infinis

Galawhistle Wind Farm
Environmental Statement

Technical Appendices

March 2010

RPS

Technical Appendix 1 - Carbon Calculation

Note: The input parameters include some variables that can be specified by default values, but others that must be site specific. Variables that can be taken from defaults are marked with purple tags on left hand side.

Input data	Enter your values here	INFORMATION SOURCE	Record comments or assumptions here	Uncertainties Min	Uncertainties Max
Wind farm characteristics					
Dimensions					
No. of turbines	22				
Life time of wind farm (years)	25				
Performance					
Turbine capacity (MW)	2.5			20	30
Capacity factor (percentage efficiency)	30			27	34
Backup					
Extra capacity required for backup (%)	5				
Additional emissions due to reduced thermal efficiency of the reserve generation (%)	10				
Carbon dioxide emissions from turbine life - (eg. manufacture, construction, decommissioning)	Calculate wrt installed capacity				
Total CO_2 emission from turbine life (tCO_2 wind farm^{-1}) *(if known use direct input of emissions from turbine life)*					
Characteristics of peatland before wind farm development					
Type of peatland	Acid bog				
Average air temperature at site (°C)	8.75	This figure was taken from http://www.metoffice.gov.uk/climate/uk/averages/19611990/sites/auchincruive.html			
Average depth of peat at site (m)	0.67	Technical Appendix 3 -Peat Slide Risk Assessment	This figure was averaged from peat depth data collected across all the Galawhistle Wind Farm site		
C Content of dry peat (% by weight)	55	http://www.viewsofscotland.org/snp_conference/PeatAudit-Guide.pdf	Carbon content of dry peat between 49-62% so 55% has been assumed		
Average extent of drainage around drainage features at site (m)	50				
Average water table depth at site (m)	1.00	Do not have watertable information for site	Estimated water table depth of 1m		
Dry soil bulk density (g cm^{-3})		Unknown			
Average soil pH	5.6	Calulating carbon savings from wind farms on scottish peat lands - a new approach	Taken from generic values Could be as low as 4		
Characteristics of bog plants					
Time required for regeneration of bog plants after restoration (years)	20		Could be between 10-20 years so the upper limit has been used.		
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha^{-1} yr^{-1})	0.25			0.12	0.31
Forestry Plantation Characteristics					
Area of forestry plantation to be felled (ha)	0	No forestry to be felled			
Average rate of carbon sequesteration in timber (tC ha^{-1} yr^{-1})	0.00				
Counterfactual emission factors					
Coal-fired plant emission factor (t CO_2 MWh^{-1})	0.86				
Grid-mix emission factor (t CO_2 MWh^{-1})	0.43				
Fossil fuel- mix emission factor (t CO_2 MWh^{-1})	0.607				
Borrow pits					

Note: Capacity factor. The average capacity factor between 1998 and 2004 for Scotland was 30% (DTI, 2006, Energy Trends, March 2006). We recommend that a site-specific capacity factor site should be used (as measured during planning stage). However, if this is unknown, the best (34%) and worst case capacity factors for Scotland (27%) should be used to determine the likely range of the results.

Note: Extra capacity required for backup. If 20% of national electricity is generated by wind energy, the extra capacity required for backup is 5% of the rated capacity of the wind plant (Dale et al 2004, Energy Policy, 32, 1949-56). We suggest this should be 5% of the actual output. If it is assumed that less than 20% of national electricity is generated by wind energy, a lower percentage should be

Note: Extra emissions due to reduced thermal efficiency of the reserve power generation ≈ 10% (Dale et al 2004, Energy Policy, 32, 1949-56)

Note: Emissions from turbine life. Note, if total emissions for the windfarm are unknown, emissions will be calculated according to turbine capacity. The normal range of CO_2 emissions is 394 to 8147 t CO_2 MW (White & Kulcinski, 2000, Fusion Eng. Des. 48, 473-48; White, 2007, Natural Resources Research, 15, 271 - 281.)

Note: A fen is a type of wetland fed by surface and/or groundwater. A bog is fed primarily by rainwater and often

Note: Time required for regeneration of previous habitat. It is suggested that loss of fixation should be assumed to be over lifetime of windfarm only.
This time could longer if plants do not regenerate. The requirements for after-use planning include the provision of suitable refugia for peat forming vegetation, the removal of structures, or an assessment of the impact of leaving them in situ. Methods used to reinstatement the site will affect to likely time for regeneration of the previous habitat.
This time could also be shorter if plants regenerate during lifetime of windfarm. If so, enter number of years estimated for regeneration.

Note: Carbon fixation by bog plants. Apparent C accumulation rate in peatland is 0.12 to 0.31 tC ha^{-1} yr^{-1} (Turunen et al., 2001, Global Biogeochemical Cycles, 15, 285-296; Botch et al., 1995, Global Biogeochemical Cycles, 9, 37-46). The SNH guidance uses a value of 0.25 tC ha^{-1} yr^{-1}.

Note: Area of forestry plantation to be felled. If the forestry was planned to be removed, with no further rotations planted, before the wind farm development, the area to be felled should be entered as zero.

Input data	Enter your values here	INFORMATION SOURCE	Record comments or assumptions here	Uncertanities Min	Uncertanities Max
Number of borrow pits	4	Appendix 3A - Chapter 3 (Project Description)			
Average length of pits (m)	136.25				
Average width of pits (m)	75				
Average depth of peat removed from pit (m)	0.67				
Wind turbine foundations					
Average length of turbine foundations (m)	20	Chapter 3 (Project Description)	The foundations are 16 x 16m, but will require excavations of 20 x 20m for access and formwork		
Average width of turbine foundations(m)	20				
Average depth of peat removed from turbine foundations(m)	0.67				
Hard-standing area associated with each turbine					
Average length of hard-standing (m)	72	Chapter 3 (Project Description)	This includes hardstanding associated with cranes		
Average width of hard-standing (m)	32				
Average depth of peat removed from hard-standing (m)	0.67				
Access tracks					
Total length of access track (m)	18000	Chapter 3 (Project Description)	This includes exisitng colliery roads and also upgraded former railway line		
Existing track length (m)	8000				
Length of access track that is floating road (m)	0		It is assumed no floating roads will be required with the current design		
Floating road width (m)	0				
Floating road depth (m)	0				
Length of floating road that is drained (m)	0				
Average depth of drains associated with floating roads (m)	0				
Length of access track that is excavated road (m)	10000	Chapter 3 (Project Description)	Assumed all new track will be excavated road		
Excavated road width (m)	5.5		Width of road includes passing places		
Excavated road depth (m)	0.67				
Length of access track that is rock filled road (m)					
Rock-filled road width (m)					
Rock-filled road depth (m)					
Length of rock-filled road that is drained (m)					
Average depth of drains associated with rock-filled roads (m)					
Cable Trenches					
Length of any cable trench that does not follow access tracks and is lined with a permeable medium (eg. sand) (m)	0	Calculating carbon savings from wind farms on Scottish peat lands - A New Approach	Assumed all cable trench will follow access tracks		
Depth of cable trench (m)	1.0		Cable trench typically depth of 0.5 m to 1m		
Peat Landslide Hazard					
Weblink: Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments	6	Technical Appendix 3 -Peat Slide Risk Assessment	Risk ranking between 3 and 9 so an average of 6 has been taken		
Improvement of C sequestration at site by blocking drains, restoration of habitat etc					
Improvement of degraded bog					
Area of degraded bog to be improved (ha)	282	Chapter 6 (Ecology)			
Water table depth in degraded bog before improvement (m)	1.00		Assumed value of 1		
Water table depth in degraded bog after improvement (m)	1.00		Assumed value of 1		
Time required for hydrology and habitat of bog to return to its previous state on improvement (years)	20		Between 10 - 20 years so an upper value of 20 has been applied.		
Improvement of felled plantation land					
Area of felled plantation to be improved (ha)	0				
Water table depth in felled area before improvement (m)	0.00				
Water table depth in felled area after improvement (m)	0.00				
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	0				

Note: Plantation carbon sequestration. This is dependent on the yield class of the forestry. The SNH technical guidance assumed yield class of 16 $m^3 ha^{-1} y^{-1}$, compared to the value of 14 $m^3 ha^{-1} y^{-1}$ provided by the Forestry Commission. Carbon sequestered for yield class 16 $m^3 ha^{-1} y^{-1}$ = 3.6 tC $ha^{-1} yr^{-1}$ (Cannell, 1999, Forestry, 72, 238-247)

Note: Coal-Fired Plant and Grid Mix Emission Factors. Coal-fired plant EF = 0.86 t CO_2 MWh^{-1}; Grid-Mix EF = 0.43 t CO_2 MWh^{-1}. Source = DEFRA, 2002, Guidelines for the measurement and reporting of emissions by Direct Participants in UK Emissions Trading Scheme (DEFRA,Oct 2002)

Note: Fossil Fuel Mix Emission Factor. The 5 year average emission factor calculated using estimated CO2 emissions for 2002 and 2003 from the National Atmospheric Emission Inventory (Baggott et al, 2007, http://www.naei.org.uk/reports.php, Report AEAT/ENV/R/2429 13/04/2007) and for 2004 to 2006 (Digest of UK Energy Statistics, 2007, http://www.berr.gov.uk/energy/statistics/source/electricity/page18527.html) is 0.607 tCO_2 MWh^{-1}

Note: Total length of access track. If areas of access track overlap with hardstanding area, exclude these from the total length of access track to avoid double counting of land area lost.

Note: Rock filled roads. Rock filled roads are assumed to be roads where no peat has been removed and rock has been placed on the surface and allowed to settle.

Note: Peat Landslide Hazard. It is assumed that measures have been taken to may limit damage (Scottish Executive, 2006, Peat Landslide Hazard and Risk Assessments, Best Practice Guide for Proposed Electricity Generation Developments, Scottish Executive, Edinburgh pp. 34-35) so that C losses due to peat landslide can be assumed to be negligible. Link: http://www.scotland.gov.uk/Publications/2006/12/21162303/1

Input data	Enter your values here	INFORMATION SOURCE	Record comments or assumptions here	Uncertanities	
				Min	Max
Restoration of peat removed from borrow pits					
Area of borrow pits to be restored (ha)	24.6		Assumed full area of borrow pit will be restored		
Water table depth in borrow pit after restoration (m)	1.00		Assumed value of 1		
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	20		Between 10 and 20 years so an upper limit of 20 years has been applied		
Removal of drainage from foundations and hardstanding					
Water table depth around foundations and hardstanding after restoration (m)	1		Assumed value of 1		
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)		Unknown			
Restoration of site after decommissioning					
Will the hydrology of the site be restored on decommissioning?	Yes				
Will the habitat of the site be restored on decommissioning?	Yes				

Choice of methodology for calculating emission factors	Site specific

Note: Restoration of site. If the water table at the site is returned to its original level or higher on decommissioning, and habitat at the site is restored, it is assumed that C losses continue only over the lifetime of the windfarm.

Note: Choice of methodology for calculating emission factors. The IPPC default methodology is the internationally accepted standard (IPCC, 1997, Revised 1996 IPCC guidelines for national greenhouse gas inventories, Vol 3, table 5-13). However, it is stated in IPCC (1997) that these are rough estimates, and "these rates and production periods can be used if countries do not have more appropriate estimates". Therefore, we have developed more site specific estimates for use here based on work from the SEERAD funded ECOSSE project (Smith et al, 2007. ECOSSE: Estimating Carbon in Organic Soils - Sequestration and Emissions. Final Report. SEERAD Report. ISBN 978 0 7559 1498 2. 166pp.)

Technical Appendix 2 - Ornithology

Introduction

7.1 This technical appendix presents the following information in support of Chapter 7 of the Galawhistle Wind Farm Environmental Statement:

- Detailed baseline survey methodology;
- Full details of the collision risk modelling methods and results, summarised in the chapter; and
- Full results for those baseline surveys for which only a summary was necessary for the chapter.

Baseline Survey Methodology

7.2 Baseline surveys were carried out between September 2007 and August 2009 to quantify the use of the proposed wind farm area at Galawhistle by breeding and non-breeding birds, and to allow an estimate of the theoretical risk of bird collision with the turbine rotors.

7.3 The following zones are defined within the Ornithology Chapter and this document as follows:

- 'Application site'. This includes all land within the site boundary originally provided by Infinis;
- 'Survey area'. The area within which baseline surveys were undertaken, compromising the application site plus at least a 500m buffer;
- 'Wind Farm Polygon' (WP). This is the area derived by applying a 200m buffer to the area enclosed by tips of the outermost rotors; and
- 'Access track'. This is the area of the proposed wind farm access track route, plus a 250m buffer either side.

7.4 Field surveys were undertaken by the following experienced surveyors:

- Andy Blyth (AB)
- Alistair Boulton (ALB)
- Angus Murray (AM)
- Chris Cathrine (CC)
- Fraser MacFarlane (FMCF)
- Rafe Dewar (RD)
- Tony Bullman (TB)
- Enda McLoughlin (EMCL)
- Chris Robinson (CJR)
- Mike Austin (MJA)
- Adam Anderson (AA)
- Eric Donnelly (ED)
- Christina Wilson (CW and CR)
- Laura Tuner (LT)
- Graeme Cook (GAC)
- Davy Galbraith (DG)
- Joe Greenlease (JG)
- Bobby Anderson (BA)
- Jamie Manners (JM)
- Garry Taylor (GT)
- Loyd Berry (LB)
- Andy Carroll (AC)
- Ken Sludden (KS)

Upland Breeding Bird Surveys

7.5 A series of upland breeding bird surveys were undertaken within the application site plus a buffer of 500m in both 2008 and 2009 (see Figure 7.2). It was not possible to survey an area of open moorland to the southeast of the application site in 2009 due to access restrictions (Figure 7.2). As this area was covered by 2008 surveys, it is not anticipated that any significant species or populations went unrecorded in 2009. Any target species breeding in this area would have been recorded during vantage point surveys.

7.6 The survey methodology followed the methods set out by Brown and Shepherd (1993)[1]. This method standardises survey effort per unit area (20-25 minutes per 500m x 500m square). While the Brown and Shepherd method was originally designed for recording wader species in upland habitats, it is commonly used for the purposes of EIAs to provide indices of upland passerine breeding activity, although it may produce under-estimates in the numbers of some species such as skylark and meadow pipit.

