged from 1 to 3 for water content (1 being dry and 5 being very wet); indicating that the peat within the site is relatively dry.
	Von Post	Von Post classification ranges from 1 (low level of humification) to 10 (highly humified and amorphous peat). The level of humification ranged from 3 to 5 between the five sub-samples.

4.4 Handling Excavated Peat (Objective 4)

This section provides guidance to help the infrastructure contractor in both planning and executing the construction works at the Proposed Development. Working in peat cannot be avoided because the site is underlain by peat of various, albeit shallow, depths (**Figure 2.2.1** and **Figure 2.4.3**). Peat will be excavated and may be stored temporarily in an appropriate location (see **Section 4.5**) where temporary storage is necessary. Careful handling of the peat is also required to ensure its suitability for reuse.

The infrastructure contractor shall provide a detailed method statement for works in peat habitats, in including but not limited to:

- How to minimise the area of impact;
- How to avoid areas of higher quality bog vegetation (with the assistance of the ECoW);
- Means of access to areas of work and to areas where peat will be reused;
- Methods of peat removal;
- Managing water in the peat and pollution prevention;
- Where to avoid unnecessary intrusive work wherever possible;
- Drainage measures and design and use of appropriate techniques to maintain local hydrology; and
- Plans for the deposition of peat on site to be agreed with the Applicant and the ECoW.

It will be necessary for the final PMP to detail the methods and timing involved in handling, storing and using peat for reinstatement, all of which will be dependent on the equipment adopted for the construction activities. The final method statement for this should be based on the following principles:

- The surface layer of peat and vegetation (acrotelm) would be stripped separately from the catotelmic peat. Where possible this would involve an excavation depth of 0.5 m and the creation of turves;
- The turves should be as large as practicably possible to minimise desiccation effects during storage;
- The turves should be kept wet but not saturated, and not allowed to dry out when in temporary storage;
- Contamination of excavated peat with other substrate materials (e.g., gravels, clays or silts) should be avoided and these materials stored separately where excavated;
- Acrotelmic material would be stored separately from catotelmic material even if some of this layer appears to be lacking vegetation, since it may contain a seedbank that is useful for re-establishing vegetation;
- Any risk of peat slide must be considered by a suitably qualified engineer and where risk is identified protective measures developed and agreed with the Applicant before further construction works take place;
- Careful handling is essential to retain any existing structure and integrity of the excavated materials and thereby maximise the potential for excavated material to be reused;
- Plan all works to reduce the need for double handling the peat;
- Movement of excavated turves and peat should be kept to a minimum and it is preferable to transport peat intended for translocation to its final destination at the time of excavation;
- Less humified catotelmic peat (consolidated peat), which maintains its structure upon excavation, should be kept separate from any highly humified amorphous peat;

- Consider the timing of excavation activities to avoid very wet weather periods in order to reduce the risk of peat becoming wet and unconsolidated, thereby reducing pollution or peat slide risk;
- Acrotelmic material would be replaced as intact as possible once construction is complete; and
- To minimise handling and transportation of peat, acrotelmic and catotelmic materials would be replaced, as far as is reasonably practicable, in the location from which it was removed. Acrotelmic material must be placed on the surface.

The handling of peat should be monitored by the ECoW and the Applicant to ensure the above principles are adopted and implemented during construction of the Proposed Development.

4.5 Temporary Peat Storage (Objective 5)

It is anticipated that during construction, on most occasions, peat and peaty soil will only be handled once and will be placed at its end use locations (as detailed in **Table 4.2.3**). However, during construction a degree of temporary peat storage will be required before the excavated material can be used in restoration and placed in its end use location.

It will be necessary for the final PMP to detail the methods and timing involved in temporary storage, where this is required. It is likely that a degree of temporary peat storage would be required, for instance in association with stripping areas of any area used for temporary land take; this material would then be used in the subsequent restoration of this temporary construction area.

The final method statement for this temporary storage of peat should be based on the following guiding principles:

- Temporary storage of peat should be minimised. Where required it should be temporarily stored in stockpiles / bunds adjacent to and surrounding each infrastructure site;
- Acrotelm, catotelm, and any clay/glacial till or other substrata should be stored separately and appropriately to ensure no mixing of materials and to prevent cross-contamination;
- Suitable storage areas should be sited in areas with lower ecological value (e.g., away from Groundwater Dependent Terrestrial Ecosystems (GWDTEs), low stability risk areas and at a minimum distance of 50m from watercourses. Identified suitable areas would form part of the final PMP and should be agreed in advance with the onsite ECoW;
- Peat turves should be stored in wet conditions where possible (e.g., within waterlogged former excavations) or irrigated in order to prevent desiccation;
- Larger stockpiles are preferable to numerous small stockpiles, which minimises exposure to sun and wind, which can lead to desiccation. Stockpiles should not exceed 2m in height and be sited with due consideration for slope stability. Benching of stored peat may be necessary to provide stability;
- Stores of non-turf, i.e., catotelm, should be bladed off to reduce surface area and desiccation of the stored peat;
- Stores of peat, particularly catotelmic material, should be inspected regularly (at least weekly) and following heavy rainfall or thaw conditions to check for any evidence of movement, tension cracks or instability in the stored peat. If there is any evidence of instability, appropriate remedial measures should be taken as necessary on the advice from a suitably qualified engineer;
- In dry weather periods, consideration should be given to watering stored turves and peat to prevent drying out, wastage and erosion;
- Pollution prevention measures should be installed around peat storage areas;
- Reinstatement would, in all instances, be undertaken at the earliest opportunity to minimise storage of turves and other materials;
- Timing the construction work, as much as possible, to avoid periods when peat materials are likely to be wetter; and
- Where practical, transportation of peat on site, from excavation to temporary storage and restoration locations, should be minimised.

4.6 Requirement for a Waste Management Plan (Objective 6)

There is no requirement for a Waste Management Plan with respect to peat on the basis that the peat excavated from the various elements of the site infrastructure would be fully reused within the restoration of the site.

5 LIMITATIONS OF THE DRAFT PEAT MANAGEMENT PLAN

As discussed in Technical Appendix 2.4: Phase 1 and 2 Peat Depth & Coring Survey Report the results of the peat depth surveys revealed a site with an almost ubiquitous covering of shallow peat. The peat depths around the site show little variation, with the exception of one deeper peat pocket on the site in the north-east, to which the Proposed Development infrastructure has been sited away from. These data and maps, and knowledge of the site, have been used to help design the Proposed Development, inform assessments, and provide the data to inform this DPMP.

The peat depth and core surveys presented in Technical Appendix 2.4: Phase 1 and 2 Peat Depth & Coring Survey Report were originally collected under a previous EIA Report submission. Additional Phase 2 Peat depth probes were collected to reflect the redesign of the turbine and infrastructure layout for the Proposed Development. The sampling points provide high resolution coverage of the site, and these revealed peats to be typically shallow, and generally homogenous throughout the site. It is considered that the peat depths collected, and interpolations derived from these data, are representative of the site and have adequately informed the layout of the Proposed Development with respect to avoiding areas of deep peat.

Therefore, the peat excavation and reuse volumes included in this DPMP are intended as an initial indication. The total peat volumes are based on a series of design assumptions and estimates for the Proposed Development layout and peat depth sample data interpolated across discrete areas of the site. Such parameters can still vary over a small scale and therefore local topographic changes in the bedrock profile may impact the total accuracy of the volume calculations.

As explained above, this DPMP would be developed into a final PMP post-consent and in advance of construction commencing, when the infrastructure contractor has been appointed. As part of this process it is proposed that further peat depth probing and coring will be undertaken at infrastructure locations, particularly wind turbine locations, post-consent and during pre-construction ground investigation surveys. These additional data will be used to aid micrositing of wind turbines away from any pockets of deeper peat into the shallowest areas, thereby minimising impacts on peatland within the micrositing tolerances, and to gather further information on the characteristics of the peat deposits present. A finalised post-consent layout will be agreed with relevant consultees, once detailed ground investigations have been undertaken and before works commence. This will demonstrate how any newly collected information has been used to inform the proposed layout and minimise impacts on features such as deep peat.

As a result, the accuracy of the predictions within this DPMP will be improved though these additional detailed site investigations prior to, and during construction. It is therefore important that the final PMP remains a live document throughout the pre-construction and construction phases and is encapsulated within the wider Construction and Environmental Management Plan (CEMP). The PMP and volumetric assessments can be updated as more information becomes available and the guiding principles within this DPMP incorporated into relevant construction method statements and plans.

6 REFERENCES & RELEVANT GUIDANCE

Forestry Civil Engineering (FCE) and Scottish Natural Heritage (SNH). (2010). *Floating Roads on Peat – A Report into Good Practice in Design, Construction and Use of Floating Roads on Peat*.

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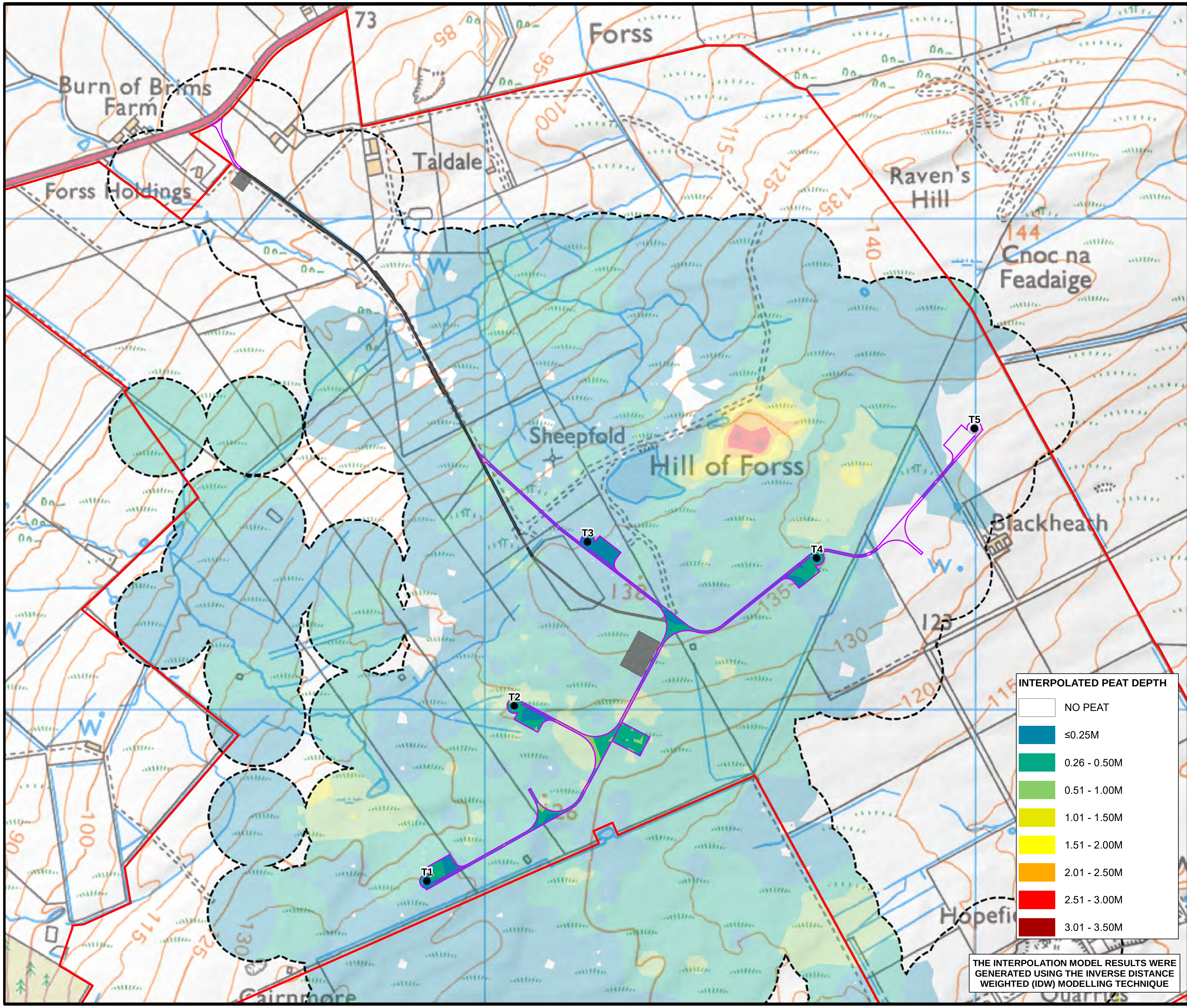

res

CAIRNMORE HILL WIND FARM

FIGURE 2.2.1

INFRASTRUCTURE AND PEAT EXCAVATION

- TURBINE LOCATION
- SITE BOUNDARY
- PEAT STUDY AREA

INFRASTRUCTURE

- EXCAVATED
- EXISTING (UPGRADE)
- TEMPORARY

EXCAVATED PEAT DEPTH

- NO PEAT
- ≤0.25M
- 0.26 - 0.50M
- 0.51 - 1.00M

0 100 200 Metres

LAYOUT DWG	T-LAYOUT NO.
N/A	PSCOhof063

DRAWING NUMBER

FIGURE 2.2.1

SCALE - 1:7,500 @ A3

ENVIRONMENTAL IMPACT ASSESSMENT REPORT AND PLANNING APPLICATION 2022

EAST POINT GEO
An ABL Group Company

Consulting Report

Technical Appendix 2.3 Peat Landslide Hazard and Risk Assessment Cairnmore Hill Wind Farm

Caithness, Scotland
RES

21-MAC-001-D-001v02

17/06/2022

Prepared for
J Cunningham

Client
RES

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CONTENTS

1. INTRODUCTION

1.1. Background

RES Limited ('the Applicant') is seeking planning permission to construct and operate a wind farm (the 'Proposed Development') and associated infrastructure of more than 20 MW and less than 50 MW, comprising up to 5 turbines on a site located approximately 4.5 km west of Thurso, on the north coast of Caithness in the Scottish Highlands (see Plate 2.3.1).

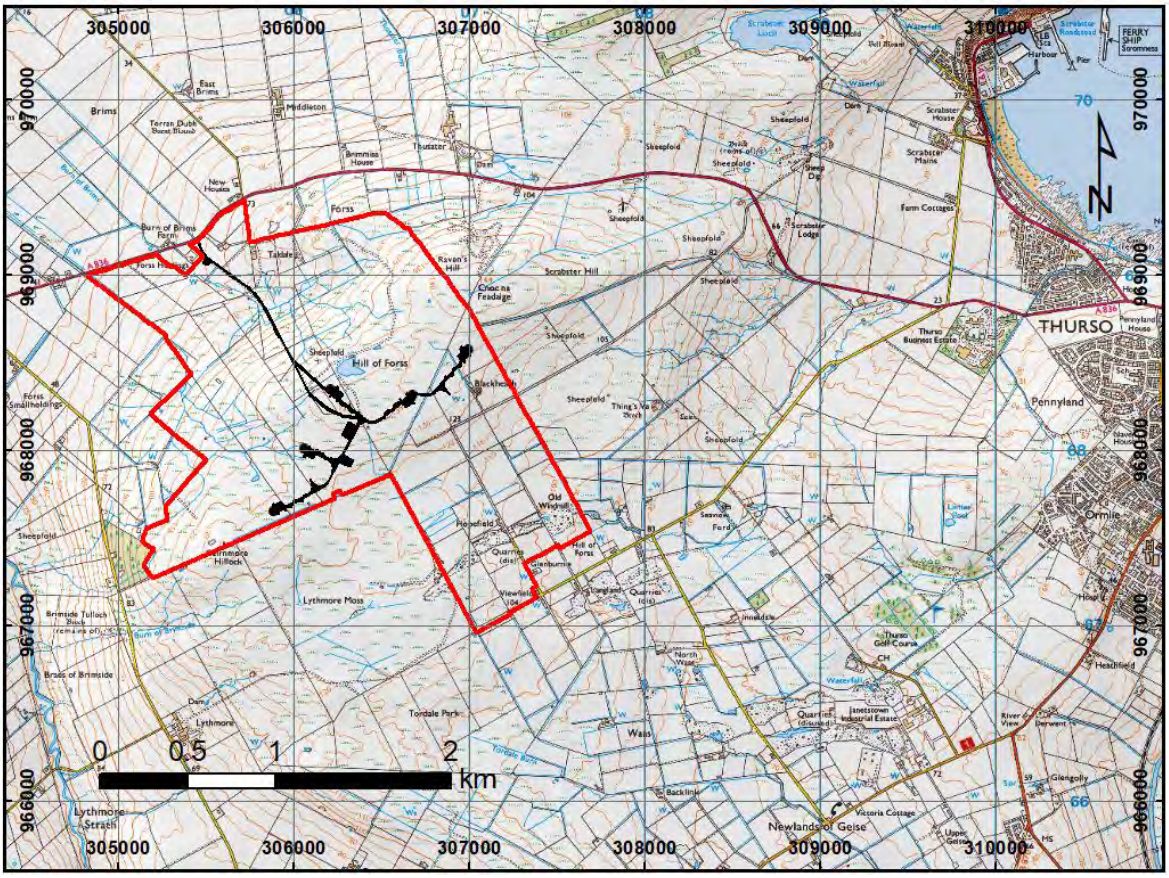

Plate 2.3.1 Proposed location of Cairnmore Hill wind farm

The Proposed Development will comprise:

- 5 three-bladed horizontal axis wind turbines of up to 138.5 m tip-height;
- turbine foundations;
- hardstanding areas at each turbine location for use by cranes erecting and maintaining the turbine;
- access tracks;
- a wind farm substation compound containing a control and substation buildings with battery energy storage;
- an on-site electrical and control network of underground (buried) cables;
- a connection from the substation to the local grid network (not part of the wind farm planning application;
- a temporary construction compound;

- a temporary enabling works compound;
- communications mast;
- drainage works including a SuDs system;
- associated ancillary works;
- habitat management; and
- engineering operations.

The Scottish Government Best Practice Guidance (BPG) provides a screening tool to determine whether a peat landslide hazard and risk assessment (PLHRA) is required (Scottish Government, 2017). This is in the form of a flowchart, which indicates that where blanket peat is present, slopes exceed 2° and proposed infrastructure is located on peat, a PLHRA should be prepared.

While this guidance applies only to Section 36 applications, it is now accepted industry good practice to undertake stability assessments wherever peat may be present in coincidence with proposed infrastructure. These conditions exist at the Proposed Development site and therefore a PLHRA has been undertaken.

1.2. Scope of Work

The scope of the PLHRA is as follows:

- Characterise the peatland geomorphology of the site to determine whether prior incidences of instability have occurred and whether contributory factors that might lead to instability in the future are present across the site;
- Determine the likelihood of a future peat landslide under natural conditions and in association with construction activities associated with the Proposed Development;
- Identify potential receptors that might be affected by peat landslides, should they occur, and quantify the associated risks; and
- Provide appropriate mitigation and control measures to reduce risks to acceptable levels such that the Proposed Development is developed safely and with minimal risks to the environment.

The contents of this PLHRA have been prepared in accordance with the BPG, noting that the guidance "*should not be taken as prescriptive or used as a substitute for the developer's [consultant's] preferred methodology*" (Scottish Government, 2017).

In section 4.1 of the BPG, the key elements of a PLHRA are highlighted, as follows (Scottish Government, 2017):

i. An assessment of the character of the peatland within the application boundary including thickness and extent of peat, and a demonstrable understanding of site hydrology and geomorphology.

ii. An assessment of evidence for past landslide activity and present-day instability e.g. pre-failure indicators.

iii. A qualitative or quantitative assessment of the potential for or likelihood of future peat landslide activity (or a landslide susceptibility or hazard assessment).

iv. Identification of receptors (e.g. habitats, watercourses, infrastructure, human life) exposed to peat landslide hazards; and

v. A site-wide qualitative or quantitative risk assessment that considers the potential consequences of peat landslides for the identified receptors.

Section 1.3 describes how this report addresses this indicative scope.

1.3. Report Structure

This report is structured as follows:

- Section 2 gives context to the landslide risk assessment methodology through a literature based account of peat landslide types and contributory factors, including review of any published or anecdotal information available concerning previous instability at or adjacent to the site;
- Section 3 provides a site description based on desk study and site observations, including consideration of aerial or satellite imagery, digital elevation data, geology and peat depth data;
- Section 4 describes the approach to and results of an assessment of peat landslide likelihood;
- Section 5 describes the approach to consequence assessment that determines potential impacts on site receptors and the associated calculated risks; and
- Section 6 provides mitigation and control measures to reduce or minimise risks prior to, during and after construction.

Where relevant information is available elsewhere in the Environmental Impact Assessment (EIA) Report, this is referenced in the text rather than repeated in this report.

1.4. Approaches to assessing peat instability for the Proposed Development

This report approaches assessment of peat instability through both a qualitative contributory factor-based approach and via more conventional stability analysis (through limit equilibrium or Factor of Safety (FoS) analysis). The advantage of the former is that many observed relationships between reported peat landslides and ground conditions can be considered together where a FoS is limited to consideration of a limited number of geotechnical parameters. The disadvantage is that the outputs of such an approach are better at illustrating relative variability in landslide susceptibility across a site rather than absolute likelihood.

The advantage of the FoS approach is that clear thresholds between stability and instability can be defined and modelled numerically, however, in reality, there is considerable uncertainty in input parameters and it is a generally held view that the geomechanical basis for stability analysis in peat is limited given the nature of peat as an organic, rather than mineral soil.

To reflect these limitations, both approaches are adopted and outputs from each approach integrated in the assessment of landslide likelihood. Plate 2.3.2 shows the approach:

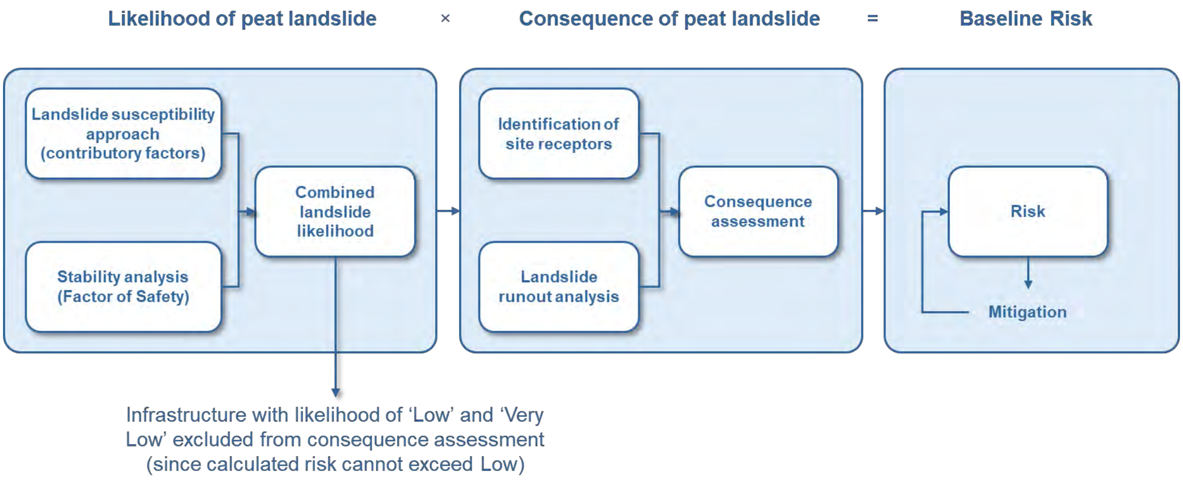

Plate 2.3.2 Risk assessment approach

2. BACKGROUND TO PEAT INSTABILITY

2.1. Peat Instability in the UK and Ireland

This section reviews published literature to highlight commonly identified landscape features associated with recorded peat landslides in the UK and Ireland. This review forms the basis for identifying similar features at the Proposed Development and using them to understand the susceptibility of the site to naturally occurring and human induced peat landslides.

Peat instability, or peat landslides, are a widely documented but relatively rare mechanism of peatland degradation that may result in damage to peatland habitats, potential losses in biodiversity and depletion of peatland carbon stores (Evans & Warburton, 2007). Public awareness of peat landslide hazards increased significantly following three major peat landslide events in 2003, two of which had natural causes and one occurring in association with a wind farm.

On 19th September 2003, multiple peat landslide events occurred in Pollatomish (Co. Mayo, Ireland; Creighton and Verbruggen, 2003) and in Channerwick in the Southern Shetland Islands (Mills et al, 2007). Both events occurred in response to intense rainfall, possibly as part of the same large scale large-scale weather system moving northeast from Ireland across Scotland. The former event damaged several houses, a main road and washed away part of a graveyard. Some of the landslides were sourced from areas of turbary (peat cutting) with slabs of peat detaching along the cuttings. The landslides in Channerwick blocked the main road to the airport and narrowly missed traffic using the road. Watercourses were inundated with peat, killing fish inland and shellfish offshore (Henderson, 2005).

In October 2003, a peat failure occurred on an afforested wind farm site in Derrybrien, County Galway, Ireland, causing disruption to the site and large-scale fish kill in the adjoining watercourses (Lindsay and Bragg, 2004).

The Derrybrien event triggered interest in the influence of wind farm construction and operation on peatlands, particularly in relation to potential risks arising from construction induced peat instability. In 2007, the (then) Scottish Executive published guidelines on peat landslide hazard and risk assessment in support of planning applications for wind farms on peatland sites. While the production of PLHRA reports is required for all Section 36 energy projects on peat, they are now also regarded as best practice for smaller wind farm applications. The guidance was updated in 2017 (Scottish Government, 2017).

Since then, a number of peat landslide events have occurred both naturally and in association with wind farms (e.g Plate 2.3.3). In the case of wind farm sites, these have rarely been reported, however landslide scars of varying age are visible in association with wind farm infrastructure on Corry Mountain, Co. Leitrim, at Sonnagh Old Wind Farm, Co. Galway (near Derrybrien; Cullen, 2011), and at Corkey Wind Farm, Co. Antrim. In December 2016, a plant operator was killed during excavation works in peat at the Derrysallagh wind farm site in Co. Leitrim (Flaherty, 2016) on a plateau in which several published examples of instability had been previously reported. A peat landslide was also reported in 2015 near the site of a proposed road for the Viking Wind Farm on Shetland (The Shetland Times, 2015) though this was not in association with construction works.

Other recent natural events include another failure in Galway at Clifden in 2016 (Irish News, 2016), Cushendall, Co. Antrim (BBC, 2014), in the Glenelly Valley, Co. Tyrone in 2017 (BBC, 2018), Drumkeeran in Co. Leitrim in July 2020 (Irish Mirror, 2020) and Benbrack in Co Cavan in July 2021 (The Anglo-Celt, 2021). Noticeably, the vast majority of reported failures since 2003 have occurred in Ireland and Northern Ireland, with the one reported Scottish example occurring on the Shetland Islands, an area previously associated with peat instability.

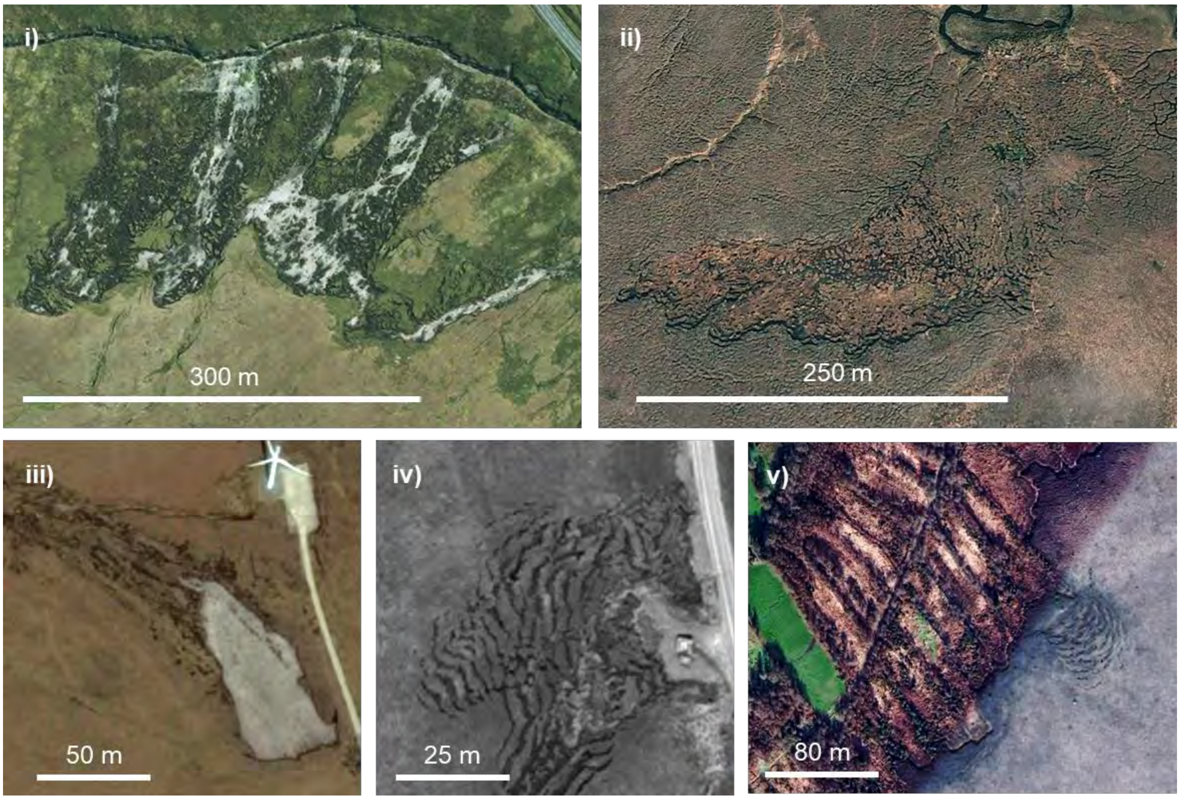

Plate 2.3.3 Characteristic peat landslide types in UK and Irish peat uplands: Top row - natural failures: i) multiple peat slides with displaced slabs and exposed substrate, ii) retrogressive bog burst with peat retained within the failed area; Bottom row - failures possibly induced by human activity: iii) peat slide adjacent to turbine foundation, iv) spreading around foundation, v) spreading upslope of cutting

This section of the report provides an overview of peat instability as a precursor to the site characterisation in Section 3 and the assessment provided in Section 4. Section 2.2 outlines the different types of peat instability documented in the UK and Ireland. Section 2.3 provides an overview of factors known to contribute to peat instability based on published literature.

2.2. Types of Peat Instability

Peat instability is manifested in a number of ways (Dykes and Warburton, 2007) all of which can potentially be observed on site either through site walkover or remotely from high resolution aerial photography:

- **minor instability:** localised and small-scale features that are not generally precursors to major slope failure and including gully sidewall collapses, pipe ceiling collapses, minor slumping along diffuse drainage pathways (e.g. along flushes); indicators of incipient instability including development of tension cracks, tears in the acrotelm (upper vegetation mat), compression ridges, or bulges / thrusts (Scottish Government, 2017); these latter features may be warning signs of larger scale major instability (such as landsliding) or may simply represent a longer term response of the hillslope to drainage and gravity, i.e. creep.
- **major instability:** comprising various forms of peat landslide, ranging from small scale collapse and outflow of peat filled drainage lines/gullies (occupying a few-10s cubic metres), to medium

scale peaty-debris slides in organic soils (10s to 100s cubic metres) to large scale peat slides and bog bursts (1,000s to 100,000s cubic metres).

Evans and Warburton (2007) present useful contextual data in a series of charts for two types of large-scale peat instability – peat slides and bog bursts. The data are based on a peat landslide database compiled by Mills (2002) which collates site information for reported peat failures in the UK and Ireland. Separately, Dykes and Warburton (2007) provide a more detailed classification scheme for landslides in peat based on the type of peat deposit (raised bog, blanket bog, or fen bog), location of the failure shear surface or zone (within the peat, at the peat-substrate interface, or below), indicative failure volumes, estimated velocity and residual morphology (or features) left after occurrence.

For the purposes of this assessment, landslide classification is simplified and split into three main types, typical examples of which are shown in Plate 2.3.4. Dimensions, slope angles and peat depths are drawn from charts presented in Evans and Warburton (2007). The term “peat slide” is used to refer to large-scale (typically less than 10,000 of cubic metres) landslides in which failure initiates as large rafts of material which subsequently break down into smaller blocks and slurry. Peat slides occur ‘top-down’ from the point of initiation on a slope in thinner peats (between 0.5m and 1.5m) and on moderate slope angles (typically 5°-15°, see Plate 2.3.4).

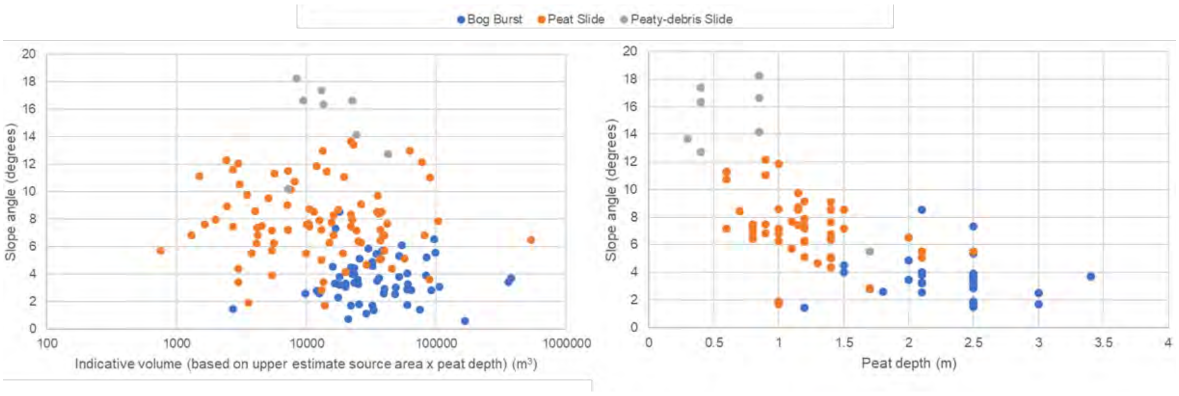

Plate 2.3.4 Reported slope angles and peat depths associated with peat slides and bog bursts (from literature review of locations, depths and slope angles, after Mills, 2002)

The term “bog burst” is used to refer to very large-scale (usually greater than 10,000 of cubic metres) spreading failures in which the landslide retrogresses (cuts) upslope from the point of failure while flowing downslope. Peat is typically deeper (greater than 1.0m and up to 10m) and more amorphous than sites experiencing peat slides, with shallower slope angles (typically 2°-5°). Much of the peat displaced during the event may remain within the initial failure zone. Bog bursts are rarely (if ever) reported in Scotland other than in the Western Isles (e.g. Bowes, 1960).

The term “peaty soil slide” is used to refer to small-scale (1,000s of cubic metres) slab-like slides in organic soils (i.e. they are <0.5m thick). These are similar to peat slides in form, but far smaller and occur commonly in UK uplands across a range of slope angles (Dykes and Warburton, 2007). Their small size means that they often do not affect watercourses and their effect on habitats is minimal.

Few if any spreading failures in peat (i.e. bog bursts) have been reported in Scotland, with only one or two unpublished examples in evidence on the Isle of Lewis and a small number of failures in Caithness. There are no published failures or news reports of landslides in proximity to the Proposed Development and the Caithness examples are located much farther to the south.

2.2.1. Factors Contributing to Peat Instability

Peat landslides are caused by a combination of factors – triggering factors and reconditioning factors (Dykes and Warburton, 2007; Scottish Government, 2017). Triggering factors have an immediate or rapid effect on the stability of a peat deposit whereas preconditioning factors influence peat stability over a much longer period. Only some of these factors can be addressed by site characterisation.