7.7 Three survey visits were made in both years: in 2008 on 8 and 9 April (visit 1), 13 and 30 May (visit 2) and 20 June (visit 3). In 2009, visits were on 24, 28, 29 April and 10, 11 May (visit 1); 25, 28, 29, 30 May (visit 2) and 18, 19, 20, 23, 24 June (visit 3). These dates followed SNH guidance[2], in order to ensure that key phases of the breeding cycle were not missed, especially in areas where existing information on the timing of breeding is absent. A single surveyor walked a pre-determined route ensuring that all parts of the survey area were approached to within 100m. A handheld GPS unit was used to ensure that the survey route was maintained. The location and behaviour of all birds (not just waders) encountered during the survey visits were recorded, with the exception of meadow pipit. For meadow pipit, an estimate of abundance was determined by recording the number of birds observed within each km². The overall abundance for meadow pipit was then calculated to provide a relative measure of abundance.

7.8 The location and behaviour of the birds were recorded in the field on 1:10,000 scale maps, with the exception of meadow pipit. For meadow pipit, an estimate of abundance was determined by recording the number of birds observed within each km².

7.9 Records from all 3 visits were combined into a final visit map, to allow an estimate of territory numbers for each species. Birds were assumed to be breeding or holding territory at the recorded location if one or more of the following was observed:

- Courtship, displaying or singing;

[1] Brown, A.F. & Shepherd, K.B. (1993) A method for censusing upland breeding waders. *Bird Study* 40: 189-195. Note that the series of surveys using this methodology had already been carried out in 2008 before SNH responded to the scoping report, recommending that a Common Bird Census methodology should be used. Brown & Shepherd was judged most appropriate and is the industry standard for wind farm surveys in comparable habitats.

[2] Scottish Natural Heritage (2005) Guidance: Survey Methods for Use in Assessing the Impacts of Onshore Wind Farms on Bird Communities.

- presence of a nest, eggs or young (including newly fledged);
- agitated behaviour, including alarm calls or distraction display;
- adults carrying food or nesting material; or
- territorial dispute

7.10 In the absence of any of these indicative behaviours, a pair observed together in suitable habitat was considered to represent a breeding pair.

7.11 Other records were considered to be of non-breeding birds.

7.12 Within visits, duplicate records of birds separated by less than a threshold distance of 500m for waders and 200m for passerines were arbitrarily considered to correspond to birds of the same pair, while those separated by more than this threshold distance were considered to be from different pairs. Exceptions to this are where surveyors recorded that birds seen within this threshold distance of each other represented different pairs and vice versa. Appropriate annotations were made on the field maps to indicate whether this was the case.

7.13 Estimates of the number of pairs/territories were derived by comparing the three visit maps. Professional judgement was used to derive territory boundaries. Breeding records or territories were generally considered to be separate from each other if they were more than 1000m apart for most waders (500m for snipe) and between 200-500m for passerines. The central location of each territory/breeding location, within and between visits, was plotted on a final map for presentation.

7.14 It is acknowledged that the Brown and Shepherd survey technique is likely to under-estimate the number of breeding snipe. The 'drumming' display indicative of breeding usually occurs at dawn and dusk before/after the recommended survey times. In addition, snipe appear to be more active on days when the weather is less suitable for general wader survey[3].

Flight Activity Surveys

7.15 Flight activity surveys were undertaken using the vantage point (VP) methodology advocated by SNH[2]. Each VP survey was undertaken by a single observer in conditions of good visibility. VP watches were generally limited to three hours duration by any single observer. Occasionally watches were extended to make up for lost time due to poor weather conditions during previous visits.

7.16 During each watch, the landscape was scanned continuously until a target species[4] was detected. Once detected, the bird was observed until it landed or flew out of sight. The time of first detection was noted, and the flight height was recorded for each 15 second period that the bird was in view, as one of five height bands: <20m, 20-40m, 40-100m, 100-150m and >150m. The height bands 20-20m and 40-100m together span the potential collision height (PCH) associated with the proposed turbines at Galawhistle (a maximum span of 27.8m to 121.2m was used for calculations, based on maximum blade length of 41.2m and maximum hub height of 80m, as the turbine tip is anticipated not to exceed 121.2m height). The paths of all observed flights (flight lines) were drawn onto 1:10,000 scale maps in the field.

[3] Mike Madders, Natural Research Ltd. (pers. comm.)
[4] Target species included swans, geese, Annex 1 (European Birds Directive) raptors, black grouse, Annex 1 waders, barn owl and short-eared owl.

7.17 It was assumed that the vertical distribution of flight activity was similar between 27.8-121.2m and between the 20-100m height band. On this basis the figures for birds in flight and occupancy at 20-100m were adjusted to the slightly increased actual PCH (27.8m to 121.2m) by simple direct proportion (number of birds in flight x 27.8-121.2m / 20-100m).

7.18 A map showing the flight lines for each target species was compiled in a Geographic Information System (ArcView v.9.3 GIS), with each flight line linked to its associated flight duration and height information held in a Microsoft Access database.

7.19 The information collected on key target species flying over the proposed wind farm site and the adjacent airspace was used to estimate the number of individuals per species predicted to collide with the turbine rotors. These estimates were obtained by estimating the annual number of flights of each of these species from the survey data and entering these estimates into an appropriate collision risk model. The collision risk modelling methods used were in accordance with the Band Model recommended by SNH[5]. These methods are described in the next section.

7.20 Flight activity surveys were undertaken using the vantage point methodology advocated by SNH[2]. The survey area included the application site plus a buffer area of 500m (Figure 7.3), plus an area to the south to cover part of the SPA to assess possible connectivity (see below).

7.21 Watches were carried out from a total of 9 VPs during the 24 months of survey.

7.22 VP3 was discontinued after 9 hours in September 2007 as it was concluded that coverage was more comprehensive from VPs 7 and 8 instead.

7.23 VP 6 was created primarily for the purpose of demonstrating any connectivity between birds breeding in the SPA and the application site, by observing whether birds do or do not fly between the SPA (to the south of the road) and the application site. Access was not permitted from winter 2008 onwards and so VP9was used as a replacement.

Table 7a.1: Location of VPs used

VP	VP name	Grid Reference
1	Sclanor Hill	NS 74142 30937
2	Meikle Auchinstilloch (west)	NS 75700 31937
4	Avermarks Hill	NS 78457 30142
5	Shiel Hill	NS 77655 28594
6	Belt Knowe	NS 75443 28243
7	Meikle Auchinstilloch (east)	NS 76403 32153
8	Monkshead	NS 76978 30186
9	Cartcraig Quarry	NS 74825 28976

* Vantage point 3 was discontinued

Collision Risk Modelling

7.24 This section contains details of the methods used for the estimation of turbine collision rates.

[5] Band, W., Madders, M. and Whitfield, D.P. (2007). Developing field and analytical methods to assess avian collision risk at wind farms. In Birds and Wind Farms. M. de Lucas, G.F.E. Janss and M. Ferrer (Eds), Quercus, Madrid.

Estimation of Turbine Collision Rates

7.25 All of the mapped flight data were collated in a GIS (ArcView v9.3). These data were used in collision risk models to predict the number of birds that would collide with the turbines within the proposed wind farm during the relevant seasons.

Choice of Directional or Non-Directional Models

7.26 For each target species, an annual collision rate was predicted using either a directional or non-directional (random) collision risk model. The choice of modelling method was based the nature of a particular species flight behaviour within the application site. The directional model is appropriate where a species tends to move across the wind farm area in a particular direction. This type of light behaviour is characteristic of species on migration or making regular movements between feeding and roosting sites. SNH advocates the use of the directional model for groups such as divers, geese, swans and ducks. A non-directional model is more appropriate where the flights of a particular species are not predominantly in any direction. This is usually the case for birds moving around within a breeding or hunting territory that is wholly or partly within the site of interest. This approach, which assumes that the direction of flights is random, is usually appropriate for breeding and non-breeding raptors and waders.

7.27 The main difference between the directional and non-directional methods concerns whether it is more appropriate to consider collision risk, either:

7.28 (a) Across a two-dimensional risk area in front of a bird as it flies towards the wind farm area with the intention of continuing on in the same direction (directional model); or

7.29 (b) Within a three-dimensional risk volume as a bird flies around within the wind farm area in no consistent direction (non-directional model).

Definition of the Risk Zone: the Wind Farm Polygon

7.30 The zone within which birds were considered to be at risk of collision was defined as the area enclosed by the tips of the outermost turbine rotors, plus a precautionary 200m buffer to allow for a degree of surveyor error when mapping flightlines. This area will be referred to as the Wind Farm Polygon or WP.

7.31 Within the WP however, the estimation of the number of birds expected to actually pass through the rotor-swept airspace differs between those species with directional flights (swans, geese and ducks) and those with non-directional flights (raptors and waders).

7.32 Any bird flying within the WP at potential collision height (PCH) was considered to be "at risk" of passing through the airspace swept by a turbine rotor (a rotor transit).

7.33 For each species in the directional flight group, the number of rotor transits was calculated as follows:

7.34 A Risk Area was defined as the area spanned by the rotors of the wind farm as presented to a particular species following its normal flight direction though the wind farm. The size of this area is determined by the distance between the outermost rotors in front of the birds, multiplied by the height of the rotors.

7.35 The Rotor-swept Area is defined as the total area swept by all of the rotors in the wind farm.

7.36 The number of rotor transits was calculated from the number of birds passing through the Risk Area by applying the ratio of the Rotor-swept Area to the Risk Area. For example: 20 birds x (5,000m2/50,000m2) = 2 rotor transits.

7.37 For each species in the non-directional group, a more appropriate way of calculating rotor transits used the ratio of the Rotor-swept Volume to the Risk Volume.

7.38 The Risk Volume is defined as the volume of airspace at PCH above the WP that is the area of the WP x the diameter of the rotors.

7.39 The Rotor-swept Volume is defined as the total area swept by all of the rotors in the wind farm. For an individual rotor this is determined by the area swept x the thickness of the rotor blades.

7.40 The modelling process can be summarised as follows:

Stage 1

7.41 The data from the VP surveys were used to estimate, for each target species, the number of flights through the collision Risk Area/Volume (as appropriate) during the appropriate season.

Stage 2

7.42 The number of flights predicted from Stage 1 was corrected to take account of the proportion of the Risk Area (for directional species) or Risk Volume (non-directional species) that would be swept by the turbine rotors.

7.43 Note that the ratio Rotor-swept Volume: Risk Volume varies between species depending on their body length. For example, the Rotor-swept Volume within which a whooper swan (length 1.6m) is at risk of collision is greater than for a curlew (length 0.6m). Either the ratio of Rotor-swept Area:Risk Area or the ratio of Rotor-swept Volume:Risk Volume was applied, as appropriate, to the total number of flights of each target species predicted from Stage 1.

7.44 For example, if there were predicted to be 2,000 lapwings flying through the Risk Volume each year and 0.2% of this volume is swept by turbine rotors, then there are predicted to be 4 rotor transits flying through the combined rotor-swept area (directional model). The same principle applies to the directional model where the number of flights is corrected on the basis of the proportion of the collision Risk Area occupied by the combined Rotor-swept Area.

Stage 3

7.45 The probability was calculated that a bird of any given species will collide with a turbine rotor if it passed through the Rotor-swept Area/Volume. This probability is a function of the dimensions and flight speed of the species of interest and various parameters of the turbine rotor in operation. The function is complicated but the calculation has been simplified through a spreadsheet supplied by SNH. The relevant species biometrics and turbine parameters were entered into this spreadsheet which then calculated the probability of collision value p(collision).

Stage 4

7.46 The predicted number of collisions per season (breeding or non-breeding) assuming that the birds take no action to avoid the turbine rotors was calculated as:

No. of birds flying through Rotor swept Area/Volume x Probability of collision p(collision)
(Stage 2 x Stage 3)

Stage 5

7.47 This estimate was then adjusted on the basis of several factors:

- A plausible range of avoidance rates – 95%, 98% and 99% avoidance.
- The proportion of the time the turbine rotors are expected to be moving.

7.48 The resulting estimates can be expressed as collisions per year or as the average time between collisions.

Baseline Description

Upland Breeding Bird Surveys

7.49 A total of 87 species including 8 species of wader and 5 raptor species were recorded in the study area during the three complete breeding bird survey visits in 2008 and 2009. No additional target species were likely to have been omitted from the inaccessible areas. The estimated number of breeding bird territories (after applying the method for determining territory numbers described by Brown and Shepherd[1]) for areas surveyed, is shown in Table 7a.2. The approximate central locations of the recorded territories for waders and Red-listed species are displayed in Figures 7.4 to 7.9.

Table 7a.2: All species recorded during the 2008 and 2009 breeding bird surveys

Species	Latin Name	Conservation status	Number of pairs or territories 2008 and 2009							
			Within survey area		Within application site		Within wind farm polygon		Within 250m of access track	
			2008	2009	2008	2009	2008	2009	2008	2009
Barn owl	*Tyto alba*	Schedule 1; Amber-listed; LBAP; SBL	1	1	1	1	1	1	0	0
Blackbird	*Turdus merula*		5	10	1	0	1	3	0	0
Blackcap	*Sylvia atricapilla*		1	1	0	0	0	0	0	0
Bullfinch	*Pyrrhula pyrrhula*	Amber-listed; UKBAP; SBL	0	1	0	0	0	0	0	0
Black-headed gull*	*Larus ridibundus*	Amber-listed; SBL	3	58	3	0	0	0	3	58
Black grouse	*Tetrao tetrix*	Red-listed; UKBAP; LBAP; SBL	0	1	0	0	0	0	0	0
Blue tit	*Cyanistes caeruleus*		1	4	1	0	1	0	0	0
Buzzard	*Buteo buteo*		1	2	0	1	0	1	0	0
Cuckoo	*Cuculus canorus*	Red-listed UKBAP	1	0	0	0	0	0	0	0
Canada goose	*Branta canadensis*		0	1	0	0	0	0	0	1
Carrion crow	*Corvus corone*		P	2	P	1	P	1	0	1
Chiffchaff	*Phylloscopus collybita*		P	0	P	0	P	0	0	0
Chaffinch	*Fringilla coelebs*		11	23	3	4	5	7	0	3
Coal tit	*Periparus ater*		P	7	0	0	0	3	0	0
Collared dove	*Streptopelia decaocto*		0	P	0	0	0	0	0	0
Common gull	*Larus canus*	Amber-listed	0	P	0	0	0	0	0	P
Curlew	*Numenius arquata*	Amber-listed UK BAP; LBAP; SBL	14	10	3	2	3	2	0	0
Crossbill	*Loxia curvirostra*	Schedule 1	1	P	1	0	1	0	0	0
Common sandpiper	*Actitis hypoleucos*	Amber-listed	4	7	2	2	2	2	0	3
Dunnock	*Prunella modularis*	Amber-listed UKBAP	P	3	P	1	P	1	0	0
Dipper	*Cinclus cinclus*		1	2	P	1	P	1	0	1
Fieldfare	*Turdus pilaris*	Schedule 1 Red-listed	P	0	P	0	P	0	0	0
Goldcrest	*Regulus regulus*		P	2	P	0	P	1	0	0
Great black-backed gull	*Larus marinus*	Amber-listed	P	0	P	0	P	0	0	0
Goosander	*Mergus merganser*		P	P	0	0	0	0	0	0
Goldfinch	*Carduelis carduelis*		2	4	1	1	1	1	0	1
Great spotted woodpecker	*Dendrocopos major*		0	1	0	0	0	0	0	0
Greylag goose	*Anser anser*	Amber-listed	P	P	0	0	0	0	0	0
Grey wagtail	*Motacilla cinerea*	Amber-listed	1	2	1	2	1	2	0	0
Golden plover	*Pluvialis apricaria*	Annex I, Amber-listed LBAP(h); SBL	P	P	P	0	P	0	0	0
Great tit	*Parus major*		4	3	0	0	0	0	0	0
Garden warbler	*Sylvia borin*		1	2	0	0	0	0	0	0
Grasshopper warbler	*Locustella naevia*	Red-listed UKBAP	1	1	0	0	0	0	0	1

Species	Latin Name	Conservation status	Number of pairs or territories 2008 and 2009							
			Within survey area		Within application site		Within wind farm polygon		Within 250m of access track	
			2008	2009	2008	2009	2008	2009	2008	2009
Greenfinch	*Carduelis chloris*		0	1	0	0	0	0	0	0
Grey heron	*Butorides virescens*		P	0	0	0	0	0	0	0
House martin	*Delichon urbicum*	Amber-listed	0	P	0	P	0	P	0	0
House sparrow	*Passer domesticus*	Red-listed UKBAP	P	P	P	0	0	0	P	0
Herring gull	*Larus argentatus*	Red-listed; UKBAP; SBL	0	P	0	0	0	0	0	0
Jackdaw	*Corvus monedula*		1	7	0	0	0	0	0	7
Kestrel	*Falco tinnunculus*	Amber-listed	P	P	P	0	P	0	P	0
Lapwing	*Vanellus vanellus*	Red-listed UKBAP; LBAP; SBL	2	2	P	P	P	P	0	0
Lesser black-backed gull	*Larus fuscus*	Amber-listed	P	0	0	0	0	0	0	0
Lesser redpoll	*Carduelis cabaret*	Red-listed UKBAP	3	3	P	P	P	P	0	2
Linnet	*Carduelis cannabina*	Red-listed; UKBAP; SBL	0	P	0	0	0	0	0	P
Little grebe	*Tachybaptus ruficollis*	Amber-listed	0	1	0	0	0	0	0	0
Mistle thrush	*Turdus viscivorus*	Amber-listed	1	2	P	0	P	1	0	0
Mallard	*Anas platyrhynchos*	Amber-listed	P	1	P	P	P	P	P	P
Magpie	*Pica pica*		0	P	0	0	0	0	0	0
Meadow pipit**	*Anthus pratensis*	Amber-listed	P	P	P	P	P	P	P	P
Moorhen	*Gallinula chloropus*		0	P	0	0	0	0	0	P
Mute swan	*Cygnus olor*		P	1	0	0	0	0	0	0
Oystercatcher	*Haematopus ostralegus*	Amber-listed	5	11	P	1	P	0	2	4
Peregrine	*Falco peregrinus*	Annex I; Schedule 1; LBAP(h); SBL	P	P	P	P	P	P	P	P
Pheasant	*Phasianus colchicus*		0	P	0	0	0	0	0	0
Pied wagtail	*Motacilla alba*		2	6	1	2	1	2	0	3
Robin	*Erithacus rubecula*	SBL	7	6	1	0	1	1	0	0
Reed bunting	*Emberiza schoeniclus*	Amber-listed UKBAP; SBL	15	22	1	6	1	7	3	4
Red grouse	*Lagopus lagopus*	Amber-listed	0	4	0	2	0	2	0	0
Red-legged partridge	*Alectoris rufa*		0	P	0	0	0	0	0	0
Redstart	*Phoenicurus phoenicurus*	Amber-listed	0	1	0	0	0	0	0	0
Raven	*Corvus corax*		1	1	1	0	1	0	0	0
Rook	*Corvus frugilegus*		P	P	P	0	P	0	0	0
Ringed plover	*Charadrius hiaticula*	Amber-listed	3	4	0	0	0	0	1	2
Siskin	*Carduelis spinus*		0	P	0	0	0	0	0	0
Skylark	*Alauda arvensis*	Red-listed UKBAP; LBAP(h)	67	148	25	58	30	59	3	7
Sparrowhawk	*Accipiter nisus*		0	P	0	0	0	0	0	0
Stonechat	*Saxicola torquatus*	LBAP(h)	14	13	3	2	4	2	1	2
Stock dove	*Columba oenas*	Amber-listed	0	1	0	0	0	0	0	1
Sand martin*	*Riparia riparia*	Amber-listed	4	22	4	15	4	15	0	0
Snipe	*Gallinago gallinago*	Amber-listed; LBAP LBAP(h)	6	6	2	2	2	2	0	1
Spotted flycatcher	*Muscicapa striata*	Red-listed; UKBAP; SBL	0	P	0	0	0	0	0	0
Sedge warbler	*Acrocephalus schoenobaenus*		5	4	0	0	0	0	0	2
Song thrush	*Turdus philomelos*	Red-listed UKBAP; LBAP; SBL	1	8	0	0	0	5	0	0
Starling*	*Sturnus vulgaris*	Red-listed; UKBAP	0	1	0	0	0	0	0	0
Swallow	*Hirundo rustica*	Amber-listed	0	3	0	3	0	3	0	0
Swift	*Apus apus*	Amber-listed	0	P	0	0	0	0	0	0
Tawny owl	*Strix aluco*		1		1		1		0	

Species	Latin Name	Conservation status	Number of pairs or territories 2008 and 2009							
			Within survey area		Within application site		Within wind farm polygon		Within 250m of access track	
			2008	2009	2008	2009	2008	2009	2008	2009
Tree pipit	*Anthus trivialis*	Red-listed; UKBAP	0	1	0	0	0	0	0	0
Tufted duck	*Aythya fuligula*	Amber-listed	0	P	0	0	0	0	0	P
Wheatear	*Oenanthe oenanthe*	Amber-listed	17	22	3	8	3	7	4	6
Woodpigeon	*Columba palumbus*		1	P	P	0	P	0	0	0
Woodcock	*Scolopax rusticola*	Amber-listed	0	1	0	0	0	0	0	0
Whinchat	*Saxicola rubetra*	Amber-listed	2	4	2	3	2	3	0	0
Whitethroat	*Sylvia communis*	Amber-listed	1	0	0	0	0	0	0	0
Wren	*Troglodytes troglodytes*		18	36	4	12	4	15	1	4
Willow warbler	*Phylloscopus trochilus*	Amber-listed	9	36	0	3	1	7	0	7
Yellowhammer	*Emberiza citrinella*	Red-listed; UKBAP; SBL	0	1	0	0	0	0	0	0
Total										

** Colony count; **Meadow pipit present breeding, but not included in survey. Average territory density estimate is 19 pairs per km^2.*

Winter Walkover Surveys

7.50 A total of 66 species was recorded between September 2007 and March 2008, and September 2008 and March 2009 inclusive. All species observations are listed in Table 7a.3.

Table 7a.3: Target species observed during winter walkover surveys 2007/08 and 2008/09

Species	Latin name	Observation
Barn owl	*Tyto alba*	Signs in sheds in centre of application site (Sep 07); fresh droppings and pellets in building north of Glenbuck Loch (Feb 08)
Black grouse	*Tetrao tetrix*	1 bird present 1.7km west of application site (Oct 07)
Blackbird	*Turdus merula*	Small numbers within WP
Black-headed gull	*Larus ridibundus*	2 near colony at access track (Feb 09)
Blue tit	*Cyanistes caeruleus*	Small flocks within WP, up to 19 birds recorded.
Brambling	*Fringilla montifringilla*	3 present within application site (Oct 07)
Bullfinch	*Pyrrhula pyrrhula*	12 at plantation edge (Dec 08)
Buzzard	*Buteo buteo*	2 adults and juvenile flying within WP (Sep 07)
Carrion crow	*Corvus corone*	Small numbers using WP throughout
Chaffinch	*Fringilla coelebs*	Mainly at plantation and near Glenbuck Loch
Coal tit	*Periparus ater*	Small numbers, mainly at plantation edge
Common gull	*Larus canus*	3 by access track at Glenbuck (Mar 08)
Common sandpiper	*Actitis hypoleucos*	4 birds flying and calling north of application site (Sep 08)
Cormorant	*Phalacrocorax carbo*	1 on Glenbuck Loch (Feb 08)
Crossbill	*Loxia curvirostra*	Up to 10 birds recorded throughout, mainly near plantation to north of site, occasional flight within WP
Curlew	*Numenius arquata*	2 birds calling and flying inside WP in Mar 08, Oct 08, Mar 09
Dipper	*Cinclus cinclus*	1 or 2 recorded throughout surveys in WP
Dunnock	*Prunella modularis*	2 birds present within WP most months
Fieldfare	*Turdus pilaris*	Up to 27 birds flying within WP (Oct 07); 5 in Nov 07; 29 birds, 25 within WP (Oct 08); 5 in Feb 08; 20 birds inside WP (Mar 08); 25 (Feb 09), 44 to south of WP (Feb 09)
Goldcrest	*Regulus regulus*	Small numbers at plantation edge throughout
Golden plover	*Pluvialis apricaria*	1 on Avermarks hill to east of site in Feb 08; 4 present near Glenbuck Loch, 1 in WP, 1 calling 500m north of WP (Feb 09)
Goldeneye	*Bucephala clangula*	Up to 21 birds on Glenbuck Loch (Oct 08). Regular use of loch throughout
Goldfinch	*Carduelis carduelis*	Mainly around Glenbuck Loch
Goosander	*Mergus merganser*	Mainly found using Glenbuck Loch
Great spotted woodpecker	*Dendrocopos major*	1 bird recorded near Glenbuck Loch
Great tit	*Parus major*	Small numbers near Glenbuck Loch
Greater black-backed gull	*Larus marinus*	2 beside Glenbuck Loch (Feb 09)
Greenfinch	*Carduelis chloris*	1 bird near Glenbuck Loch
Grey heron	*Ardea cinerea*	2 birds near Glenbuck Loch
Grey wagtail	*Motacilla cinerea*	Occasional record
Greylag goose	*Anser anser*	Skein of 12 recorded flying south of site (Sep 08); 2 on Loch in Feb 08

Species	Latin name	Observation
Hen harrier	*Circus cyaneus*	2 ringtails (juveniles) calling at northwest section of WP in Oct 08
Jackdaw	*Corvus monedula*	Occasional usage of WP from varying sizes of flocks
Kestrel	*Falco tinnunculus*	Hunting regularly inside and outside of WP; possible nest in plantation edge 2km NW of WP (Mar 08); 1 bird calling in centre of WP (Oct 08)
Lesser black-backed gull	*Larus fuscus*	2 in Feb 09
Lesser redpoll	*Carduelis cabaret*	Up to 7 flying within application site (Oct 07). Regular use of plantation edge
Little grebe	*Tachybaptus ruficollis*	1 on Glenbuck Loch (Feb 09)
Magpie	*Pica pica*	1 record of 2 birds outside WP
Mallard	*Anas platyrhynchos*	Up to 13 birds on Glenbuck Loch (Sep 08)
Meadow pipit	*Anthus pratensis*	Small numbers across WP throughout surveys
Mistle thrush	*Turdus viscivorus*	1 north of application site (Oct 07)
Mute swan	*Cygnus olor*	Up to 7 birds on Glenbuck Loch (Oct 07). Regular use throughout
Oystercatcher	*Haematopus ostralegus*	3 present at Glenbuck Loch Feb 08; 2 in flight in WP (Mar 09)
Peregrine	*Falco peregrinus*	1 flushed from track west of WP in Feb 08; 2 flights to west near access track in Mar 09
Pied wagtail	*Motacilla alba*	Occasional record
Pochard	*Aythya ferina*	Up to 26 present on Glenbuck Loch (Feb 08)
Raven	*Corvus corax*	Small numbers regularly flying within WP
Red grouse	*Lagopus lagopus*	Small numbers within WP throughout
Redshank	*Tringa totanus*	2 birds near Glenbuck Loch (Oct 08)
Redwing	*Turdus iliacus*	2 birds within WP (Nov 08); 10 in WP (Feb 09)
Reed bunting	*Emberiza schoeniclus*	Small numbers within WP throughout
Robin	*Erithacus rubecula*	Small numbers along plantation edge and near Glenbuck Loch
Rook	*Corvus frugilegus*	Moderate usage of WP throughout
Siskin	*Carduelis spinus*	Found mainly along plantation edge throughout
Skylark	*Alauda arvensis*	Small numbers using WP throughout surveys
Snipe	*Gallinago gallinago*	Up to 15 present in WP, including flock of 13 (Nov 07); regular use throughout including 2 birds within application site (Oct 07); 3 in WP (Nov 08)
Snow bunting	*Plectrophenax nivalis*	1in flight inside WP (Jan 08); 3 birds in Nov 08
Song thrush	*Turdus philomelos*	2 flying in WP (Feb 08); 2 at plantation edge (Mar 08); 3 in WP in Nov 08
Starling	*Sturnus vulgaris*	2 present in WP Mar 08 and Nov 08; 25 south of WP in Feb 09
Stonechat	*Saxicola torquatus*	Small numbers found within WP
Swallow	*Hirundo rustica*	Occasional record of stragglers
Treecreeper	*Certhia familiaris*	2 near Glenbuck Loch (Nov 08)
Tufted duck	*Aythya fuligula*	Up to 12 birds on Glenbuck Loch (Feb 09). Regular use throughout
Woodcock	*Scolopax rusticola*	1 present north of Glenbuck Loch (Feb 08 and Nov 08)
Woodpigeon	*Columba palumbus*	Small numbers crossing WP
Wren	*Troglodytes troglodytes*	Moderate usage of WP throughout surveys

Collision Risk Modelling

7.51 Of the target species recorded during the flight activity surveys, 9 species had at least 3 statistically-independent flight events that might be at risk of a turbine collision within the proposed wind farm per season (Table 7.11 of ES). There was considered be to sufficient information to enable robust collision risk predictions for these species, and it follows that the observed lack of "at risk" flight activity for the other target species means that their risk of turbine collisions is low.