Preconditioning factors may influence peat stability over long periods of time (years to hundreds of years), and include:

i. Impeded drainage caused by a peat layer overlying an impervious clay or mineral base (hydrological discontinuity);

ii. A convex slope or a slope with a break of slope at its head (concentration of subsurface flow);

iii. Proximity to local drainage, either from flushes, pipes or streams (supply of water);

iv. Connectivity between surface drainage and the peat/impervious interface (mechanism for generation of excess pore pressures);

v. Artificially cut transverse drainage ditches, or grips (elevating pore water pressures in the basal peat-mineral matrix between cuts, and causing fragmentation of the peat mass);

vi. Increase in mass of the peat slope through peat formation, increases in water content or afforestation;

vii. Reduction in shear strength of peat or substrate from changes in physical structure caused by progressive creep and vertical fracturing (tension cracking or desiccation cracking), chemical or physical weathering or clay dispersal in the substrate;

viii. Loss of surface vegetation and associated tensile strength (e.g. by burning or pollution induced vegetation change);

ix. Increase in buoyancy of the peat slope through formation of sub-surface pools or water-filled pipe networks or wetting up of desiccated areas; and

x. Afforestation of peat areas, reducing water held in the peat body, and increasing potential for formation of desiccation cracks which are exploited by rainfall on forest harvesting.

Triggering factors are typically of short duration (minutes to hours) and any individual trigger event can be considered as the ‘straw that broke the camel’s back’:

i. Intense rainfall or snowmelt causing high pore pressures along pre-existing or potential rupture surfaces (e.g. between the peat and substrate);

ii. Rapid ground accelerations (e.g. from earthquakes or blasting);

iii. Unloading of the peat mass by fluvial incision or by artificial excavations (e.g. cutting);

iv. Focusing of drainage in a susceptible part of a slope by alterations to natural drainage patterns (e.g. by pipe blocking or drainage diversion); and

v. Loading by plant, spoil or infrastructure.

External environmental triggers such as rainfall and snowmelt cannot be mitigated against, though they can be managed (e.g. by limiting construction activities during periods of intense rain). Unloading of the peat mass by excavation, loading by plant and focusing of drainage can be managed by careful design, site specific stability analyses, informed working practices and monitoring.

2.2.2. Consequences of Peat Instability

Both peat slides and bog bursts have the potential to be large in scale, disrupting extensive areas of blanket bog and with the potential to discharge large volumes of material into watercourses.

A key part of the risk assessment process is to identify the potential scale of peat instability should it occur and identify the receptors of the consequences. Potential sensitive receptors of peat failure are:

- The development infrastructure and turbines (damage to turbines, tracks, substation, etc);
- Site workers and plant (risk of injury / death or damage to plant);
- Wildlife (disruption of habitat) and aquatic fauna;
- Watercourses and lochs (particularly associated with public water supply);
- Site drainage (blocked drains / ditches leading to localised flooding / erosion); and
- Visual amenity (scarring of landscape).

While peat failures may cause visual scarring of the peat landscape, most peat failures revegetate fully within 50 to 100 years and are often difficult to identify on the ground after this period of time (Feldmeyer-Christe and Küchler, 2002; Mills, 2002). Typically, it is short-term (seasonal) effects on watercourses that are the primary concern or impacts on public water supply.

3. DESK STUDY

3.1. Topography

The site is located on the Hill of Forss at elevations of between 125m and 140m AOD (Figure 2.3.1). The site access track rises from the A836 road up the northern flank of the hill. The Hill of Forss is of relatively gentle topography, comprising a ridge of low relief running between a small water body in the southwest and Cnoc na Feadaige in the northeast (at 144m AOD), the latter lying just outside the application boundary. To the south of the Hill of Forss, slopes fall gently onto Lythmore Moss.

Slope angles are generally very shallow (<5°) under the development footprint, other than on the north flank of the Hill of Forss where the slope angle increases slightly to between 6 and 7° (Figure 2.3.2). Plate 2.3.5 shows a perspective view of the site with key locations highlighted.

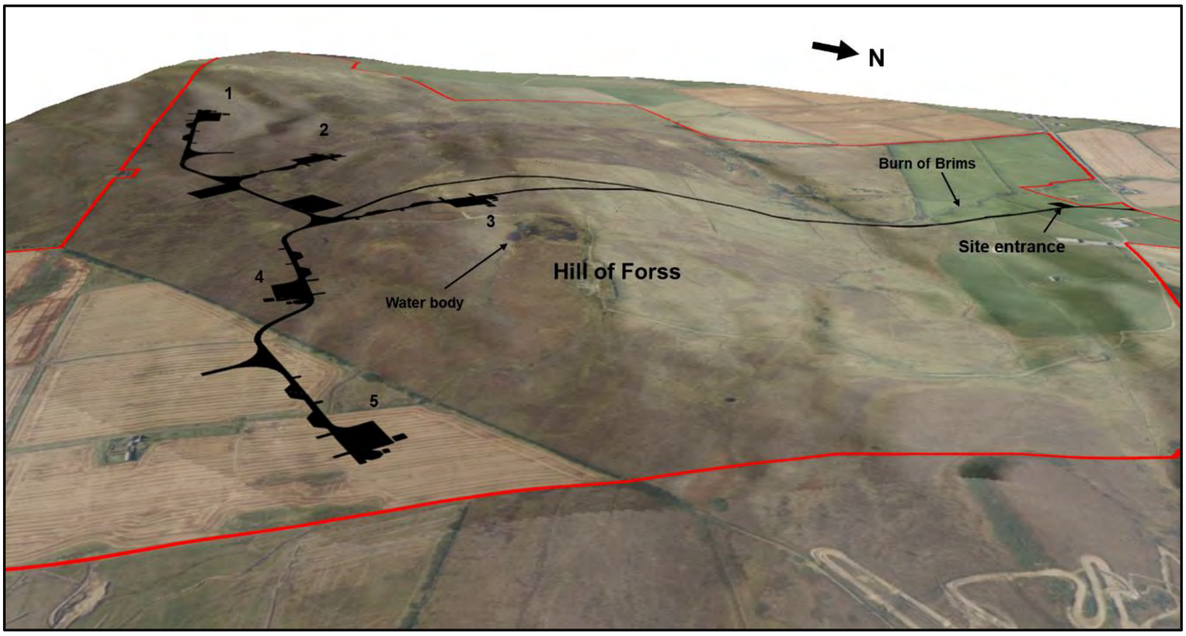

Plate 2.3.5 Perspective view of main infrastructure area (note 2x vertical exaggeration)

3.2. Geology

1:50,000 scale geological mapping available from the British Geological Survey (BGS) shows the site to be underlain by the Scrabster Flagstone Member, comprising interbedded siltstones and sandstones, and the Holborn Sandstone Member, again comprising interbedded siltstones and sandstones (Figure 2.3.3).

Equivalent 1:50,000 maps of superficial geology show glacial till (Forse Member) surrounding the Hill of Forss with small pockets of peat on its summit and on Lythmore Moss (Figure 2.3.3).

Reference to the Carbon and Peatland Map 2016 layers for Scotland indicate no nationally important Category 1 or Category 2 peatlands or carbon-rich soils within the site boundary (see inset on Figure 2.3.3).

There are no geologically designated sites within the Proposed Development.

3.3. Hydrology

The Hill of Forss contains a small, unnamed waterbody drained by a minor watercourse to the northwest, which itself is joined by a herringbone pattern of moor drains (Figure 2.3.4). Ultimately, these natural and artificial watercourses drain into the Burn of Brims outside the site boundary. Moor drains (or grips) are extensive across the site (Photo 2.3.1), in particular on the north flank of the Hill of Forss and on its western and southern sides (including towards Lythmore Moss).

Average annual rainfall for Caithness is c. 1,000mm per year (Met Office, 2019), which is relatively dry.

3.4. Land Use

Land use across the site is generally limited to sheep grazing. A number of stone walls cross the site to manage stock movement. As noted previously, there have been significant efforts expended on land drainage across the site. Quarrying has been undertaken locally.

Technical Appendix 7.1: National Vegetation Classification & Habitats Survey notes that burning has taken place in some parts of the site (Photo 2.3.2).

3.5. Peat Depth and Character

Peat probing has been undertaken in a number of phases since the original scheme commenced planning in 2016. Probing near key features was undertaken as part of the geomorphological walkover in November 2016. Phase 1 probing (100 m grid, 240 locations) was undertaken within the area proposed for infrastructure in September 2016 and Phase 2 probing (infrastructure-specific probing) was undertaken at turbines and along tracks between August 2018 and March 2019 (generating an additional 703 locations). Following further revisions to the layout and reduction in turbine numbers to 5 turbines, additional Phase 2 probing was undertaken in 2022 taking the total number of probed locations to 1,309.

Interpolation of peat depths was undertaken in the ArcGIS (Geographical Information System) environment using an inverse distance weighted (IDW) approach. This approach was selected because it preserves recorded depths at each probe location, unlike some other approaches (e.g. kriging), is computationally simple, and minimises ‘bullseye’ effects. The approach was selected after comparison of outputs with four other methods (natural neighbour, kriging, TIN and spline).

The peat depth model is shown on Figure 2.3.5 with probing locations superimposed. The model indicates:

- The majority of the site comprises organic soils of less than 0.5m depth.
- The two largest areas of peat are located east of the small water body on the Hill of Forss and in the west of the site northwest of Turbine 1. While the peat in these deposits is locally deep, infrastructure has been placed to avoid all three.
- The representation of peat on published geological maps is not supported by field evidence, and therefore Figure 2.3.5 supersedes the peat extent shown on Figure 2.3.3.

Comparison of the proposed infrastructure with the peat depth model indicates that the proposed layout falls almost entirely outside areas of peat, with minor overlaps at Turbine 2 and on the temporary access track.

Coring of the peat and organic soils across the site (see Technical Appendix 2.4) indicated the peat soils to be fibrous in nature, with no evidence of amorphous peat.

Observations of the base of the peat/organic soil made in a number of moor drains indicates flagstone underlying the peat, often with areas of cobbles or bedrock exposed in areas of very thin soil. However, a clay till was observed in proximity to Turbines 1 and 3 (see Technical Appendix 2.4).

3.6. Peatland Geomorphology

Digital aerial photography with a ground resolution of 1.0m was used to interpret and map geomorphological features within the site boundary. Additional imagery available on both Google Earth™ and bing.com/maps was also referred to in order to validate the air photo interpretation. This interpretation and the resulting geomorphological map (Figure 2.3.4) were subsequently verified during a walkover undertaken by an experienced peatland geomorphologist in November 2016. Photos 2.3.1 to 2.3.4 show typical ground conditions identified during the walkover.

Figure 2.3.4 provides a geomorphological map of the site. The presence, characteristics and distribution of peatland geomorphological features are helpful in understanding the hydrological function of a peatland, the balance of erosion and peat accumulation (or condition), and the sensitivity of a peatland to potential land-use changes.

In general, the site comprises heavily managed terrain, with areas of organic soil and shallow peat subject to significant artificial drainage. Artificial drain densities are very high in several parts of the site, with parallel drains sometimes c. 10m apart (even in areas with no peat). In some areas, sporadic areas of diffuse natural drainage systems were noted, but these have been significantly disrupted and compartmentalised by the artificial drains present across much of the site.

Otherwise, the site generally lacks features typical of upland blanket bog, with very few pools, gullies, haggs and groughs or flushes. No pipes were observed (e.g. through collapsed pipe ceilings) and no instability features, evidence of incipient instability or past landslides were noted. Instead, much of the site is dominated by planar terrain with a variety of vegetation covers and localised exposed substrate (where soils are thin).

Photo 2.3.1 Densely spaced drainage towards the south of the site

Photo 2.3.2 Degraded planar wet heath, although surface vegetation is blackened, charring of soil is not observed

Photo 2.3.3 Waterlogged summit (over bedrock) near water body

Photo 2.3.4 Generally shallow but very wet peat soils in hollow adjacent to water body

4. ASSESSMENT OF PEAT LANDSLIDE LIKELIHOOD

4.1. Introduction

This section provides details on the landslide susceptibility and limit equilibrium approaches to assessment of peat landslide likelihood used in this report. The assessment of likelihood is a key step in the calculation of risk, where risk is expressed as follows:

Risk = Probability of a Peat Landslide x Adverse Consequences

The probability of a peat landslide is expressed in this report as peat landslide likelihood, and is considered below. Due to the combination of moderate slopes and thinner peat at this site, the most likely mode of failure is peat slides, and this is the failure mechanism considered in this report.

4.2. Limit Equilibrium Approach

4.2.1. Overview

Stability analysis has been undertaken using the infinite slope model to determine the Factor of Safety (FoS) for a series of 25m x 25m grid cells within the Proposed Development boundary. For the proposed development, the areas of true peat (organic soil ≥0.5m depth) are relatively limited (Figure 2.3.5) and the limit equilibrium approach has been applied within these areas only. The limit equilibrium approach is the most frequently cited approach to quantitatively assessing the stability of peat slopes (e.g. Scottish Government, 2017; Boylan et al, 2008; Evans and Warburton, 2007; Dykes and Warburton, 2007; Creighton, 2006; Warburton et al, 2003; Carling, 1986). The approach assumes that failure occurs by shallow translational landsliding, which is the mechanism usually interpreted for peat slides. Due to the relative length of the slope and depth to the failure surface, end effects are considered negligible and the safety of the slope against sliding may be determined from analysis of a 'slice' of the material within the slope.

The stability of a peat slope is assessed by calculating a Factor of Safety, F, which is the ratio of the sum of resisting forces (shear strength) and the sum of driving forces (shear stress) (Scottish Government, 2017):

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

In this formula c' is the effective cohesion (kPa), γ is the bulk unit weight of saturated peat (kN/m^3), γw is the unit weight of water (kN/m^3), z is the vertical peat depth (m), h is the height of the water table as a proportion of the peat depth, β is the angle of the substrate interface (°) and ϕ' is the angle of internal friction of the peat (°). This form of the infinite slope equation uses effective stress parameters, and assumes that there are no excess pore pressures, i.e. that the soil is in its natural, unloaded condition. The choice of water table height reflects the full saturation of the soils that would be expected under the most likely trigger conditions, i.e. heavy rain.

Where the driving forces exceed the shear strength (i.e. where the bottom half of the equation is larger than the top), F is < 1, indicating instability. A factor of safety between 1 and 1.4 is normally taken in engineering to indicate marginal stability (providing an allowance for variability in the strength of the soil, depth to failure, etc). Slopes with a factor of safety greater than 1.4 are generally considered to be stable.

There are numerous uncertainties involved in applying geotechnical approaches to peat, not least because of its high water content, compressibility and organic composition (Hobbs, 1986; Boylan and Long, 2014). Peat comprises organic matter in various states of decomposition with both pore water and water within plant constituents, and the frictional particle-to-particle contacts that are modelled in standard geotechnical approaches are different in peats. There is also a tensile strength component to peat which is assumed to be dominant in the acrotelm, declining with increasing decomposition and depth. As a result, analysis utilising geotechnical approaches is often primarily of value in showing relative stability across a site given credible and representative input parameters rather than in providing an absolute estimate of stability. Representative data inputs have been derived from published literature for drained analyses considering natural site conditions.

4.2.2. Data Inputs

Stability analysis was undertaken in ArcMap GIS software. A 25m x 25m grid was superimposed on the full site extent and key input parameters derived for each grid cell. Only cells falling in areas of peat (>0.5m) were considered in the analysis. In total, c. 410 grid cells were analysed. A 25m x 25m cell size was chosen because it is sufficiently small to define a credible landslide size and avoid 'smoothing' of important topographic irregularities.

Parameter	Values	Rationale	Source
Effective cohesion (c')	2, 5	Credible conservative cohesion values for humified peat based on literature review	5, basal peat (Warburton et al., 2003) 8.74, fibrous peat (Carling, 1986) 7 - 12, H8 peat (Huat et al, 2014) 5.5 - 6.1, type not stated (Long, 2005) 3, 4, type not stated (Long, 2005) 4, type not stated (Dykes and Kirk, 2001)
Bulk unit weight (γ)	10.5	Credible mid-range value for humified catotelmic peat	10.8, catotelm peat (Mills, 2002) 10.1, Irish bog peat (Boylan et al 2008)
Effective angle of internal friction (ϕ')	20, 30	Credible conservative friction angles for humified peat based on literature review (only 20° used in analysis)	40 - 65, fibrous peat (Huat et al, 2014) 50 - 60, amorphous peat (Huat et al, 2014) 36.6 - 43.5, type not stated (Long, 2005) 31 - 55, Irish bog peat (Hebib, 2001) 34 - 48, fibrous sedge peat (Farrell & Hebib, 1998) 32 - 58, type not stated (Long, 2005) 23, basal peat (Warburton et al, 2003) 21, fibrous peat (Carling, 1986)
Slope angle from horizontal (β)	Various	Mean slope angle per 25 m x 25 m grid cell	5 m digital terrain model of site
Peat depth (z)	Various	Mean peat depth per 25 m x 25 m grid cell	Interpolated peat depth model of site
Height of water table as a proportion of peat depth (h)	1	Assumes peat mass is fully saturated (normal conditions during intense rainfall events or snowmelt, which are the most likely natural hydrological conditions at failure)	

Table 2.3.1 Geotechnical parameters for drained infinite slope analysis

Table 2.3.1 shows the input parameters and assumptions for the stability analysis undertaken. The shear strength parameters c' and ϕ' are usually derived in the laboratory using undisturbed samples of peat collected in the field and therefore site specific values are often not available ahead of detailed site investigation for a development. Therefore, for this assessment, a literature search has been undertaken to identify a range of credible but conservative values for c' and ϕ' quoted in fibrous and humified peats. FoS analysis was undertaken with conservative ϕ' of 20° and values of 2 kPa and 5 kPa for c'. These values fall at the low end of a large range of relatively low values (when compared to other soils).

4.2.3. Results

The outputs of the drained analysis (effective stress) are shown on Figure 2.3.6 for the more conservative parameter combination (minimum c' and ϕ') and indicate that even with minimum strength parameters, there is likely to be stability across the site. This is consistent with the lack of observation of instability features during the site walkover and on review of aerial imagery.

4.3. Landslide Susceptibility Approach

4.3.1. Overview

The landslide susceptibility approach is based on the layering of contributory factors to produce unique 'slope facets' that define areas of similar susceptibility to failure. These slope facets vary in size and are different to the regular grid used for the FoS approach, however, as with the FoS approach, the assessment is restricted to areas where peat is present. The number and size of slope facets varies from one part of the site to another according to the complexity of ground conditions. In total, c. 230 facets were considered in the analysis, with an average area of c. 550m^2 (or an average footprint of c. 23m x 23m, consistent with smaller to medium scale peaty soil or peat slides reported in the published literature.

Eight contributory factors are considered in the analysis: slope angle (S), peat depth (P), substrate geology (G), peat geomorphology (M), drainage (D), slope curvature (C), forestry (F), and land use (L). For each factor, a series of numerical scores between 0 and 3 are assigned to factor 'classes', the significance of which is tabulated for each factor. The higher a score, the greater the contribution of that factor to instability for any particular slope facet. Scores of 0 imply neutral / negligible influence on instability.

Factor scores are summed for each slope facet to produce a peat landslide likelihood score (S_{PL}), the maximum being 24 (8 factors, each with a maximum score of 3).

$$S_{PL} = S_S + S_P + S_G + S_M + S_D + S_C + S_F + S_L$$

In practice, a maximum score is unlikely, as the chance of all contributory factors having their highest scores in one location is very small. The following sections describe the contributory factors, scores and justification for the Proposed Development.

It should be noted that the methodology employed for the Proposed Development has developed since the previous assessment in 2019, and a number of factor tables have been updated, most notably slope curvature.

4.3.2. Slope Angle (S)

Table 2.3.2 shows the slope ranges, their association with instability and related scores for the slope angle contributory factor. Slope angles were derived from the 5 m digital terrain model shown on Figure 2.3.1 and scores assigned based on reported slope angles associated with peat landslides rather than a simplistic assumption that 'the steeper a slope, the more likely it is to fail' (e.g. Plate 2.2).

Slope range (°)	Association with instability	Peat slide
≤2.0	Slope angle ranges for peat slides are based on lower and upper limiting angles for observations of occurrence (see Plate 2.3.4 and increase with increasing slope angle until the upper limiting angle.	0
2.0 - 5.0		2
5.0 – 10.0		3
10.0 - 15.0		3
>15.0		3

Table 2.3.2 Slope classes, association with instability and scores

Figure 2.3.2 shows the distribution of slope angle scores across the site. Due to the very gentle slopes on the summits where peat is present, slope angle scores are typically low.

4.3.3. Peat Depth (P)

Table 2.3.3 shows the peat depths, their association with instability and related scores for the peat depth contributory factor. Peat depths were derived from the peat depth model shown on Figure 2.3.5 and reflect the peat depth ranges most frequently associated with peat landslides (see Plate 2.3.4).

Peat depth range (m)	Association with instability	Peat slide
>1.5	Bog bursts are the dominant failure mechanism in this depth range where basal peat is more likely to be amorphous	1
0.5 - 1.5	Peat slides are the dominant failure mechanism in this depth range where basal peat is less likely to be amorphous	3
<0.5	Organic soil rather than peat, failures would be peaty-debris slides rather than peat slides or bog bursts and are outside the scope	0

Table 2.3.3 Peat depth classes, association with instability and scores

The distribution of peat depth scores is shown on Figure 2.3.7. Peat depth scores are generally high, reflecting the relatively shallow peat present.

4.3.4. Substrate Geology (G)

Table 2.3.4 shows substrate type, their association with instability and related scores for the peat depth contributory factor. The shear surface or failure zone of peat failures typically overlies an impervious clay or mineral (bedrock) base giving rise to impeded drainage. This, in part, is responsible for the presence of peat, but also precludes free drainage of water from the base of the peat mass, particularly under extreme conditions (such as after heavy rainfall, or snowmelt).

Peat failures are frequently cited in association with glacial till deposits in which an iron pan is observed in the upper few centimetres (Dykes and Warburton, 2007). They have also been observed over glacial till without an obvious iron pan, or over impermeable bedrock. They are rarely cited over permeable bedrock, probably due to the reduced likelihood of peat formation.

Substrate Geology	Association with instability	Peat slide
Cohesive (clay) or iron pan	Failures are often associated with clay substrates and/or iron pans	3

Till with a minor clay component	A minor clay component is more likely to be associated with instability than granular till or bedrock	2
Granular or bedrock	Failures are less frequently associated with bedrock or granular (silt / sand / gravel) substrates	1

Table 2.3.4 Substrate geology classes, association with instability and scores

Observations from site (both observations and coring) indicated bedrock underlying the organic soils and peat, other than in the south of the site where clay was observed. Accordingly, the northern peat areas are scored as impermeable bedrock and the southern peat areas as cohesive (clay) (Figure 2.3.7).

4.3.5. Peat Geomorphology (M)

Table 2.3.5 shows the geomorphological features identified across the site, their association with instability and related scores. The proposed development site lacks geomorphological features typical of undisturbed upland blanket peatlands when compared with other sites in Scotland.

Geomorphology	Association with instability	Peat slide
Incipient instability (cracks, ridges, bulging)	Failures are likely to occur where pre-failure indicators are present	3
Planar with pipes	Failures generally occur on planar slopes, and are often reported in areas of piping	3
Planar with pools / quaking bog	Bog bursts are more likely in areas of perched water (pools) or subsurface water bodies (quaking bog)	2
Flush / Sphagnum lawn (diffuse drainage)	Peat slides are often reported in association with areas of flushed peat or diffuse drainage	3
Planar (no other features) / undrained ground	Failures generally occur on planar slopes rather than dissected or undulating slopes	2
Peat between rock outcrops	Failures are rarely reported in areas of peat with frequent rock outcrops	1
Slightly eroded (minor gullies)	Failures are rarely reported in areas with gullying or bare peat	1
Heavily eroded (extensive gullies) / bare peat	Failures are not reported in areas that are heavily eroded or bare	0

Table 2.4.5 Peat geomorphology classes, association with instability and scores

Figure 2.3.7 shows the geomorphological classes from Figure 2.3.4 re-coloured to correspond with Table 2.4.5.

4.3.6. Artificial Drainage (D)

Table 2.3.6 shows artificial drainage feature classes, their association with instability and related scores. Transverse / oblique drainage lines may reduce peat stability by creating lines of weakness in the peat slope and encouraging the formation of peat pipes. Review of published literature indicates that a number of peat failures have been identified which have failed over moorland grips (Warburton et al, 2004). The influence of changes in hydrology become more pronounced the more transverse the orientation of the drainage lines are relative to the overall slope.

The effect of drainage lines is captured through the use of a 25m buffer on each artificial drainage line (producing a 50m wide zone of influence) present within the peat soils at the site. Buffers are shown on Figure 2.3.7.

Drainage Feature	Association with instability	Peat slide
Drains aligned along contours (<15 °)	Drains aligned to contour create lines of weakness in slopes	3
Drains oblique (15-60°) to contour	Most reports of peat slides and bog bursts in association with drainage occurs where drains are oblique to slope	2
Drains aligned downslope (<30° to slope)	Failures are rarely associated with artificial drains parallel to slope or adjacent to natural drainage lines	1
No / minimal artificial drainage	No influence on stability	0

Table 2.3.6 Drainage feature classes, association with instability and scores

4.3.7. Slope Curvature (C)

Table 2.3.7 shows slope (profile) curvature classes, their association with instability and related scores. Convex and concave slopes (i.e. positions in a slope profile where slope gradient changes by a few degrees) have frequently been reported as the initiation points of peat landslides by a number of authors. The geomechanical reason for this is that convexities are often associated with thinning of peat, such that thicker peat upslope applies stresses to thinner 'retaining' peat downslope. Conversely, buckling and tearing of peat may trigger failure at concavities (e.g. Dykes & Warburton, 2007; Boylan and Long, 2011). However, review of reported peat landslide locations against Google Earth elevation data indicates that the majority of peat slides occur on rectilinear (straight) slopes and that the reporting of convexity as a key driver may be misleading.

Profile Curvature	Association with instability	Peat slide
Rectilinear Slope	Peat slides are most frequently reported on rectilinear slopes, while bog bursts are often reported on rectilinear slopes	3
Convex Slope	Peat slides are often reported on or above convex slopes while bog bursts are most frequently associated with convex slopes	2
Concave Slope	Peat failures are occasionally reported in association with concave slopes	1

Table 2.3.7 Slope curvature classes, association with instability and scores

Axes of convexity (running along the contour) were assigned a 25m buffer to produce 50m (upslope to downslope) convexity zones and these were assigned scores in accordance with Table 2.3.7 above. Given the location of peat at the site on generally rectilinear slopes, the highest score applies across the site and there are no areas with buffers of concavity or convexity (Figure 2.3.7).

4.3.8. Forestry (F)

Table 2.3.8 shows forestry classes, their association with instability and related scores. A report by Lindsay and Bragg (2004) on Derrybrien suggested that row alignments, desiccation cracking and loading (by trees) could all influence peat stability. There is no afforested terrain within the site and therefore the full site is assigned a score of 0 (Figure 2.3.7).

Forestry Class	Association with instability	Peat slide
Deforested, rows oblique to slope	Deforested peat is less stable than afforested peat, and inter ridge cracks oblique to slope may be lines of weakness	3
Deforested, rows aligned to slope	Deforested peat is less stable than afforested peat, but slope aligned inter ridge cracks have less impact	2
Afforested, rows oblique to slope	Afforested peat is more stable than deforested peat, but inter ridge cracks oblique to slope may be lines of weakness	2
Afforested, rows aligned to slope	Afforested peat is more stable than deforested peat, but potentially less stable than unforested (never planted) peat	1
Not afforested	No influence on stability	0

Table 2.3.8 Forestry classes, association with instability and scores

4.3.9. Land use (L)

Table 2.3.9 shows land use classes, their association with instability and related scores. A variety of land uses have been associated with peat failures (see Section 2.2). While it is hypothesised that burning may cause desiccation cracking in peat and facilitate water flows to basal peat (and potential shear surfaces), there is little evidence directly relating burnt ground to peat landslide events and the general lack of peat (which struggles to 'rewet' once burnt) on site means that changes to the physical structure of peat are unlikely. Land use scores are shown on Figure 2.3.7 and are limited to an area adjacent to quarrying (with a score of 2).

Land Use	Association with instability	Peat slide
Machine cutting	Machine cutting may compartmentalise slopes, but has been reported primarily in association with peat slides	3
Quarrying	Quarrying may remove slope support from upslope materials, and has been observed with spreading failures (bog bursts)	2
Hand cutting (turbary)	Hand cutting may remove slope support from upslope materials, and has been reported with raised bog failures	1
Burning (deep cracking to substrate)	Failures are rarely associated with burning, but deep desiccation cracking will have the most severe effects	2
Burning (shallow cracking)	Failures are rarely associated with burning, shallow desiccation cracking will have very limited effects	1
Grazing	Failures have not been associated with grazing, no influence on stability	0

Table 2.3.9 Land use classes, association with instability and scores

4.3.10. Generation of Slope Facets

The eight contributory factor layers shown on Figure 2.3.7 were combined in ArcMap to produce approximately 1,170 slope facets. Scores for each facet were then summed to produce a peat landslide likelihood score. These likelihood scores were then converted into descriptive 'likelihood classes' from 'Very Low' to 'Very High' with a corresponding numerical range of 1 to 5 (in a similar format to the Scottish Government BPG).

Summed Score from Contributory Factors	Typical site conditions associated with score	Likelihood (Qualitative)	Landslide Likelihood Score
≤ 7	Unmodified peat with no more than low weightings for peat depth, slope angle, underlying geology and peat morphology	Very Low	1
8 - 12	Unmodified or modified peat with no more than moderate or some high scores for peat depth, slope angle, underlying geology and peat morphology	Low	2
13 - 17	Unmodified or modified peat with high scores for peat depth and slope angle and / or high scores for at least three other contributory factors	Moderate	3
18 - 21	Modified peat with high scores for peat depth and slope angle and several other contributory factors	High	4
> 21	Modified peat with high scores for most contributory factors (unusual except in areas with evidence of incipient instability)	Very High	5

Table 2.3.10 Likelihood classes derived from the landslide susceptibility approach

Table 2.3.10 describes the typical site conditions associated with each score range. A judgement was made that for a facet to have a moderate or higher likelihood of a peat landslide, a likelihood score would be required equivalent to both the worst case peat depth and slope angle scores (3 in each case, i.e. 3 x 2 classes) alongside three intermediate scores (of 2, i.e. 2 x 3 classes) for other contributory factors. This means that any likelihood score of 13 or greater would be equivalent to at least a moderate likelihood of a peat landslide. Given that the maximum score attainable is 24, this seems reasonable.

4.3.11. Results

Figure 2.3.8 shows the outputs of the landslide susceptibility approach for peat slides. The results indicate that the majority of the site has a 'Low' or 'Very Low' likelihood of a peat landslide, with some areas calculated to have 'Moderate' likelihoods. This aligns with the FoS approach, which also indicates the site to be stable.

Two sections of the proposed layout intersect with areas of 'Moderate' peat landslide likelihood and therefore a consequence assessment is required (Plate 2.3.2). These sections are:

- A 60m section of the turning head adjacent to the control building and substation compound (referred to henceforth as Source Zone 1).
- A 75m section of track extending from the same compound towards the temporary construction compound (referred to as Source Zone 2).

These sections of infrastructure are highlighted in burgundy on Figure 2.3.8. In order to calculate risk associated with these potential source zones, it is necessary to identify the potential consequences of instability, should it occur. Plate 2.3.6 shows risk levels as a product of landslide likelihood (susceptibility) and consequence. Section 5 of this report describes the consequence assessment and risk calculation for all areas where infrastructure intersects "Moderate" likelihood of a peat landslide.

		Adverse Consequence (scores bracketed)				
		Very High (5)	High (4)	Moderate (3)	Low (2)	Very Low (1)
Peat landslide likelihood (scores bracketed)	Very High (5)	High	High	Medium	Low	Low
	High (4)	High	Medium	Medium	Low	Negligible
	Moderate (3)	Medium	Medium	Low	Low	Negligible
	Low (2)	Low	Low	Low	Negligible	Negligible
	Very Low (1)	Low	Negligible	Negligible	Negligible	Negligible

Score	Risk Level	Action suggested for each zone
17 - 25	High	Avoid project development at these locations
11 - 16	Medium	Project should not proceed in MEDIUM areas unless risk can be avoided or mitigated at these locations, without significant environmental impact, in order to reduce risk ranking to LOW or NEGLIGIBLE.
5 - 10	Low	Project may proceed pending further post-consent investigation in LOW areas to refine risk level and/or mitigate any residual hazards through micro-siting or specific design measures
1 - 4	Negligible	Project should proceed with good practice monitoring and mitigation of ground instability / landslide hazards at these locations as appropriate

Plate 2.3.6 Top: risk ranking as a product of likelihood and consequence; Bottom: suggested action given each level of calculated risk

5. ASSESSMENT OF CONSEQUENCE AND RISK

5.1. Introduction

In order to calculate risk, the potential consequences of a peat landslide must be determined. This requires identification of receptors and an assessment of the consequences for these receptors should a peat landslide occur. This section describes the consequence assessment and then provides risk results based on the product of likelihood and consequence.

5.2. Receptors

Peat uplands are typically host to the following receptors: watercourses and associated water supplies (both private and public), terrestrial habitats (e.g. groundwater dependent terrestrial ecosystems or GWDTEs) and infrastructure, both that related to the wind farm and other infrastructure, e.g. roads and power lines. These are considered for the Proposed Development below.

5.2.1. Watercourses

Natural watercourses within the site are not designated and those outside the site are not hydrologically connected to the site other than through diffuse drainage lines or moor drains. Accordingly, watercourses and the summit waterbody are assigned a consequence score of 2 (see Table 2.3.11 below).

Receptor and type	Consequence	Score	Justification for Consequence Score
Watercourses	Short term increase in turbidity and acidification, potential fish kill	2	Undesignated watercourse distant from source zones, no sensitive species noted
Terrestrial habitats (non wet modified bog and GWDTE)	Short to medium term loss of vegetation cover, carbon release from drying landslide runout	2	Habitats near source zones are not generally priority peatland habitats, long term effects unlikely following revegetation
Terrestrial habitats (wet modified bog and GWDTE)	Short to medium term loss of vegetation cover, carbon release from drying landslide runout	3	Long term effects on GWDTE and wet modified bog are unlikely following revegetation
Wind farm infrastructure (Project)	Damage to infrastructure, injury to site personnel, possible loss of life	5	Loss of life, though very unlikely, is a severe consequence; financial implications of damage and re-work are less significant

Table 2.3.11 Receptors considered in the consequence analysis

5.2.2. Habitats

Technical Appendix 7.1 of the EIA indicates that the majority of vegetation on site is wet heath, with significant degradation from a history of over-grazing, drainage and burning. Away from wet heath areas, improved grassland and arable fields occupy the site periphery. There are localised areas of wet modified bog and these habitat types are assigned a consequence score of 3 (see Table 2.3.11).

There is potential for GWDTE in some parts of the site. These do not overlap with infrastructure, although a moderately groundwater dependent area of wet heath is located downslope of Source Zone 2. Specific GWDTE features are assigned a consequence score of 3 (see Table 2.3.11).

5.2.3. Infrastructure

There are no public roads or significant non-wind farm infrastructure passing through the proposed development or within close proximity to proposed infrastructure. Infrastructure that would be most affected in the event of a peat landslide would be the Proposed Development infrastructure. These effects would be most likely during construction, at which time personnel would be using the access track network or be present at infrastructure locations for long periods. While commercial losses would be important to the Applicant, loss of life / injury would be of greater concern, and a consequence score of 5 is assigned for any infrastructure locations subject to potential peat landslides (Table 2.3.11). However, risks to life can be mitigated through safe systems of working. These infrastructure risks are not considered to be 'environmental' risks and are not explicitly considered in the consequence assessment below.