7.52 The flight activity data for the 9 species were extrapolated to estimates of their total annual flights through the Risk Area or Risk Volume, respectively[6]. These annual totals were then entered into the collision risk model to generate estimates of the annual frequency of turbine collisions for each species.

Greylag goose plus unidentified grey goose (mid-September to mid-May)

7.53 A total of 127 birds were observed flying through the Risk Area during the surveys. This extrapolates to an annual total of 852 birds through the Risk Area (Table 7a.4, step 4). The 22 turbines of the proposed wind farm would together sweep 55% of the Risk Area, leading to an estimate of 466 birds flying through the Rotor-swept Area each year (step 8). After accounting for the probability that a given rotor transit will result in a collision (step 9), plus the likely operation rate of the turbines (step 11), the modelling process leads to a range of estimates for different levels of avoidance by the geese (step 12).

7.54 The survey data lead to predicted collision rates ranging from 1 every 6 months (95% avoidance) to 1 every 29 months (99% avoidance) (Table 7a.4).

[6] The Risk Area is the appropriate concept for a species like greylag goose where collision risk is modelled using the directional approach. See paragraph 7.34 for further details.

Table 7a.4: Collision risk modelling results for greylag plus unidentified grey geese during the period mid September to mid May.

	Vantage Point								
Step in modelling process	**VP 1**	**VP 2**	**VP 3**	**VP 4**	**VP 5**	**VP 6**	**VP 7**	**VP 8**	**VP 9**
Step 1. Number of birds flying over WP at PCH7	1	0	0	0	0	0	70	6	50
Step 2. Occupancy rate (birds at risk, per minute survey effort, per ha of viewshed)	3.14 E-07	0	0	0	0	0	2.54E-05	2.73 E-06	3.20E-05
Step 3. Average occupancy rate among VPs (weighted mean of VPs 1-9)	6.48E-06								
Step 4. Estimated number of birds through Risk Area during period8 (Step 3. x number of ha in windfarm x number of pot. active minutes)	852 birds								
Step 5. Risk Area9	214,240 m2								
Step 6. Total Rotor-swept Area in wind farm10	117,319 m2								
Step 7. Ratio Rotor-swept:Risk Area (Step 6/Step 5)	0.55								
Step 8. Estimated number of rotor transits during period (Step 4 x Step 7)	466 birds								
Step 9. Probability of collision p(collision)11 (calculated from SNH spreadsheet)	0.10								
Step 10. Estimated collisions assuming no avoidance (Step 8 x Step 9)	49								
Step 11. - taking turbine operation rate into account: 85%	41								
Step 12. Estimated number of collisions each non-breeding season, assuming avoidance rate:									
95%	2.06 (approximately 1 every 6 months)								
98%	0.82 (approximately 1 every 14 months)								
99%	0.41 (approximately 1 every 29 months)								

[7] PCH was taken to be 27.8 to 121.2 m above the ground.
[8] This step incorporates an additional 25% occupancy to account for presumed flight activity at night.
[9] The Risk Area was calculated as the width of the wind farm area (including 200m buffer from rotors) X the 82m vertical span of the rotors. The minimum width of the wind farm (2,600m) was used in order to produce the precautionary maximum ratio of rotor-swept area to risk area.
[10] Assumes 22 turbines, each with a Rotor-swept Volume of πr2 x (rotor width + bird length). Rotor radius is 41.2m for all turbines.

Pink-footed goose plus unidentified grey goose (mid-September to mid-May)

7.55 A total of 189 birds were observed flying through the Risk Area during the surveys. This extrapolates to an annual total of 1,831 birds through the Risk Area (Table 7a.5, step 4). The 22 turbines of the proposed wind farm would together sweep 55% of the Risk Area, leading to an estimate of 1,002 birds flying through the Rotor-swept Area each year (step 8). After accounting for the probability that a given rotor transit will result in a collision (step 9), plus the likely operation rate of the turbines (step 11), the modelling process leads to a range of estimates for different levels of avoidance by the geese (step 12).

7.56 The survey data lead to predicted collision rates ranging from 1 every 2-3 months (95% avoidance) to 1 every 14 months (99% avoidance) (Table 7a.5).

[11] Based on bird length = 0.84m, wingspan = 1.68m, flight speed = 17.1m/sec.

Table 7a.5: Collision risk modelling results for pink-footed goose, plus unidentified grey geese, during the period mid September to mid May.

	Vantage Point								
Step in modelling process	**VP 1**	**VP 2**	**VP 3**	**VP 4**	**VP 5**	**VP 6**	**VP 7**	**VP 8**	**VP 9**
Step 1. Number of birds flying over WP at PCH12	0	0	59	80	0	0	0	0	50
Step 2. Occupancy rate (birds at risk, per minute survey effort, per ha of viewshed)	0	0	3.57 E-04	5.81 E-05	0	0	0	0	3.20E-05
Step 3. Average occupancy rate among VPs (weighted mean of VPs 1-9)	1.39-E05								
Step 4. Estimated number of birds through Risk Area during period13 (Step 3. x number of ha in windfarm x number of pot. active minutes)	1,831 birds								
Step 5. Risk Area14	214,240 m2								
Step 6. Total Rotor-swept Area in wind farm15	117,319 m2								
Step 7. Ratio Rotor-swept:Risk Area (Step 6/Step 5)	0.55								
Step 8. Estimated number of rotor transits during period (Step 4 x Step 7)	1,002 transits								
Step 9. Probability of collision p(collision)16 (calculated from SNH spreadsheet)	0.100								
Step 11. Estimated collisions assuming no avoidance (Step 8 x Step 9)	100								
- taking turbine operation rate into account: 85%	85								
Step 12. Estimated number of collisions each non-breeding season, assuming avoidance rate:									
95%	4.26 (approximately 1 every 2-3 months)								
98%	1.70 (approximately 1 every 7 months)								
99%	0.85 (approximately 1 every 14 months)								

[12] PCH was taken to be 27.8 to 121.2 m above the ground.
[13] This step incorporates an additional 25% occupancy to account for possible flight activity at night.
[14] The Risk Area was calculated as the width of the wind farm area (including 200m buffer from rotors) X the 82.4m vertical span of the rotors. The minimum width of the wind farm (2,600m) was used in order to produce the precautionary maximum ratio of rotor-swept area to risk area.
[15] Assumes 22 turbines, each with a Rotor-swept Volume of πr^2 x (rotor width + bird length). Rotor radius is 41.2m for all turbines.

Hen Harrier (breeding and non-breeding seasons)

Breeding season

7.57 Occupancy of the Risk Volume totalled 515 seconds during the surveys. This extrapolates to a total of 4,447 seconds during the breeding seasons. The 22 turbines of the proposed wind farm would together sweep 0.09% of the Risk Volume, leading to an estimate of 4.14 seconds occupancy of the Rotor-swept Volume each year. After accounting for the probability of a given rotor transit leading to a collision, plus the likely operation rate of the turbines, the modelling process generates a range of estimates for different levels of avoidance by the birds (Table 7a.6).

[16] Based on bird length = 0.84m, wingspan = 1.68m, flight speed = 17.1m/sec.

7.58 The survey data lead to predicted collision rates ranging from 1 every 25 years (95% avoidance) to 1 every 125 years (99% avoidance) (Table 7a.6).

Table 7a.6: Collision risk modelling results for hen harrier during the breeding season.

	Vantage Point								
Step in modelling process	**VP1**	**VP 2**	**VP 3**	**VP 4**	**VP 5**	**VP 6**	**VP 7**	**VP 8**	**VP 9**
Step 1. Occupancy of WP at PCH17 (seconds at risk)	0	0	0	0	362	0	99	54	0
Step 2. Occupancy rate (time at risk, per minute survey effort, per ha of viewshed)	0	0	0	0	2.43E-04	0	4.8E-05	3.37 E-05	0
Step 3. Average occupancy rate among VPs (weighted mean of VPs 1-9)	4.50E-05								
Step 4. Estimated occupancy of Risk Volume18 (Step 3. x number of ha in windfarm x number of pot. active minutes during breeding season)	4,447 seconds								
Step 5. Risk Volume19	508,781,107 m3								
Step 6. Total Rotor-swept Volume in WF20	473,967 m3								
Step 7. Ratio Rotor-swept:Risk Volume (Step 6/Step 5)	0.00093157								
Step 8. Estimated occupancy of Rotor-swept Volume each breeding season (Step 4 x Step 7)	4.14 seconds								
Step 9. Number of rotor transits represented by Step 8 occupancy (Step 8/transit time21)	8 transits								
Step 10. Probability of collision p(collision)22 (calculated from SNH spreadsheet)	0.11								
Step 11. Estimated collisions assuming no avoidance (Step 9 x Step 10)	0.94								
- taking turbine operation rate into account: 85%	0.80								
Estimated number of collisions each breeding season, assuming avoidance rate:									
95%	0.040 (approximately 1 every 25 years)								
98%	0.016 (approximately 1 every 63 years)								
99%	0.008 (approximately 1 every 125 years)								

Non-breeding season

7.59 Occupancy of the Risk Volume totalled 300 seconds during the surveys. This extrapolates to a total of 1,769 seconds during the non-breeding seasons. The 22 turbines of the proposed wind farm would together sweep 0.09% of the Risk Volume, leading to an estimate of 1.65 seconds occupancy of the Rotor-swept Volume each year. After accounting for the probability of a given rotor transit leading to a collision, plus the likely operation rate of the turbines, the modelling process generates a range of estimates for different levels of avoidance by the birds (Table 7a.7).

7.60 The survey data lead to predicted collision rates ranging from 1 every 63 years (95% avoidance) to 1 every 314 years (99% avoidance) (Table 7a.7).

[17] PCH was taken to be 27.8 to 121.2 m above the ground.
[18] This step assumes that hen harriers do not fly at night.
[19] The Risk Volume was calculated as the wind farm area (including 200m buffer from rotors) X the 82m vertical span of the rotors.
[20] Assumes 22 turbines, each with a Rotor-swept Volume of πr2 x (rotor width + bird length). Rotor radius is 41.2m for all turbines.

[21] The time taken for a harrier to make one pass through the Rotor-swept Volume (transit time) is given by: (the width of the rotors (=3.52m) + the length of a hen harrier (=0.52m)) / average flight speed of hen harrier (8 metres per second)
[22] Based on bird length = 0.52m, wingspan = 1.2m, flight speed = 8m/sec .

Table 7a.7: Collision risk modelling results for hen harrier during the non-breeding season.

	Vantage Point								
Step in modelling process	**VP1**	**VP 2**	**VP 3**	**VP 4**	**VP 5**	**VP 6**	**VP 7**	**VP 8**	**VP 9**
Step 1. Occupancy of WP at PCH23 (seconds at risk)	0	0	0	0	0	0	0	300.0	0
Step 2. Occupancy rate (time at risk, per minute survey effort, per ha of viewshed)	0	0	0	0	0	0	0	1.85E-04	0
Step 3. Average occupancy rate among VPs (weighted mean of VPs 1-9)	2.59E-05								
Step 4. Estimated occupancy of Risk Volume24 (Step 3. x number of ha in windfarm x number of pot. active minutes in non breeding season)	1,769 seconds								
Step 5. Risk Volume25	508,781,107 m3								
Step 6. Total Rotor-swept Volume in WF26	473,967 m3								
Step 7. Ratio Rotor-swept:Risk Volume (Step 6/Step 5)	0.00093157								
Step 8. Estimated occupancy of Rotor-swept Volume each non-breeding season (Step 4 x Step 7)	1.65 seconds								
Step 9. Number of rotor transits represented by Step 8 occupancy (Step 8/transit time27)	3 transits								
Step 10. Probability of collision p(collision)28, calculated from SNH spreadsheet)	0.11								
Step 11. Estimated collisions assuming no avoidance (Step 9 x Step 10)	0.37								
- taking turbine operation rate into account: 85%	0.32								
Estimated number of collisions each non-breeding season, assuming avoidance rate:									
95%	0.016 (approximately 1 every 63 years)								
98%	0.006 (approximately 1 every 157 years)								
99%	0.003 (approximately 1 every 314 years)								

[23] PCH was taken to be 27.8 to 121.2 m above the ground.
[24] This step assumes that hen harriers do not fly at night.
[25] The Risk Volume was calculated as the wind farm area (including 200m buffer from rotors) X the 82.4m vertical span of the rotors.
[26] Assumes 22 turbines, each with a Rotor-swept Volume of πr2 x (rotor width + bird length). Rotor radius is 41.2m for all turbines.

Curlew (non-breeding and breeding)

<u>Non-breeding season</u>

7.61 Occupancy of the Risk Volume totalled 4,366 seconds during the surveys. This extrapolates to a total of 29,217 seconds during the 2 non-breeding seasons. The 22 turbines of the proposed wind farm would together sweep 0.09% of the Risk Volume, leading to an estimate of 27.76 seconds occupancy of the Rotor-swept Volume each year. After accounting for the probability of a given rotor transit leading to a collision, plus the likely operation rate of the turbines, the modelling process generates a range of estimates for different levels of avoidance by the birds (Table 7a.8).

[27] The time taken for a harrier to make one pass through the Rotor-swept Volume (transit time) is given by: (the width of the rotors (=3.52m) + the length of a hen harrier (=0.52m)) / average flight speed of hen harrier (8 metres per second).
[28] Based on bird length = 0.52m, wingspan = 1.2m, flight speed = 8m/sec.

7.62 The survey data lead to predicted collision rates ranging from 1 every 2.4 years (95% avoidance) to 1 every 12.2 years (99% avoidance) (Table 7a.8).

Table 7a.8: Collision risk modelling results for curlew during the non-breeding season.