5.3. Consequences

5.3.1. Overview

A consequence assessment has been undertaken by determining the potential for landslides sourced at infrastructure locations with a Moderate natural likelihood of peat instability to impact the receptors identified above. For example, if a turbine is located in a Moderate area (likelihood score of 3) of open slope and is located 50m from a watercourse (with a consequence score of 2), it is probable that a landslide triggered during construction would reach that watercourse. The calculated risk would be a product of the likelihood and consequence scores (likelihood: 3 x consequence: 2 = risk: 6, see Plate 2.3.6) and be equivalent to a "Medium" risk.

Figure 2.3.9 shows in burgundy the two infrastructure locations that overlap with moderate likelihoods, based on the combined landslide likelihood scores described in Section 4. In order to determine the likelihood of impact on watercourses and infrastructure, 'runout pathways' have been defined that show the estimated maximum footprint of the landslide. Runout pathways are divided in a downslope direction into 50m, 100m, 250m and 500m zones on the basis of typical runout distances detailed in Mills (2002). The likelihood of runout passing from one runout zone to the next (e.g. from the 50m zone into the 100m zone) is based on the proportion of the published peat landslide population that reaches each runout distance shown on Plate 2.3.7 (0-50m: 100%, 50-100m: 87%, 100-250m: 56%, 250-500m: 44%). The first 50m includes the landslide source area.

5.3.2. Limits on runout

Landslide runout may be "supply-limited" by the availability of peat material generated in the failure or source zone. Typically, mobilised material thins with increasing distance from the source zone as rafts of landslide material break down into blocks, and blocks become abraded and roll, breaking down further into a blocky slurry. Following identification of runout zones, additional analysis has been undertaken to approximate this effect.

The analysis assumes a source volume equivalent to the source footprint (0m - 50m zone) multiplied by the average peat depth in this source zone (from the peat depth model). This volume is then distributed over the full runout pathway (i.e. mobilised volume / runout area) to generate an average thickness of deposit. As the runout length and area increases, the volume thins, in keeping with observed peat landslide deposits. Where deposits fall below 0.2m in thickness, it is assumed that runout will stall due to the roughness of surface vegetation relative to the thickness of landslide material. If the thickness is calculated to be 0.2m or less in the zone adjoining a watercourse, then it is judged that there will be no significant impact on that watercourse (even if a landslide occurs).

Other barriers may include topographic or physical barriers. Figure 2.3.9 shows that the runout zones from Source Zones 1 and 2 coalesce downslope in a shallow trough and are likely to be directed towards the southern site boundary, which is demarcated by a stone wall. Moreover, the gradient is very gentle here, with a fall of around 5m over 250m distance, and it is considered very unlikely that any mobilised material would displace far, and if it reached the end of the 250m runout zone, would be arrested by the wall.

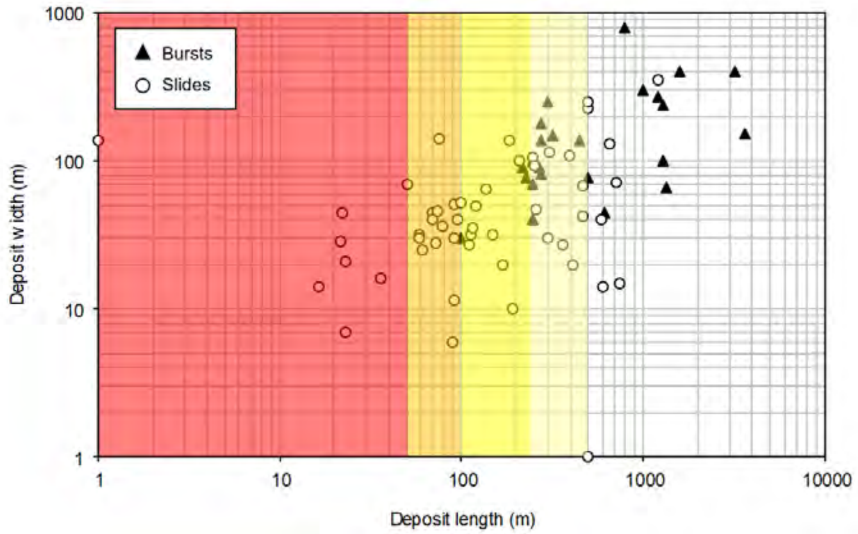

Plate 2.3.7 Runout distances for published peat landslides (after Mills, 2002), colours on the plot correspond to runout pathway zones on Figure 2.3.9

5.3.3. Results of runout analysis

Based on the source and runout zones shown on Figure 2.3.9:

- Runout from Source Zone 1 will not leave the site boundary and will not impact potential GWDTE features, although there may be some minor impact on the wet modified bog adjacent to the stone wall.
- Runout from Source Zone 2 will follow the pathway for runout from Source Zone 1, with the same minimal impact.

5.4. Calculated Risk

Risk levels have been calculated as a product of likelihood and consequence and are shown on Table 2.3.12 below, with key receptor identified, citing the key receptor, the depth of runout at the receptor (based on reduction in debris thickness as the runout area increases downslope and the landslide becomes exhausted of debris) and the calculated risk.

Source Zone	Infrastructure	Landslide Thickness (m)		Receptor	Likelihood	Consequence	Risk
		Source	Receptor				
1	Turning head	0.59	0.59 – 0.19	Wet modified bog / wet dwarf shrub heath	Moderate	Low	Low
2	Access track	0.55	0.55 – 0.11		Moderate	Low	Low

Table 2.3.12 Source locations, runout thicknesses environmental receptors and risks

Based on the calculated risks shown on Table 2.3.12, site-wide good practice measures should be sufficient to manage and mitigate any construction induced instability risks. This is considered in the next section.

6. RISK MITIGATION

6.1. Overview

A number of mitigation opportunities exist to further reduce the risk levels identified at the Proposed Development site. These range from infrastructure specific measures (which may act to reduce peat landslide likelihood, and, in turn, risk) to general good practice that should be applied across the site to engender awareness of peat instability and enable early identification of potential displacement and opportunities for mitigation.

Risks may be mitigated by:

i. Post-consent site specific review of the ground conditions contributing to Moderate likelihoods which may result in a reduced likelihood, and in turn, further reduction in risk; examples include tension cracks along the peat escarpment and artificial drains aligned oblique to contour; and

ii. Precautionary construction measures – including use of monitoring, good practice and a geotechnical risk register relevant to all locations.

Based on the analysis presented in this report, risks are calculated to be “Low” or “Negligible” across the site, and site-specific mitigation is not required to reduce risks pre-consent. Sections 6.1 to 6.3 provide information on good practice pre-construction, during construction and post-construction (i.e. during operation).

6.2. Good Practice Prior to Construction

Site safety is critical during construction, and it is recommended that detailed intrusive site investigation and laboratory analysis are undertaken ahead of the construction period in order to characterise the strength of the soils in the areas in which excavations are proposed. These investigations should be sufficient to:

1. Determine the strength of free-standing soils in excavations;
2. Determine the strength of loaded peat (where excavators and plant are required to operate on floating hardstandings or track, or where operating directly on the bog surface); and
3. Identify sub-surface water-filled voids or natural pipes delivering water to the excavation zone, e.g. through the use of ground penetrating radar or careful pre-excavation site observations.

A comprehensive Geotechnical Risk Register should be prepared post-consent but pre-construction detailing sequence of working for excavations, measures to minimise peat slippage, design of retaining structures for the duration of open hole works, monitoring requirements in and around the excavation and remedial measures in the event of unanticipated ground movement. The risk register should be considered a live document and updated with site experience as infrastructure is constructed. Ideally, a contractor with experience of working in deep peat should be engaged to undertake the works.

6.3. Good Practice During Construction

The following good practice should be undertaken during construction:

For excavations:

- Use of appropriate supporting structures around excavations (e.g. for turbines, crane pads and compounds) to prevent collapse and the development of tension cracks;

- Avoid cutting trenches or aligning excavations across slopes (which may act as incipient back scars for peat failures) unless appropriate mitigation has been put in place;
- Implement methods of working that minimise the cutting of the toes of slope, e.g. working up-to-downslope during excavation works;
- Monitor the ground upslope of excavation works for creep, heave, displacement, tension cracks, subsidence or changes in surface water content;
- Monitor cut faces for changes in water discharge, particularly at the peat-substrate contact; and
- Minimise the effects of construction on natural drainage by ensuring that natural drainage pathways are maintained or diverted such that there is alteration of the hydrological regime of the site is minimised or avoided; drainage plans should avoid creating drainage/infiltration areas or settlement ponds towards the tops of slopes (where they may act to both load the slope and elevate pore pressures).

For cut tracks:

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

For floating tracks:

- Allow peat to undergo primary consolidation by adopting rates of road construction appropriate to weather conditions;
- Monitor the effects of secondary compression over the life of the development while the tracks are utilised (up to 25 years) to ensure running surfaces remain elevated above the ground surface and do not cause ponding;
- Identify ‘stop’ rules, i.e. weather dependent criteria for cessation of track construction based on local meteorological data;
- Run vehicles at 50% load capacity until the tracks have entered the secondary compression phase; and
- Prior to construction, setting out the centreline of the proposed track to identify any ground instability concerns or particularly wet zones.

For storage of peat and for restoration activities:

- Ensure stored peat is not located upslope of working areas or adjacent to drains or watercourses;
- Undertake site specific stability analysis for all areas of peat storage (if on sloping ground) to ensure the likelihood of destabilisation of underlying peat is minimised;
- Avoid storing peat on slope gradients >3° and preferably store on ground with neutral slopes and natural downslope barriers to peat movement;
- Monitor effects of wetting / re-wetting stored peat on surrounding peat areas, and prevent water build up on the upslope side of peat mounds;

- Undertake regular monitoring of emplaced peat in restoration areas, if applicable, to identify evidence of creep or pressure on retaining structures (dams and berms); and
- Maximise the interval between material deliveries over newly constructed tracks that are still observed to be within the primary consolidation phase.

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

- The geotechnical risk register prepared prior to construction should be updated with site experience as infrastructure is constructed;
- Full site walkovers should be undertaken at scheduled intervals to be agreed with the Local Authority to identify any unusual or unexpected changes to ground conditions (which may be associated with construction, or which may occur independently of construction);
- All construction activities and operational decisions that involve disturbance to peat deposits should be overseen by an appropriately qualified geotechnical engineer with experience of construction on peat sites;
- Awareness of peat instability and pre-failure indicators should be incorporated in site induction and training to enable all site personnel to recognise ground disturbances and features indicative of incipient instability;
- A weather policy should be agreed and implemented during works, e.g. identifying ‘stop’ rules (i.e. weather dependent criteria) for cessation of track construction or trafficking; and
- Monitoring checklists should be prepared with respect to peat instability addressing all construction activities proposed for site.

It is considered that taken together, these mitigation measures should be sufficient to reduce risks to construction personnel to Negligible by reducing consequences to minor injury or programme delay (i.e. Moderate consequences) with a Very Low likelihood of occurrence.

6.4. Good Practice Post-Construction

Following cessation of construction activities, monitoring of key infrastructure locations should continue by full site walkover to look for signs of unexpected ground disturbance, including:

- Ponding on the upslope side of infrastructure sites and on the upslope side of access tracks;
- Changes in the character of peat drainage within a 50m buffer strip of tracks and infrastructure (e.g. upwelling within the peat surface upslope of tracks, sudden changes in drainage behaviour downslope of tracks);
- Blockage or underperformance of the installed site drainage system;
- Slippage or creep of stored peat deposits; and
- Development of tension cracks, compression features, bulging or quaking bog anywhere in a 50m corridor surrounding the site of any construction activities or site works.

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

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Cairnmore Hill Wind Farm
Phase 1 and 2 Peat Depth & Coring Survey Report
Technical Appendix 2.4

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CONTENTS

List of Figures

1 INTRODUCTION

MacArthur Green was commissioned by RES Ltd ('the Applicant'), to undertake peat depth and coring surveys to aid the design process and to inform an assessment of the nature and condition of the peatland at the proposed Cairnmore Hill Wind Farm (hereafter referred to as the 'Proposed Development').

This report has been produced by MacArthur Green in accordance with Scottish Environment Protection Agency (SEPA) and Scottish Natural Heritage (SNH) guidelines[1]. Those contributing to the preparation of the technical appendix have undergraduate and/or postgraduate degrees in relevant subjects, have professional experience, and hold professional memberships relating to their field of expertise (e.g., Chartered Institute of Ecology and Environmental Management (CIEEM) or Association of Geographic Information (AGI)).

This report was previously submitted in support of the Environmental Impact Assessment (EIA) for Cairnmore Hill Wind Farm original planning application (2019). This report has been updated to reflect the new layout and includes the additional peat depth data that was collected in 2022.

2 AIMS AND OBJECTIVES

The surveys were split into two phases, with the following aims and objectives:

2.1 Phase 1

- **Aim 1: Gather high resolution peat depth data on a 100 m² systematic grid for the peat study area[2].**
    - Objective 1.1: Inform the layout of the Proposed Development's infrastructure to help reduce impacts associated with blanket mire habitats; and
    - Objective 1.2: Provide peat depth data to: 1) inform the impact of the Proposed Development on carbon losses arising from disturbance to peatland habitats; and 2) inform a draft Peat Management Plan (PMP) for the site.

2.2 Phase 2

- **Aim 1: Gather additional high-resolution peat depth data around proposed turbine and infrastructure locations.**
    - Objective 1.1: Further inform the layout of the Proposed Development's infrastructure to help reduce impacts associated with peatland habitats; and
    - Objective 1.2: Provide peat depth data to inform the impact of the Proposed Development on carbon losses arising from disturbance to peatland habitats.
- **Aim 2: Present data on the nature of peat deposits at key infrastructure locations**.
    - Objective 2.1: Provide data to inform a draft PMP.
    - Objective 2.2: Assess the accuracy of peat depth probe samples.

These surveys detail the depth and character of the peatland across the site. A full and detailed description of the vegetation present on the site, which may also contribute to the characterisation of the peatland condition, can be found in Technical Appendix 7.1: National Vegetation Classification (NVC) & Habitats Survey Report and Technical Appendix 7.4: Caledonian Conservation Baseline Non-Avian Ecology Report 2014: Hill of Forss Wind Farm.

3 THE SITE AND STUDY AREA

The Proposed Development is for five wind turbines and associated infrastructure and covers an area of approximately 3.58 km² located approximately 4.5 km west of Scrabster on the north coast of Caithness in the Scottish Highlands.

The peat depth and mire assessment study area ('peat study area') covers approximately 309.38 ha and reaches an elevation of 138 m above sea level (a.s.l.) at the summit of Cairnmore Hillock to the west of the site (see **Figure 2.4.1**).

There is no forestry or woodland in the peat study area. The site is used largely for grazing and is drained by multiple minor watercourses and drains which eventually discharge off the north coast. The general habitats on the site include grazed and degraded wet heath and wet modified bog. For a full description of the site, see Chapter 2: Development Description and Chapter 3: Site Selection, Design Evolution and Alternatives.

4 METHODOLOGY

The peat surveys were carried out by MacArthur Green on the following dates:

- 7th to 9th of September 2016 inclusive (Phase 1 probing);
- 28th to 31st of August 2018 inclusive (Phase 2 probing and peat coring);
- 4th to 7th March 2019 (additional Phase 2 probing); and
- 29th March 2022 (additional Phase 2 probing following redesign).

Surveys followed best practice guidance published at the time of survey with regard to surveying for developments on peatland.[1,3]

The methods employed for peat depth probing and peat coring are detailed further in Sections 4.1 and 4.2 below.

4.1 Phase 1 Peat Probing

4.1.1 Peat Depth Analysis

The adopted sampling frequency took due consideration of good practice and published guidance referred to above.

The following methods were employed:

[1] Scottish Government, Scottish Natural Heritage, SEPA. (2017). *Peatland Survey. Guidance on Developments on Peatland*. http://www.gov.scot/Resource/0051/00517174.pdf
[2] The peat study area for the Proposed Development comprised the area as detailed in Figure 2.4.1.
[3] Scottish Renewables and SEPA (2012). Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste.

An initial feasibility exercise overlaying a 200 m2 grid across the peat study area was used to generate sampling points.

In areas where peat or infrastructure was indicated, the peat study area was sampled using a 100 m2 systematic grid (**Figure 2.4.1**). A random point was selected within the peat study area and the grid was established around the random point. The grid was orientated north to south for ease of navigation.

Geographical Information System (GIS) was used to generate the systematic grid and related sampling locations.

240 samples were generated in total.

Sampling locations were downloaded on to hand-held Global Positional System (GPS) units, which were used to locate sampling locations in the field.

A custom made collapsible solid steel peat depth probe was used at each sample point to establish substratum depth. Full depth recordings were taken to the nearest centimetre (cm)4.

The underlying substrate was defined as peat-based or non-peat based.

Peat depth data were modelled using 'Inverse Distance Weighted' (IDW) interpolation in ArcMAP 10.8©. This interpolation method is best suited to situations where the density of samples is great enough to capture the local surface variation needed for the analysis (Childs, 2004).

A depth model was generated using the following categories of peat depth:

a. 0; 0-50 cm; 51-100 cm, 101-200 cm, 101-200 cm and 100 cm intervals thereafter.

4.2 Phase 2 Peat Probing & Coring

4.2.1 Peat Depth Analysis

The first phase of peat depth probing and analysis (Phase 1 peat survey) was carried out on a 100 m² systematic grid. This peat depth data and other constraints were used to inform the layout of the Proposed Development, including the turbine locations, substation, access track alignments, compounds etc.

The second phase of intensive peat probing (Phase 2 peat survey) supplements the original data and gathers further high-resolution data for the site on and adjacent to the footprint of proposed infrastructure.

The following methods were employed:

1. Where infrastructure likely requires the excavation of peat, e.g., at wind turbines, substation, compounds etc., peat depth samples were taken at 10 m intervals along crosshairs from the central point of the infrastructure feature.

   The alignment of proposed access tracks was sampled at 50 m intervals, with measurements taken on the access track centreline and points 10 m perpendicular to the centreline on either side of the proposed track.

   GIS was used to generate the sampling locations.

   In total 1,022 Phase 2 sample locations were generated. The Phase 2 peat depth probing locations sampled are also shown in **Figure 2.4.1**.

   Sampling locations were downloaded on to hand-held GPS units, which were used to locate sample points in the field.

   A custom made collapsible solid steel peat depth probe was used at each sample point to establish peat depth. Full depth recordings were taken[4].

   Peat depth data were modelled using IDW interpolation in ArcMap 10.8©, as per the Phase 1 probing data.

   A depth model was generated using the following categories of peat depth:

   a. 0; 0-50 cm; 51-100 cm, 101-200 cm, 101-200 cm and 100 cm intervals thereafter.

4.2.2 Peat Coring

Peat coring analysis methods follow those detailed within Hobbs (1986: see Hobbs Appendix A p.78-79) and Hodgson (1974).

1. Peat cores were taken at four locations, determined after a review of the proposed infrastructure layout at the time of survey, and analysis of peat depths from the Phase 1 peat survey. Additionally, a peat depth probe was taken adjacent to the core sample. Coring locations are detailed in Table 4.2.1 below and shown in **Figure 2.4.1**.

   A 'Russian Corer' (volume 0.5 litres (l)) was used to take peat cores.

   At each core sample location, the full peat depth profile was sampled, which involved taking 50 cm length cores from the surface layer through to the basal layer (where peat meets the underlying substrata).

   For each sample core, the following information was collected in the field:

   a. A photograph of each 50 cm core;
   b. Depth of the acrotelm;
   c. Degree of humification (as per Hodgson, 1974):
      i. Amorphous Peats - peats with fibre < 1/3rd volume when not rubbed - reduces to < 1/10 by rubbing, (optional - yields soluble dark humidified matter).
      ii. Fibrous Peats - peats with fibre > 2/3rds volume when not rubbed - reduces to no less than > 4/10 by rubbing, (optional - yields little soluble dark humidified matter).
      iii. 'Intermediate' if assessment falls between amorphous and fibrous.
   d. Degree of humification using the Von Post Scale (refer to Annex B).
   e. Fine Fibre Content: F0 (none), F1, F2, F3 (very high);
   f. Coarse Fibre Content: R0 (none), R1, R2, R3 (very high);
   g. Water Content: B1 (dry) to B5 (very wet); and

[4] As this is a peat assessment, only peat depths were recorded; where the sample point fell on mineral soil/bare rock the probe depth was recorded as zero.

h. Type of substrate underlying the peat (where this could be determined).

Table 4.2.1 Peat core sample numbers, locations and corresponding infrastructure

Sample Core ID	Number of 50 cm cores sampled	Easting	Northing	Infrastructure
T030	1	306410	968665	North-east of Turbine 3
T059	2	306706	968498	North-east of Turbine 4
T146	1	306106	968022	North-east of Turbine 2
T175	1	305875	967673	North of Turbine 1

5 LIMITATIONS

Limitations with regard to peat probing, relate to the survey method and analysis as follows:

- Obtaining a false depth measurement because of the probe meeting obstructions within the peat (e.g., hitting roots, stones etc). This was mitigated against as far as possible by taking an additional probe at each sample where it was suspected that the probe was hitting a barrier.
- In some cases, peat depth may be over-estimated if the substratum underlying the peat is soft.
- Difficulty with inserting the probes into drier more humified peat, which was mitigated against as far as possible by using a custom-made solid steel probe with detachable steel handles to allow probes to be forced into the peat.
- The Phase 2 probing and coring sample locations were selected based on the infrastructure layout at the time of survey.

The condition of the peat on site is typically shallow, with the majority of the site considered 'non-blanket mire' peat habitat (i.e., generally heaths on shallow peat or organo-mineral soils less than 50 cm depth).

Additionally, much of the site has been subject to high levels of modification through drainage and burning to facilitate contemporary and historic grazing, resulting in degradation and homogenisation of the peatland habitats. It is considered that the data presented provides an accurate representation of the peatland condition throughout the site, and this has been used to inform the design of the Proposed Development in the avoidance of peat deep areas.

The risk of encountering deep peat on the site is considered low based on the high resolution, site-wide peat data presented in this report. As such, the Applicant was previously in correspondence with SEPA (September 2019), which proposed the acceptance of a 50 m micrositing condition that will enable a finalised layout to be agreed with the appropriate consultees following further detailed pre-construction ground investigation (GI) works and peat probing surveys.

The above limitations associated with the method used to assess peat depth are not considered a significant factor and the Phase 2 and coring data presented are deemed to remain valid and provide an accurate representation of the typical peat conditions on the site data; these data can be relied upon to inform the objectives of the peat survey.

6 RESULTS

The results are presented as follows:

- Section 6.1 presents the results of the peat depth probing;
- Section 6.2 provides a comparison of probed and cored (true) peat depths; and
- Section 6.3 presents the results of the coring survey.

6.1 Phase 1 & Phase 2 Probing

During the peat depth probing surveys, a total of 240 peat depth probes were taken during Phase 1 and 1,022 probes during Phase 2. Therefore, there is a combined peat depth dataset of 1,262 probes, as shown in **Figure 2.4.1**.

Figure 2.4.2 and **Figure 2.4.3** show the results of the peat depth surveys at the site. **Figure 2.4.2** shows the specific depth class at each sample location and **Figure 2.4.3** shows the results of the IDW peat depth modelling based on the 1,262 sample depths collected. **Figure 2.4.3** is based on IDW data interpolation and consequently the peat depth contours and boundaries are to a degree indicative; therefore, they cannot be taken as definite boundaries, as actual peat depths 'in the field' may vary to a degree around these boundaries.

Chart 6.1.1 and **Chart 6.1.2** present the percentage and frequency of samples falling within the peat depth categories recorded in the peat survey area.

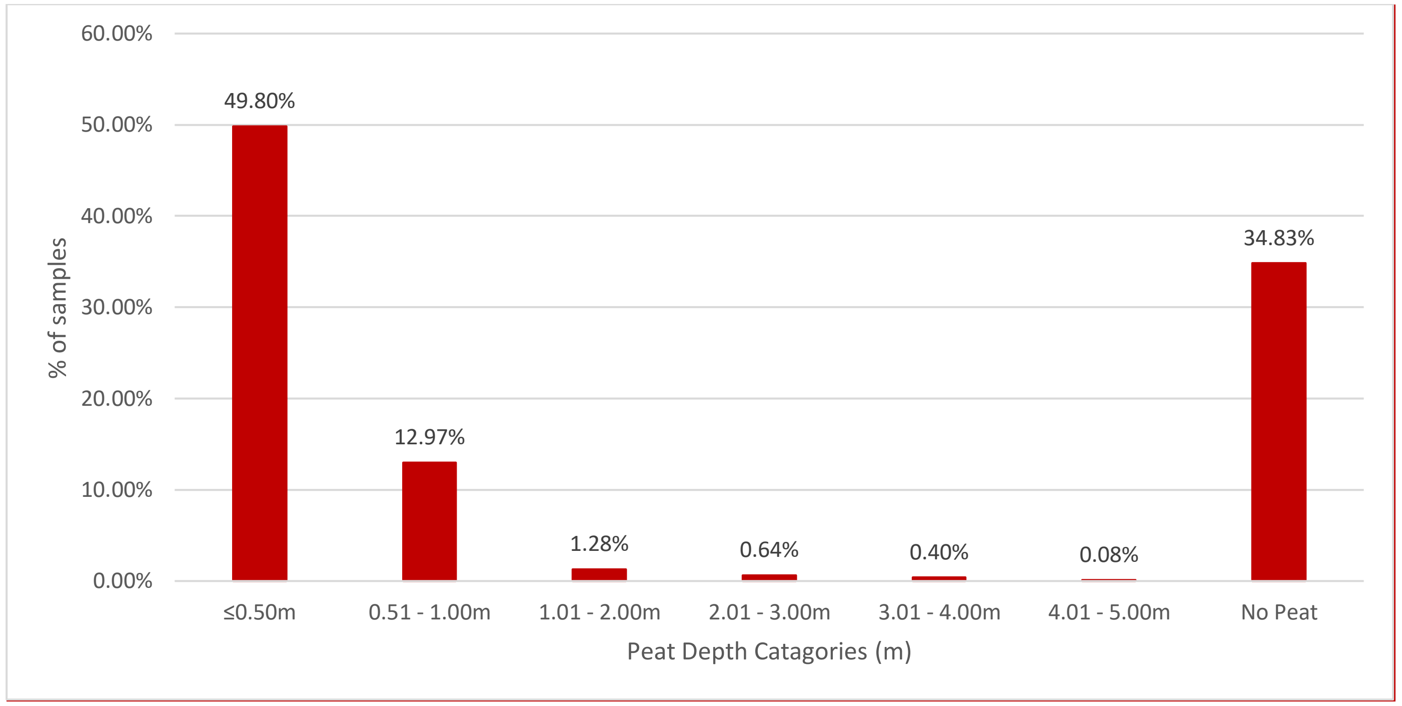

Chart 6.1.1 % Peat Depth Categories

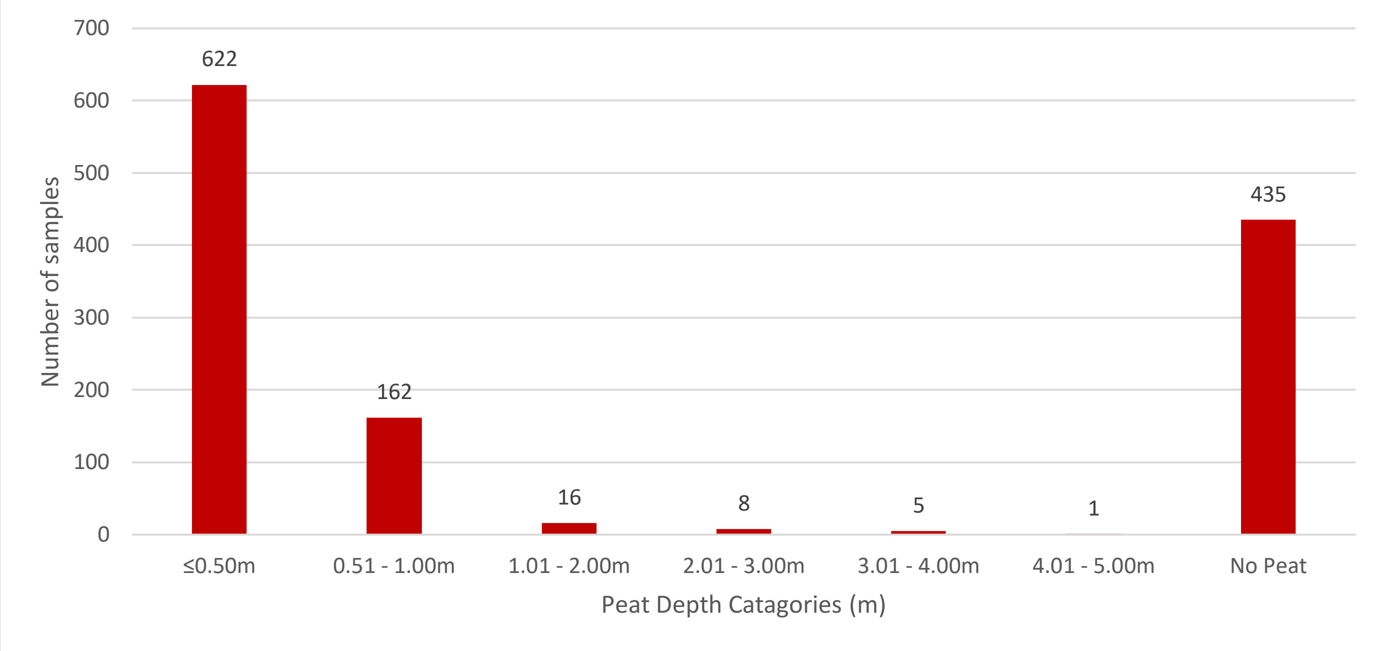

Chart 6.1.2 Peat Depth Frequency Distribution

As shown in **Figure 2.4.2** and **Figure 2.4.3**, and further highlighted by **Chart 6.1.1** and **Chart 6.1.2**, the majority of the peat survey area has either no peat present or has a shallow depth of peat present; generally, under 50 cm, and therefore more appropriately considered, or referred to, as organo-mineral soils.

Where peat or organo-mineral soils are present within the site, the depths are typically shallow; mean 28 cm and median 23 cm. There are rare, isolated deeper pockets of peat within the site boundary. A maximum depth within the site boundary of 333 cm was recorded north west of Turbine 4. The deepest pocket of peat (493 cm) was recorded south, beyond the site boundary at Lythmore Moss (**Figure 2.4.2**).

The data shows:

- 622 samples (49.8 %) fell on land with less than or equal to 50 cm depth of peat or organo-mineral soil;
- 162 samples (12.97 %) fell on land with between 51 cm and 100 cm of peat;
- Only 30 samples (2.40 %) fell on land with more than 100 cm depth of peat; and
- 435 samples (34.85 %) fell on land with no peat.

Only sampling points on non-peat or organo-mineral habitats (e.g., bare rock, brown mineral soil or clay) were recorded as 0 cm of peat. Peat or organo-mineral soil was recorded at all other points.

Land where peat depth is greater than 50 cm is classified as 'blanket bog' by SNH (MacDonald *et al.*, 1998) and JNCC (JNCC, 2010); however, some areas with a peat depth of less than 50 cm can still form part of the wider hydrologically connected mire, or macrotope. As per above, much of the peatland or organo-mineral soil habitats within the site have less than 50 cm of peat/soil present. Within the site, such areas can be classified as several habitat types depending on the species present, including mires, wet heaths and marshy grasslands. As described within Technical Appendices 7.1: National Vegetation Classification & Habitats Survey Report and 7.4: Caledonian Conservation Baseline Non-Avian Ecology Report 2014: Hill of Forss Wind Farm, the predominant habitats at the site are wet heaths, small sedge mires and some marsh/marshy grassland; with these habitat areas correlating with the areas of shallow peat or organo-mineral soils.

6.2 Accuracy of Peat Depth Probes

At each core sample location, a peat depth probe was taken adjacent to the core sample to compare the probed depth against the true depth determined by measuring the depth of material retained in the core sample. To ensure the full depth of peat is sampled, a core is extracted that confirms the peat/substratum boundary has been reached. This approach allows a relative assessment of the accuracy of the peat depth probing. Peat or organo-mineral soil was present at all four sample locations. The results are presented in Table 6.2.1 below.

Table 6.2.1 Difference between probed and true (cored) depth

Sample Core ID	Probed Depth (cm)	Cored Depth (cm)	Difference (Probed - Cored) (cm)	Infrastructure
T030	35	11	24	North-east of Turbine 3
T059	89	73	16	North of Turbine 4
T146	52	5	47	East of Turbine 2
T175	51	23	28	Turbine 1

As can be seen within **Table 6.2.1** there was a tendency for the peat probes to overestimate the true peat depths determined via coring at the site (mean overestimation of 28.75 cm).

The overestimation of peat depth from the probes is due to the upper peat layer being underlain by other soft non-peat substrates into which the probe could still easily penetrate. The layers beneath the peat/organo-mineral soil at the site appear to be underlain by soft clays; in particular, see **photograph 4** and **photograph 5** in **Annex C**. As the physical dimensions of the peat probe are narrower than the Russian corer, penetrating beyond the peat layer into soft clay is easier for the probe. Overall, it is assumed that the probed data will give the impression of deeper peat than exists across the site.

6.3 Core Sample Results

Section 6.3.1 to **Section 6.3.11** below present the information of the key variables recorded on the nature of peat deposits within the peat study area from the coring survey. Annex A presents the results for each of the variables from all the core samples and Annex C presents the photographs of each subsample taken. The cores from all four core sample locations were sent to a laboratory for further analysis.

6.3.1 Depth of Acrotelm

The catotelm and acrotelm represent two distinct layers within undisturbed peat that control the hydrological regime. The catotelm is the bottom layer of peat that is mostly below the water table. The acrotelm overlies the catotelm and is the 'living' layer in which most water table fluctuations occur. The thickness of the acrotelm usually varies up to around 50 cm, but it largely depends upon the habitat. Anaerobic and aerobic conditions alternate periodically with the fluctuation of the water table, favouring more rapid microbial activity than in the catotelm. The acrotelm consists of the living parts of mosses and dead and poorly decomposed plant material. It has a very loose structure that can contain and release large quantities of water in a manner that limits variations of the water table in peat bogs[5].

Acrotelm was recorded at three sample locations (see **Chart 6.3.1**), however the mean depth was 5.75 cm, which is considered very shallow. The remaining sample location indicated no discernible acrotelm. The lack and/or absence of observed acrotelm at all coring locations is likely due to effects caused by drainage, historical burning and intensive grazing which is common throughout the peat study area.

In the context of any development, it is recommended that for the purposes of construction and subsequent reinstatement, that where a sufficient peat depth exists, the top 50 cm of material should be treated as acrotelm. This approach will allow excavation of intact turves for reinstatement purposes where they are present, which will in turn facilitate quicker regeneration of disturbed areas. Even if little vegetation is present within this top layer it should still be treated as acrotelmic material as it may contain a seedbank, particularly in open habitats, which will aid re-vegetation of reinstatement areas.

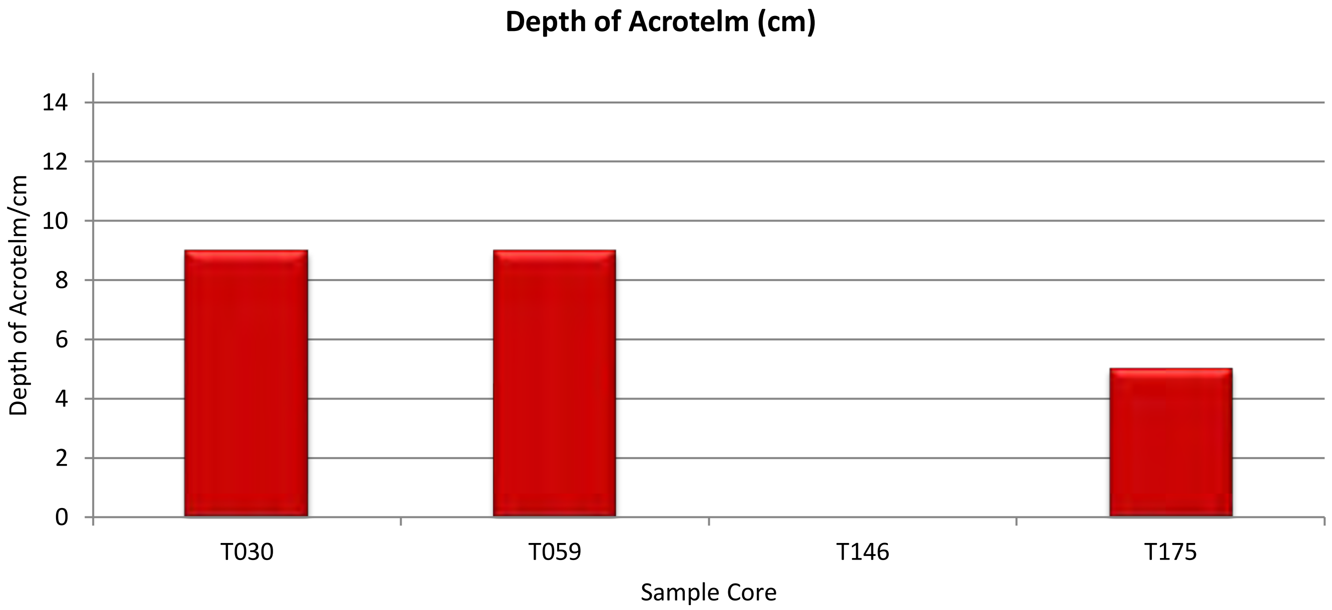

Chart 6.3.1 Depth of Acrotelm

6.3.2 Degree of Humification

The degree of humification was recorded in the field, in accordance with the methods discussed in **Section 4.2.2** above; with each 0.5 m subsample being categorised as either fibrous, intermediate, or amorphous peat.

None of the core samples obtained showed any high levels of humification, and were all classed as fibrous, highlighting the intact nature of the peat on the site. From the four sample cores taken, there were a total of five separate 0.5 m subsamples extracted and analysed. The results are summarised below.

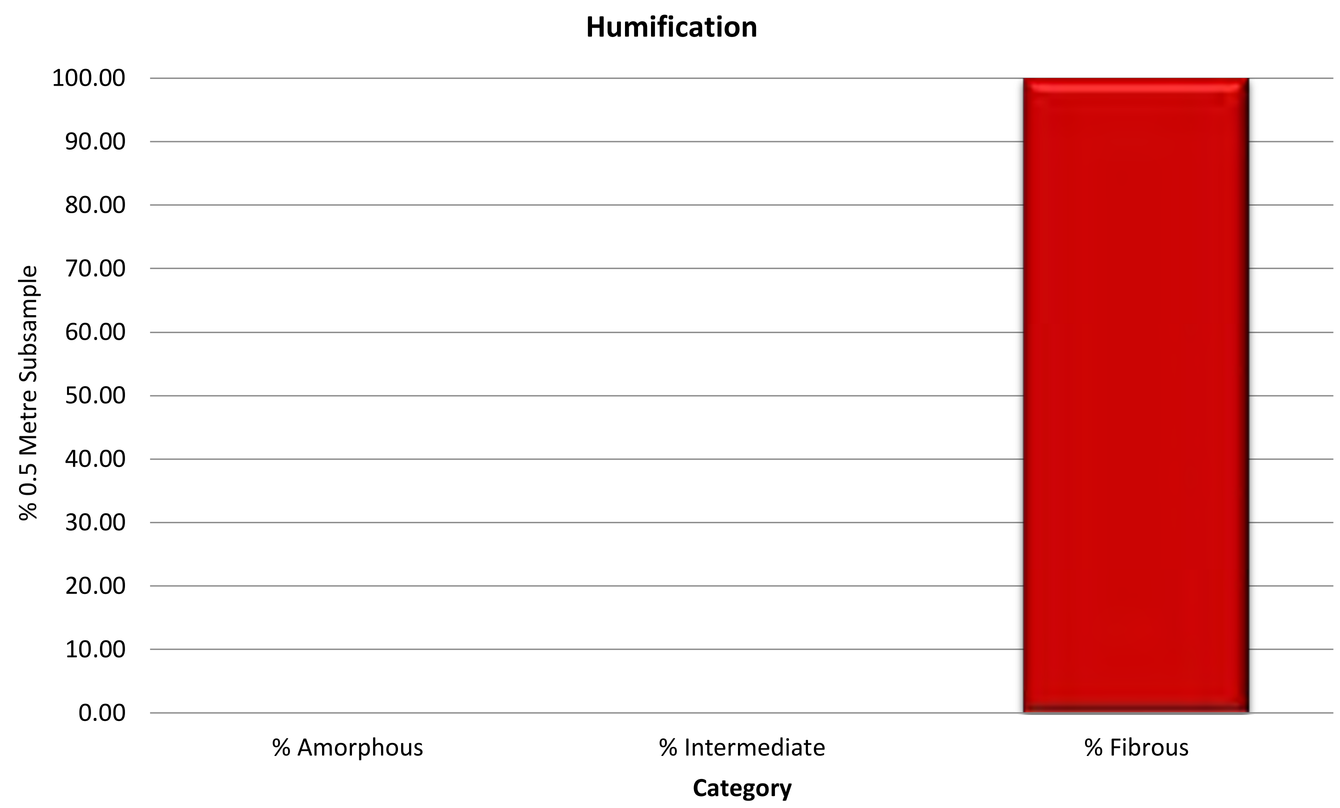

Chart 6.3.2, Degree of humification: % of 0.5 metre subsamples

Chart 6.3.2 above shows the degree of humification, in percentage of 0.5 m subsamples, for four sample locations. The following considerations are highlighted:

- 0% of peat from the 0.5 m subsamples was amorphous in nature;
- 0% of the peat from the 0.5 m subsamples was intermediate in nature; and
- 100% of the peat within 0.5 m subsamples (n = 5) was fibrous in nature.

Interpretation of the data suggests that the peat across the study area is generally fibrous in nature and not well humified.

6.3.3 Fibrous Content

The proportions of coarse and fine fibres within the peat samples were ascertained in the field according to the Hobbs scale (see **Section 4.2.2**). The results are presented below.

[5] Quinty, F. & Rochefort, L. (2003). *Peatland restoration guide, 2nd ed. Canadian Sphagnum Peat Moss Association and New Brunswick Department of Natural Resources and Energy*. Québec, 106 pp.

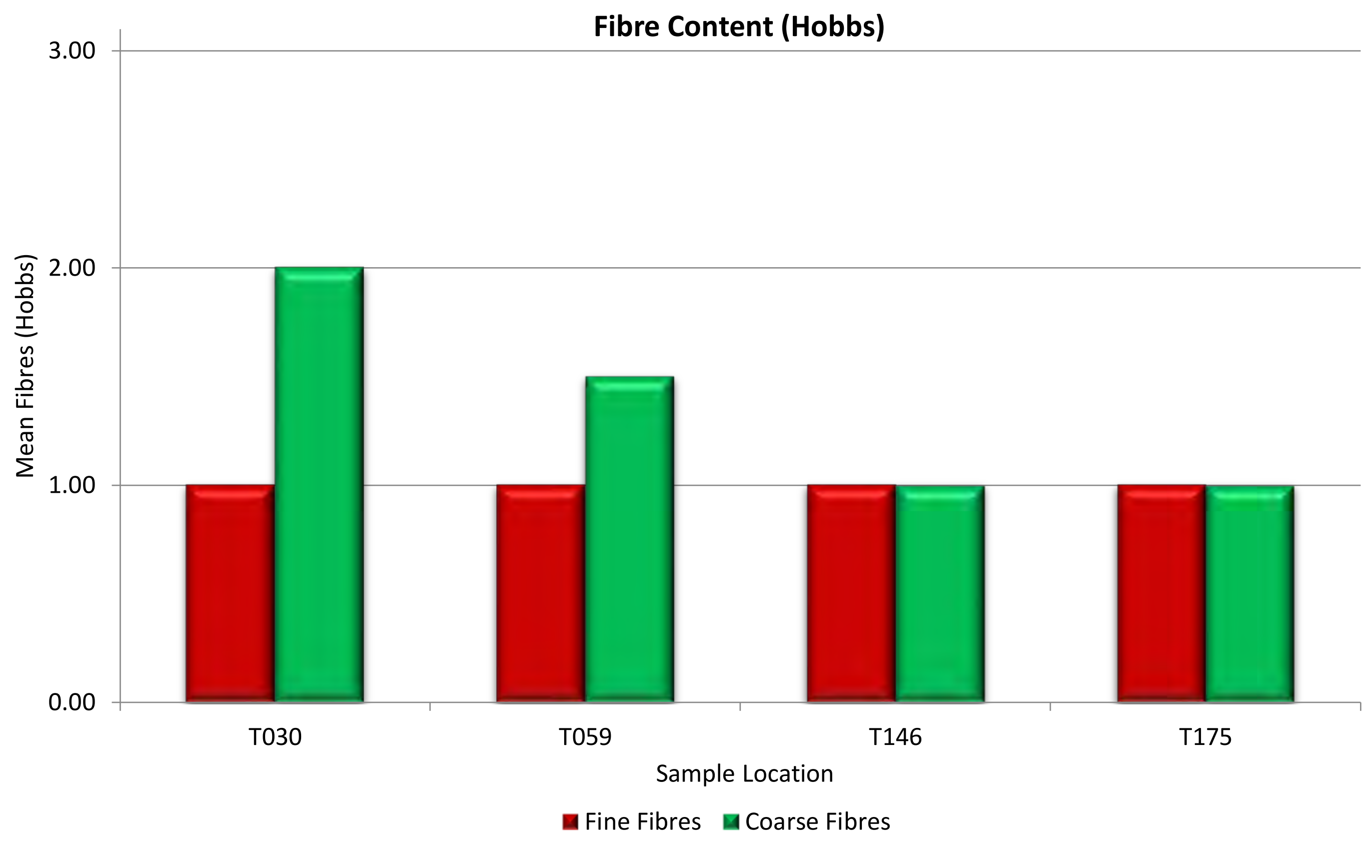

Chart 6.3.3 Levels of Coarse & Fine Fibres: % 0.5 metre subsamples

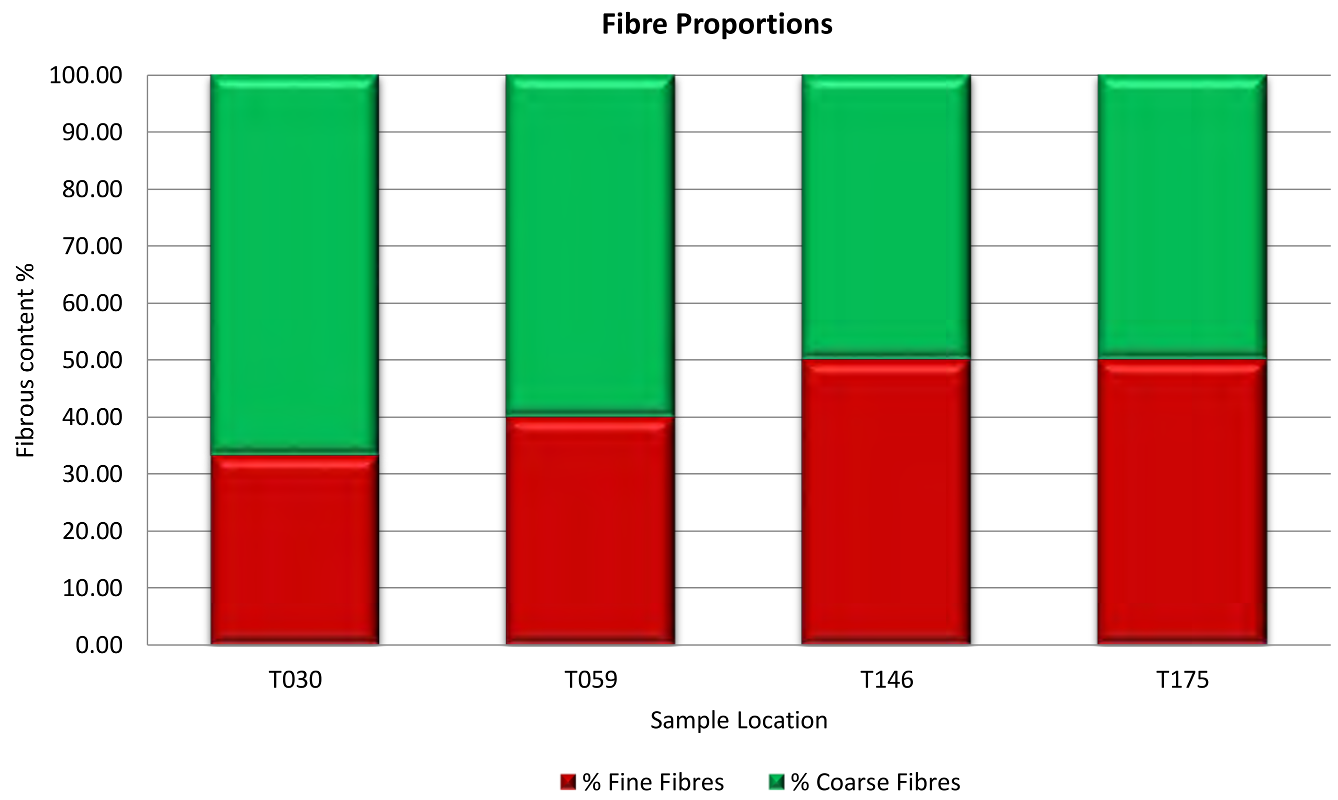

Chart 6.3.4 Fibrous Content : % 0.5 metre subsamples

Chart 6.3.3 above shows the level of coarse and fine fibres (using the Hobbs scale) present in four core locations and **Chart 6.3.4** shows the percentage of fibrous content for fine and coarse fibres that were present in each of the four sample locations. The following considerations are highlighted:

- All samples were assessed as having low fine fibre content (F1) according to the Hobbs scale;
- One sample (T030) was assessed as having moderate coarse fibre content (R2) according to the Hobbs scale. ample T059 was scored as having a low to moderate fibre content (between R1 and R2), according to the Hobbs scale. The remaining two samples were recorded as having a low coarse fibre content (R1); and
- Overall, the 0.5 m subsamples had a relatively even split of fine and coarse fibres.

6.3.4 Water Content

The water content of subsamples was determined in the field using the Hobbs scale (B1 Dry – B5 Very Wet). The results below provide a summary mean for each core location.

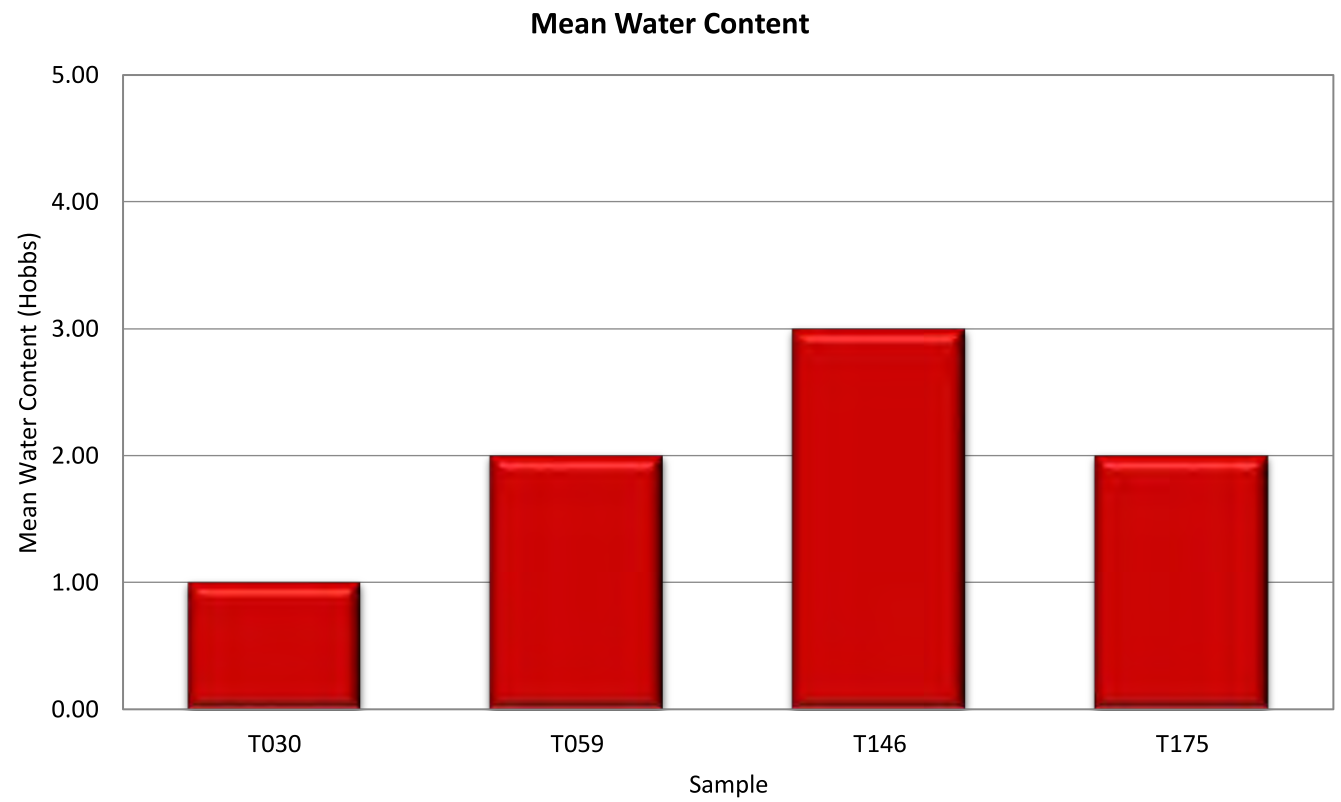

Chart 6.3.5 Mean Water Content: Core Location Summary.

- The vertical axis in **Chart 6.3.5** above, refers to the water content of sampled peat; 1 = dry to 5 = very wet;
- For the purpose of this analysis, a mean water content was estimated for cores that had more than one 0.5 m subsample;
- One sample (T030) was recorded as B1 on the Hobbs scale, i.e. dry peat;
- Three samples were recorded as either B2 and B3 on the Hobbs scale, i.e. semi-dry peats with some moisture;

- No peats were recorded as wet or very wet (B4 or B5); and
- The relative dryness within the peats may possibly be attributed to the effects of localised drainage and intensive grazing within the peat study area.

6.3.5 Von Post (Degree of humification)

An estimate of the degree of humification according to the Von Post scale (see **Annex B**) was carried out on samples at all core locations, see **Chart 6.3.6** below.

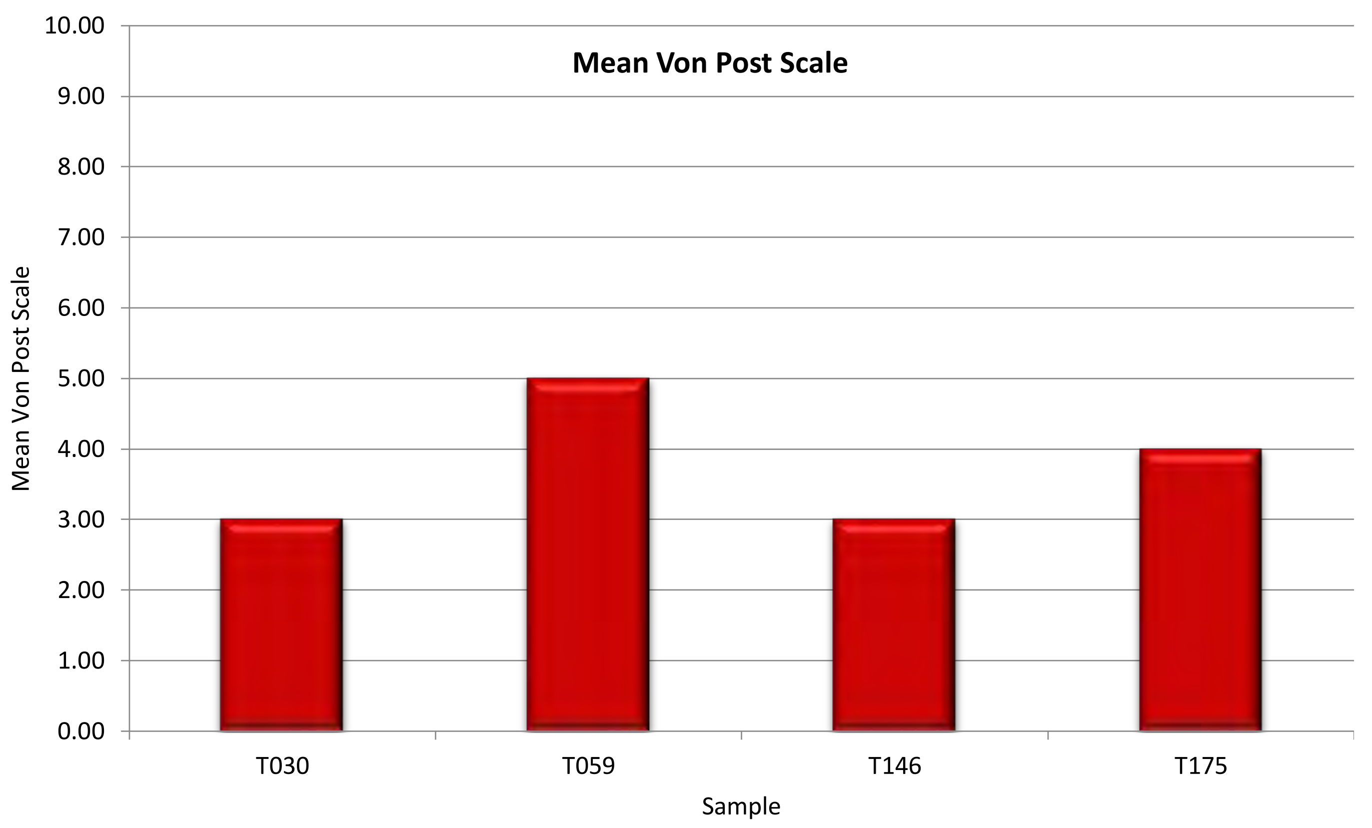

Chart 6.3.6 Mean Von Post

- The vertical axis in **Chart 6.3.6**, above refers to the Von Post Scale of Peat Decomposition (H1 to H10, see Annex B for details);
- For the purpose of this analysis, a mean degree of humification was estimated for cores that had more than one 0.5 m subsample;
- Three samples scored relatively low on the Von Post scale (H3 to H4), indicating relatively weak decomposition; and
- One sample (T059) scored moderate on the Von Post scale (H5), indicating intermediate decomposition.

6.3.6 pH of Peat Samples

Five peat subsamples (each of 0.5m depth) were obtained from four sample core locations and were sent to the laboratory for analysis. All samples were successfully analysed. The pH values determined are provided below.

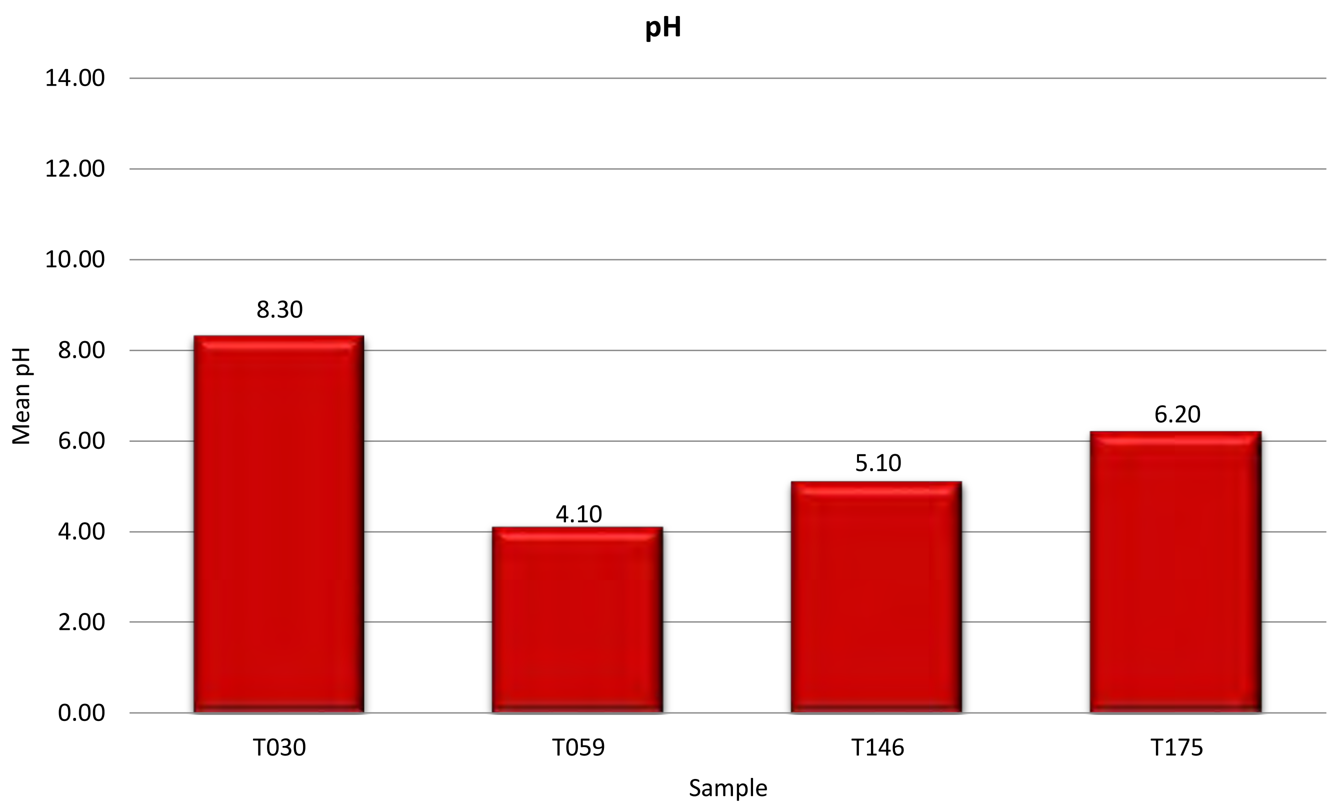

Chart 6.3.7 Mean pH

- The mean pH value of the five subsamples was 5.93, with a range from 4.10 to 8.30 (see Annex B);
- **Chart 6.3.7** provides the mean pH for each core location and indicates that 75% of sub-samples were acidic in nature; and
- Sample T030 was alkaline with a pH reported as 8.3. Alkaline peat samples can occur in instances where base-rich groundwater interacts with and influences peat character, for example in the formation of 'fen' peat that can be found in fen or swamp habitats (as opposed to acidic ombrogenous peat formed directly from precipitation). Additionally, the pH of peat samples can also be raised in the presence of an underlying alkaline geology. Further evidence of alkalinity within the site can be observed in Technical Appendix 7.1: National Vegetation Classification and Habitats Survey Report, which details areas of calcareous grassland and base-rich flushes within the site.

6.3.7 Dry Matter (%)

Oven dry matter (%) was calculated for five subsamples sent to the laboratory. The mean dry matter for each core location is illustrated in **Chart 6.3.8** and **Chart 6.3.9** below.

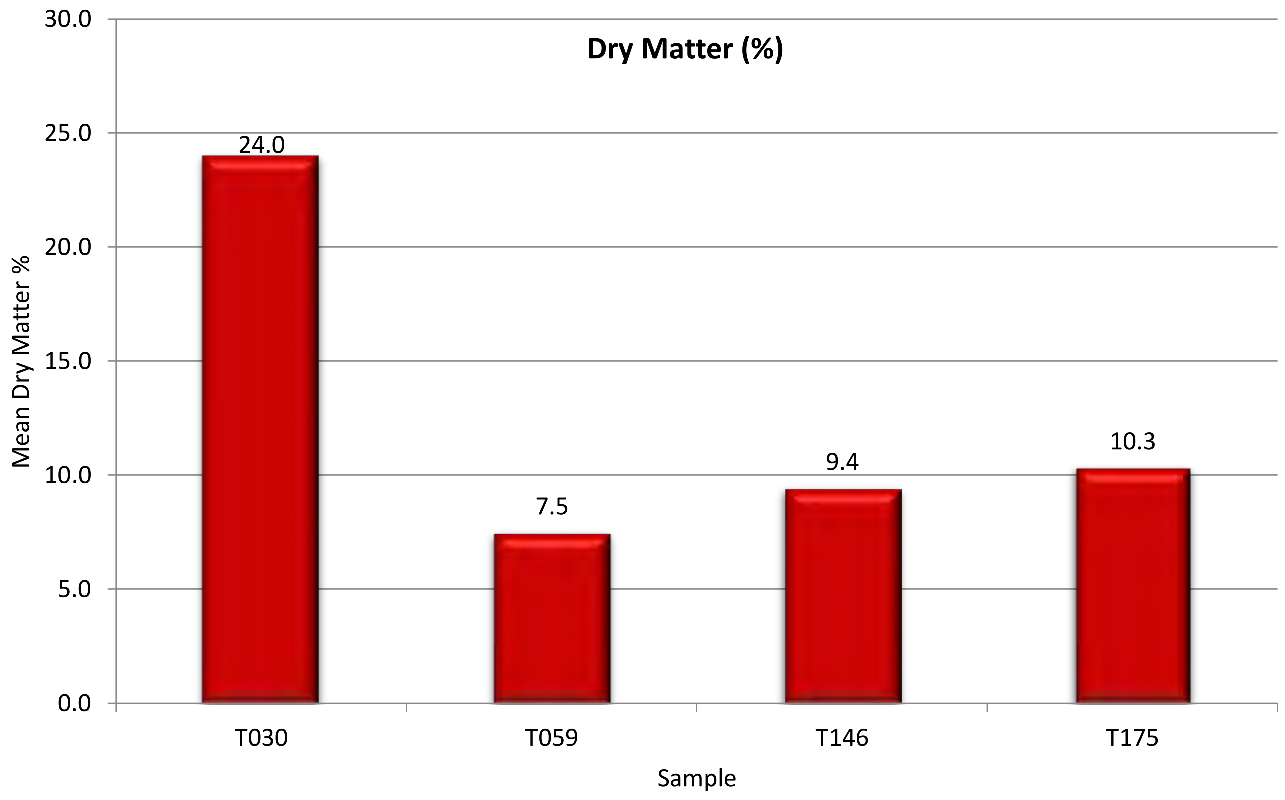

Chart 6.3.8 Core Mean Dry Matter (%)

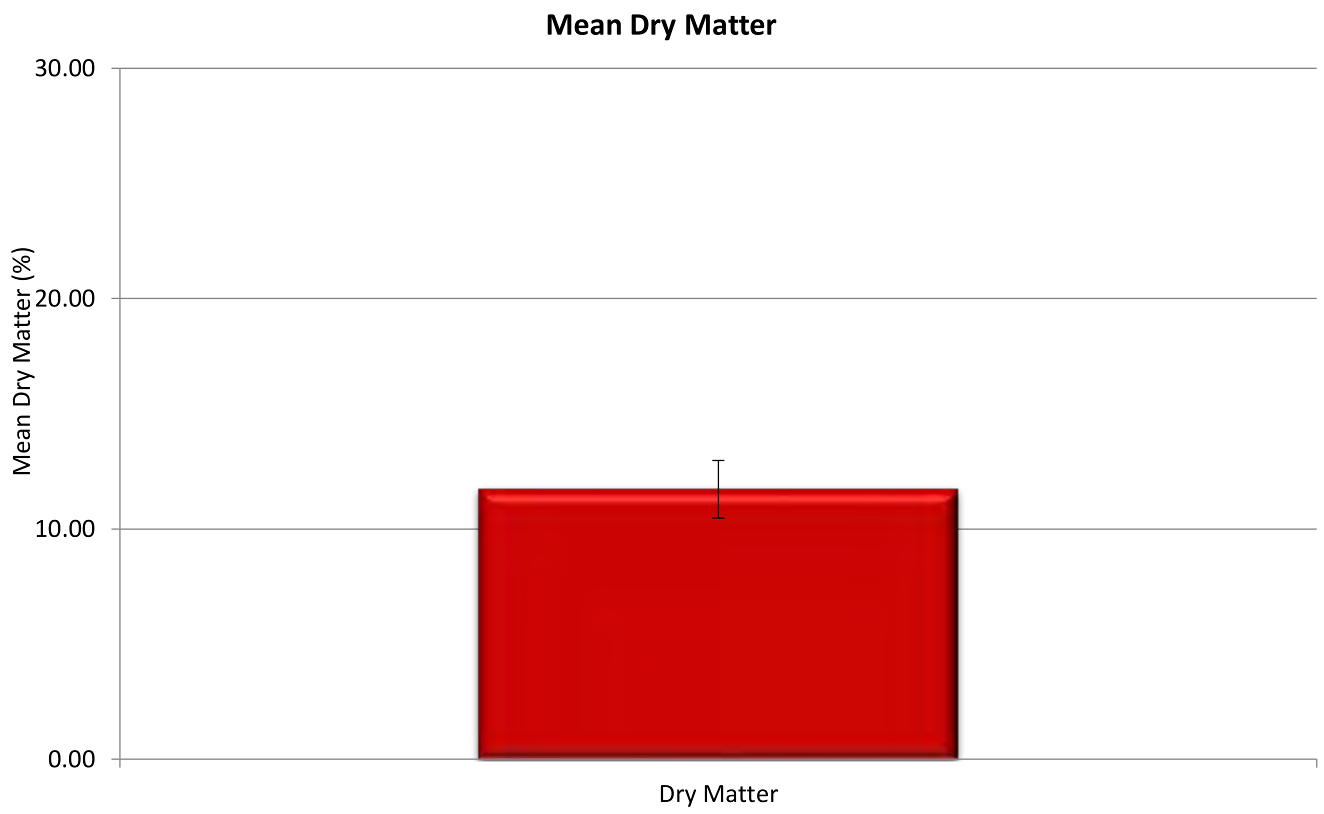

Chart 6.3.9 Subsample Mean Dry Matter (%)

Table 6.3.1 Descriptive Statistics

Mean	Standard Error	95% Confidence Interval	95% CL Lower	95% CL Upper	Precision
11.72	6.98	2.56	9.16	14.28	21.84

Chart 6.3.8, **Chart 6.3.9**, and **Table 6.3.1** show the dry matter mean and summary statistics for the five subsamples analysed. The following considerations are highlighted:

- For the purpose of the analysis in **Chart 6.3.8**, a mean dry matter content was estimated for cores that had more than one 0.5 m subsample; and
- The mean dry matter percentage from the cores is 11.72%; with maximum and minimum values of 24% and 7.5% respectively (see **Annex A**).

6.3.8 Wet Bulk Density (g/l)

Wet Bulk Density (g/l) was calculated from five subsamples sent to the laboratory. The mean wet bulk density for each core location is illisutrated in **Chart 6.3.10** and **Chart 6.3.11**.