	Vantage Point								
Step in modelling process	**VP 1**	**VP 2**	**VP 3**	**VP 4**	**VP 5**	**VP 6**	**VP 7**	**VP 8**	**VP 9**
Step 1. Occupancy of WP at PCH29 (seconds at risk)	0	0	0	126.0	4176.0	0	64.0	0	0
Step 2. Occupancy rate (time at risk, per minute survey effort, per ha of viewshed)	0	0	0	9.71E-05	2.19E-03	0	2.30E-05	0	0
Step 3. Average occupancy rate among VPs (weighted mean of VPs 1-9)	3.13E-04								
Step 4. Estimated occupancy of Risk Volume30 (Step 3. x number of ha in windfarm x number of pot. active minutes in non breeding season)	29,217 seconds								
Step 5. Risk Volume31	508,781,107 m3								
Step 6. Total Rotor-swept Volume in WF32	483,353m3								
Step 7. Ratio Rotor-swept:Risk Volume (Step 6/Step 5)	0.00095								
Step 8. Estimated occupancy of Rotor-swept Volume each non-breeding season (Step 4 x Step 7)	27.76 seconds								
Step 9. Number of rotor transits represented by Step 8 occupancy (Step 8/transit time33)	108 transits								
Step 10. Probability of collision p(collision)34 (calculated from SNH spreadsheet)	0.09								
Step 11. Estimated collisions assuming no avoidance (Step 9 x Step 10)	9.64								
- taking turbine operation rate into account: 85%	8.19								
Estimated number of collisions each non-breeding season, assuming avoidance rate:									
95%	0.410 (approximately 1 every 2.4 years)								

[29] PCH was taken to be 27.8 to 121.2 m above the ground.
[30] This step assumes that curlews do not fly at night.
[31] The Risk Volume was calculated as the wind farm area (including 200m buffer from rotors) X the 82m vertical span of the rotors.
[32] Assumes 22 turbines, each with a Rotor-swept Volume of πr2 x (rotor width + bird length). Rotor radius is 41.2m for all turbines.

[33] The time taken for a curlew to make one pass through the Rotor-swept Volume (transit time) is given by: (the width of the rotors (=3.52m) + the length of a curlew (=0.60m)) / average flight speed of curlew (16 metres per second)
[34] Based on bird length = 0.60m, wingspan = 1.0m, flight speed = 16m/sec .

	Vantage Point								
Step in modelling process	VP 1	VP 2	VP 3	VP 4	VP 5	VP 6	VP 7	VP 8	VP 9
98%	0.164 (approximately 1 every 6.1 years)								
99%	0.082 (approximately 1 every 12.2 years)								

Breeding Season

7.63 Occupancy of the Risk Volume totalled 2,195 seconds during the surveys. This extrapolates to a total of 22,726 seconds during the 2 breeding seasons. The 22 turbines of the proposed wind farm would together sweep 0.09% of the Risk Volume, leading to an estimate of 21.59 seconds occupancy of the Rotor-swept Volume each year. After accounting for the probability of a given rotor transit leading to a collision, plus the likely operation rate of the turbines, the modelling process generates a range of estimates for different levels of avoidance by the birds (Table 7a.9).

7.64 The survey data lead to predicted collision rates ranging from 1 every 3.1 years (95% avoidance) to 1 every 15.7 years (99% avoidance) (Table 7a.9).

Table 7a.9: Collision risk modelling results for curlew during the breeding season

	Vantage Point								
Step in modelling process	VP1	VP 2	VP 3	VP 4	VP 5	VP 6	VP 7	VP 8	VP 9
Step 1. Occupancy of WP at PCH35 (seconds at risk)	43	34	0	436	960	19	133	392	178
Step 2. Occupancy rate (time at risk, per minute survey effort, per ha of viewshed)	2.67E-05	2.28E-05	0	6.01E-04	9.38E-04	1.76E-05	9.82E-05	3.46E-04	2.90E-04
Step 3. Average occupancy rate among VPs (weighted mean of VPs 1-9)	3.08E-04								

[35] PCH was taken to be 27.8 to 121.2 m above the ground.

	Vantage Point								
Step in modelling process	VP1	VP 2	VP 3	VP 4	VP 5	VP 6	VP 7	VP 8	VP 9
Step 4. Estimated occupancy of Risk Volume36 (Step 3. x number of ha in windfarm x number of pot. active minutes during breeding season)	22,726 seconds								
Step 5. Risk Volume37	508,781,107 m3								
Step 6. Total Rotor-swept Area in WF38	483353 m3								
Step 7. Ratio Rotor-swept Area:Risk Area (Step 6/Step 5)	0.00095								
Step 8. Estimated occupancy of Rotor-swept Area each breeding season (Step 4 x Step 7)	21.59 seconds								
Step 9. Number of rotor transits represented by Step 8 occupancy (Step 8/transit time39)	84 transits								

[36] This step assumes that curlews do not fly at night.
[37] The Risk Volume was calculated as the wind farm area (including 200m buffer from rotors) X the 82m vertical span of the rotors.
[38] Assumes 22 turbines, each with a Rotor-swept Volume of πr2 x (rotor width + bird length). Rotor radius is 41.2m for all turbines.

	Vantage Point								
Step in modelling process	VP1	VP 2	VP 3	VP 4	VP 5	VP 6	VP 7	VP 8	VP 9
Step 10. Probability of collision p(collision)40 (calculated from SNH spreadsheet)	0.09								
Step 11. Estimated collisions assuming no avoidance (Step 9 x Step 10)	7.5								
- taking turbine operation rate into account: 85%	6.4								
Estimated number of collisions each breeding season, assuming avoidance rate:									
95%	0.32 (approximately 1 every 3.1 years)								
98%	0.127 (approximately 1 every 7.8 years)								
99%	0.064 (approximately 1 every 15.7 years)								

[39] The time taken for a curlew to make one pass through the Rotor-swept Volume (transit time) is given by: (the width of the rotors (=3.52m) + the length of a curlew (=0.60m)) / average flight speed of curlew (16 metres per second)

[40] Based on bird length = 0.60m, wingspan = 1.0m, flight speed = 16m/sec .

Golden Plover (non-breeding and breeding seasons)

Non-breeding season

7.65 Occupancy of the Risk Volume totalled 1,001 seconds during the surveys. This extrapolates to a total of 9,191 seconds during the 2 non-breeding seasons. The 22 turbines of the proposed wind farm would together sweep 0.09% of the Risk Volume, leading to an estimate of 8.07 seconds occupancy of the Rotor-swept Volume each year. After accounting for the probability of a given rotor transit leading to a collision, plus the likely operation rate of the turbines, the modelling process generates a range of estimates for different levels of avoidance by the birds (Table 7a.10).

7.66 The survey data lead to predicted collision rates ranging from 1 every 14.2 years (95% avoidance) to 1 every 70.8 years (99% avoidance) (Table 7a.10).

Table 7a.10: Collision risk modelling results for golden plover during the non-breeding season.

	Vantage Point								
Step in modelling process	**VP 1**	**VP 2**	**VP 3**	**VP 4**	**VP 5**	**VP 6**	**VP 7**	**VP 8**	**VP 9**
Step 1. Occupancy of WP at PCH41 (seconds at risk)	0	0	0	819	53	0	129	0	0
Step 2. Occupancy rate (time at risk, per minute survey effort, per ha of viewshed)	0	0	0	6.31 E-04	2.78E -05	0	4.64E-05	0	0
Step 3. Average occupancy rate among VPs (weighted mean of VPs 1-9)	9.84E-05								
Step 4. Estimated occupancy of Risk Volume42 (Step 3. x number of ha in windfarm x number of pot. active minutes in non breeding season)	9,191 seconds								
Step 5. Risk Volume43	508,781,107 m3								

[41] PCH was taken to be 27.8 to 121.2 m above the ground.

[42] This step assumes that golden plovers do not fly at night.

	Vantage Point								
Step in modelling process	VP 1	VP 2	VP 3	VP 4	VP 5	VP 6	VP 7	VP 8	VP 9
Step 6. Total Rotor-swept Volume in WF44	446,984 m3								
Step 7. Ratio Rotor-swept:Risk Volume (Step 6/Step 5)	0.0008785								
Step 8. Estimated occupancy of Rotor-swept Volume each non-breeding season (Step 4 x Step 7)	8.07 seconds								
Step 9. Number of rotor transits represented by Step 8 occupancy (Step 8/transit time45)	19 transits								
Step 10. Probability of collision p(collision)46 (calculated from SNH spreadsheet)	0.08								
Step 11. Estimated collisions assuming no avoidance (Step 9 x Step 10)	1.59								
- taking turbine operation rate into account: 85%	1.35								
Estimated number of collisions each non-breeding season, assuming avoidance rate:									
95%	0.068 (approximately 1 every 14.8 years)								
98%	0.027 (approximately 1 every 36.9 years)								
99%	0.014 (approximately 1 every 73.9 years)								

[43] The Risk Volume was calculated as the wind farm area (including 200m buffer from rotors) X the 82m vertical span of the rotors.
[44] Assumes 22 turbines, each with a Rotor-swept Volume of πr2 x (rotor width + bird length). Rotor radius is 41.2m for all turbines.
[45] The time taken for a golden plover to make one pass through the Rotor-swept Volume (transit time) is given by: (the width of the rotors (=3.52m) + the length of a golden plover (=0.29m)) / average flight speed of golden plover (9 metres per second)
[46] Based on bird length = 0.29m, wingspan = 0.76m, flight speed = 9m/sec .

Breeding season

7.67 Occupancy of the Risk Volume totalled 465 seconds during the surveys. This extrapolates to a total of 7,030 seconds during the 2 breeding seasons. The 22 turbines of the proposed wind farm would together sweep 0.09% of the Risk Volume, leading to an estimate of 6.18 seconds occupancy of the Rotor-swept Volume each year. After accounting for the probability of a given rotor transit leading to a collision, plus the likely operation rate of the turbines, the modelling process generates a range of estimates for different levels of avoidance by the birds (Table 7a.11).

7.68 The survey data lead to predicted collision rates ranging from 1 every 19 years (95% avoidance) to 1 every 96 years (99% avoidance) (Table 7a.11).

Table 7a.11: Collision risk modelling results for golden plover during the breeding season.

	Vantage Point								
Step in modelling process	VP1	VP 2	VP 3	VP 4	VP 5	VP 6	VP 7	VP 8	VP 9
Step 1. Occupancy of WP at PCH47 (seconds at risk)	0	0	0	465	0	0	0	0	0
Step 2. Occupancy rate (time at risk, per minute survey effort, per ha of viewshed)	0	0	0	6.41E-04	0	0	0	0	0
Step 3. Average occupancy rate among VPs (weighted mean of VPs 1-9)	9.54-05								

[47] PCH was taken to be 27.8 to 121.2 m above the ground.

	Vantage Point								
Step in modelling process	**VP1**	**VP 2**	**VP 3**	**VP 4**	**VP 5**	**VP 6**	**VP 7**	**VP 8**	**VP 9**
Step 4. Estimated occupancy of Risk Volume (Step 3. x number of ha in windfarm x number of pot. active minutes48 during breeding season)	7,030 seconds								
Step 5. Risk Volume49	508,781,107 m3								
Step 6. Total Rotor-swept Volume in WF50	446,984 m3								
Step 7. Ratio Rotor-swept:Risk Volume (Step 6/Step 5)	0.0008785								
Step 8. Estimated occupancy of Rotor-swept Volume each breeding season (Step 4 x Step 7)	6.18 seconds								
Step 9. Number of rotor transits represented by Step 8 occupancy (Step 8/transit time51)	15 transits								
Step 10. Probability of collision p(collision)52 (calculated from SNH spreadsheet)	0.083								
Step 11. Estimated collisions assuming no avoidance (Step 9 x Step 10)	1.22								
- taking turbine operation rate into account: 85%	1.04								
Estimated number of collisions each breeding season, assuming avoidance rate:									
95%	0.052 (approximately 1 every 19 years)								
98%	0.021 (approximately 1 every 48 years)								
99%	0.010 (approximately 1 every 96 years)								

[48] This step assumes that golden plovers do not fly at night.
[49] The Risk Volume was calculated as the wind farm area (including 200m buffer from rotors) X the 82.4m vertical span of the rotors.
[50] Assumes 22 turbines, each with a Rotor-swept Volume of $\pi r2$ x (rotor width + bird length). Rotor radius is 41.2m for all turbines.
[51] The time taken for a golden plovers to make one pass through the Rotor-swept Volume (transit time) is given by: (the width of the rotors (=3.52m) + the length of a golden plover (=0.29m)) / average flight speed of golden plover (9 metres per second).

Lapwing (breeding season)

7.69 Occupancy of the Risk Volume totalled 543 seconds during the surveys. This extrapolates to a total of 4,372seconds during the 2 breeding seasons. The 22 turbines of the proposed wind farm would together sweep 0.09% of the Risk Volume, leading to an estimate of 3.86 seconds occupancy of the Rotor-swept Volume each year. After accounting for the probability of a given rotor transit leading to a collision, plus the likely operation rate of the turbines, the modelling process generates a range of estimates for different levels of avoidance by the birds (Table 7a.12).

7.70 The survey data lead to predicted collision rates ranging from 1 every 23 years (95% avoidance) to 1 every 117 years (99% avoidance) (Table 7a.12).

[52] Based on bird length = 0.29m, wingspan = 0.76m, flight speed = 9m/sec.

Table 7a.12: Collision risk modelling results for lapwing during the breeding season.

	Vantage Point								
Step in modelling process	VP1	VP 2	VP 3	VP 4	VP 5	VP 6	VP 7	VP 8	VP 9
Step 1. Occupancy of WP at PCH53 (seconds at risk)	0	0	0	0	191	0	352	0	0
Step 2. Occupancy rate (time at risk, per minute survey effort, per ha of viewshed)	0	0	0	0	1.87E-04	0	2.60E-04	0	0
Step 3. Average occupancy rate among VPs (weighted mean of VPs 1-9)	5.93E-05								
Step 4. Estimated occupancy of Risk Volume54 (Step 3. x number of ha in windfarm x number of pot. active minutes during breeding season)	4,372 seconds								
Step 5. Risk Volume55	508,781,107 m3								
Step 6. Total Rotor-swept Volume in WF56	449,330 m3								
Step 7. Ratio Rotor-swept:Risk Volume (Step 6/Step 5)	0.0008832								
Step 8. Estimated occupancy of Rotor-swept Volume each breeding season (Step 4 x Step 7)	3.86 seconds								
Step 9. Number of rotor transits represented by Step 8 occupancy (Step 8/transit time57)	13 transits								
Step 10. Probability of collision p(collision)58 (calculated from SNH spreadsheet)	0.08								
Step 11. Estimated collisions assuming no avoidance (Step 9 x Step 10)	1.00								
- taking turbine operation rate into account: 85%	0.85								
Estimated number of collisions each breeding season, assuming avoidance rate:									
95%	0.043 (approximately 1 every 23 years)								
98%	0.017 (approximately 1 every 58 years)								

[53] PCH was taken to be 27.8 to 121.2 m above the ground.
[54] This step assumes that lapwings do not fly at night.
[55] The Risk Volume was calculated as the wind farm area (including 200m buffer from rotors) X the 82.4m vertical span of the rotors.
[56] Assumes 22 turbines, each with a Rotor-swept Volume of πr2 x (rotor width + bird length). Rotor radius is 41.2m for all turbines.

[57] The time taken for a lapwing to make one pass through the Rotor-swept Volume (transit time) is given by: (the width of the rotors (=3.52m) + the length of a lapwing (=0.31m/ average flight speed of lapwing (12.8 metres per second).
[58] Based on bird length = 0.31m, wingspan = 0.87m, flight speed = 12.8m/sec.

	Vantage Point								
Step in modelling process	VP1	VP 2	VP 3	VP 4	VP 5	VP 6	VP 7	VP 8	VP 9
99%	0.009 (approximately 1 every 117 years)								

Peregrine (non-breeding and breeding season)

Non-breeding season

7.71 Occupancy of the Risk Volume totalled 1,104 seconds during the surveys. This extrapolates to a total of 6,900 seconds during the non-breeding seasons. The 22 turbines of the proposed wind farm would together sweep 0.09% of the Risk Volume, leading to an estimate of 6.4 seconds occupancy of the Rotor-swept Volume each year. After accounting for the probability of a given rotor transit leading to a collision, plus the likely operation rate of the turbines, the modelling process generates a range of estimates for different levels of avoidance by the birds (Table 7a.13).

7.72 The survey data lead to predicted collision rates ranging from 1 every 12 years (95% avoidance) to 1 every 62 years (99% avoidance) (Table 7a.13).

Table 7a.13: Collision risk modelling results for peregrine during the non-breeding season.

	Vantage Point								
Step in modelling process	VP 1	VP 2	VP 3	VP 4	VP 5	VP 6	VP 7	VP 8	VP 9
Step 1. Occupancy of WP at PCH59 (seconds at risk)	156	0	0	345	139	0	464	0	0
Step 2. Occupancy rate (time at risk, per minute survey effort, per ha of viewshed)	6.23E-05	0	0	3.66E-04	9.66 E-05	0	2.24E-04	0	0
Step 3. Average occupancy rate among VPs (weighted mean of VPs 1-9)	1.01E-04								
Step 4. Estimated occupancy of Risk Volume60	6,900 seconds								
(Step 3. x number of ha in windfarm x number of pot. active minutes in non breeding season)									
Step 5. Risk Volume61	508,781,107 m3								
Step 6. Total Rotor-swept Volume in WF62	469,275 m3								
Step 7. Ratio Rotor-swept:Risk Volume (Step 6/Step 5)	0.0009223								
Step 8. Estimated occupancy of Rotor-swept Volume each non-breeding season (Step 4 x Step 7)	6.4 seconds								
Step 9. Number of rotor transits represented by Step 8 occupancy (Step 8/transit time63)	21 transits								
Step 10. Probability of collision p(collision)64 (calculated from SNH spreadsheet)	0.09								
Step 11. Estimated collisions assuming no avoidance (Step 9 x Step 10)	1.91								

[59] PCH was taken to be 27.8 to 121.2 m above the ground.
[60] This step assumes that peregrines do not fly at night.

[61] The Risk Volume was calculated as the wind farm area (including 200m buffer from rotors) X the 82.4m vertical span of the rotors.
[62] Assumes 22 turbines, each with a Rotor-swept Volume of πr2 x (rotor width + bird length). Rotor radius is 41.2m for all turbines.
[63] The time taken for a peregrine to make one pass through the Rotor-swept Volume (transit time) is given by: (the width of the rotors (=3.52m) + the length of a peregrine (=0.48m)) / average flight speed of peregrine (12 metres per second).
[64] Based on bird length = 0.48m, wingspan = 1.1m, flight speed = 12m/sec.

	Vantage Point								
Step in modelling process	VP 1	VP 2	VP 3	VP 4	VP 5	VP 6	VP 7	VP 8	VP 9
- taking turbine operation rate into account: 85%	1.62								
Estimated number of collisions each non-breeding season, assuming avoidance rate:									
95%	0.081 (approximately 1 every 12 years)								
98%	0.032 (approximately 1 every 31years)								
99%	0.016 (approximately 1 every 62 years)								

Breeding season

7.73 Occupancy of the Risk Volume totalled 838 seconds during the surveys. This extrapolates to a total of 6,237 seconds during the breeding seasons. The 22 turbines of the proposed wind farm would together sweep 0.09% of the Risk Volume, leading to an estimate of 5.75 seconds occupancy of the Rotor-swept Volume each year. After accounting for the probability of a given rotor transit leading to a collision, plus the likely operation rate of the turbines, the modelling process generates a range of estimates for different levels of avoidance by the birds (Table 7a.14).

7.74 The survey data lead to predicted collision rates ranging from 1 every 13 years (95% avoidance) to 1 every 68 years (99% avoidance) (Table 7a.14).

Table 7a.14: Collision risk modelling results for peregrine during the breeding season.

	Vantage Point								
Step in modelling process	VP1	VP 2	VP 3	VP 4	VP 5	VP 6	VP 7	VP 8	VP 9
Step 1. Occupancy of WP at PCH65 (seconds at risk)	0	0	0	0	221	485	93	39	0
	0	0	0	0	1.48E-04	3.98E-04	4.51E-05	2.44E-05	0

[65] PCH was taken to be 27.8 to 121.2 m above the ground.

	Vantage Point								
Step in modelling process	VP1	VP 2	VP 3	VP 4	VP 5	VP 6	VP 7	VP 8	VP 9
Step 2. Occupancy rate (time at risk, per minute survey effort, per ha of viewshed)									
Step 3. Average occupancy rate among VPs (weighted mean of VPs 1-9)	6.31E-05								
Step 4. Estimated occupancy of Risk Volume66 (Step 3. x number of ha in windfarm x number of pot. active minutes during breeding season)	6,237 seconds								
Step 5. Risk Volume67	508,781,107 m3								
Step 6. Total Rotor-swept Volume in WF68	469,275 m3								
Step 7. Ratio Rotor-swept:Risk Volume (Step 6/Step 5)	0.0009223								
Step 8. Estimated occupancy of Rotor-swept Volume each breeding season (Step 4 x Step 7)	5.75 seconds								

[66] This step assumes that peregrines do not fly at night.
[67] The Risk Volume was calculated as the wind farm area (including 200m buffer from rotors) X the 82.4m vertical span of the rotors.
[68] Assumes 22 turbines, each with a Rotor-swept Volume of πr2 x (rotor width + bird length). Rotor radius is 41.2m for all turbines.

	Vantage Point								
Step in modelling process	VP1	VP 2	VP 3	VP 4	VP 5	VP 6	VP 7	VP 8	VP 9
Step 9. Number of rotor transits represented by Step 8 occupancy (Step 8/transit time69)	19								
Step 10. Probability of collision p(collision)70 (calculated from SNH spreadsheet)	0.09								
Step 11. Estimated collisions assuming no avoidance (Step 9 x Step 10)	1.72								
- taking turbine operation rate into account: 85%	1.47								
Estimated number of collisions each breeding season, assuming avoidance rate:									
95%	0.073 (approximately 1 every 13 years)								
98%	0.029 (approximately 1 every 34 years)								
99%	0.015 (approximately 1 every 68 years)								

[69] The time taken for a peregrine to make one pass through the Rotor-swept Volume (transit time) is given by: (the width of the rotors (=3.52m) + the length of a peregrine (=0.48m/ average flight speed of peregrine (12 metres per second).
[70] Based on bird length = 0.48m, wingspan = 1.1m, flight speed = 12.0m/sec.

Red kite (non-breeding and breeding season)

Non-breeding season

7.75 Occupancy of the Risk Volume totalled 47 seconds during the surveys. This extrapolates to a total of 217 seconds during the non-breeding seasons. The 22 turbines of the proposed wind farm would together sweep 0.09% of the Risk Volume, leading to an estimate of 0.21 seconds occupancy of the Rotor-swept Volume each year. After accounting for the probability of a given rotor transit leading to a collision, plus the likely operation rate of the turbines, the modelling process generates a range of estimates for different levels of avoidance by the birds (Table 7a.15).

7.76 The survey data lead to predicted collision rates ranging from 1 every 354 years (95% avoidance) to fewer than 1 every 1,000 years (99% avoidance) (Table 7a.15).

Table 7a.15: Collision risk modelling results for red kite during the non-breeding season.

	Vantage Point								
Step in modelling process	VP1	VP 2	VP 3	VP 4	VP 5	VP 6	VP 7	VP 8	VP 9
Step 1. Occupancy of WP at PCH71 (seconds at risk)	0	0	0	0	0	47	0	0	0
Step 2. Occupancy rate (time at risk, per minute survey effort, per ha of viewshed)	0	0	0	0	0	4.3E-05	0	0	0
Step 3. Average occupancy rate among VPs (weighted mean of VPs 1-9)	3.17E-06								
Step 4. Estimated occupancy of Risk Volume72 (Step 3. x number of ha in windfarm x number of pot. active minutes in non breeding season)	217 seconds								
Step 5. Risk Volume73	508,781,107 m3								
Step 6. Total Rotor-swept Volume in WF74	490,392 m3								

[71] PCH was taken to be 27.8 to 121.2 m above the ground.
[72] This step assumes that red kites do not fly at night.
[73] The Risk Volume was calculated as the wind farm area (including 200m buffer from rotors) X the 82.4m vertical span of the rotors.

Step in modelling process	Vantage Point VP1	VP 2	VP 3	VP 4	VP 5	VP 6	VP 7	VP 8	VP 9
Step 7. Ratio Rotor-swept:Risk Volume (Step 6/Step 5)	0.0009639								
Step 8. Estimated occupancy of Rotor-swept Volume each non-breeding season (Step 4 x Step 7)	0.21 seconds								
Step 9. Number of rotor transits represented by Step 8 occupancy (Step 8/transit time75)	0.6 transit								
Step 10. Probability of collision p(collision)76 (calculated from SNH spreadsheet)	0.11								
Step 11. Estimated collisions assuming no avoidance (Step 9 x Step 10)	0.07								
- taking turbine operation rate into account: 85%	0.06								
Estimated number of collisions each non-breeding season, assuming avoidance rate:									
95%	0.003 (approximately 1 every 354 years)								
98%	0.001 (approximately 1 every 885 years)								
99%	0.001 (fewer than 1 every 1,000 years)								

[74] Assumes 22 turbines, each with a Rotor-swept Volume of πr2 x (rotor width + bird length). Rotor radius is 41.2m for all turbines.
[75] The time taken for a kite to make one pass through the Rotor-swept Volume (transit time) is given by: (the width of the rotors (=3.52m) + the length of a red kite (=0.66m)) / average flight speed of red kite (12 metres per second).
[76] Based on bird length = 0.66m, wingspan = 1.95m. flight speed = 12m/sec.

Breeding season

7.77 Occupancy of the Risk Volume totalled 482 seconds during the surveys. This extrapolates to a total of 2,863 seconds during the breeding seasons. The 22 turbines of the proposed wind farm would together sweep 0.09% of the Risk Volume, leading to an estimate of 2.76 seconds occupancy of the Rotor-swept Volume each year. After accounting for the probability of a given rotor transit leading to a collision, plus the likely operation rate of the turbines, the modelling process generates a range of estimates for different levels of avoidance by the birds (Table 7a.16).

7.78 The survey data lead to predicted collision rates ranging from 1 every 26 years (95% avoidance) to 1 every 133 years (99% avoidance) (Table 7a.16).

Table 7a.16: Collision risk modelling results for red kite during the breeding season.

Step in modelling process	Vantage Point VP1	VP 2	VP 3	VP 4	VP 5	VP 6	VP 7	VP 8	VP 9
Step 1. Occupancy of WP at PCH77 (seconds at risk)	482	0	0	0	0	0	0	0	0
Step 2. Occupancy rate (time at risk, per minute survey effort, per ha of viewshed)	2.02 E-04	0	0	0	0	0	0	0	0
Step 3. Average occupancy rate among VPs (weighted mean of VPs 1-9)	2.90E-05								
Step 4. Estimated occupancy of Risk Volume78 (Step 3. x number of ha in windfarm x number of pot. active minutes during	2,863 seconds								

[77] PCH was taken to be 27.8 to 121.2 m above the ground.
[78] This step assumes that red kites do not fly at night.

	Vantage Point								
Step in modelling process	**VP1**	**VP 2**	**VP 3**	**VP 4**	**VP 5**	**VP 6**	**VP 7**	**VP 8**	**VP 9**
breeding season)									
Step 5. Risk Volume79	508,781,107 m3								
Step 6. Total Rotor-swept Volume in WF80	490,392 m3								
Step 7. Ratio Rotor-swept:Risk Volume (Step 6/Step 5)	0.0009639								
Step 8. Estimated occupancy of Rotor-swept Volume each breeding season (Step 4 x Step 7)	2.76 seconds								
Step 9. Number of rotor transits represented by Step 8 occupancy (Step 8/transit time81)	8 transits								
Step 10. Probability of collision p(collision)82 (calculated from SNH spreadsheet)	0.11								
Step 11. Estimated collisions assuming no avoidance (Step 9 x Step 10)	0.9								
- taking turbine operation rate into account: 85%	0.7								
Estimated number of collisions each breeding season, assuming avoidance rate:									
95%	0.037 (approximately 1 every 26 years)								
98%	0.015 (approximately 1 every 66 years)								
99%	0.007 (approximately 1 every 133 years)								

[79] The Risk Volume was calculated as the wind farm area (including 200m buffer from rotors) X the 82.4m vertical span of the rotors.

[80] Assumes 22 turbines, each with a Rotor-swept Volume of πr2 x (rotor width + bird length). Rotor radius is 41.2m for all turbines.

[81] The time taken for a kite to make one pass through the Rotor-swept Volume (transit time) is given by: (the width of the rotors (=3.52m) + the length of a red kite (=0.66m)) / average flight speed of red kite (12 metres per second).