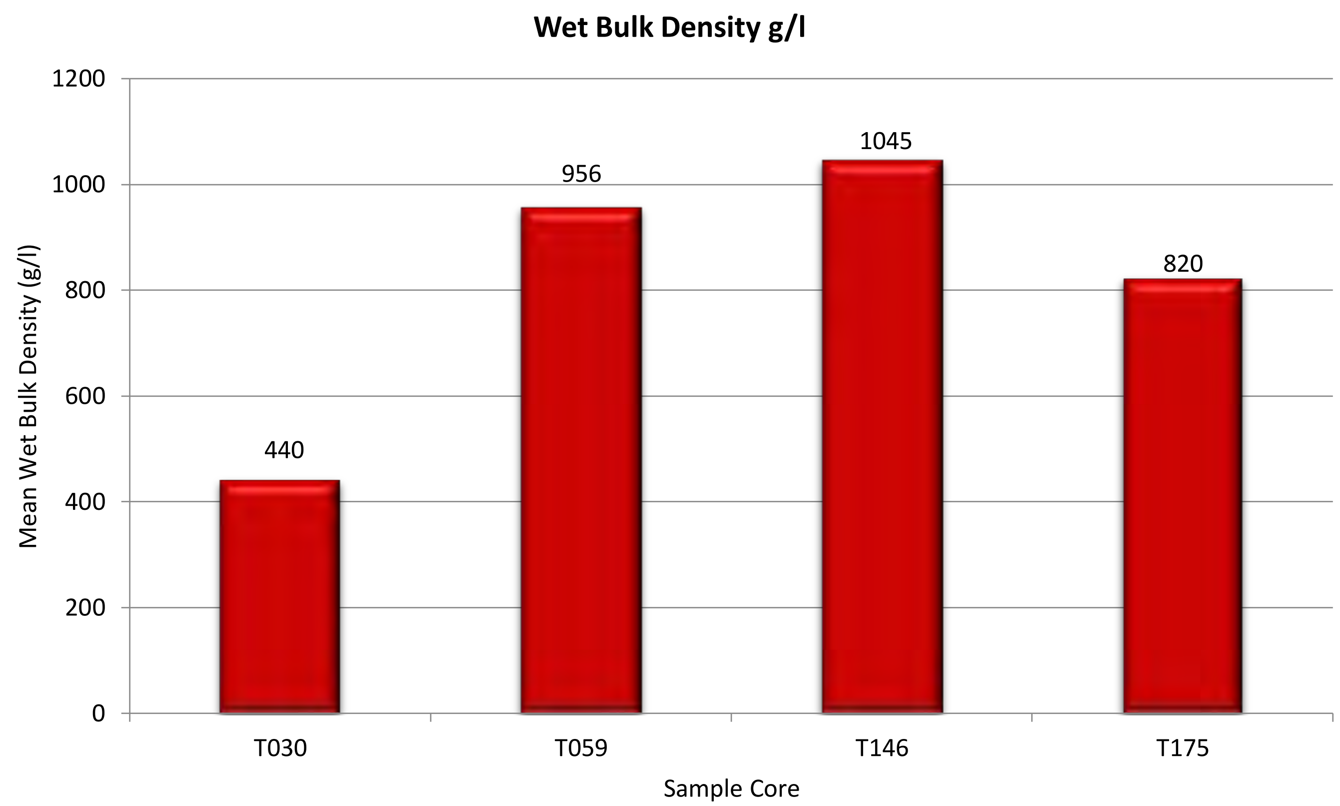

Chart 6.3.10 Core Mean Wet Bulk Density (g/l)

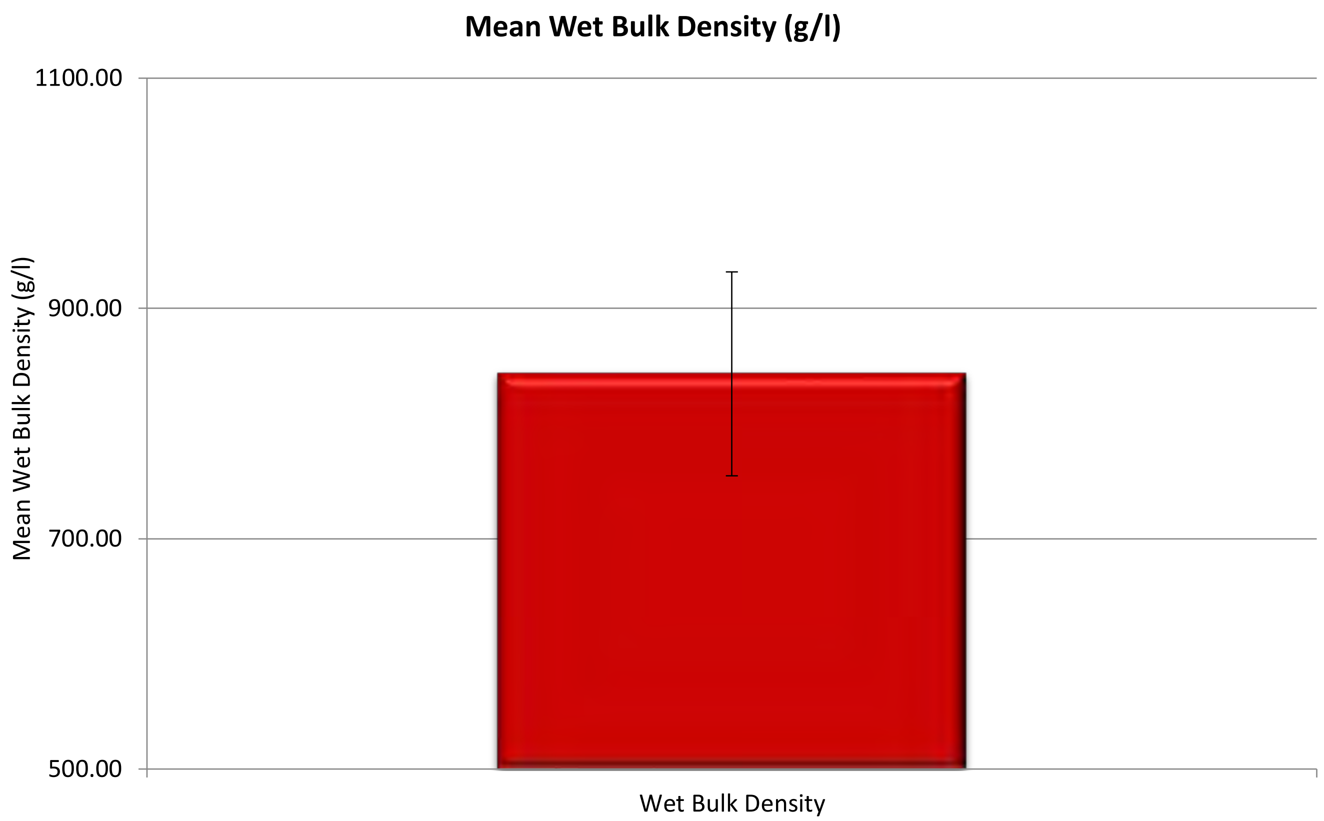

Chart 6.3.11 Subsample Mean Wet Bulk Density (g/l)

Table 6.3.2 Descriptive Statistics

Mean	Standard Error	95% Confidence Interval	95% CL Lower	95% CL Upper	Precision
843.20	241.45	88.55	754.65	931.75	10.50

Chart 6.3.10, **Chart 6.3.11**, and **Table 6.3.2** show the wet bulk density mean and summary statistics for the five subsamples analysed. The following considerations are highlighted:

- For the purpose of the analysis in **Chart 6.3.11**, a mean wet bulk density was estimated for cores that had more than one 0.5 m subsample; and
- The mean wet bulk density from the cores is 843.20 g/l; with maximum and minimum values of 1045 g/l and 440g/l respectively (see **Annex A**).

6.3.9 Dry Bulk Density (g/cm³)

Dry Bulk Density (g/cm³) was calculated for five subsamples sent to the laboratory. The mean dry bulk density for each core location is illustrated in **Chart 6.3.12** and **Chart 6.3.13** below.

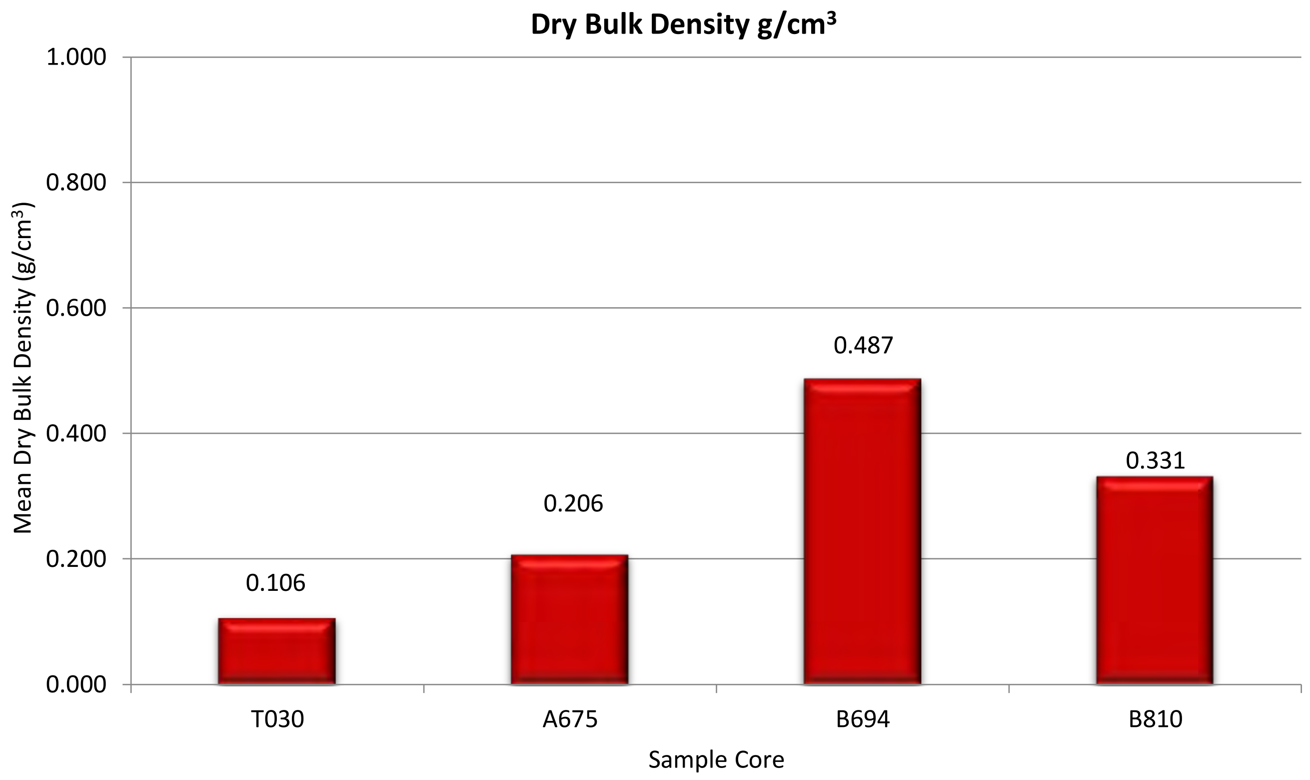

Chart 6.3.12 Core Mean Dry Bulk Density (g/cm³)

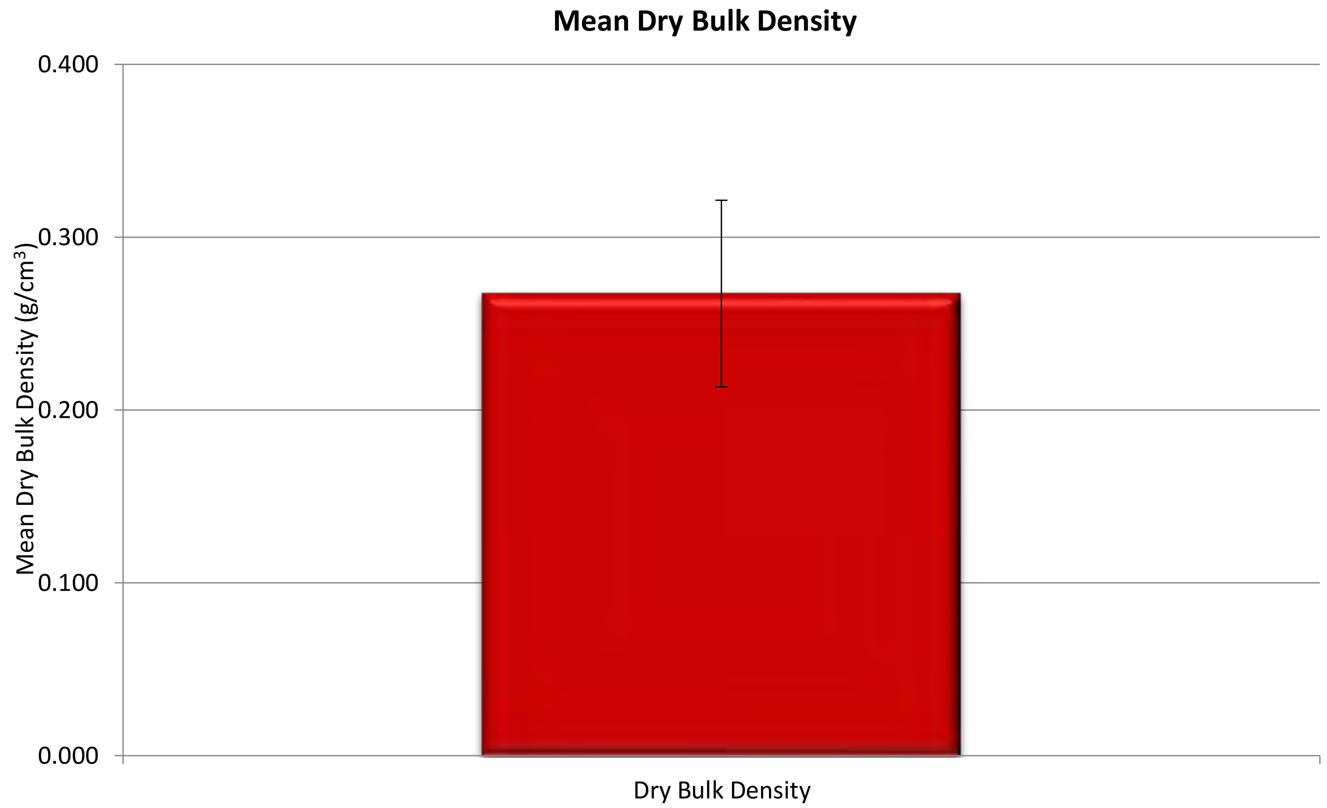

Chart 6.3.13 Subsample Mean Dry Bulk Density (g/cm³)

Table 6.3.3 Descriptive Statistics

Mean	Standard Error	95% Confidence Interval	95% CL Lower	95% CL Upper	Precision
0.267	0.147	0.054	0.214	0.321	20.10

Chart 6.3.12, **Chart 6.3.13**, and **Table 6.3.3** show the dry bulk density mean and summary statistics for the five subsamples analysed. The following considerations are highlighted:

- For the purpose of the analysis in Chart 6.3.13, a mean dry bulk density was estimated for cores that had more than one 0.5 m subsample; and
- The mean dry bulk density from the cores is 0.267 g/cm^3; with maximum and minimum values of 0.487 g/cm^3 and 0.106 g/cm^3 respectively (see Annex A).

6.3.10 Total Carbon (%)

Total Carbon content (% dry weight) was calculated for five subsamples sent to the laboratory. The mean total carbon density for each core location is illustrated in **Chart 6.3.14** and **Chart 6.3.15**.

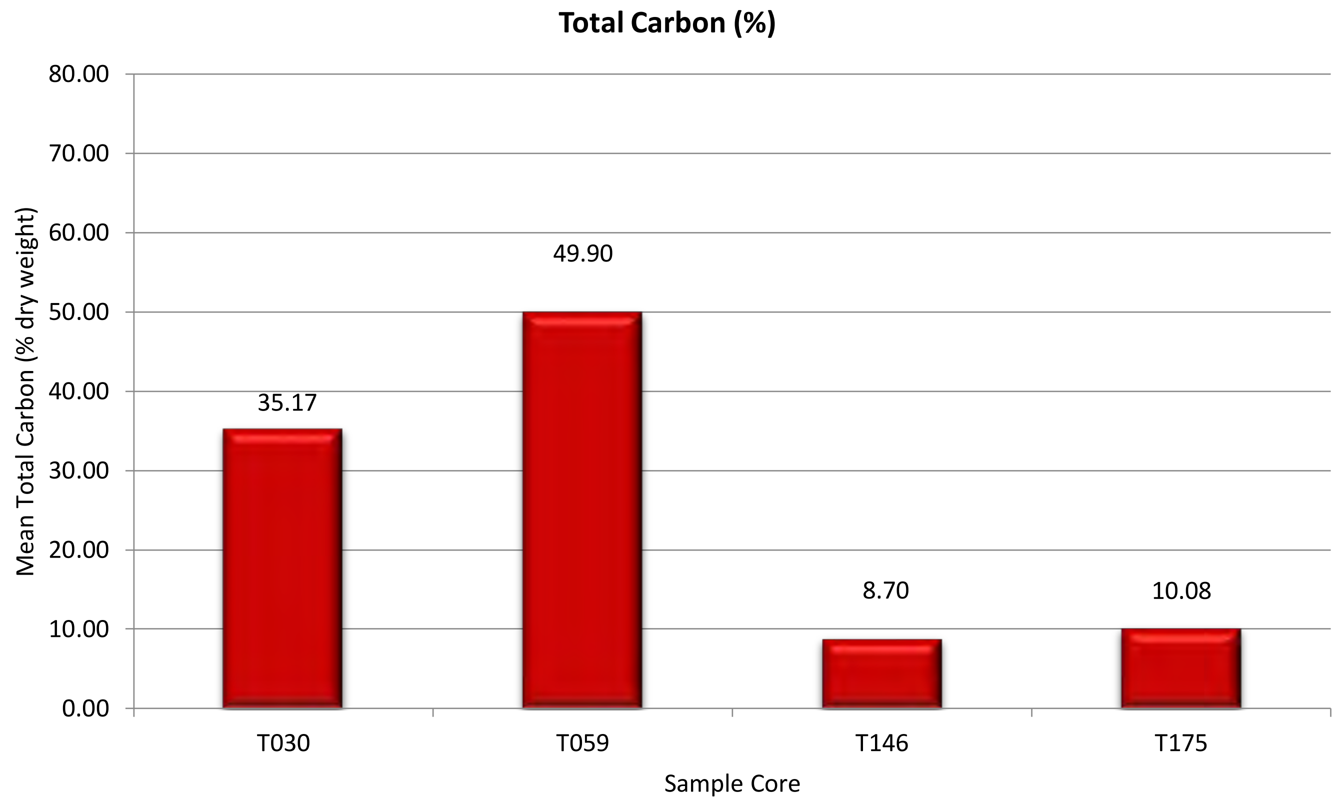

Chart 6.3.14 Core Mean Total Carbon (% weight)

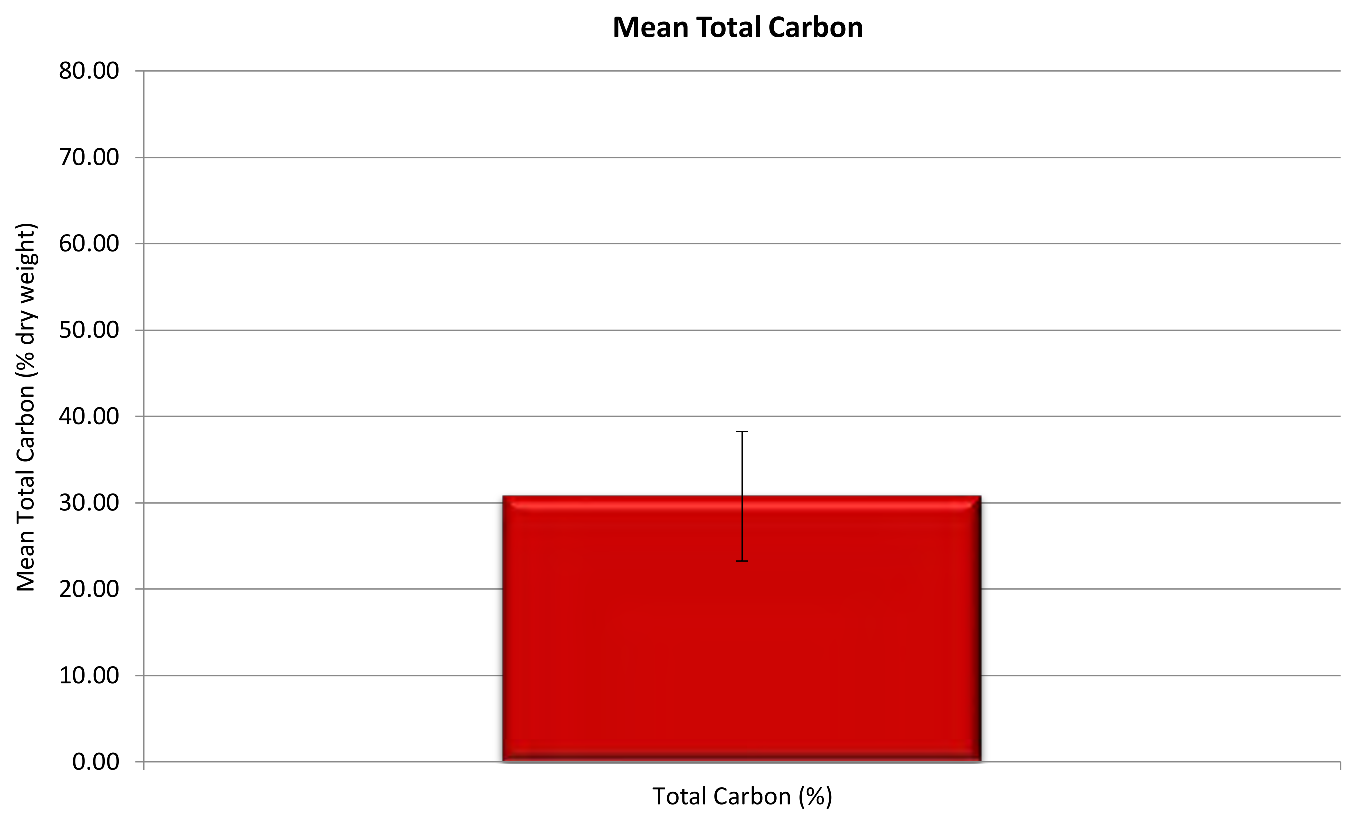

Chart 6.3.15 Subsample Mean Total Carbon (% weight)

Table 6.3.4 Descriptive Statistics

Mean	Standard Error	95% Confidence Interval	95% CL Lower	95% CL Upper	Precision
30.75	20.45	7.50	23.25	38.25	24.39

Chart 6.3.14, **Chart 6.3.15**, and **Table 6.3.4** show the total carbon mean and summary statistics for the five subsamples analysed. The following considerations are highlighted:

- For the purpose of the analysis in **Chart 6.3.15**, a mean was estimated for cores that had more than one 0.5 m subsample; and
- The mean total carbon (%) from the cores is 30.75%; with maximum and minimum values of 51.64% and 8.70% respectively (see **Annex A**).

6.3.11 Underlying Substrates

At each sample location, where possible, a broad characterisation was made of the underlying substrate below the peat horizon. The raw data is provided in **Annex A** of this report and it appears that the majority or the sample locations were underlain by clays or till; see also core photographs in **Annex C**.

7 SUMMARY

7.1 Peat Depth Analysis

The peat depth analysis from the Phase 1 and Phase 2 surveys demonstrates the general lack of deep peat on the site.

Combining the results from the Phase 1 and Phase 2 depth surveys highlights the majority of the peat study area has either no peat present or has a shallow depth of peat present; generally, under 50 cm, and therefore more appropriately considered, or referred to, as organo-mineral soils (see also **Figure 2.4.2** and **Figure 2.4.3**). Where peat or organo-mineral soils are present within the site, the depths are typically shallow; mean 28 cm and median 23 cm. There are some isolated rare deeper pockets of peat; maximum depth within the peat study area was recorded as 493 cm and maximum depth recorded within the site boundary was 333 cm ~285 m north west of Turbine 4.

The data revealed the following key results:

- 622 samples (49.8 %) fell on land with less than or equal to 50 cm depth of peat or organo-mineral soil;
- 162 samples (12.97 %) fell on land with between 51 cm and 100 cm of peat;
- Only 30 samples (2.40 %) fell on land with more than 100 cm depth of peat; and
- 435 samples (34.85 %) fell on land with no peat.

Only sampling points on non-peat or organo-mineral habitats (e.g., bare rock, brown mineral soil, clay) were recorded as 0 cm of peat. Peat or organo-mineral soil was recorded at all other points.

7.2 Peat Coring

The peat core sample results presented in **Section 6.3**, highlight the physical and chemical properties of the peat on site. The most notable results from the core analysis are detailed below:

- Peat probes undertaken at the site tend to overestimate the true depth of peat present due to underlying soft clays below the peat horizon;
- The depth of acrotelm is typically very shallow;
- The peat on site is highly fibrous, and not well humified;
- The peat on site is relatively dry, which may be attributed to the draining of the site for the purposes of livestock grazing;
- Samples analysed in the field to the Von Post scale were scored low (between H3 and H4) with one sample scored as moderate (H5), indicating an overall low to intermediate level of decomposition at the site;
- pH samples were generally acidic as would be expected from ombrogenous peat, however core sample T030 had an alkaline pH, which is less common for Scotland, however consistent with the presence of alkaline fen and flush communities reported on site;
- Dry matter, wet bulk density, dry bulk density and total carbon content statistics were calculated from five subsamples sent to the laboratory from four core sample locations; and
- With the exception of core sample T059, the total carbon content of all other cores was lower than is typically observed in high quality peat.

Overall, the peats and organo-mineral soils sampled across the peat study area were shallow, relatively dry and fibrous in nature, and exhibited low levels of decomposition.

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Scottish Government, Scottish Natural Heritage, SEPA. (2017). *Peatland Survey. Guidance on Developments on Peatland*. http://www.gov.scot/Resource/0051/00517174.pdf

Scottish Renewables and Scottish Environmental Protection Agency (2012). *Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste*.

ANNEX A. PEAT CORING DATA

Sample No.	Turbine	X	Y	Planted / Unplanted	Sub-sample	Probed depth (cm)	Cored Depth (cm)	Depth of Acrotelm (cm)	Photo	Colour	Depth of Sub Sample	Amorphous 0 = No, 1 = Yes	Intermediate 0 = No, 1 = Yes	Fibrous 0 = No, 1 = Yes	Fine Fibres	Coarse Fibres
T030a	NE of T3	306410	968665	Unplanted	T030a	35	11	9	Yes	Dark brown	0-11	0.00	0.00	1.00	1.00	2.00
T059a	N of T4	306706	968498	Unplanted	T059a	89	73	9	Yes	Mid brown	0-50	0.00	0.00	1.00	1.00	2.00
T059b	N of T4	306706	968498	Unplanted	T059b	-	-	-	Yes	Mid brown	50-73	0.00	0.00	1.00	1.00	1.00
T146a	E of T2	306106	968022	Unplanted	T146a	52	5	0	Yes	Light brown	0-5	0.00	0.00	1.00	1.00	1.00
T175a	T1	305875	967673	Unplanted	T175a	51	23	5	Yes	Orange/light brown	0-23	0.00	0.00	1.00	1.00	1.00

Sample No.	Turbine	X	Y	Water Content	Von Post Scale	Wet Bulk Density g/l	Dry Bulk Density g/l	Dry Bulk Density g/cm3	Dry Matter %	Moisture %	pH	Total Carbon (fresh) mg/l	Total Carbon, dry matter mg/kg	Total Carbon % dry weight	Substrate
T030a	NE of T3	306410	968665	1.00	3.00	440.00	105.60	0.11	24.00	75.90	8.30	37217.00	351700.00	35.17	
T059a	N of T4	306706	968498	2.00	5.00	910.00	204.75	0.20	22.50	77.50	4.00	105592.00	516400.00	51.64	
T059b	N of T4	306706	968498	2.00	5.00	1001.00	208.21	0.21	20.80	79.30	4.20	100011.00	481500.00	48.15	Till/Rock
T146a	E of T2	306106	968022	3.00	3.00	1045.00	486.97	0.49	46.60	53.40	5.10	42357.00	87000.00	8.70	Clay
T175a	T1	305875	967673	2.00	4.00	820.00	331.28	0.33	40.40	59.60	6.20	33360.00	100800.00	10.08	Clay

ANNEX B. VON POST SCALE OF HUMIFICATION

Degree of Decomposition	Nature of Squeezed Liquid	Proportion of Peat Extruded	Nature of Plant Residues	Description
H1	Clear, Colourless	None	Plant structure unaltered. Fibrous, elastic	Undecomposed
H2	Almost clear, yellow-brown	None	Plant structure distinct, almost unaltered.	Almost undecomposed
H3	Slightly turbid, brown	None	Plant structures distinct, most remains easily identifiable	Very weakly decomposed
H4	Strongly turbid, brown	None	Plant structure distinct, most remains identifiable	Weakly decomposed
H5	Strongly turbid, contains a little peat in suspension	Very little	Plant structure clear but indistinct and difficult to identify	Moderately decomposed
H6	Muddy, much peat in suspension	One third	Plant structure indistinct but clearer in residue, most remains undefinable	Well decomposed
H7	Strongly muddy	One half	Plant structure indistinct	Strongly decomposed
H8	Thick mud, little free water	Two thirds	Plant structure very indistinct – only resistant material such as roots	Very strongly decomposed
H9	No free water	Nearly all	Plant structure almost unrecognisable	Almost completely decomposed
H10	No free water	All	Plant structure not recognisable, amorphous	Completely decomposed

ANNEX C. PHOTOGRAPHS OF CORE SAMPLES

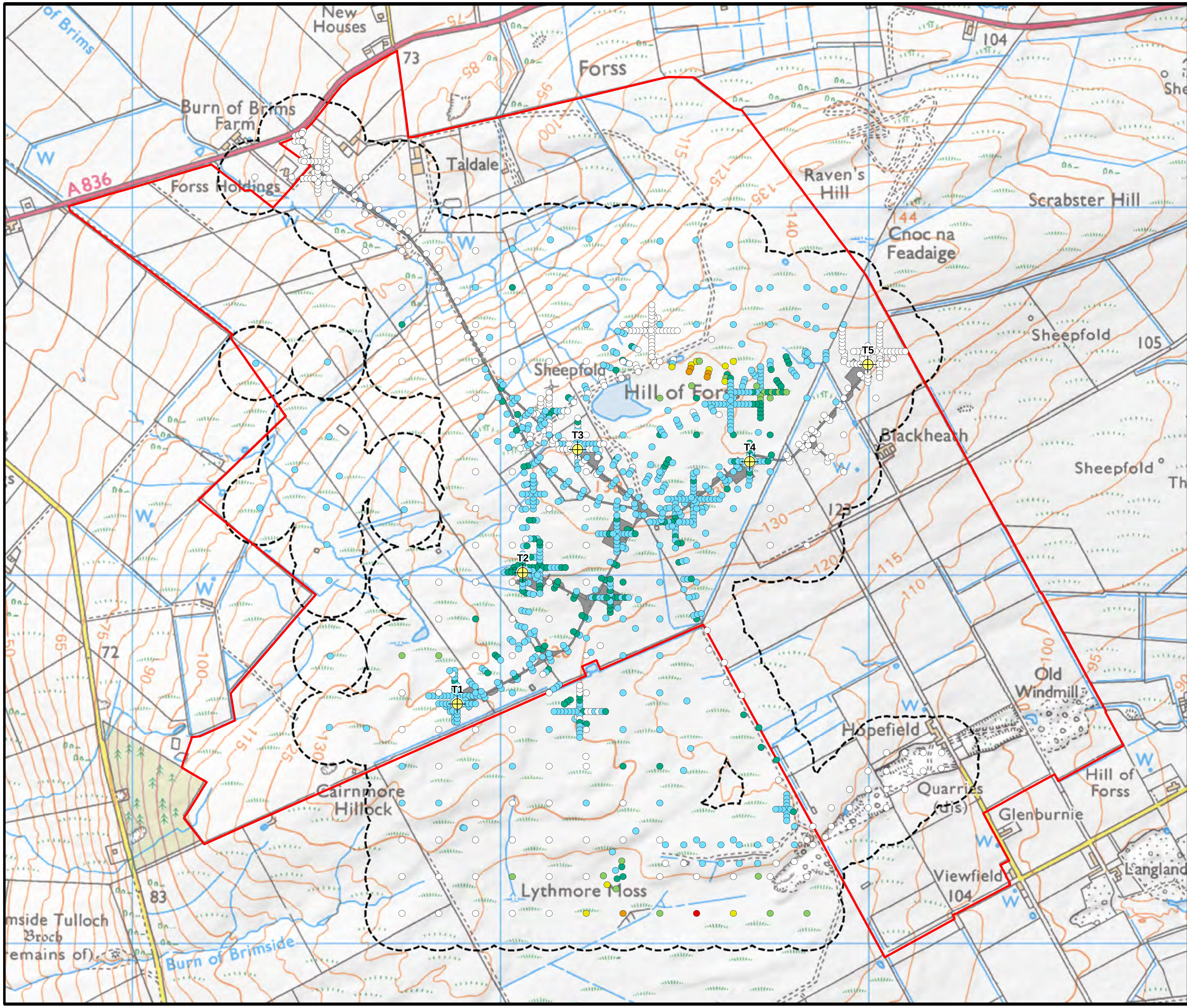
Photo 1 Core Sample T030a

Photo 2 Core Sample T059a

Photo 3 Core Sample T059b

Photo 4 Core Sample T146a

Photo 5 Core Sample T175a



CAIRNMORE HILL WIND FARM

FIGURE 2.4.2

PHASE 1 AND PHASE 2 SAMPLING PEAT DEPTHS

KEY

- TURBINE LOCATION
- SITE BOUNDARY
- INFRASTRUCTURE
- PEAT STUDY AREA

SAMPLE LOCATION PEAT DEPTHS

- NO PEAT
- ≤0.50M
- 0.51 - 1.00M
- 1.01 - 2.00M
- 2.01 - 3.00M
- 3.01 - 4.00M
- 4.01 - 5.00M

0 100 200 Metres

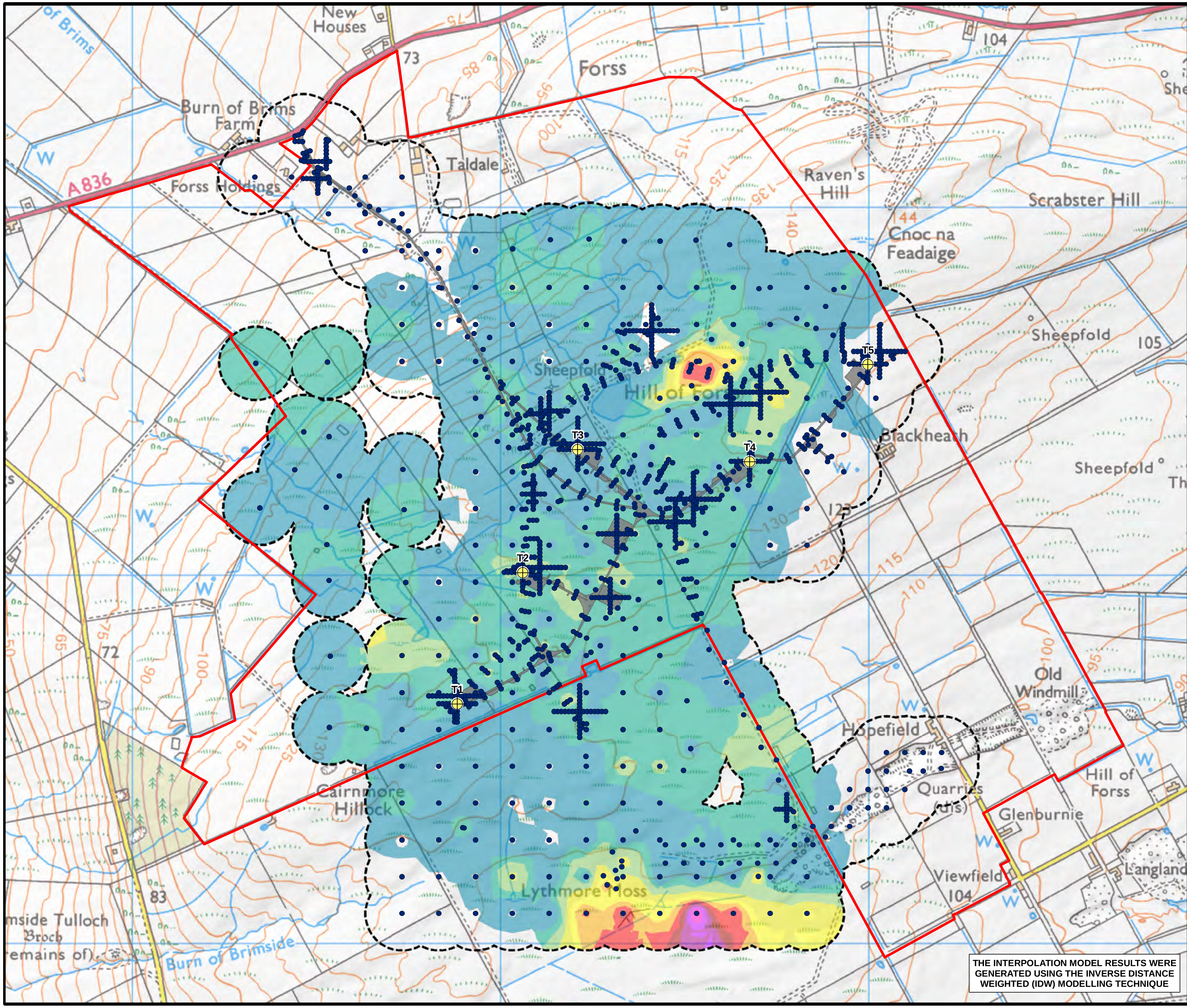
LAYOUT DWG	T-LAYOUT NO.
N/A	PSCOhof063

DRAWING NUMBER

FIGURE 2.4.2

SCALE - 1:10,000 @ A3

ENVIRONMENTAL IMPACT ASSESSMENT REPORT AND PLANNING APPLICATION 2022



CAIRNMORE HILL WIND FARM

FIGURE 2.4.3

PHASE 1 AND PHASE 2 INTERPOLATED PEAT DEPTHS

KEY

- TURBINE LOCATION
- SITE BOUNDARY
- INFRASTRUCTURE

INTERPOLATED PEAT DEPTH

- NO PEAT
- ≤0.25M
- 0.26 - 0.50M
- 0.51 - 1.00M
- 1.01 - 1.50M
- 1.51 - 2.00M
- 2.01 - 2.50M
- 2.51 - 3.00M
- 3.01 - 3.50M
- 3.51 - 4.00M
- 4.01 - 4.51M
- 4.51 - 4.93M
- PEAT SAMPLE LOCATION

0 100 200 Metres

LAYOUT DWG	T-LAYOUT NO.
N/A	PSCOhof063

DRAWING NUMBER

FIGURE 2.4.3

SCALE - 1:10,000 @ A3

ENVIRONMENTAL IMPACT ASSESSMENT REPORT AND PLANNING APPLICATION 2022

MacArthur Green

Cairnmore Hill Wind Farm Hydrological Sensitivities Technical Appendix 2.5

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1.1	Minor updates	Jenni Cunningham	07/06/2022
2.0	Internal Approval	Holly Clark	13/06/2022

CONTENTS

List of Figures

1 INTRODUCTION

MacArthur Green was commissioned by the Applicant, Renewable Energy Systems (RES) Ltd, to assess the water environment surrounding the proposed Cairnmore Hill Wind Farm (hereafter referred to as 'the Proposed Development').