[82] Based on bird length = 0.66m, wingspan = 1.95m, flight speed = 12m/sec.

Snipe (breeding and non-breeding seasons)

Breeding season

7.79 Occupancy of the Risk Volume totalled 167 seconds during the surveys. This extrapolates to a total of 2,525 seconds during the breeding seasons. The 22 turbines of the proposed wind farm would together sweep 0.09% of the Risk Volume, leading to an estimate of 2.2 seconds occupancy of the Rotor-swept Volume each year. After accounting for the probability of a given rotor transit leading to a collision, plus the likely operation rate of the turbines, the modelling process generates a range of estimates for different levels of avoidance by the birds (Table 7a.17).

7.80 The survey data lead to predicted collision rates ranging from 1 every 35 years (95% avoidance) to 1 every 175 years (99% avoidance) (Table 7a.17).

Table 7a.17: Collision risk modelling results for snipe during the breeding season.

	Vantage Point								
Step in modelling process	**VP1**	**VP 2**	**VP 3**	**VP 4**	**VP 5**	**VP 6**	**VP 7**	**VP 8**	**VP 9**

	Vantage Point								
Step in modelling process	VP1	VP 2	VP 3	VP 4	VP 5	VP 6	VP 7	VP 8	VP 9
Step 1. Occupancy of WP at PCH83 (seconds at risk)	0	0	0	167	0	0	0	0	0
Step 2. Occupancy rate (time at risk, per minute survey effort, per ha of viewshed)	0	0	0	2.30 E-04	0	0	0	0	0
Step 3. Average occupancy rate among VPs (weighted mean of VPs 1-9)	3.43E-05								
Step 4. Estimated occupancy of Risk Volume84 (Step 3. x number of ha in windfarm x number of pot. active minutes during breeding season)	2,525 seconds								
Step 5. Risk Volume85	508,781,107 m3								
Step 6. Total Rotor-swept Volume in WF86	444,638 m3								
Step 7. Ratio Rotor-swept:Risk Volume (Step 6/Step 5)	0.0008739								

[83] PCH was taken to be 27.8 to 121.2 m above the ground.
[84] This step takes no account of flight activity at night.
[85] The Risk Volume was calculated as the wind farm area (including 200m buffer from rotors) X the 82.4m vertical span of the rotors.
[86] Assumes 22 turbines, each with a Rotor-swept Volume of $\pi r2$ x (rotor width + bird length). Rotor radius is 41.2m for all turbines.

	Vantage Point								
Step in modelling process	**VP1**	**VP 2**	**VP 3**	**VP 4**	**VP 5**	**VP 6**	**VP 7**	**VP 8**	**VP 9**
Step 8. Estimated occupancy of Rotor-swept Volume each breeding season (Step 4 x Step 7)	2.21 seconds								
Step 9. Number of rotor transits represented by Step 8 occupancy (Step 8/transit time87)	10								
Step 10. Probability of collision p(collision)88 (calculated from SNH spreadsheet)	0.07								
Step 11. Estimated collisions assuming no avoidance (Step 9 x Step 10)	0.67								
- taking turbine operation rate into account: 85%	0.57								
Estimated number of collisions each breeding season, assuming avoidance rate:									
95%	0.029 (approximately 1 every 35years)								
98%	0.011 (approximately 1 every 87 years)								

[87] The time taken for a snipe to make one pass through the Rotor-swept Volume (transit time) is given by: (the width of the rotors (=3.52m) + the length of a snipe (=0.27m/ average flight speed of snipe (17.1 metres per second).
[88] Based on bird length = 0.27m, wingspan = 0.47m, flight speed = 17.1m/sec.

	Vantage Point								
Step in modelling process	**VP1**	**VP 2**	**VP 3**	**VP 4**	**VP 5**	**VP 6**	**VP 7**	**VP 8**	**VP 9**
99%	0.006 (approximately 1 every 175 years)								

Non-breeding season

7.81 Occupancy of the Risk Volume totaled 120 seconds during the surveys. This extrapolates to a total of 560 seconds during the non-breeding seasons. The 22 turbines of the proposed wind farm would together sweep 0.09% of the Risk Volume, leading to an estimate of 0.49 seconds occupancy of the Rotor-swept Volume each year. After accounting for the probability of a given rotor transit leading to a collision, plus the likely operation rate of the turbines, the modelling process generates a range of estimates for different levels of avoidance by the birds (Table 7a.18).

7.82 The survey data lead to predicted collision rates ranging from 1 every 157 years (95% avoidance) to 1 every 787 years (99% avoidance) (Table 7a.18).

Table 7a.18: Collision risk modelling results for snipe during the non-breeding season.

	Vantage Point								
Step in modelling process	**VP 1**	**VP 2**	**VP 3**	**VP 4**	**VP 5**	**VP 6**	**VP 7**	**VP 8**	**VP 9**
Step 1. Occupancy of WP at PCH89 (seconds at risk)	0	0	0	0	0	0	120	0	0
Step 2. Occupancy rate (time at risk, per minute survey effort, per ha of viewshed)	0	0	0	0	0	0	4.32E-05	0	0
Step 3. Average occupancy rate among VPs (weighted mean of VPs 1-9)	6.00E-6								
Step 4. Estimated occupancy of Risk Volume90 (Step 3. x number of ha in windfarm x number of pot. active minutes in non breeding season)	560 seconds								
Step 5. Risk Volume91	508,781,107 m3								
Step 6. Total Rotor-swept Volume in WF92	444,638 m3								
Step 7. Ratio Rotor-swept:Risk Volume (Step 6/Step 5)	0.0008739								
Step 8. Estimated occupancy of Rotor-swept Volume each non-breeding season (Step 4 x Step 7)	0.49 seconds								
Step 9. Number of rotor transits represented by Step 8 occupancy (Step 8/transit time93)	2.2								
Step 10. Probability of collision p(collision)94 (calculated from SNH spreadsheet)	0.07								
Step 11. Estimated collisions assuming no avoidance (Step 9 x Step 10)	0.15								
- taking turbine operation rate into account: 85%	0.13								

[89] PCH was taken to be 27.8 to 121.2 m above the ground.
[90] This step takes no account of flight activity at night.

[91] The Risk Volume was calculated as the wind farm area (including 200m buffer from rotors) X the 82.4m vertical span of the rotors.
[92] Assumes 22 turbines, each with a Rotor-swept Volume of πr2 x (rotor width + bird length). Rotor radius is 41.2m for all turbines.
[93] The time taken for a snipe to make one pass through the Rotor-swept Volume (transit time) is given by: (the width of the rotors (=3.52m) + the length of a snipe (=0.27m)) / average flight speed of snipe (17.1 metres per second).
[94] Based on bird length = 0.27m, wingspan = 0.47m, flight speed = 17.1m/sec.

	Vantage Point								
Step in modelling process	**VP 1**	**VP 2**	**VP 3**	**VP 4**	**VP 5**	**VP 6**	**VP 7**	**VP 8**	**VP 9**
Estimated number of collisions each non-breeding season, assuming avoidance rate:									
95%	0.006 (approximately 1 every 157 years)								
98%	0.003 (approximately 1 every 393 years)								
99%	0.001 (approximately 1 every 787 years)								

Details of Flight Activity Survey Effort

7.83 Details of vantage point survey effort from 2007-09, including dates and times are shown below in Table 7a.19. Effort includes surveys conducted at VP3 and hen harrier surveys from VP6.

Date	Month	Vantage Point	Observer	Start Time	End Time	Duration
11-Sep-07	9	3	EMCL	10:30	13:30	3:00
11-Sep-07	9	3	EMCL	14:00	17:00	3:00
11-Sep-07	9	1	CJR	10:30	13:30	3:00
11-Sep-07	9	1	CJR	14:00	17:00	3:00
27-Sep-07	9	2	MJA	13:00	16:00	3:00
27-Sep-07	9	3	AA	09:30	12:30	3:00
27-Sep-07	9	3	AA	13:00	16:00	3:00
27-Sep-07	9	2	MJA	09:30	12:30	3:00
28-Sep-07	9	6	ED	08:30	11:30	3:00
28-Sep-07	9	4	AA	08:50	11:50	3:00
28-Sep-07	9	4	AA	12:20	15:20	3:00
28-Sep-07	9	6	ED	12:00	15:00	3:00
28-Sep-07	9	5	MJA	09:05	12:05	3:00
28-Sep-07	9	5	MJA	12:30	15:30	3:00
22-Oct-07	10	7	AA	12:40	15:40	3:00
22-Oct-07	10	1	EMCL	09:20	12:20	3:00
22-Oct-07	10	7	AA	09:10	12:10	3:00
22-Oct-07	10	1	EMCL	13:20	16:20	3:00
23-Oct-07	10	2	EMCL	09:20	12:20	3:00
23-Oct-07	10	5	AA	12:10	15:10	3:00
23-Oct-07	10	5	AA	08:40	11:40	3:00
23-Oct-07	10	2	EMCL	13:05	16:05	3:00
24-Oct-07	10	4	AA	08:30	11:30	3:00
24-Oct-07	10	4	AA	12:00	15:00	3:00
30-Oct-07	10	8	MJA	09:05	12:05	3:00
30-Oct-07	10	8	MJA	12:30	15:30	3:00
30-Oct-07	10	6	CW	08:45	11:45	3:00
30-Oct-07	10	6	CW	12:45	15:45	3:00
07-Nov-07	11	4	MJA	09:30	12:30	3:00
07-Nov-07	11	4	MJA	12:40	15:40	3:00
07-Nov-07	11	5	CW	09:10	12:10	3:00
07-Nov-07	11	5	CW	12:30	15:30	3:00
09-Nov-07	11	1	CW	13:00	16:00	3:00
09-Nov-07	11	7	EMCL	08:55	11:55	3:00
09-Nov-07	11	7	EMCL	12:35	15:35	3:00
09-Nov-07	11	1	CW	09:00	12:00	3:00
12-Nov-07	11	2	CW	13:30	16:30	3:00
12-Nov-07	11	2	CW	09:30	12:30	3:00
13-Nov-07	11	6	CW	08:45	11:45	3:00
13-Nov-07	11	6	CW	11:00	14:00	3:00
20-Nov-07	11	8	CW	09:00	12:00	3:00
20-Nov-07	11	8	CW	13:00	16:00	3:00

Date	Month	Vantage Point	Observer	Start Time	End Time	Duration
10-Dec-07	12	7	CN	09:40	11:40	2:00
10-Dec-07	12	7	CN	11:50	13:50	2:00
10-Dec-07	12	1	MJA	09:30	11:30	2:00
10-Dec-07	12	1	MJA	11:50	13:50	2:00
11-Dec-07	12	5	MJA	09:10	11:10	2:00
11-Dec-07	12	6	CN	09:15	11:15	2:00
11-Dec-07	12	6	CN	11:30	13:30	2:00
11-Dec-07	12	5	MJA	11:30	13:30	2:00
12-Dec-07	12	8	MJA	11:55	13:55	2:00
12-Dec-07	12	8	MJA	09:45	11:45	2:00
13-Dec-07	12	4	MJA	12:30	14:30	2:00
13-Dec-07	12	4	MJA	10:20	12:20	2:00
18-Dec-07	12	8	MJA	12:05	14:05	2:00
18-Dec-07	12	4	MJA	09:25	11:25	2:00
19-Dec-07	12	1	EMCL	10:10	12:10	2:00
20-Dec-07	12	2	CN	09:00	12:00	3:00
20-Dec-07	12	6	MJA	08:50	10:50	2:00
20-Dec-07	12	2	CN	12:15	14:15	2:00
20-Dec-07	12	5	MJA	11:50	13:50	2:00
21-Dec-07	12	2	CN	08:50	09:50	1:00
21-Dec-07	12	7	CN	10:05	12:05	2:00
14-Jan-08	1	6	MJA	12:15	14:15	2:00
14-Jan-08	1	6	MJA	10:00	12:00	2:00
15-Jan-08	1	5	MJA	11:50	13:50	2:00
15-Jan-08	1	5	MJA	09:45	11:45	2:00
16-Jan-08	1	8	MJA	09:25	11:25	2:00
16-Jan-08	1	8	MJA	11:40	13:40	2:00
28-Jan-08	1	7	CJR	10:30	12:30	2:00
28-Jan-08	1	2	LT	13:00	15:00	2:00
28-Jan-08	1	4	MJA	09:30	12:30	3:00
28-Jan-08	1	2	LT	10:45	12:45	2:00
28-Jan-08	1	7	CJR	12:45	14:45	2:00
28-Jan-08	1	1	EMCL	12:55	14:55	2:00
28-Jan-08	1	1	EMCL	10:40	12:40	2:00
28-Jan-08	1	4	MJA	12:35	15:35	3:00
29-Jan-08	1	7	CJR	11:05	13:05	2:00
29-Jan-08	1	1	EMCL	10:00	12:00	2:00
29-Jan-08	1	2	LT	11:00	13:00	2:00
29-Jan-08	1	5	AA	08:10	10:10	2:00
01-Feb-08	2	8	AA	11:20	13:20	2:00
01-Feb-08	2	6	AA	08:30	10:30	2:00
05-Feb-08	2	8	MJA	12:30	16:30	4:00