This assessment characterises the water bodies within the catchment of the Proposed Development and sets out the general principles of design which the Contractor will follow to minimise changes to the hydrological regime and reduce the potential effect of the construction activities on the following sensitive features:

- Watercourses and drains;
- Public and private water supplies;
- Groundwater Dependent Terrestrial Ecosystems (GWDTE) 1; and
- Flood risk.

2 ASSESSMENT

2.1 Hydrological Catchments

The Proposed Development infrastructure drains into three catchments through a series of drains, minor and major watercourses.

- Burn of Brims;
- Burnside Burn; and
- Forss Water.

The major and minor watercourses across the site are shown in **Figure 2.5.1**.

The main access track and Turbine (T) 3 are located to the north of the site within the Burn of Brims catchment. Reaches of the Burn of Brims tributaries have been straightened and downstream of the site the channel appears to have been heavily modified, flowing through a series of field drains to the coastline north of the Proposed Development at the Port of Brims.

The western extent of the site, in the location of T1 and T2 infrastructure, drains north-west through tributaries of Forss Water which eventually discharges into Crosskirk Bay at the coastline north of the Proposed Development.

The southern extent of the site, where the Control building, substation compound, T4, T5 and associated infrastructure and the temporary construction compound are sited, drains east through a series of field drains into Burnside Burn which discharges into Thurso Bay.

2.1.1 Watercourse Buffer

The watercourse buffers provide built-in mitigation to protect watercourses from pollution events. A 50 m buffer from infrastructure and construction activities has been applied to the major watercourses, and a 25 m buffer has been applied to minor watercourses within the site.

The 50 m buffer was applied to all major watercourses which are marked on 1:50 000 scale mapping. A 25m buffer was applied to all minor watercourses marked on 1.25000 scale mapping. A 10m buffer has been applied to all drain features shown on the 1:25,000 scale map which have been assessed as highly ephemeral features, and not controlled waters (as shown in **Figure 2.5.1**).

The overall design has also aimed to minimise the crossing of drainage ditches where possible within the wider constraints of the site. The Proposed Development breaches the watercourse buffers where existing tracks are utilised (to prevent new ground disturbance), this includes three existing watercourse crossings which may require upgrading.

Whilst the Proposed Development does largely avoid the drainage network, under the proposed layout additional three new watercourse crossings will be required including one additional temporary watercourse crossing which will be required on the temporary access track during the construction phase only. All watercourse crossings required for the proposed development are detailed further in **Section 2.2**.

A site wide application will be made to SEPA for a Construction Site Licence addressing surface runoff from the construction site. This application will include a Pollution Prevention Plan. A 10 m buffer from all construction related activities (e.g., refuelling, plant and vehicle operations) will be applied to all watercourses as well as man-made drainage ditches during the construction phase. Mitigation measures outlined within the Pollution Prevention Plan for the site will minimise release of pollutants to the water environment to inadvertent short-term releases only. The applied buffers will reduce the potential for any inadvertent pollutant releases to transfer to the water environment. To further minimise the risk of pollution to the water environment, construction activities which have the potential to result in inadvertent pollutant releases (e.g., excavations) or are higher risk activities (e.g., concrete works) will only be conducted in dry conditions and will be overseen by an on-site Ecological Clerk of Works (ECoW).

2.1.2 Existing Infrastructure

In addition to the watercourse buffers, potential effects on the surrounding water environment have been minimised by utilising existing infrastructure where possible.

The main access to the Proposed Development will be through a field currently used for grazing adjacent to the Forss Holding property (see **Figure 2.1**). This will join an existing access track located to the western side of the Hill of Forss and on to T3. From this existing track there are two distinct spurs of new access track. The first spur extends to the west to T1 with T2 held on a small discrete spur off this. The temporary construction compound and Control building and substation are located along this spur. A second spur extends to the east to T4 and T5.

The Proposed Development requires approximately 2.42 km of new access tracks and 360 m of temporary track. The design utilises approximately 960 m of existing tracks within the site to reduce the total area of ground disturbance.

Where existing access tracks require upgrading works, the running width of the track will be extended to 4 m on straight sections, with 0.25 m wide shoulders on each side.

2.2 Watercourse Crossings

The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) ('CAR') guidance[2] determines the level of authorisation required for wind farm development related activities within the water

[1] As defined within SEPA (2017). Guidance Note 31: Guidance on Assessing the Impacts of Windfarm Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems. Available for download from http://www.sepa.org.uk/media/143868/lupsgu31_planning_guidance_on_groundwater_abstractions.pdf (Accessed on May 2022)

environment. The construction of watercourse crossings is one such example of a controlled activity. There are three levels of authorisation relevant to watercourse crossings; adherence to General Binding Rules (GBR), Registration and application for a Simple Licence.

- GBRs are a set of clear guidelines on how a low-risk activity can be undertaken. There is no requirement to register a GBR activity with SEPA.
- A Registration is required for small-scale activities that pose low environmental risk individually but, cumulatively, can result in greater environmental risk. The Applicant must apply to SEPA to register these activities.
- An application is required to SEPA for obtaining a Simple CAR Licence if site-specific controls are required, particularly if constraints upon the activity are to be imposed for activities which may pose a greater environmental risk.

Crossings do not require authorisation where they are located on minor watercourses which are not marked on OS 1:50,0000 scale mapping or are below the threshold for a Registration. This is with exception of culverting for land-gain. No new watercourse crossings are required on any major watercourses hence there are no new watercourse crossings that require authorisation under CAR. Under CAR Practical Guidance[2] (page 95) certain maintenance, repair, removal and replacements activities occurring at existing watercourse crossings may require authorisation.

The Proposed Development will cross a total of six watercourses (including drains) as shown on **Figure 2.5.2**. Three new watercourse crossings (WC4, WC5 and WC6) would be required as part of the track layout. The design of the new watercourse crossings would be agreed with SEPA prior to construction and would ensure the continued safe passage of mammals.

Figure 2.5.3 and **Figure 2.5.4** show the infrastructure on 1:25,000 OS mapping and aerial imagery respectively. The figures show that the infrastructure will utilise three existing culvert crossings (WC1, WC2 and WC3) on minor watercourses.

The main access track consists of new access track joining with the existing track to be upgraded as detailed in Chapter 2 of the EIA Report. This existing track crosses a major tributary of the Burn of Brims and the existing watercourse crossing may be subject to upgrading works following a structural assessment. Any proposed construction works will be undertaken in accordance with CAR and GBR dependent on the works required.

The works will be undertaken in accordance with best practice guidance for work within the water environment (outlined in Technical Appendix 2.1: Outline Construction Environmental Management Plan (CEMP)).

The Proposed Development has been designed to avoid crossing any major watercourses unless to utilise an existing stretch of track (with an existing watercourse crossing). The only new watercourse crossings are on minor channels and drains. No significant effects are considered on the water environment as a result of the required watercourse crossings.

2.3 Public and Private Abstractions

SEPA requires the location of all groundwater abstractions for drinking water supplies to be obtained by consultation with local authorities and local residents, as outlined in Appendix 3 of the SEPA LUPS Guidance Note 31.

Data requests had previously been made to Scottish Water and The Highland Council (THC) in 2016 and 2018 to obtain information regarding public and private water supplies within 2 km of the site, based on the site boundary for the previous submission.

Data requests were made in 2022 for the Proposed Development and consultation responses are outlined in the following sections.

2.3.1 Public Abstractions

A Freedom of Information (FOI) request was made to Scottish Water in 2016 (FOI dated 8th November 2016) and again in 2018 (FOI dated 24th August 2018).

Scottish Water responded on the 29th November 2016 and confirmed that there were no Scottish Water drinking water catchments or water abstraction sources designated as Drinking Water Protected under the Water Framework Directive in the area that may be affected by the previous proposed development. The response noted that it was made in respect to drinking water protected areas only, excluding assets such as supply or sewer pipes, water and waste water treatment works.

No further information was received following resubmission of the data request in 2018.

The Scottish Water scoping consultation response for the Proposed Development received on the 25th January 2022 confirmed that there were no Scottish Water drinking water catchments or water abstraction sources designated as Drinking Water Protected under the Water Framework Directive in the area that may be affected by the Proposed Development.

No assets were identified within the red line boundary of the Proposed Development in the Scoping response from Scottish Water. It is therefore determined that no assets such as supply or sewer pipes, water and wastewater treatment works are located within the Proposed Development boundary.

A freedom of information (FOI) request was made to SEPA on the 2nd March 2022 for the following information regarding known records for abstractions greater than $10m^3$/day within 2km of the Proposed Development site boundary:

- Site name or property address;
- Source type;
- Grid reference of the property and source; and
- Water usage and abstraction rates where known.

[2] SEPA, 2022. The Water Environment (Controlled Activities (Scotland) Regulations 2011 (as amended), A Practical Guide, Version 9.1.

2.3.2 Private Abstractions

A FOI request was made to THC on 8th November 2016 and again on 24th August 2018 for the previous proposed development regarding registered private water supplies (PWS). The response has been included in the risk assessment of the Proposed Development on PWS below in **Section 2.3.4**.

A FOI request was made to The Highland Council (THC) on 17th February 2022 for the following information regarding registered PWS for the Proposed Development:

- Site name or property address;
- Source type;
- Grid reference of the property and source,
- Water usage and abstraction rates where known.

The THC issued private water supply register relevant information as of February 2022.

Concerning the private water supply register, THC noted that some sources did not have registered property locations and that the register represented only those supplies that had been notified to THC. There is likely to be a number of unregistered PWS that have not been notified to the Council as it falls upon the resident to inform their local Environmental Health Officer of any private water abstractions in use.

The database was clipped to a 5km search area of the Proposed Development site boundary. A number of PWS sources and supplied properties were found to be located within the defined search area as detailed in **Table 1** below.

Table 1: Registered PWS and supplied properties within 5km of site boundary.

Unique ID	Location	Address	Source	Usage
33593	305400, 969100	Holding No 11, Forss, By Thurso	Groundwater - Well	FB1 PWS Domestic < 50 Persons
31582	305200, 965300	Westfield	Groundwater - Well	FB1 PWS Domestic < 50 Persons
31654	-	Westfield, By Thurso, Caithness	I.D: 31582 Groundwater - Spring	FW1 Domestic House (Private)
33571	306100, 965200	Achnabrae, Skaill, Reay	Groundwater - Spring	FB1 PWS Domestic < 50 Persons
33576	-	Achnabrae, Skaill, Reay	I.D 33571- Groundwater Spring	FW1 Domestic House (Private)
46618	310036, 968558	Henderson Park Ind. Estate, Thurso, Caithness, KW14 7XW	Surface - Watercourse	FA1 PWS Commercial < 100m2
31590	307200, 962900	Lieurary Mains, Westfield, Caithness	Groundwater - Spring	FB1 PWS Domestic < 50 Persons
31659	-	Westfield, By Thurso, Caithness	I.D: 31590 Groundwater - Spring	FW1 Domestic House (Private)
45009	301607, 965145	Achnabraeskaill, 9 Skaill, Thurso, Highland, KW14 7YD	Groundwater - Spring	FB1 PWS Domestic < 50 Persons
45011	301607, 965145	Achnabraeskaill, 9 Skaill, Thurso, Highland, KW14 7YD	I.D 45009 Groundwater - Spring	FW1 Domestic House (Private)

2.3.3 Resident Consultation

Following the response from the Council, all properties located within a condensed 2 km search area were contacted via letter to confirm if the property is supplied by a PWS or Scottish Water Mains. The search zone included properties within 2km of the Proposed Development boundary where there was potential for hydrological connectivity to the Proposed Development. Following assessment of the catchment layout a 2km search zone was considered sufficient for assessment as distances greater than 2km were considered not hydrologically connected to the Proposed Development.

If the property is supplied by PWS, residents or property owners are asked to provide further information by completing a questionnaire. A template of the letter is provided in **Annex A**. A total of 29 properties were contacted.

A total of nine responses have been received at the time of writing, all of which have confirmed that these properties are not supplied by a PWS and are connected to Scottish Water Mains. No new PWS have been identified to those already registered within 2km of the site boundary.

2.3.4 PWS Assessment

An assessment of hydrological connectivity between identified PWS and the Proposed Development is shown in **Table 2**. One property was identified within 250 m of the site boundary as shown on **Figure 2.5.5**. As detailed in **Table 2**, the PWS at this property was confirmed as no longer in use. All other PWS sources have been determined as not hydrologically or hydrogeologically connected to the Proposed Development.

Table 2: Assessment of registered PWS hydrological connectivity within 5km of site boundary.

Unique ID	Distance from site boundary (m)	Hydrological Connectivity
33593	53.57	PWS is located within the same catchment as the Proposed Development (Burnside Burn: waterbody ID: 20626). Previous EIA TA2.5 Hydrological Sensitivities reported that the applicant had approached the landowner at PWS Holding No 11 Forss to confirm if the registered source location reflected the property or the point of abstraction. It was reported that the landowner confirmed that the property no longer used the registered well and that it was now connected to the public mains and supplied by Scottish Water. The property has therefore been scoped out of the assessment.
31582	1971.1	PWS source located within a separate catchment (Forss Water - Allt Forsiescye to sea. Waterbody ID: 20633) to development (Burnside Burn: waterbody ID: 20626). No impact from drainage from the Proposed Development and PWS source can be scoped out from further assessment.
31654	-	Property supplied by source ID: 31582, scoped out from further assessment as above.
33571	1999.72	PWS source is within a separate catchment (Forss Water - Allt Forsiescye to sea. Waterbody ID: 20633) to the Proposed Development (Burnside Burn: waterbody ID: 20626). No impact from drainage from the Proposed Development and PWS source can be scoped out from further assessment.
33576	-	Property supplied by source ID: 33576, scoped out from further assessment as above.
46618	2556.27	PWS is within the same catchment as the Proposed Development (Burnside Burn: waterbody ID: 20626). PWS considered hydrologically disconnected as the surface water abstraction source is from Wolfburn tributary. This is a tributary of Burnside Burn draining from a small hill to the south-west of the development. Based on site topography and drainage, no runoff from the Proposed Development will impact this PWS location.

Unique ID	Distance from site boundary (m)	Hydrological Connectivity
31590	4066.6	PWS source is located within a separate catchment (Forss Water - Allt Forsiescye to sea. Waterbody ID: 20633) to the Proposed Development (Burnside Burn: waterbody ID: 20626). No impact from drainage from the Proposed Development and PWS source can be scoped out from further assessment.
31659	-	Property supplied by source ID: 31659, scoped out from further assessment as above.
45009	4160.09	PWS source is located within a separate catchment (Forss Water - Allt Forsiescye to sea. Waterbody ID: 20633) to the Proposed Development (Burnside Burn: waterbody ID: 20626). No impact from drainage from the Proposed Development and PWS source can be scoped out from further assessment.
45011	4160.09	PWS source is located within a separate catchment (Forss Water - Allt Forsiescye to sea. Waterbody ID: 20633) to the Proposed Development (Burnside Burn: waterbody ID: 20626). No impact from drainage from the Proposed Development and PWS source can be scoped out from further assessment.

2.4 Groundwater Dependent Terrestrial Ecosystems

National Vegetation Classification (NVC) communities recorded within the NVC study area have been mapped as potential Groundwater Dependent Terrestrial Ecosystems (GWDTE) based on Appendix 4 of SEPA's Land Use Planning System Guidance Note 31 (LUPSG31, September, 2017[3]). The NVC survey results are included in Technical Appendix 7.1: National Vegetation Classification and Habitats Survey and an assessment of the GWDTE is within Annex C of the same Technical Appendix.

GWDTE have been assessed where they are within 100m of excavations less than m in depth, and 250m of excavations greater than 1 m in depth. The buffers stated are defined in LUPSG31 and are shown in **Figure 7.4** as part of Technical Appendix 7.1. It has been assumed that tracks and temporary hardstanding will require excavations less than 1m, whilst excavations for the remaining infrastructure are assumed to be at a depth of 1 m or greater, as a conservative approach.

The following potential GWDTE habitats were identified on site and assessed as majority ombrotrophic with the potential to be partially dependent on groundwater.

- M15;
- M23;
- MG10a;
- S27; and
- Springs.

The site layout was designed based on the principles of avoidance first, minimisation and mitigation across all site constraints. The avoidance of the 250 m buffer of these features was not feasible in all instances amongst other site constraints. The habitats have been assessed and mitigation proposed where required to minimise the potential effect on the groundwater flow paths to maintain localised hydrological flows. Reference should be made to Annex C of Technical Appendix 7.1: National Vegetation Classification and Habitats Survey for full details of the assessment.

2.5 Flood Risk

The Proposed Development is not within an area identified by SEPA to be at risk of significant flooding from both rivers and coastal waters. Eastern parts of the proposed development are mapped within a Potentially Vulnerable Area (PVA: 01/01) within the River Thurso Catchment.

The Proposed Development is also located within 1 km of flood risk zone for the Forss Water. Additionally, there are small, localised areas within the site boundary that are at medium to low risk of fluvial flooding and high risk of surface water flooding, largely associated with depressions in the topography, as indicated by the Indicative River and Coastal Flood Map.

The previous submission concluded the site is not within an area at high risk of fluvial flooding, heavy rainfall and resulting surface runoff has historically overwhelmed the intensive drainage network within the area. Utilisation of existing access tracks will reduce the impermeable footprint of the Proposed Development and therefore minimise the total runoff volumes from the site.

Culverts required at the three new watercourse crossing points as noted in **Section 2.2** will be sized appropriately, allowing conveyance for a 1:200 year flood event. However, the design should be site specific and may need to be reviewed on ephemeral drains to prevent oversized culverts that may result from uncertainty in calculating the 1:200 year peak flow event on very small catchments.

An FOI request was made to The Highland Council (THC) on 2nd March 2022 for information regarding flood risk and recorded flood incidents.

The response received from THC on the 18th March 2022 stated THC had reviewed their records and had no reports of flooding or records of flooding within the red line boundary. The need for further Flood Risk Assessment was considered unnecessary based upon THC Flood Risk and Drainage supplementary guidance[4].

As noted above, a Pollution Prevention Plan which will include sustainable drainage management (SuDs) will also be submitted to SEPA as part of the CAR licence application. This will detail measures for both sediment management and attenuation of runoff which require different drainage designs and will recognise the site-specific sensitivities of the site and its existing drainage network. Specific consideration should be given to the drainage around T2; whilst the impact of the footprint of the T2 is small in relation to the increase in the impermeable area of the catchment, attenuation proposals for construction runoff in this area should be specifically stated in the drainage management plan and construction site CAR Licence that will be issued to SEPA's review and approval.

3 SUMMARY

The Proposed Development has been designed to utilise existing access tracks and, where feasible, design any new infrastructure out with a 50 m buffer from major watercourses and a 25 m buffer from minor watercourses. A temporary rotor lit pad and crane hardstanding at T2 are located approximately 15 m from a drain. No

[3] As defined within SEPA (2017). Land Use Planning Guidance Note 31: Guidance on Assessing the Impacts of Windfarm Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems. Available for download from http://www.sepa.org.uk/media/143868/lupsgu31_planning_guidance_on_groundwater_abstractions.pdf. (Accessed on May 2022)

[4] The Highland Council (THC), N.D, Flood Risk and Drainage Impact Assessment: Supplementary Guidance.

construction activities will occur within 10m of any watercourses or drains. This design approach provides in-built mitigation for pollution prevention of the water environment.

Following data requests to Scottish Water and THC there are no public water abstractions or active private water abstractions within 2km of the Proposed Development that require further mitigation as a result of the Proposed Development.

Mitigation will be required to maintain shallow localised flow paths around infrastructure, indicated by the presence of MG10a, M15, M23 and S27 GWDTE habitats.

Localised areas within the site boundary are identified as 'Medium' to 'Low' risk of fluvial flooding and 'High' risk of surface water flooding, however, this is largely associated with depressions in the topography. The Proposed Development is not within an area identified by SEPA to be at risk of significant flooding from both rivers and coastal waters.

The design of the new watercourse crossings would be agreed with SEPA prior to construction and would ensure the continued safe passage of mammals. A Pollution Prevention plan including SuDs will also be submitted to SEPA as part of the Construction Site Licence (CSL) application.

ANNEX A. ANNEX 1: PRIVATE WATER SUPPLIES LETTER TEMPLATE

Property address:

If the above address is incorrect, please add a note here: ______________________________

Please tick one of the below boxes to confirm how your property is supplied by water:

☐ Scottish Water Mains

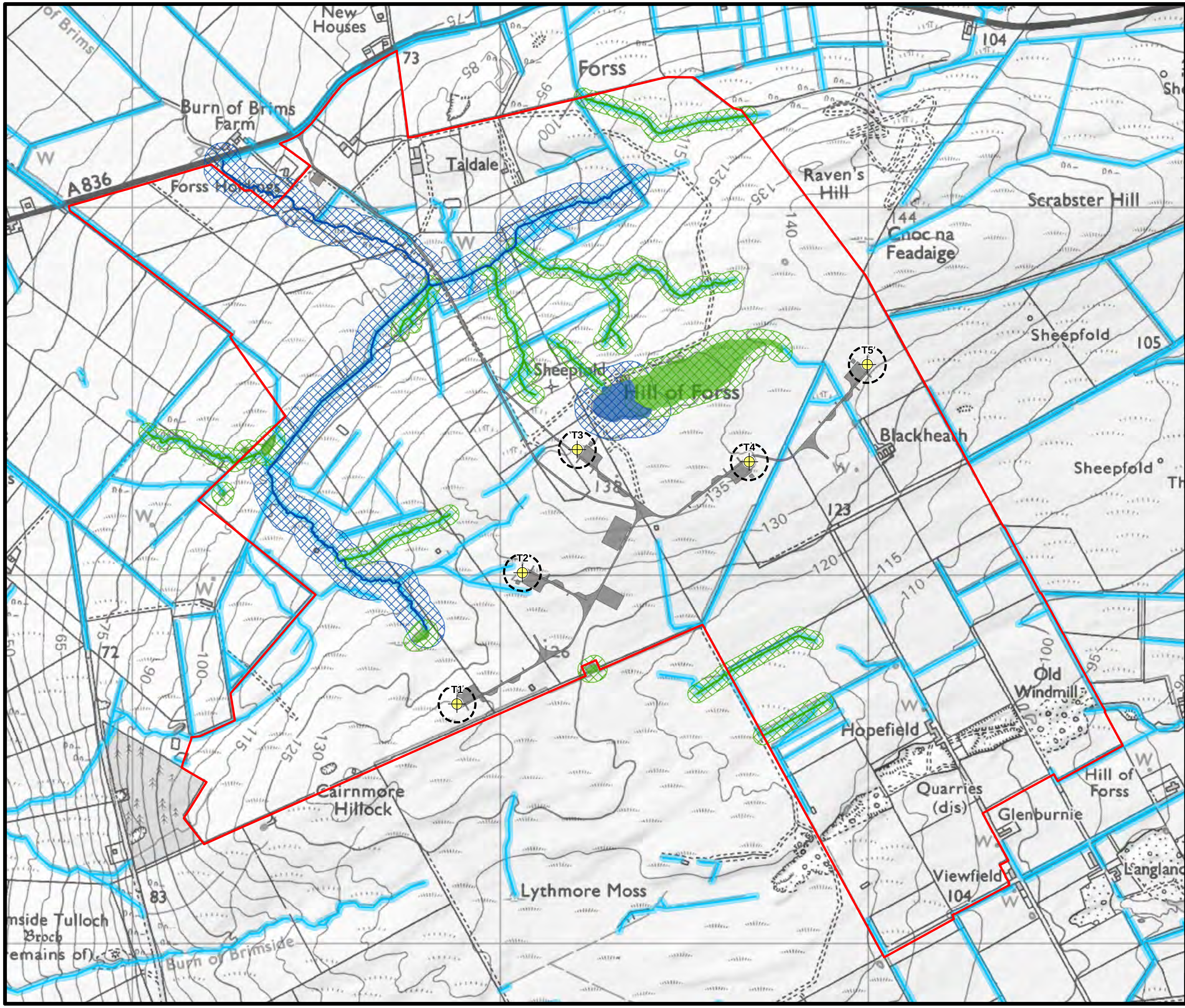
☐ Private Water Supply

If your property is supplied by a private water supply, please mark the location of your water supply on the map provided. Please also complete the below table with as much information as you can to help us understand your water supply.

Please then return this form and the map to MacArthur Green in the self-addressed envelope.

Thank you in advance for your help.

	Comments
Source location (please mark on the map and provide a grid reference if known)	
Source type (well, borehole, spring, groundwater, surface runoff, active pump)	
Use of supply (e.g. domestic, livestock, supply to industrial/ commercial properties)	
Abstraction rate (m^3/day if known)	
Number of properties, people and/ or livestock supplied	
Any additional comments on the condition of the water supply	



CAIRNMORE HILL WIND FARM

FIGURE 2.5.1

HYDROLOGICAL FEATURES

KEY

- TURBINE LOCATION
- SITE BOUNDARY
- INFRASTRUCTURE
- 50M TURBINE BUFFER

WATERBODY

- MAIN
- MINOR

WATERCOURSE

- MAIN
- MINOR
- ORDNANCE SURVEY VECTORMAP

BUFFER AREAS

- MAJOR (50M)
- MINOR (25M)
- OS VM (10M)

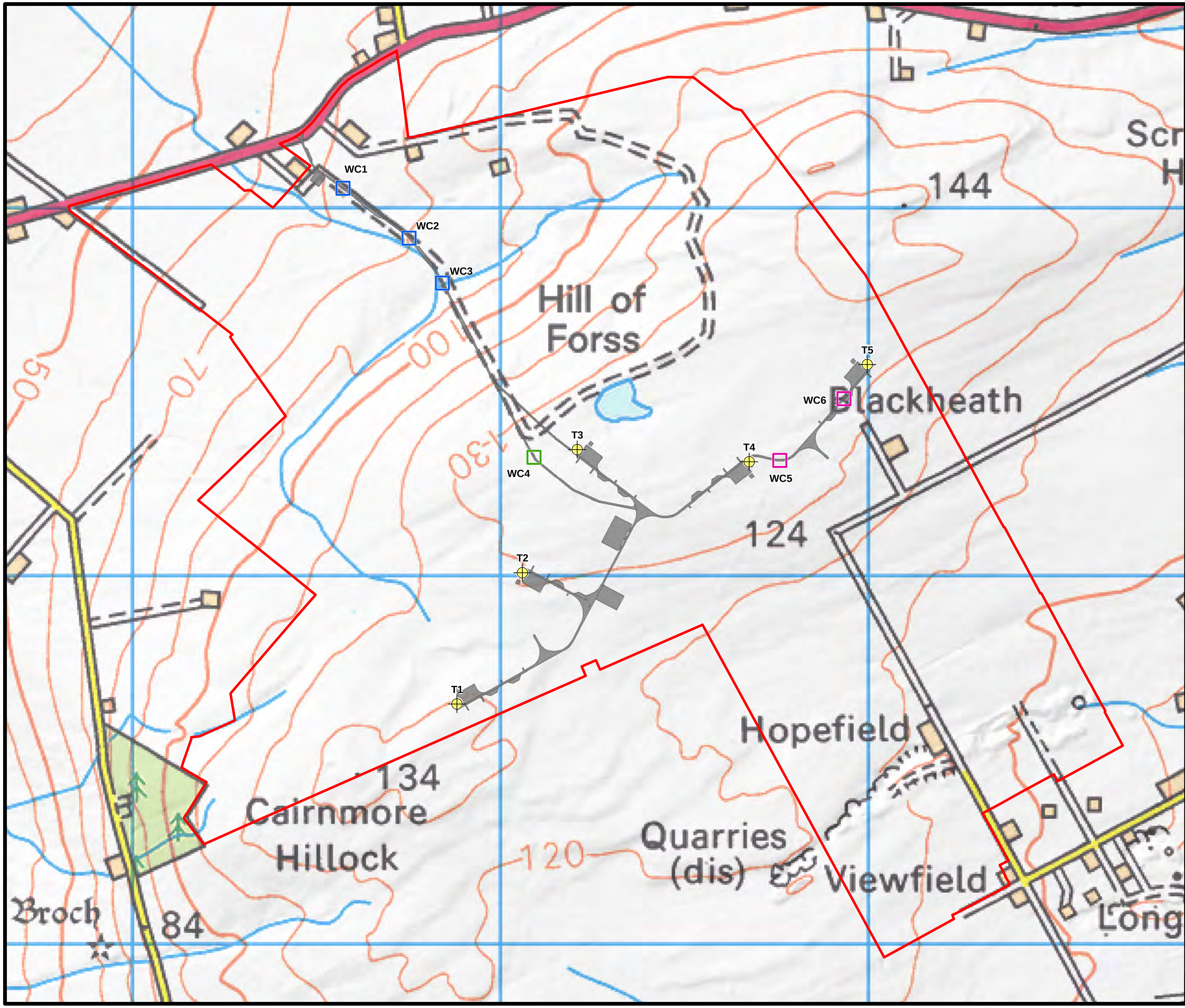
0 100 200 Metres

LAYOUT DWG	T-LAYOUT NO.
N/A	PSCOhof063

DRAWING NUMBER
FIGURE 2.5.1

SCALE - 1:10,000 @ A3

ENVIRONMENTAL IMPACT ASSESSMENT REPORT AND PLANNING APPLICATION 2022



CAIRNMORE HILL WIND FARM

FIGURE 2.5.2

WATERCOURSE CROSSINGS (1:50,000)

KEY

- TURBINE LOCATION
- SITE BOUNDARY
- INFRASTRUCTURE

WATERCOURSE CROSSING

- EXISTING
- NEW
- NEW (TEMPORARY)

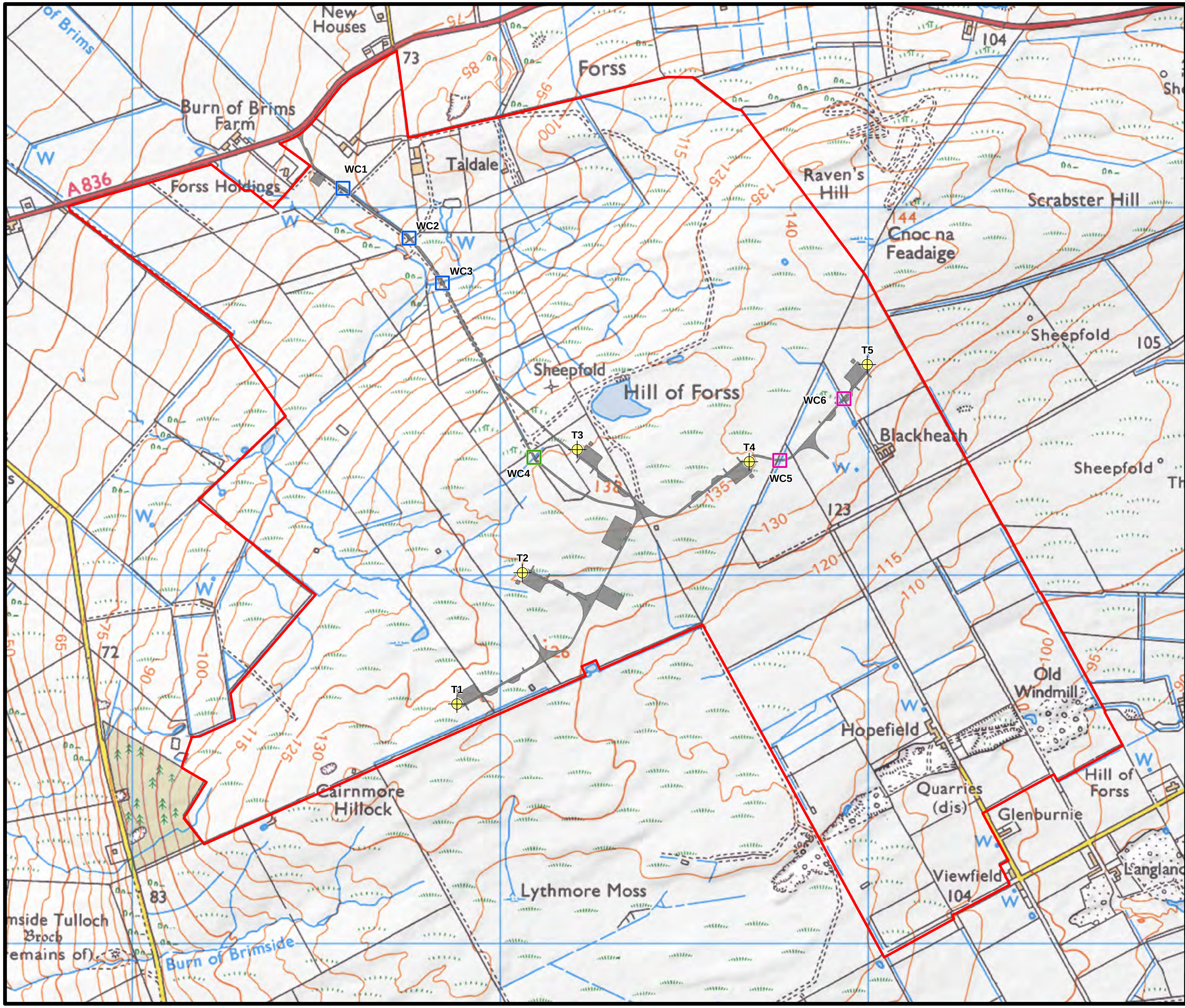
0 100 200 Metres

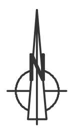
LAYOUT DWG	T-LAYOUT NO.
N/A	PSCOhof063

DRAWING NUMBER
FIGURE 2.5.2

SCALE - 1:10,000 @ A3

ENVIRONMENTAL IMPACT ASSESSMENT REPORT AND PLANNING APPLICATION 2022





CAIRNMORE HILL WIND FARM

FIGURE 2.5.3

WATERCOURSE CROSSINGS (1:25,000)

KEY

- TURBINE LOCATION
- SITE BOUNDARY
- INFRASTRUCTURE

WATERCOURSE CROSSING

- EXISTING
- NEW
- NEW (TEMPORARY)

0 100 200 Metres

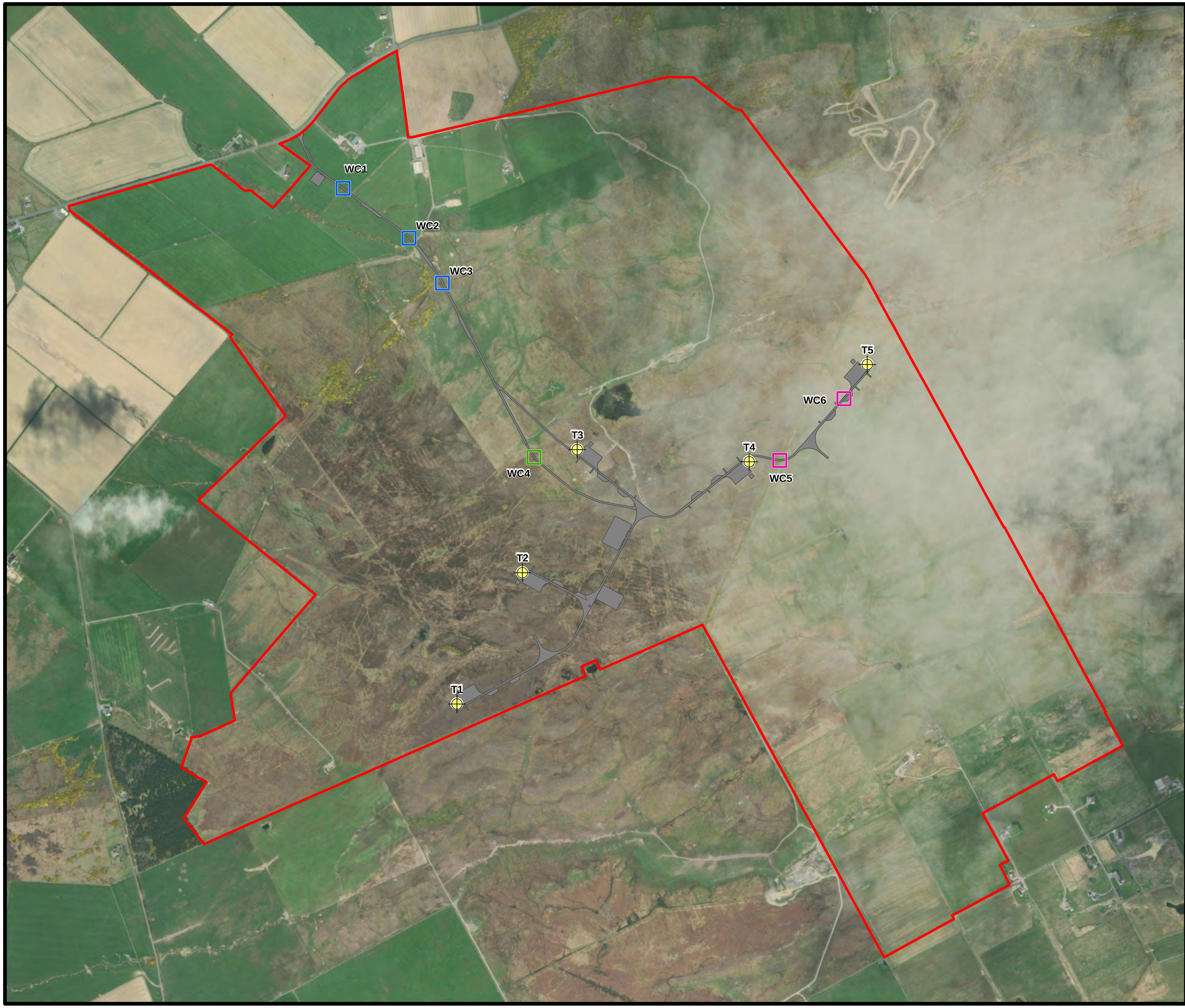
LAYOUT DWG	T-LAYOUT NO.
N/A	PSCOhof063

DRAWING NUMBER

FIGURE 2.5.3

SCALE - 1:10,000 @ A3

ENVIRONMENTAL IMPACT ASSESSMENT REPORT AND PLANNING APPLICATION 2022



CAIRNMORE HILL WIND FARM

FIGURE 2.5.4

WATERCOURSE CROSSINGS (AERIAL)

SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY

KEY

- TURBINE LOCATION
- SITE BOUNDARY
- INFRASTRUCTURE

WATERCOURSE CROSSING

- EXISTING
- NEW
- NEW (TEMPORARY)

0 100 200 Metres

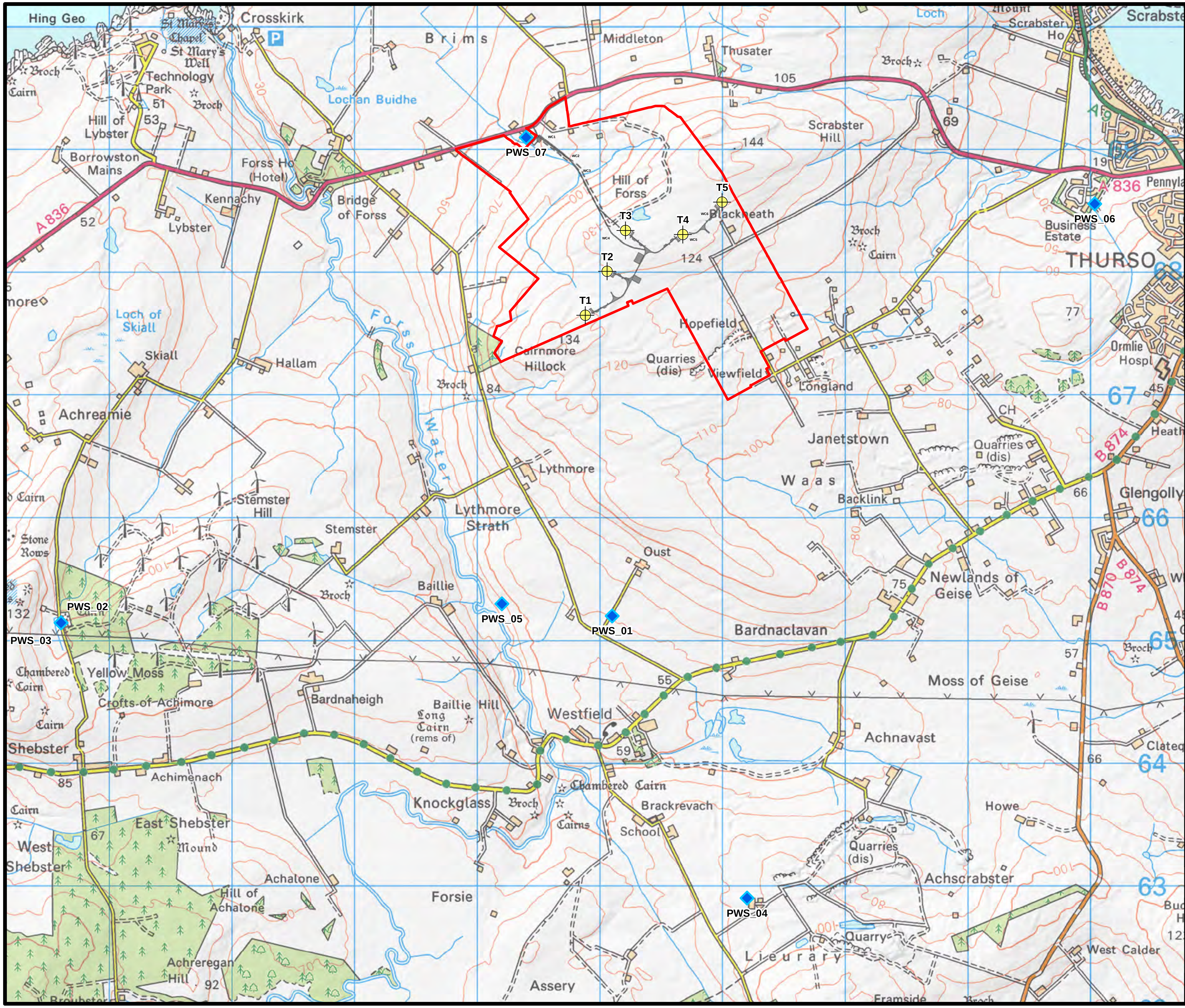
LAYOUT DWG	T-LAYOUT NO.
N/A	PSCOhof063

DRAWING NUMBER

FIGURE 2.5.4

SCALE - 1:10,000 @ A3

ENVIRONMENTAL IMPACT ASSESSMENT REPORT AND PLANNING APPLICATION 2022



CAIRNMORE HILL WIND FARM

FIGURE 2.5.5

PRIVATE WATER SUPPLIES

KEY

- TURBINE LOCATION
- SITE BOUNDARY
- INFRASTRUCTURE
- REGISTERED PRIVATE WATER SUPPLY (PWS) LOCATION

0 0.5 1 km

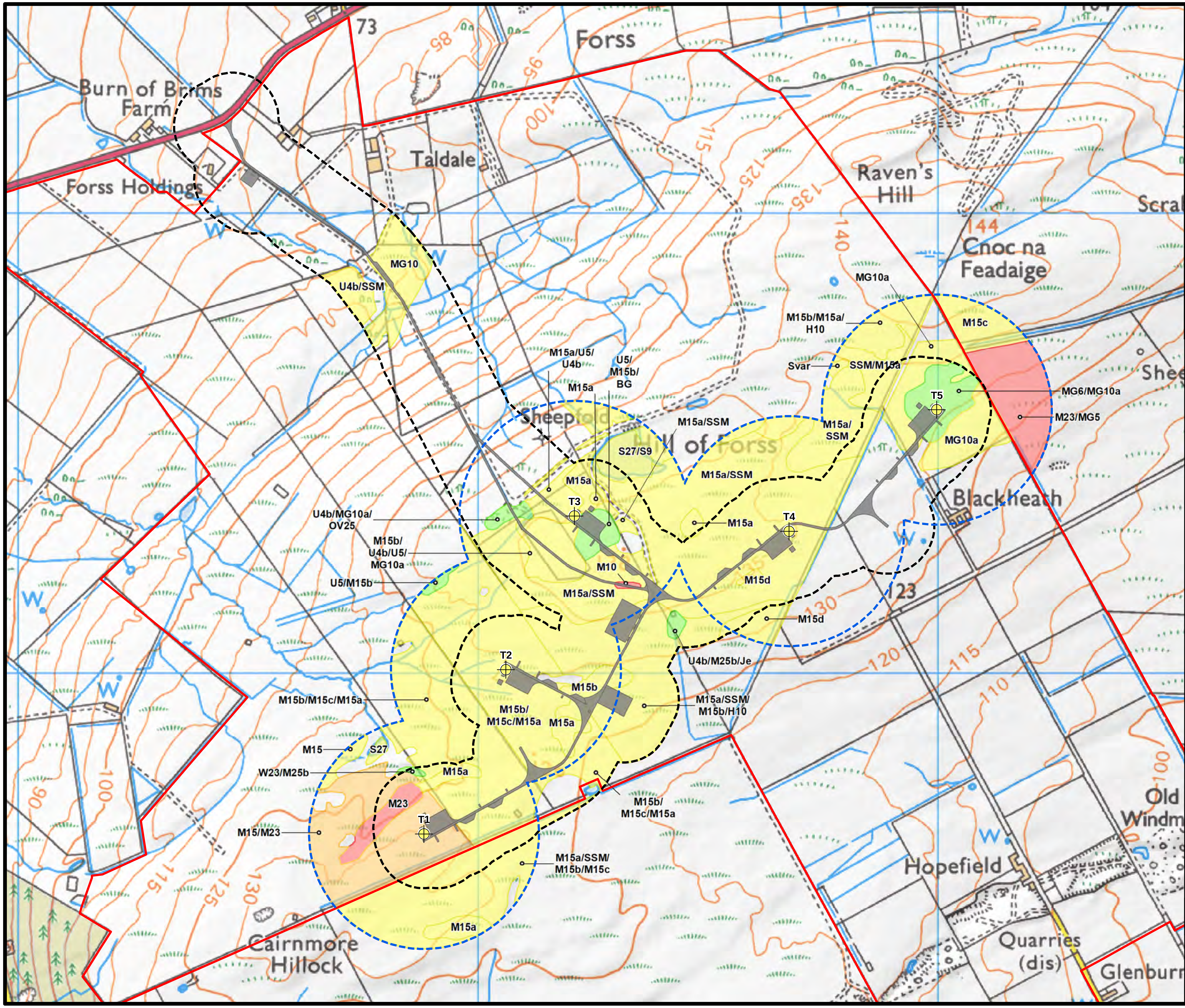
LAYOUT DWG	T-LAYOUT NO.
N/A	PSCOhof063

DRAWING NUMBER

FIGURE 2.5.5

SCALE - 1:30,000 @ A3

ENVIRONMENTAL IMPACT ASSESSMENT REPORT AND PLANNING APPLICATION 2022



CAIRNMORE HILL WIND FARM

FIGURE 2.5.6

GROUNDWATER DEPENDENT TERRESTRIAL ECOSYSTEMS (GWDTE)

KEY

- TURBINE LOCATION
- SITE BOUNDARY
- INFRASTRUCTURE

GWDTE BUFFER ZONES

- 100M
- 250M

POTENTIAL GWDTE

- HIGHLY DOMINANT
- HIGHLY SUB-DOMINANT
- MODERATELY DOMINANT
- MODERATELY SUB-DOMINANT

0 100 200 Metres

LAYOUT DWG	T-LAYOUT NO.
N/A	PSCOhof063

DRAWING NUMBER

FIGURE 2.5.6

SCALE - 1:8,000 @ A3

ENVIRONMENTAL IMPACT ASSESSMENT REPORT AND PLANNING APPLICATION 2022

MacArthur Green

Cairnmore Hill Wind Farm Carbon Balance Assessment Technical Appendix 2.6

Date: 20/06/2022

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1	Internal Approval	David H. MacArthur	18/05/2022
1.1	Updated	Judy McKay	13/06/2022
2	Internal Approval	David H. MacArthur	20/06/2022

CONTENTS

1 INTRODUCTION

This Carbon Balance Assessment Report has been prepared on behalf of RES Ltd ('the Applicant') in support of an application for consent to construct and operate a wind farm (hereafter referred to as 'the Proposed Development') at a site in Caithness approximately 4.5 km west of Scrabster which would be known as Cairnmore Hill Wind Farm.

This report was previously submitted in support of the Environmental Impact Assessment (EIA) for Cairnmore Hill Wind Farm original planning application (2019). This report has been updated to reflect the new layout and includes the additional peat depth data that was collected in 2022. Whilst the proposed development will generate renewable energy and will contribute to carbon emissions reduction targets, it is recognised that the construction of the proposed infrastructure and subsequent operation and decommissioning will include activities that either directly or indirectly result in carbon dioxide (CO_2) emissions. In particular, the construction of the infrastructure could result in the potential loss of CO_2 from carbon stored within the peat deposits within the Proposed Development site.

The Scottish Government has published an online calculation tool (the "carbon calculator") that should be used to calculate the greenhouse gas emissions and carbon payback times for wind farm developments on Scottish peatlands. This online tool, originally published in 2011 (described in Smith *et al*, 2011), is supported by two further documents published by the Scottish Government, 2016, and Scottish Renewables & SEPA, 2012.

The carbon calculator must be used for developments with a generating capacity of 50 MW or more. Since the Proposed Development is under 50 MW, there is no requirement for this assessment, but it has been done to show good practice. The calculation compares an estimate of the carbon emissions from the construction, operation and decommissioning of the Proposed Development to those emissions estimated from other electricity generation sources.

2 DEVELOPMENT DESCRIPTION

The site covers an area of approximately 3.58 km² located approximately 4.5 km west of Scrabster on the north coast of Caithness in the Scottish Highlands. Five horizontal axis turbines are proposed. The site is low lying, with the highest point at 138 m above sea level at Hill of Forss within the centre of the site; Cairnmore Hillock reaches 134 m to the west of the site. The southern central area of the site is a level plateau area of relatively shallow peatland by Lythmore Moss, which is characterised by heavily grazed and degraded wet heath and wet modified bog. The edges of the site are underlain by mineral soils, and are dominated by semi-improved grasslands, improved pasture and fields ploughed and used for crops. There is no woodland present within the site.

There are a number of small watercourses present within the site, many of which feed into the Burn of Brims.

3 CARBON ASSESSMENT METHODOLOGY

The online carbon calculator tool calculates carbon losses and savings over the lifetime of an onshore wind farm sited on peatlands. The methodology adopted to calculate the impact on the carbon balance of the site as a result of the Proposed Development has been outlined in various literature sources (Nayak *et al*., 2008; Smith *et al.,* 2011; Scottish Government, 2016).

This methodology has been used to complete the online carbon calculator version 1.6.1 (Reference: BAJW-48L2-L5DK).

This report should be read in conjunction with the online carbon calculator inputs and outputs and the project description contained in Chapter 2: Development Description. Whilst various guidance indicates that actual measurements of the site infrastructure are utilised in the calculations, for projects in the planning stage no infrastructure has been constructed. Therefore, the assumptions for the infrastructure are either based on information provided for the Proposed Development (where practical) or standard, default information that is representative for the site. In each case, an explanation of the assumptions adopted and their respective source is provided in the following section.

4 CARBON BALANCE ASSESSMENT INPUT PARAMETERS

Information relating to the design, construction and operation of the Proposed Development was collated, including details of the proposed infrastructure, local ecology and potential for loss of stored carbon, potential restoration proposals and the benefits of replacing fossil fuel generated electricity with electricity generated from renewable energy sources. This information was entered into the online carbon calculator. The information entered is explained below.

4.1 Wind Farm Characteristics

4.1.1 Dimensions

The detailed description of the Proposed Development provided in Chapter 2: Development Description, Section 2.3.1 identifies that planning consent will be sought for five turbines with an operational life of 35 years. The carbon balance assessment presented below is based on these considerations.

4.1.2 Performance

The capacity factor (sometimes referred to as load factor) for the Proposed Development is determined by dividing the annual generation output (MWh) by the installed capacity (MW) multiplied by the number of operational hours per annum. Generation output is a function of a wind turbine's power curve and the prevailing wind resource at the site.

The capacity factor for the Proposed Development is estimated to be 49.7% (minimum 41.8% and maximum 57.8%). These values have been generated from the Applicant's internal wind analysis at the site.

Chapter 2: Development Description, Section 2.3.2 indicates that the turbines would have a power rating of 4.3 MW.

4.1.3 Backup

It is recognised that due to the inherent variability of wind generated electricity, conventional generation facilities will be required to provide stability in the overall supply of electricity. Nayak *et al.* (2008) refers to 'backup power generation' and identifies that the balancing capacity required is estimated as 5% of the rated capacity of the wind farm. However, this balancing capacity is only necessary where wind power contributes more than 20% of the national supply. It is expected that wind generation will contribute greater than 20% by 2025 in all four of the 'Future Energy Scenarios'. These represent four potential pathways developed by National Grid, updated each year, and agreed with Ofgem and include scenarios with both fast and slow decarbonisation (Scottish Government, 2016). The values for 'fraction of output to backup' used in the calculator are expected 5% and maximum 5% to represent full requirement for backup power generation and minimum 0% to represent no backup power generation required, as per Nayak *et al.* (2008).

Where the balancing capacity is obtained from fossil fuel generating stations, emissions will increase by 10% due to reduced thermal efficiency of the reserve generation stations. This value is fixed in the carbon calculator.

4.1.4 CO_2 Emissions from Turbine Life (tCO_2/MW)

Carbon dioxide emissions during the life of a turbine include those emissions that occur during the manufacturing, transportation, erection, operation, dismantling and removal of the structures. This has been calculated based on the default values embedded within the carbon calculator.

4.2 Characteristics of Peatland before the Proposed Development

4.2.1 Type of Peatland

The central area of the site is a level plateau area of relatively shallow peatland over Lythmore Moss, which is characterised by heavily grazed and degraded wet heath and wet modified bog. The edges of the site are underlain by mineral soils, and are dominated by semi-improved grasslands, improved pasture and fields ploughed and used for crops. There is no woodland present within the site.

The detailed accounts of the habitats present within the site are provided in Technical Appendix 5.1: National Vegetation Classification & Habitats Survey Report and Technical Appendix 5.4: Caledonian Conservation Baseline Non-Avian Ecology Report 2014: Hill of Forss Wind Farm. These reports indicate that the vast majority of the peatland present is acidic in nature, however there are some minor base-rich influences seen in flushes. For the purpose of the carbon assessment, the type of peatland has been designated as “acid bog”.

4.2.2 Average Annual Air Temperature at Site

Met office climate averages (1991-2020) from the station nearest to the Proposed Development were used to obtain the average annual air temperature. This is 8.6 ˚C (minimum 1.1 ˚C and maximum 16.75 ˚C). The maximum value which can be entered into the online calculator is 15 ˚C.

4.2.3 Average Depth of Peat at Site

Extensive peat probing has been carried out, initially on a 100 m^2 grid across the site and latterly focused around the locations of the proposed infrastructure. Across the site 1,262 peat probe samples were recorded. Results of peat depth probing are summarised in Technical Appendix 2.5: Phase 1 and 2 Peat Depth & Coring Survey. Most of the peat study area has either no peat present or has a shallow depth of peat present; generally, under 0.5 m, and therefore more appropriately considered, or referred to, as organo-mineral soils. Where peat or organo-mineral soils are present within the site, the depths are typically shallow; mean 0.28 m and median 0.31 m. There are some isolated rare deeper pockets of peat; maximum depth recorded in the site was 3.33 m, with the deepest record in the wider peat study area (which extends outwith the site boundary) at 4.93 m.

For the purposes of the carbon assessment, the expected, minimum and maximum values are 0.28 m, 0 m and 3.33 m respectively.

The assessment of peat/soil depth assumes peat exists to the full depth of the probed depth value. Therefore, some peat probes may classify organic soils or underlying clay as peat, and consequently may represent an overestimation of volume of peat present (see Technical Appendix 2.4: Phase 1 and 2 Peat Depth & Coring Survey Report for full details).

4.2.4 Carbon Content of Dry Peat

From the laboratory test results (Technical Appendix 2.4: Phase 1 and 2 Peat Depth & Coring Survey Report) the carbon content of dry peat has a mean value of 30.75 %, with minimum and maximum values of 8.70% and 51.64% respectively. The online calculator restricts the minimum value to between 19 and 65, so a value of 19 has been used.

4.2.5 Average Extent of Drainage around Drainage Features at Site

The extent of drainage incorporated into the Proposed Development influences the total volume of peat impacted by the construction of the Proposed Development. Therefore, the extent of drainage has an impact on the carbon payback time calculated for the Proposed Development.

A review of the available literature (Nayak *et al.,* 2008) found that the extent of drainage effects is reported as being anything from 2 m to 50 m horizontally around the site of disturbance. Research into the effects of moor gripping and water table data from other sites yielded a horizontal draw down distance typically of about 2 m. It is thought that in extreme cases, this may extend between 15 m and 30 m, though 15 m is considered to be an appropriate distance.

Smith *et al.* (2011), identified the average extent of drainage impact at three sites (Cross Lochs, Farr Windfarm and Exe Head) as ranging from 3 m to 9 m. However, the actual extent of drainage at any given location will be dependent on local site conditions, including underlying substrata and topography.

Site specific values are not available, so the standard values from ‘Windfarm Carbon Calculator Web Tool, User Guidance’ have been used. Therefore, the expected value is 10 m, minimum is 5 m and maximum 50 m.

When determining the carbon loss from peat removed as part of the construction of the drainage works, the area where peat is removed is not included in the extent of drainage calculations because this has already been accounted for in the direct losses.

4.2.6 Average Water Table Depth at Site

Guidance provided in “Calculating Potential Carbon Losses & Savings from Wind Farms on Scottish Peatlands” (Scottish Government, 2016) indicates that on intact peat sites the depth to water table may be less than 0.1 m, but up to 0.3 m on eroded peat sites. Site specific values are not available, so the values for ‘degraded peat’ from ‘Windfarm Carbon Calculator Web Tool, User Guidance’ have been used given the quality of the peatland present as described within Technical Appendix 5.1: National Vegetation Classification & Habitats Survey Report. Therefore, the expected value is 0.3 m, minimum is 0.1 m and maximum is 0.5 m.

4.2.7 Dry Soil Bulk Density

Site specific values from dry soil bulk density laboratory tests are in Technical Appendix 2.4: Phase 1 and 2 Peat Depth & Coring Survey, Section 6.3.9. The average value is 0.267 g cm^{-3}, minimum is 0.106 g cm^{-3} and maximum is 0.487 g cm^{-3}. The online calculator restricts the maximum value to between 0.05 and 0.3, so a value of 0.3 g cm^{-3} has been used.

4.3 Characteristics of Bog Plants

4.3.1 Regeneration of Bog Plants

From experience of peat management, restoration and regeneration work on other wind farm developments in similar environments, and monitoring bog plant restoration, this can vary widely depending on the location of the site, the target bog plants for restoration, and preceding land use. The site is relatively low altitude compared to other wind farms in Scotland and therefore a shorter restoration period than average may be reasonably expected. Regeneration should occur rapidly across restored areas of the site. The speed of regeneration will also depend on species present and their colonising ability and traits, as well as the methods of restoration and maintenance of hydrology. Restoration may be quickly colonised by soft rush as this species is a quick coloniser of disturbed organic soils. Typical bog plants may take longer to establish where suitable conditions exist. The values stated take this into account considering available literature and anecdotal observations of wind farms in Scotland. Five years assumed a reasonable precautionary estimate for regeneration of most bog plants, some taking hold sooner (min value) and some requiring longer to establish (max value). A minimum and maximum of 2 and 10 years is assumed.

4.3.2 Carbon Accumulation

There are several factors controlling the carbon cycle in peatlands, including plant community, temperature range, extent and type of drainage, depth to water table and peat chemistry. The estimated global average for apparent carbon accumulation rate in peatland ranges from 0.12 to 0.31 tC ha^{-1} yr^{-1} (Botch *et al.,* 1995; Turunen *et al.,* 2001).

The carbon calculator guidance (Technical Note, Version 2.10.0, Scottish Government) suggests a mid-range value of 0.25 tC ha^{-1} yr^{-1}, which falls within the range quoted above. For the purposes of the carbon assessment, this accumulation rate of 0.25 tC ha^{-1} yr^{-1} has been used as the expected value, with the accumulation rates of 0.12 tC ha^{-1} yr^{-1} and 0.31 tC ha^{-1} yr^{-1} adopted as the minimum and maximum values respectively.

4.4 Forestry Plantation Characteristics

4.4.1 Area of Forestry Plantation to be Felled

There is no forestry within the site, and as such no felling will take place for the Proposed Development.

4.5 Counterfactual Emission Factors

The counterfactual emission factors for three methods of energy generation are fixed in the carbon assessment. These values, from Carbon Calculator v1.6.1, are shown in **Table 1** below.

Table 1 Carbon Dioxide Emissions from Electricity Generation

Fuel Source	Carbon Dioxide Emissions (tCO_2 MWh^{-1})
Coal-fired plant	0.920
Grid-mix	0.25358
Fossil fuel-mix	0.450

4.6 The Development Infrastructure

4.6.1 Borrow Pits

There are no borrow pits planned for the Proposed Development.

4.6.2 Foundations and Hardstanding Areas

The turbine foundations are described in Chapter 2: Development Description as a tapered octagonal block of approximately 20 m diameter and from 3 m – 3.5 m depth of 16 to 20 m, subject to prevailing ground conditions. Sloping batters would increase the excavated area to approximately 30 m diameter at ground level; possibly greater where poor ground conditions are encountered. The exact quantities of concrete, reinforcement, diameters and depths will vary depending on the actual make of the turbine used.

Based on the peat probing undertaken, the average peat depth at the turbine footprint is estimated to be 0.3 m (minimum 0 m, maximum 0.75 m).

The proposed dimensions of the crane hardstandings are 30 m by 55 m, with the same excavation footprint.

Based on the peat probing survey results, the average peat depth at the crane hardstandings is calculated as 0.34 m (minimum 0 m, maximum 0.75 m).

4.6.3 Volume of Concrete

It is expected that the total volume of concrete used in the construction of the entire wind farm will be 2,304 m^3 (minimum 1,904 m^3, maximum 2,804 m^3). RES civils team have done extensive work calculating reasonable estimates for turbine foundation requirements for different tip heights and varying ground conditions. The estimate is 400 m^3 per turbine (minimum 320, maximum 500 m^3), plus substation (262 m^3), battery storage (32 m^3) and temporary infrastructure (10 m^3).

4.6.4 Access Tracks

A combination of new and existing access tracks would be incorporated into the Proposed Development. During the design and construction phases of the Proposed Development small changes to the access track layout could be introduced (e.g., as a result of micrositing of the wind turbines), leading to minor variations in the overall track length.

The total length of access tracks for the Proposed Development is 4,028 m, of which 976 m is existing track. Of the new tracks to be constructed, 3,052 m will require excavation. No floating or rock-filled roads are planned.

4.6.5 Excavated Access Tracks (Roads)

Where the peat depth is less than 1 m, the proposed access track would likely be constructed by excavating the peat, with the aim of minimising the haulage of excavated material. The proposed width of the excavated access track is 5 m (4.5 m plus verges of 0.25 m).

The average peat depth in the excavated sections of access track, based on peat probing results, is 0.29 m (minimum 0 m, maximum 0.75 m).

4.6.6 Cable Trenches

Chapter 2: Development Description, Section 2.3.35 states that each turbine would be connected to the substation by underground cable and that the cables would be likely to follow the onsite tracks. No permanent displacement of peat is anticipated, see Technical Appendix 2.2: Draft Peat Management Plan. The expected value is 0 m for 'Length of any cable trench on peat that does not follow access tracks and is lined with a permeable medium (e.g., sand)'.

4.6.7 Additional Peat Excavated

The Proposed Development would include additional features which will require excavation of peat, as follows: Control Building & Substation. The combined area of this facility is 2,773.5 m^2 and the associated predicted volume of peat to be excavated by the substation is calculated to be 1,140 m^3. See Technical Appendix 2.2: Draft Peat Management Plan, and Figure 2.2.1.

4.7 Peat Landslide Hazard

The peat landslide hazard is automatically defined by the online carbon calculator and is shown to be 'negligible'. This value is fixed in the carbon calculator.

4.8 Improvement of Carbon Sequestration at the Site

Any local improvements to carbon sequestration, such as areas of peatland habitat restoration, would result in a reduction in the net carbon emissions from the Proposed Development.

4.8.1 Improvement of Degraded Bog

There is no Habitat Management Plan for bog areas.

4.8.2 Improvement of Plantation Land

The site does not contain any forestry.

4.8.3 Early Removal of Drainage from Foundations and Hardstandings

Temporary drainage would be constructed around the wind turbine foundations and crane hardstandings as part of the Proposed Development. This drainage would be removed on completion of the construction works, and therefore, the area surrounding the foundations and hardstandings can be assumed to be drained only up to the time of completion of backfilling, and removal of any temporary surface water drains. Subsequently, the hydrological regime adjacent to the foundation and hardstanding is assumed to return to its pre-construction condition. For the purposes of the carbon calculator the expected value for completion of backfilling, removal of any surface drains, and restoration of the hydrology is 0.3 years (minimum 0.1 years, maximum 3 years).

4.9 Restoration of Site after Decommissioning

The restoration work undertaken as part of the decommissioning phase would be likely to result in a reduction in total carbon lost. By restoring the hydrological conditions and returning the remaining stored carbon to anaerobic conditions, further oxidative loss would be limited or prevented. The restoration of existing habitats represents an opportunity to enhance carbon sequestration. For the purposes of the carbon assessment no benefit has been assumed for the post-decommissioning restoration works, and therefore 100% loss of carbon from the drained volume of soil has been accounted for. During construction and decommissioning, good industry practice would be employed to minimise any disruption to peatland hydrology. It has been assumed that the access tracks constructed would remain in-situ following decommissioning.

4.9.1 Blocking of Gullies

In the event that any gullies in peat have formed due to erosion during the operational phase, these would be blocked using good industry practice techniques to promote restoration of the local hydrological conditions. This approach has been assumed in the carbon assessment.

4.9.2 Blocking of Artificial Drainage Channels

It is assumed any drainage channels constructed with the access tracks would be blocked to facilitate re-wetting of adjacent habitats.

4.9.3 Control of Grazing

It is assumed that grazing will be controlled on degraded areas in the future. This will form part of a decommissioning and restoration plan for the site in future.

4.9.4 Management of Favoured Species Reintroduction

The reintroduction of favoured species has been taken into account in the carbon assessment. This will form part of a decommissioning and restoration plan for the site in future.

4.10 Methodology for Calculating Emission Factors

Whilst two methodologies exist, namely the IPCC method (IPCC, 1997) and Ecosse project method (Smith *et al.*, 2007), the latter method is required to be adopted for a planning application. The Ecosse method, which is based on site-specific values, is considered to provide appropriate site-specific results, whereas the values determined from the IPCC method are considered to be rough estimates.

4.11 Summary of Input Data

The expected values entered into the carbon calculator are summarised in **Annex A** of this report.

5 RESULTS

Based on the figures input to the carbon calculator as described in **Section 4** and provided in **Annex A**, the total carbon losses associated with the Proposed Development are summarised in **Table 2** and fully detailed in **Annex B**.

Table 2 Total Carbon Losses Due to Wind Farm

Source of Losses	Carbon Losses (tCO_2) Expected Value	Carbon Losses (tCO_2) Minimum Value	Carbon Losses (tCO_2) Maximum Value
Turbine life	18,479	18,352	18,637
Back up	14,832	0	14,832
Reduced carbon fixing potential	396	109	2,398
Soil organic matter	1,513	-1,542	17,759
DOC & POC leaching	3	0	5,791
Felling of forestry	0	0	0
Total	**35,223**	**16,919**	**59,417**

The carbon losses calculated are independent of the generation mix used to calculate the overall carbon balance with the exception of the back-up generation capacity (which is assumed to be from conventional fossil fuel sources).

The predicted payback time for the Proposed Development, as determined from the carbon calculator tool, is shown in **Table 3** below and fully detailed in **Annex B**.

Table 3 Carbon Payback Period

Generation Source	Counterfactual emission factors (2022) (t CO_2 MWh^{-1})	Carbon Payback Period (years)		
		Expected Value	Minimum Value 0% Balancing Capacity	Maximum Value 5% Balancing Capacity
Coal-fired plant	0.920	0.4	0.1	0.8
Grid-mix	0.25358	1.5	0.4	3
Fossil fuel-mix	0.450	0.8	0.2	1.7

The 'Grid Mix' generation source includes renewable energy sources that are operational, therefore the 'Fossil Fuel Mix' represents the most likely scenario when considering replacing existing generation capacity with electricity generated from the Proposed Development.

Based on the assumptions detailed in **Section 4** above, the expected payback time, assuming a requirement for back up generation capacity, and therefore the predictions for the growth in the contribution of wind energy generation to be met, is calculated to be approximately 0.9 years, if replacing generation capacity from the 'Fossil Fuel Mix'. Using the worst-case scenario, represented by adopting the maximum values entered in the carbon assessment and taking account of a requirement for back up generation capacity, the payback time is calculated to be 1.8 years.

6 CONCLUSION

The output from the carbon balance assessment indicates, based on the best estimate values determined from the information currently available, that the Proposed Development would pay back the carbon emissions associated with its construction, operation and subsequent decommissioning in 0.8 years.

Outputs from the carbon assessment demonstrate the following key points:

- The data used to undertake the carbon assessment has adopted conservative values;
- No allowance has been accounted for in the carbon assessment for any site improvements that are incorporated into the final design of the Proposed Development, that would reduce further any carbon losses.

Changes to the factors incorporated into the carbon assessment could impact on the overall carbon payback period calculated. However, the sensitivity analysis embedded within the carbon calculator tool takes such variations into account by considering a range of values for each factor considered. Furthermore, by adopting conservative input values for various factors contributing to the overall carbon payback calculation, the carbon savings resulting from the operation of the Proposed Development (and the diversion of energy generation from a fossil fuel-mix), could be significantly greater than the carbon emissions predicted to occur from the construction, operation and subsequent decommissioning of the Proposed Development.

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ANNEX A. CARBON CALCULATOR INPUTS

Carbon Calculator v1.6.1		
Cairnmore Hill Wind Farm	Location:	58.589806, -3.613223

Input data	Expected value	Minimum value	Maximum value	Source of data
Wind farm characteristics				
Dimensions				
No. of turbines	5	5	5	Chapter 2: Development Description, Section 2.3.1
Duration of consent (years)	35	35	35	Chapter 2: Development Description, Section 2.7.1
Performance				
Power rating of 1 turbine (MW)	4.3	4.3	4.3	Chapter 2: Development Description, Section 2.3.2
Capacity factor	49.7	41.8	57.8	These values have been generated from the Applicant's wind analysis for the site. Email comms S Kolydas, 06/05/2022
Fraction of output to backup (%)	5	0	5	Calculating Potential Carbon Losses & Savings from Wind Farms on Scottish Peatlands, Technical Note, Version 2.10.0, Para 19.
Additional emissions due to reduced thermal efficiency of the reserve generation (%)	10	10	10	Fixed
Total CO2 emission from turbine life (tCO2 MW^{-1}) (eg. manufacture, construction, decommissioning)	Calculate wrt installed capacity	Calculate wrt installed capacity	Calculate wrt installed capacity	
Characteristics of peatland before wind farm development				
Type of peatland	Acid bog	Acid bog	Acid bog	Technical Appendix 5.1: National Vegetation Classification & Habitats Survey Report, Section 2
Average annual air temperature at site (°C)	8.6	1.1	15	Met office climate averages, nearest station (Strathy East, 1991-2020).
Average depth of peat at site (m)	0.28	0	3.33	Technical Appendix 2.4: Phase 1 & 2 Peat Depth and Coring Report, Section 6.1
C Content of dry peat (% by weight)	30.75	19	51.64	Technical Appendix 2.5: Phase 1 & 2 Peat Depth and Coring Report, Section 6.3.10. The mean total carbon (%) from the cores is 30.75 %; with maximum and minimum values of 51.64 % and 8.70 % respectively. The online calculator restricts the minimum value to between 19 and 65, so a value of 19 has been used. 19
Average extent of drainage around drainage features at site (m)	10	5	50	Site specific values are not available. Standard values are from ""Windfarm Carbon Calculator Web Tool, User Guidance".

Input data	Expected value	Minimum value	Maximum value	Source of data
Average water table depth at site (m)	0.3	0.1	0.5	Site specific values are not available. Standard values are from "Windfarm Carbon Calculator Web Tool, User Guidance". Values for 'degraded peat' have been used given the quality of the peatland present as described within Technical Appendix 5.1: National Vegetation Classification & Habitats Survey Report.
Dry soil bulk density (g cm-3)	0.267	0.106	0.3	Technical Appendix 2.4: Phase 1 and 2 Peat Depth & Coring Survey, Section 6.3.9. The online calculator restricts the maximum value to between 0.05 and 0.3, so a value of 0.3 has been used.
Characteristics of bog plants				
Time required for regeneration of bog plants after restoration (years)	5	2	10	From experience of monitoring bog plant restoration, this can vary widely depending on the location of the site and the target bog plants for restoration, and preceding land use. The site is relatively low altitude compared to other windfarms in Scotland and therefore a shorter restoration period, than average, may be reasonably expected. Regeneration should occur rapidly across restored areas of the site. The speed of regeneration will also depend on species present and their colonising ability and traits,
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha-1 yr-1)	0.25	0.12	0.31	Calculating Potential Carbon Losses & Savings from Wind Farms on Scottish Peatlands, Technical Note, Version 2.10.0, para 25.
Forestry Plantation Characteristics				
Area of forestry plantation to be felled (ha)	0	0	0	Technical Appendix 5.1: National Vegetation Classification & Habitats Survey Report. No forestry on site.
Average rate of carbon sequestration in timber (tC ha-1 yr-1)	0	0	0	Technical Appendix 5.1: National Vegetation Classification & Habitats Survey Report. No forestry on site.
Counterfactual emission factors (fixed)				
Coal-fired plant emission factor (t CO2 MWh-1)	0.92	0.92	0.92	
Grid-mix emission factor (t CO2 MWh-1)	0.25358	0.25358	0.25358	
Fossil fuel-mix emission factor (t CO2 MWh-1)	0.45	0.45	0.45	
Borrow pits				
Number of borrow pits	0	0	0	No borrow pits or stone extraction areas planned (Chapter 2: Development Description).
Average length of pits (m)	0	0	0	
Average width of pits (m)	0	0	0	

Input data	Expected value	Minimum value	Maximum value	Source of data
Average depth of peat removed from pit (m)	0	0	0	
Foundations and hard-standing area associated with each turbine				
Average length of turbine foundations (m)	20	16	20	Figure 2.3 Wind Turbine Foundation. Chapter 2: Development Description (para. 2.3.9)
Average width of turbine foundations (m)	20	16	20	Figure 2.3 Wind Turbine Foundation. Chapter 2: Development Description (para. 2.3.9)
Average depth of peat removed from turbine foundations(m)	0.34	0	0.75	Calculated in GIS from Phase 1 and Phase 2 peat depth survey results collected by MacArthur Green (CAH_PeatVolCalcs_Rev3_EIA.xlsx). Technical Appendix 2.4: Phase 1 & 2 Peat Depth and Coring Report.
Average length of hard-standing (m)	55	54.5	55.5	Figure 2.4 - Typical Crane Hardstand
Average width of hard-standing (m)	35	34.5	35.5	Figure 2.4 - Typical Crane Hardstand
Average depth of peat removed from hard-standing (m)	0.34	0	0.75	Calculated in GIS from Phase 1 and Phase 2 peat depth survey results collected by MacArthur Green (CAH_PeatVolCalcs_Rev3_EIA.xlsx). Technical Appendix 2.4: Phase 1 & 2 Peat Depth and Coring Report.
Volume of concrete used in construction of the ENTIRE windfarm				
Volume of concrete (m^3)	2304	1904	2804	RES' civils team have done extensive work calculating reasonable estimates for turbine foundation requirements for different tip heights and varying ground conditions. Foundations 400 m^3 x5 (minimum 320, maximum 500 m^3), plus substation (262 m^3), battery storage (32 m^3) and temporary infrastructure (10 m^3). Source: email comms, C Campbell, 17/05/2022.
Access tracks				
Total length of access track (m)	4028	4008	4048	Sum of new and existing track
Existing track length (m)	976	966	986	Upgraded track. Chapter 2: Development Description, Section 2.2.7 and 'Cairnmore Hill - Infrastructure Track Centreline (11-05-22).shp'
Length of access track that is floating road (m)	0	0	0	No floating access tracks
Floating road width (m)	0	0	0	
Floating road depth (m)	0	0	0	
Length of floating road that is drained (m)	0	0	0	
Average depth of drains associated with floating roads (m)	0	0	0	

Input data	Expected value	Minimum value	Maximum value	Source of data
Length of access track that is excavated road (m)	3052	3042	3062	New track + temporary track. Chapter 2: Development Description, Section 2.2.7 and 'Cairnmore Hill - Infrastructure Track Centreline (11-05-22).shp'
Excavated road width (m)	5	5	5	Chapter 2: Development Description (para. 2.3.12) and Figure 2.5 - Typical Access Track Details.
Average depth of peat excavated for road (m)	0.29	0	0.75	Calculated in GIS from Phase 1 and Phase 2 peat depth survey results collected by MacArthur Green. Technical Appendix 2.4: Phase 1 & 2 Peat Depth and Coring Report. See also CAH_PeatVolCalcs_Rev3_EIA.xlsx.
Length of access track that is rock filled road (m)	0	0	0	
Rock filled road width (m)	0	0	0	
Rock filled road depth (m)	0	0	0	
Length of rock filled road that is drained (m)	0	0	0	
Average depth of drains associated with rock filled roads (m)	0	0	0	
Cable trenches				
Length of any cable trench on peat that does not follow access tracks and is lined with a permeable medium (eg. sand) (m)	0	0	0	All cables will follow access tracks. Chapter 2: Development Description, Section 2.3.35
Average depth of peat cut for cable trenches (m)	0	0	0	All cables will follow access tracks. Chapter 2: Development Description, Section 2.3.35. No permanent displacement of peat anticipated. See also Technical Appendix 2.2: Draft Peat Management Plan, Section 4.2.
Additional peat excavated (not already accounted for above)				
Volume of additional peat excavated (m^3)	1140	1140	1197	All cables will follow access tracks. Chapter 2: Development Description, Section 2.3.35
Area of additional peat excavated (m^2)	2773.5	2773.5	2773.5	All cables will follow access tracks. Chapter 2: Development Description, Section 2.3.35. No permanent displacement of peat anticipated. See also Technical Appendix 2.2: Draft Peat Management Plan, Section 4.2.
Peat Landslide Hazard				
Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments	Negligible	Negligible	Negligible	Fixed
Improvement of C sequestration at site by blocking drains, restoration of habitat etc				

Input data	Expected value	Minimum value	Maximum value	Source of data
Improvement of degraded bog				
Area of degraded bog to be improved (ha)	0	0	0	No Habitat Management Plan for bog.
Water table depth in degraded bog before improvement (m)	-	-	-	
Water table depth in degraded bog after improvement (m)	-	-	-	
Time required for hydrology and habitat of bog to return to its previous state on improvement (years)	-	-	-	
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)	-	-	-	
Improvement of felled plantation land				
Area of felled plantation to be improved (ha)	0	0	0	No felling
Water table depth in felled area before improvement (m)	-	-	-	
Water table depth in felled area after improvement (m)	-	-	-	
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	-	-	-	
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)	-	-	-	
Restoration of peat removed from borrow pits				
Area of borrow pits to be restored (ha)	0	0	0	No borrow pits.
Depth of water table in borrow pit before restoration with respect to the restored surface (m)	-	-	-	
Depth of water table in borrow pit after restoration	-	-	-	

Input data	Expected value	Minimum value	Maximum value	Source of data
with respect to the restored surface (m)				
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	-	-	-	
Early removal of drainage from foundations and hardstanding				
Water table depth around foundations and hardstanding before restoration (m)	0.3	0.1	0.5	Site specific values are not available. Standard values are from ""Windfarm Carbon Calculator Web Tool, User Guidance"". Values for 'degraded peat' have been used.
Water table depth around foundations and hardstanding after restoration (m)	0.1	0.05	0.3	Site specific values are not available. Standard values are from ""Windfarm Carbon Calculator Web Tool, User Guidance"". Values for 'intact peat' have been used.
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	0.25	0.1	3	These parameters refer to the removal of drainage around foundations and hardstandings after construction, not the removal of hardstandings and turbine foundations after decommissioning.
Restoration of site after decommissioning				
Will the hydrology of the site be restored on decommissioning?	Yes	Yes	Yes	
Will you attempt to block any gullies that have formed due to the windfarm?	Yes	Yes	Yes	This will form part of a decommissioning and restoration plan for the Site in the future.
Will you attempt to block all artificial ditches and facilitate rewetting?	Yes	Yes	Yes	This will form part of a decommissioning and restoration plan for the Site in the future.
Will the habitat of the site be restored on decommissioning?	Yes	Yes	Yes	
Will you control grazing on degraded areas?	Yes	Yes	Yes	This will form part of a decommissioning and restoration plan for the site in the future.
Will you manage areas to favour reintroduction of species	Yes	Yes	Yes	This will form part of a decommissioning and restoration plan for the site in the future.
Methodology				
Choice of methodology for calculating emission factors	Site specific (required for planning applications)			
Forestry input data	N/A			
Construction input data	N/A			

ANNEX B. CARBON CALCULATOR RESULTS

1. Windfarm CO_2 emission saving over...	Exp.	Min.	Max.
...coal-fired electricity generation (t CO_2 / yr)	86,117	72,428	100,152
...grid-mix of electricity generation (t CO_2 / yr)	23,736	19,963	27,605
...fossil fuel-mix of electricity generation (t CO_2 / yr)	42,122	35,427	48,987
Energy output from windfarm over lifetime (MWh)	3,276,174	2,755,414	3,810,118

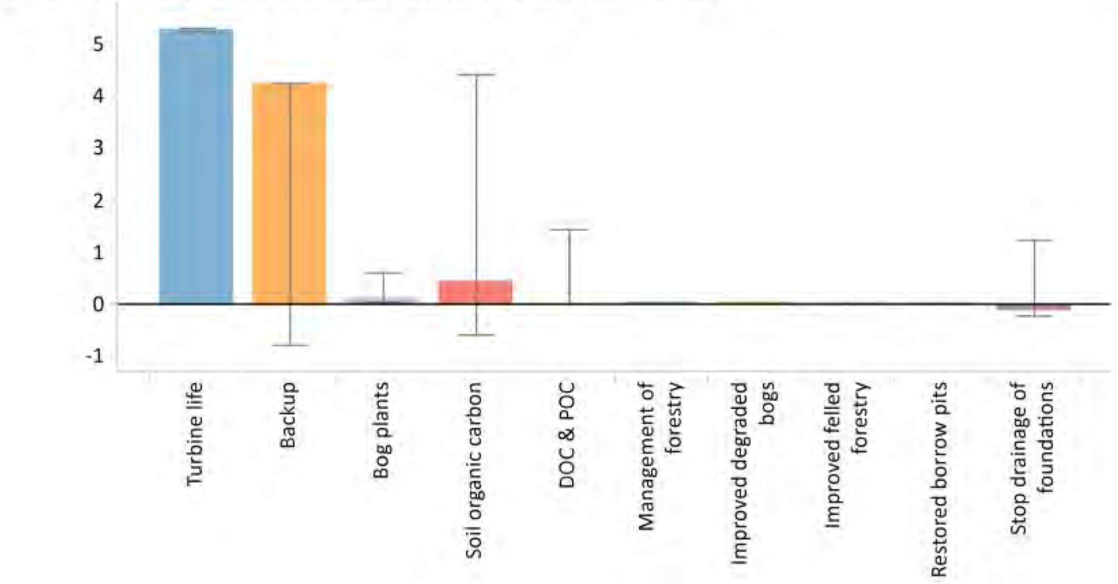
Total CO_2 losses due to wind farm (tCO_2 eq.)	Exp.	Min.	Max.
2. Losses due to turbine life (eg. manufacture, construction, decommissioning)	18,479	18,352	18,637
3. Losses due to backup	14,832	0	14,832
4. Losses due to reduced carbon fixing potential	396	109	2,398
5. Losses from soil organic matter	1,513	-1,542	17,759
6. Losses due to DOC & POC leaching	3	0	5,791
7. Losses due to felling forestry	0	0	0
Total losses of carbon dioxide	35,223	16,919	59,417

8. Total CO_2 gains due to improvement of site (t CO_2 eq.)	Exp.	Min.	Max.
8a. Change in emissions due to improvement of degraded bogs	0	0	0
8b. Change in emissions due to improvement of felled forestry	0	0	0
8c. Change in emissions due to restoration of peat from borrow pits	0	0	0
8d. Change in emissions due to removal of drainage from foundations & hardstanding	-361	0	-5,756
Total change in emissions due to improvements	-361	0	-5,756

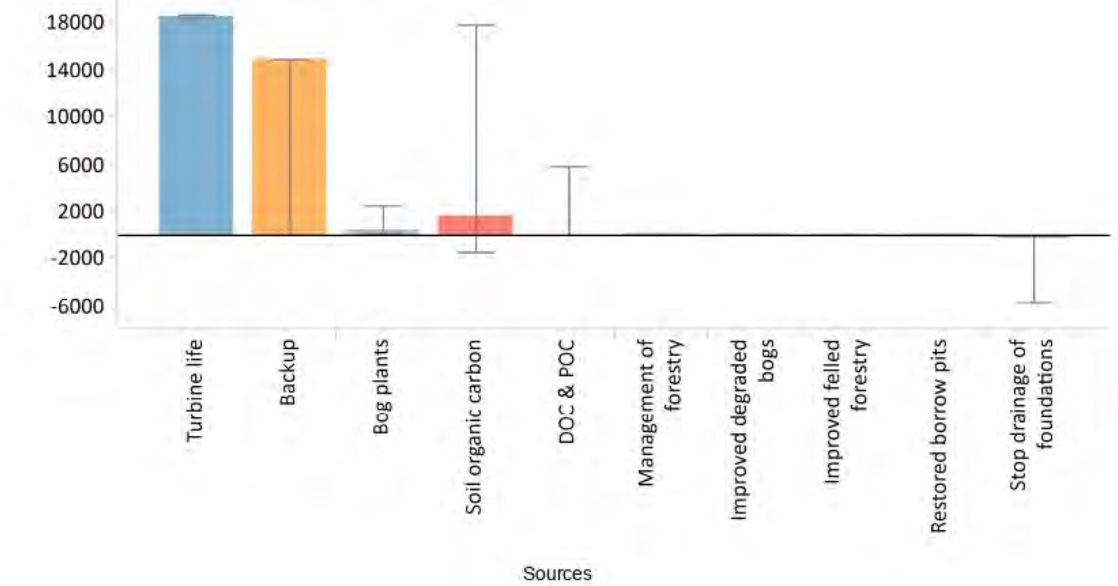
RESULTS	Exp.	Min.	Max.
Net emissions of carbon dioxide (t CO_2 eq.)	34,862	11,163	59,417
Carbon Payback Time			
...coal-fired electricity generation (years)	0.4	0.1	0.8
...grid-mix of electricity generation (years)	1.5	0.4	3
...fossil fuel-mix of electricity generation (years)	0.8	0.2	1.7

ANNEX C. CARBON CALCULATOR CHARTS

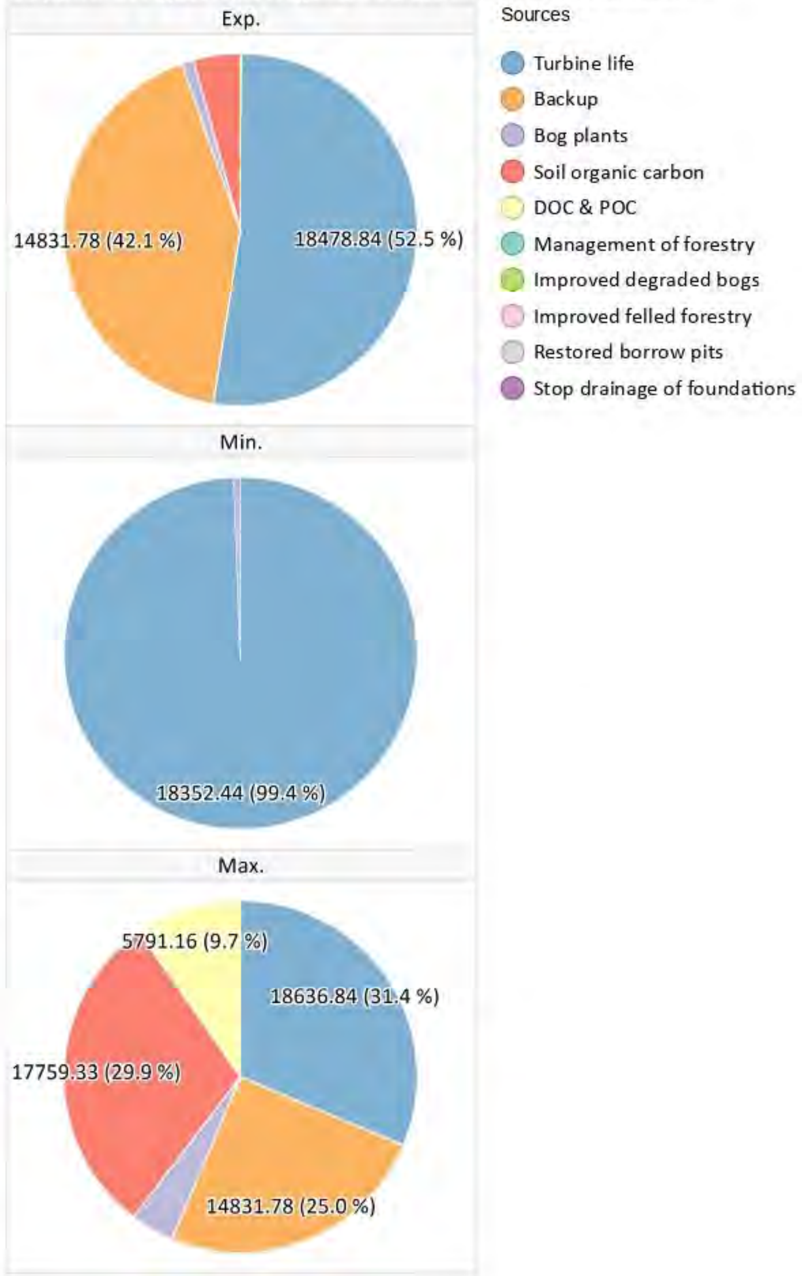
Carbon payback time (months) using fossil-fuel mix as conterfactual



Greenhouse gas emissions (t CO2 eq.)



Proportions of greenhouse gas emissions from different sources



Outdoor Access Management Plan

Cairnmore Hill Wind Farm

Author	Euan Hogg
Date	22/04/2022
Ref	03022-3860565

Contents

1 Introduction

1.1 This document provides information on how public access rights would be managed for the construction phase and operational phase of the Cairnmore Hill Wind Farm (hereafter referred to as the Proposed Development).

1.2 There will be no restrictions to public access rights following completion of construction works.

1.3 Construction of the Proposed Development is anticipated to last approximately 12 months. It is assumed during each year of construction that from the start of December to the end of March, construction activities would cease. This cessation is due to operational constraints relating to anticipated adverse weather conditions. When construction activities cease, access restrictions would be removed. During the period when construction activities are possible, access restrictions would remain in place.

2 Project Description

2.1 This Outdoor Access Management Plan has been prepared by RES (the Applicant) in support of an application for consent to construct and operate a wind farm of between 20 MW and 50 MW. The Proposed Development will comprise up to 5 turbines at a site located approximately 4.5 km west of Thurso, on the north coast of Caithness in the Scottish Highlands.

3 Methodology

3.1 This Outdoor Access Management Plan has been drafted in line with the requirements set out in the SNH "Guidance for the Preparation of Outdoor Access Plans" (SHN, 2010). The SNH guidance stipulates that there should be five steps set out within an Outdoor Access Plan (see Table 1).

Table 1: The Five Steps for Outdoor Access Plans

Step 1	Identify the Purpose, Aims & Objectives of the Outdoor Access Plan.
Step 2	Establish the Outdoor Access Baseline affected by the development proposal.
Step 3	Identify predicted development impacts and potential enhancements on the Outdoor Access Baseline.
Step 4	Mitigate the predicted development impacts, and design potential enhancements.
Step 5	Manage & Monitor the implementation of the Outdoor Access Plan.

This Plan has been structured to broadly follow the steps detailed above.

4 Access Baseline

4.1 The Applicant has engaged with The Scottish Rights of Way and Access Society (Scotways) prior to the submission of this application. The National Catalogue of Rights of Way does not record any Rights of Way which shall be impacted by the proposed development.

4.2 There is a Core Path (The Highland Council (THC) Reference: CA13.07) which runs through the site. As shown in Figure 5.1.2 (EIA-Report Volume 3a) the path enters the eastern edge of the proposed development's site boundary and finishing at the property known as 'Hopefield.'

4.3 There would be no proposed closures or diversions of any of the Public Rights of Way.

4.4 Wider access rights apply across the site and enable public access to Cairnmore Hillock (ND 05659 67571) and Hill of Forss (ND 06342 68631).

5 Potential Access Impacts

5.1 The primary access impact associated with proposed development would be during the construction phase. No access restrictions are anticipated during the operational phase of the proposed development. The Applicant is committed to keeping any access impacts to an absolute minimum and keeping the Core Path open throughout the construction period.

5.2 The primary access point for traffic throughout the construction of the proposed development would be from the A836 and would access the site using the a newly constructed access from the public highway.

6 Access Arrangements

The Applicant is committed to enabling day to day access where this would not compromise the safety of the general public.

Where restrictions or diversions are necessary, information would be provided at the vehicular entrance to the proposed development and communicated to the local community via Construction Community Liaison Group meetings. Where an access restriction would be required, alternative routes would be suggested, the duration would be kept to a minimum and access would be made available at evenings, weekend and public holidays during restricted periods.

Figure 2.7.1 shows the typical warning sign that would be used to warn of access restrictions and the health and safety risks associated with the construction activities. These signs include information including:

- the start date of the restriction;
- the duration of the restriction;
- details (including a map) of any diversion that is in place; and
- the telephone number of the construction manager who can provide further information.

Figure 2.7.1 - Standard generic access restriction/construction activity warning sign

7 Wind Farm Access Tracks

7.1 As part of the Proposed Development, the Applicant will construct new access tracks (EIA-Report Volume 2: Chapter 2: Proposed Development).

7.2 Access to the proposed new tracks would be restricted while those construction operations are ongoing. Following completion of these works, access provision would be reinstated. Upon completion of the proposed development, the public would be able to fully access the tracks described above.

8 Wider Access Rights

8.1 Members of the public have wider access rights to land in Scotland under the provisions of the Land Reform (Scotland) Act 2003. The proposed development would not restrict any wider access rights to the site.

8.2 The only restrictions that are proposed would be to areas where construction activities are being carried out, such as excavations at turbine foundations, during track construction and turbine erection. These restrictions would be in line with the provisions of the Land Reform (Scotland) Act 2003, S6 (1)(g)(i).

8.3 Where temporary restrictions are required, these would be kept to the minimum required time and appropriate signage would be erected.

9 Access Enhancements

9.1 As detailed previously, there is a core path which transects the site boundary. It is proposed that the Applicant will install information boards on site, which could be conditioned, with a final design being approved by THC. The information boards could reference the history and cultural heritage of the local area as well as the natural environment. An example is provided below

(Figure 2.7.2).

Figure 2.7.2 - Example information board suggested for erection on site.

9.2 The Applicant also proposes the encouragement of public access to the site with the upgrade of an on-site sheepfold, the creation of dry-stone fielding and car parking at the site entrance with a community noticeboard. The sheep fold proposed for upgrade is shown in Figure 2.7.3 and an example noticeboard in Figure 2.7.4.

Figure 2.7.3 - Existing sheepfold for proposal of upgrade onsite.

Figure 2.7.4 - Example noticeboard which is proposed to be erected at site

10 Conclusions

10.1 The Applicant aims to maintain public access to all core paths during the construction of the proposed development when there would be no significant health and safety risk.

10.2 After construction activity, public access would revert to pre-construction arrangements. There should be no permanent restriction of access as a result of the proposed development.

11 References

Paths for All, 2010. Signage Guidance for Outdoor Access - A Guide to Good Practice.

SNH, 2010. Guidance for the Preparation of Outdoor Access Plans.

SHN, 2010. Good Practice during Wind Farm Construction.

SHN, 2005. The Scottish Outdoor Access Code.

Technical Appendix 2.8: Cairnmore Hill Wind Farm - Shadow Flicker Assessment

Author: Stefanos Kolydas Date: 03 August 2022 Ref: 03022-4242452

Revision History

Issue	Date	Author	Checker	Approver	Nature And Location Of Change
01	03/08/2022	Stefanos Kolydas	Judith Homann	Euan Hogg	First Created

CONTENTS

Technical Appendix 2.8: Shadow Flicker Assessment

1.1 Introduction

1.1.1 Shadow flicker is a phenomenon caused by the moving shadow of the turbine rotor being cast over a narrow opening, such as a window or open door. The likelihood of disturbance from shadow flicker is dependent on the distance from turbines, turbine orientation, the time and day of the year and the weather conditions.

1.1.2 The Scottish Government web-based renewable advice for onshore wind turbines recommends that a separation between turbines and dwellings beyond 10 rotor diameters should avoid nuisance issues and annoyance to nearby residents[1]. The advice quotes:

> *"In most cases however, where separation is provided between wind turbines and nearby dwellings (as a general rule 10 rotor diameters), 'shadow flicker' should not be a problem."*

1.1.3 The Applicant is aware that there is potential for shadow flicker to affect the surrounding properties and has therefore conducted a full assessment to quantify the impact. The results of this assessment are detailed below.

1.2 Methodology

1.2.1 Using proprietary specialist modelling software, WindPRO 3.4, an annual analysis of shadow flicker for the proposed development was carried out, taking into account the behaviour of the sun, the local topography and the turbine layout and dimensions. Based on turbine locations, the distance of the neighbouring wind farms and likley shadow lengths, no cumulative assessment was deemed necessary.

1.2.2 It should be noted that the analysis was performed using the following assumptions:

- The sun will always be visible during daylight hours (conservative assumption; the location is known to encounter cloud cover approximately 80% of the year, (Met Office))[2];
- The wind will always be sufficient to turn turbine blades at these times (conservative assumption);
- The alignment of the turbine rotor blades with respect to the sun's position will always produce maximum shadow casting (conservative assumption; it is unlikely that the wind, and therefore the rotor blades, will track the sun in practice);
- All receptors have relevantly orientated windows (In reality this may not be true);
- The intensity of the sun will be insufficient to cast strong shadows at elevations less than 2.0°;

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[1] Scottish Government, Onshore Wind Turbines: Planning Advice, (2014). Available online from: https://www.gov.scot/publications/onshore-wind-turbines-planning-advice/

[2] Northern Scotland: climate - Available online from: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/uk-past-events/regional-climates/northern-scotland_-climate---met-office.pdf

- Shielding due to features such as trees or other obstacles has not been taken into account;
- Terrain shielding, however, is modelled; and
- This assessment is based on a 117m rotor diameter, 138.5m tip height machine and refers to the operational year 2026.

1.2.3 The significance of the shadow flicker effect to the surrounding properties has been assessed according to the Department of Energy & Climate Change (DECC) guidelines, stating:

"It is recommended that shadow flicker at neighbouring offices and dwellings within 500 m should not exceed 30 hours per year or 30 minutes per day."[3]

1.3 Results

1.3.1 Eight occupied[4] properties surrounding the proposed development, within the 1,170 m distance buffer, could experience shadow flicker primarily in the morning, with the rising of the sun. Table 3.1 provides a summary of the results. Property 68, Atlantic View, located 1,084 m north west of the nearest turbine, T3, could experience the most significant impact of shadow flicker on 153 days of the year with maximum duration of up to 38 minutes per day. All properties detailed in Table 3.1, with the exception of H80, exceed 30 hours per year. All properties detailed in Table 2.8.1, with the exception of H89, exceeded 30 minutes per day. Figure 2.8.1 details the locations of affected houses relative to the proposed development.

1.3.2 It should be emphasised that this analysis provides an extremely conservative estimate of the extent that the properties would be affected by shadow flicker. Due to frequent cloud cover, low irradiance intensity, turbines not turning at all times and turbine rotors not being aligned with the sun in a way to cast maximum shadow onto the proposed property, the actual amount of shadow flicker affecting the aforementioned properties is likely to be much less.

Table 2.8.1: Summary of Results

House	Description	Easting	Northing	Days per year	Max hours per day	Total hours
H24	Strathmore House	304958	967245	99	0.68	45.15
H39	Braighmor	304931	967630	122	0.50	40.45
H68	Atlantic View	305422	969089	153	0.63	51.57
H75	Dunhobby	307282	969480	83	0.92	50.22
H78	Thorvik Brims	307012	969550	63	0.98	39.42
H79	Windrift	306607	969561	64	0.97	38.35
H80	Thusater Farm	306899	969729	44	0.68	20.83
H89	Ornum Farm House 1	307865	967917	116	0.47	41.77

[3] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/48052/1416-update-uk-shadow-flicker-evidence-base.pdf, p13 (Accessed on 02 August 2022)

[4] Hopefield and Taldale not included as financial beneficiaries

1.4 Reflected Light

1.4.1 A related visual effect to shadow flicker is that of reflected light. Theoretically, should light be reflected off a rotating turbine blade onto an observer then a stroboscopic effect could be experienced. In practice, a number of factors limit the severity of the phenomenon and there are no known reports of reflected light being a significant problem at other wind farms.

1.4.2 Firstly, wind turbines have a semi-matt surface finish which means that they do not reflect light as strongly as materials such as glass or polished vehicle bodies. Secondly, due to the convex surfaces found on a turbine, light would generally be reflected in a divergent manner. Thirdly, the variability in flow within a wind farm results in slightly differing orientation of rotor directions, therefore it is unlikely that an observer would experience simultaneous reflections from a number of turbines. Fourthly, as with shadow flicker, certain weather conditions and solar positions are required before an observer would experience the phenomenon. Therefore, it is concluded that the proposed development would not cause a material reduction to amenity owing to reflected light.

1.5 Mitigations & Residual Effects

1.5.1 Mitigation options to be considered by the applicant, may include, but not limited to:

- Planting tree belts between the affected residential property and the responsible turbine(s), or,
- Installing blinds at the affected residential property. In the unlikely event that there is extreme nuisance, mitigation could be to the extreme of shutting down individual turbines during periods when shadow flicker could theoretically occur.