Date	Month	Vantage Point	Observer	Start Time	End Time	Duration
06-Feb-08	2	5	MJA	09:15	12:15	3:00
06-Feb-08	2	5	MJA	12:30	15:30	3:00
07-Feb-08	2	4	MJA	09:50	12:50	3:00
07-Feb-08	2	4	MJA	13:00	16:00	3:00
08-Feb-08	2	6	MJA	11:55	15:55	4:00
11-Feb-08	2	7	EMCL	11:15	13:15	2:00
11-Feb-08	2	1	MJA	09:05	11:05	2:00
11-Feb-08	2	1	MJA	11:15	13:15	2:00
11-Feb-08	2	7	EMCL	09:00	11:00	2:00
12-Feb-08	2	6	MJA	08:55	10:55	2:00
12-Feb-08	2	8	MJA	12:30	14:30	2:00
12-Feb-08	2	1	EMCL	12:45	14:45	2:00
12-Feb-08	2	2	EMCL	10:15	12:15	2:00
13-Feb-08	2	2	MJA	09:55	11:55	2:00
13-Feb-08	2	2	MJA	12:05	14:05	2:00
14-Feb-08	2	7	MJA	10:55	12:55	2:00
05-Mar-08	3	8	MJA	12:00	16:00	4:00
06-Mar-08	3	1	LT	12:50	14:50	2:00
06-Mar-08	3	1	LT	10:40	12:40	2:00
06-Mar-08	3	2	EMCL	10:20	12:20	2:00
06-Mar-08	3	2	EMCL	12:45	14:45	2:00
06-Mar-08	3	6	MJA	09:50	13:50	4:00
07-Mar-08	3	5	MJA	10:15	13:45	3:30
14-Mar-08	3	2	MJA	10:10	12:10	2:00
14-Mar-08	3	7	AM	10:05	14:35	4:30
14-Mar-08	3	1	MJA	12:50	14:50	2:00
17-Mar-08	3	6	MJA	09:10	11:10	2:00
17-Mar-08	3	4	AM	09:05	14:05	5:00
17-Mar-08	3	5	MJA	11:58	14:28	2:30
18-Mar-08	3	7	MJA	11:40	13:40	2:00
20-Mar-08	3	8	LT	10:00	12:00	2:00
04-Apr-08	4	6	ED	12:50	16:50	4:00
05-Apr-08	4	6	ED	10:45	13:45	3:00
05-Apr-08	4	5	ED	15:00	18:00	3:00
07-Apr-08	4	4	CJR	10:30	14:30	4:00
07-Apr-08	4	5	EMCL	11:00	13:00	2:00
07-Apr-08	4	5	EMCL	13:15	15:15	2:00
13-Apr-08	4	1	ED	13:50	16:50	3:00
13-Apr-08	4	2	ED	10:00	13:00	3:00
16-Apr-08	4	7	LT, GAC	10:10	12:10	2:00
16-Apr-08	4	7	LT & GAC	12:30	14:30	2:00
17-Apr-08	4	7	LT	09:35	12:35	3:00

Date	Month	Vantage Point	Observer	Start Time	End Time	Duration
18-Apr-08	4	2	LT	09:45	13:45	4:00
18-Apr-08	4	1	ALB	09:40	13:40	4:00
20-Apr-08	4	4	ALB	16:01	19:01	3:00
20-Apr-08	4	8	ALB	12:28	15:28	3:00
21-Apr-08	4	8	ALB	06:55	10:55	4:00
22-May-08	5	5	DG	08:35	11:35	3:00
22-May-08	5	1	JG	12:00	13:30	1:30
22-May-08	5	1	JG	08:30	11:30	3:00
22-May-08	5	6	JM	11:15	14:15	3:00
22-May-08	5	6	JM	07:45	10:45	3:00
22-May-08	5	5	DG	12:25	13:25	1:00
26-May-08	5	8	ED	15:30	19:00	3:30
26-May-08	5	5	DG	11:20	13:50	2:30
26-May-08	5	1	DG	15:10	17:40	2:30
26-May-08	5	6	DG	08:30	10:00	1:30
27-May-08	5	7	ED	09:15	12:45	3:30
30-May-08	5	4	AA	08:00	11:00	3:00
30-May-08	5	4	AA	11:30	15:30	4:00
03-Jun-08	6	8	MJA	09:25	13:25	4:00
03-Jun-08	6	5	MJA	14:05	16:05	2:00
04-Jun-08	6	7	MJA	09:00	12:00	3:00
04-Jun-08	6	2	MJA	12:15	15:15	3:00
05-Jun-08	6	5	ED	14:40	18:10	3:30
05-Jun-08	6	2	AC	07:30	11:00	3:30
05-Jun-08	6	7	AC	11:10	14:40	3:30
06-Jun-08	6	8	DG	11:10	14:40	3:30
07-Jun-08	6	7	ED	12:55	16:55	4:00
07-Jun-08	6	2	ED	09:55	11:55	2:00
08-Jun-08	6	1	ED	11:00	15:02	4:02
17-Jun-08	6	6	ED	09:00	13:00	4:00
20-Jun-08	6	8	ED	10:55	13:55	3:00
20-Jun-08	6	4	ED	14:55	18:55	4:00
29-Jun-08	6	5	ED	09:20	10:50	1:30
01-Jul-08	7	6	ED	13:45	16:45	3:00
01-Jul-08	7	2	ED	17:30	19:30	2:00
02-Jul-08	7	1	ED	10:25	13:25	3:00
02-Jul-08	7	4	ED	15:15	18:15	3:00
03-Jul-08	7	5	DG	10:42	12:42	2:00
03-Jul-08	7	8	DG	13:30	16:30	3:00
03-Jul-08	7	8	DG	17:00	18:00	1:00
04-Jul-08	7	2	ED	13:30	15:30	2:00
04-Jul-08	7	1	ED	16:30	19:30	3:00

Date	Month	Vantage Point	Observer	Start Time	End Time	Duration
07-Jul-08	7	7	AM	07:45	10:45	3:00
07-Jul-08	7	2	AM	11:05	14:05	3:00
11-Jul-08	7	4	MJA	09:45	13:45	4:00
16-Jul-08	7	4	DG	14:09	17:09	3:00
16-Jul-08	7	6	DG	08:54	11:54	3:00
18-Jul-08	7	8	IG	13:15	16:15	3:00
19-Jul-08	7	5	IG	14:10	17:10	3:00
29-Jul-08	7	6	AA	09:00	13:00	4:00
29-Jul-08	7	5	AA	13:40	15:40	2:00
30-Jul-08	7	4	ED	13:25	17:28	4:03
30-Jul-08	7	1	MJA	09:40	13:40	4:00
30-Jul-08	7	2	ED	11:05	13:05	2:00
05-Aug-08	8	8	MJA	14:10	17:10	3:00
05-Aug-08	8	7	MJA	10:35	13:35	3:00
08-Aug-08	8	1	MJA	09:20	12:20	3:00
08-Aug-08	8	2	MJA	13:10	16:10	3:00
11-Aug-08	8	4	MJA	13:05	16:05	3:00
11-Aug-08	8	5	MJA	09:15	12:15	3:00
12-Aug-08	8	4	MJA	09:35	12:35	3:00
12-Aug-08	8	5	MJA	13:25	14:25	1:00
20-Aug-08	8	1	MJA	10:20	13:20	3:00
20-Aug-08	8	2	MJA	14:05	16:35	2:30
21-Aug-08	8	7	GAC	06:10	09:10	3:00
21-Aug-08	8	8	GAC	09:40	12:40	3:00
22-Aug-08	8	8	GAC	10:00	11:00	1:00
22-Aug-08	8	2	GAC	12:48	13:48	1:00
22-Aug-08	8	1	GAC	14:10	15:10	1:00
22-Aug-08	8	7	GAC	11:35	12:35	1:00
27-Aug-08	8	8	CN	13:45	14:45	1:00
27-Aug-08	8	7	CN	10:55	11:55	1:00
28-Aug-08	8	4	CN	10:10	11:10	1:00
28-Aug-08	8	5	CN	13:00	16:00	3:00
14-Sep-08	9	7	ED	13:10	16:10	3:00
17-Sep-08	9	4	CN	09:25	12:25	3:00
17-Sep-08	9	5	CN	13:15	16:15	3:00
17-Sep-08	9	2	AM	11:30	14:30	3:00
17-Sep-08	9	7	AM	08:00	11:00	3:00
18-Sep-08	9	2	CN	08:55	11:55	3:00
18-Sep-08	9	1	CN	12:35	15:35	3:00
19-Sep-08	9	8	CN	13:25	16:25	3:00
19-Sep-08	9	4	CN	09:35	12:35	3:00
20-Sep-08	9	9	CN	08:15	11:15	3:00

Date	Month	Vantage Point	Observer	Start Time	End Time	Duration
20-Sep-08	9	8	CN	12:25	15:25	3:00
21-Sep-08	9	5	AM	08:30	11:30	3:00
23-Sep-08	9	9	CN	14:00	17:00	3:00
23-Sep-08	9	1	CN	09:25	12:25	3:00
02-Oct-08	10	8	GAC	10:15	13:15	3:00
02-Oct-08	10	9	GAC	14:45	17:45	3:00
05-Oct-08	10	5	AM	12:30	15:30	3:00
05-Oct-08	10	4	AM	08:10	11:10	3:00
09-Oct-08	10	7	LT	09:00	12:00	3:00
09-Oct-08	10	2	LT	12:15	15:15	3:00
14-Oct-08	10	1	AM	12:20	15:20	3:00
14-Oct-08	10	2	AM	08:30	11:30	3:00
20-Oct-08	10	7	GAC	10:20	13:20	3:00
21-Oct-08	10	5	GAC	13:35	16:35	3:00
21-Oct-08	10	9	GAC	10:00	13:00	3:00
22-Oct-08	10	1	MA	09:15	12:15	3:00
31-Oct-08	10	8	GAC	09:35	12:35	3:00
31-Oct-08	10	4	GAC	13:00	16:00	3:00
06-Nov-08	11	7	LT	09:30	12:30	3:00
06-Nov-08	11	2	LT	12:45	15:45	3:00
20-Nov-08	11	2	AM	08:50	11:50	3:00
20-Nov-08	11	1	AM	12:30	15:30	3:00
27-Nov-08	11	4	MJA	10:55	12:55	2:00
27-Nov-08	11	5	AM	10:30	12:30	2:00
27-Nov-08	11	5	MJA	13:45	15:45	2:00
27-Nov-08	11	9	AM	13:45	15:45	2:00
27-Nov-08	11	7	GAC	13:30	15:30	2:00
28-Nov-08	11	9	AC	12:10	14:10	2:00
28-Nov-08	11	9	AC	09:10	11:10	2:00
28-Nov-08	11	4	MJA	13:25	15:25	2:00
28-Nov-08	11	7	GAC	09:25	10:25	1:00
28-Nov-08	11	1	GAC	11:05	14:05	3:00
28-Nov-08	11	4	MJA	10:25	12:25	2:00
28-Nov-08	11	5	MJA	08:30	09:30	1:00
28-Nov-08	11	5	AC	15:00	15:45	0:45
29-Nov-08	11	8	ED	13:20	16:20	3:00
29-Nov-08	11	8	ED	09:20	12:20	3:00
01-Dec-08	12	8	AM	08:50	10:50	2:00
01-Dec-08	12	4	AM	12:00	15:00	3:00
03-Dec-08	12	1	AM	12:40	15:40	3:00
03-Dec-08	12	2	AM	09:40	11:40	2:00
14-Dec-08	12	5	AM	12:10	15:10	3:00

Date	Month	Vantage Point	Observer	Start Time	End Time	Duration
14-Dec-08	12	9	AM	09:00	11:00	2:00
15-Dec-08	12	9	AM	08:30	10:30	2:00
15-Dec-08	12	8	AM	11:45	14:45	3:00
17-Dec-08	12	1	LT	09:15	12:15	3:00
20-Dec-08	12	4	AM	08:50	10:50	2:00
20-Dec-08	12	5	AM	12:00	15:00	3:00
21-Dec-08	12	7	ED	12:00	13:30	1:30
21-Dec-08	12	2	ED	09:30	11:30	2:00
21-Dec-08	12	7	ED	14:00	15:30	1:30
24-Dec-08	12	2	ED	11:10	13:10	2:00
24-Dec-08	12	7	ED	13:55	15:55	2:00
28-Dec-08	12	9	AM	13:45	15:45	2:00
28-Dec-08	12	8	AM	11:35	12:35	1:00
28-Dec-08	12	4	AM	09:45	10:45	1:00
05-Jan-09	1	1	GAC	10:00	12:00	2:00
05-Jan-09	1	2	GAC	12:30	14:30	2:00
06-Jan-09	1	5	MJA	13:30	15:30	2:00
06-Jan-09	1	4	MJA	10:30	12:30	2:00
07-Jan-09	1	8	MJA	10:55	12:55	2:00
07-Jan-09	1	9	MJA	14:00	16:00	2:00
09-Jan-09	1	7	GAC	09:40	11:40	2:00
09-Jan-09	1	7	GAC	12:00	14:00	2:00
14-Jan-09	1	1	GAC	10:05	12:05	2:00
20-Jan-09	1	8	MJA	10:10	13:10	3:00
20-Jan-09	1	9	MJA	14:30	16:30	2:00
21-Jan-09	1	4	MJA	09:00	11:00	2:00
21-Jan-09	1	5	MJA	11:55	13:55	2:00
26-Jan-09	1	5	AM	12:35	14:35	2:00
26-Jan-09	1	4	AM	09:30	11:30	2:00
28-Jan-09	1	9	GAC	12:52	14:52	2:00
28-Jan-09	1	1	GAC	10:05	12:05	2:00
29-Jan-09	1	2	AM	11:05	13:35	2:30
29-Jan-09	1	2	AM	08:35	10:05	1:30
29-Jan-09	1	7	GAC	11:35	14:35	3:00
29-Jan-09	1	8	GAC	10:05	11:05	1:00
13-Feb-09	2	2	AM	11:50	14:50	3:00
13-Feb-09	2	1	AM	08:50	10:50	2:00
18-Feb-09	2	2	CN	13:25	15:25	2:00
18-Feb-09	2	7	CN	09:45	12:45	3:00
18-Feb-09	2	4	GAC	11:00	14:00	3:00
19-Feb-09	2	2	CN	11:30	12:30	1:00
20-Feb-09	2	9	CN	13:30	16:00	2:30

Date	Month	Vantage Point	Observer	Start Time	End Time	Duration
20-Feb-09	2	8	CN	09:15	12:15	3:00
22-Feb-09	2	8	AM	13:00	15:00	2:00
22-Feb-09	2	4	AM	09:00	12:00	3:00
23-Feb-09	2	7	GAC	13:30	16:30	3:00
23-Feb-09	2	1	GAC	10:45	12:45	2:00
25-Feb-09	2	5	GAC	11:30	14:30	3:00
28-Feb-09	2	9	AM	11:25	13:55	2:30
28-Feb-09	2	8	AM	09:25	10:25	1:00
28-Feb-09	2	9	AM	14:30	15:30	1:00
04-Mar-09	3	8	GAC	13:55	16:55	3:00
04-Mar-09	3	8	GAC	09:55	12:55	3:00
12-Mar-09	3	1	GAC	06:45	09:45	3:00
12-Mar-09	3	7	GAC	10:25	13:25	3:00
13-Mar-09	3	1	GAC	11:10	13:10	2:00
13-Mar-09	3	9	GAC	08:55	10:55	2:00
16-Mar-09	3	9	CN	12:40	15:40	3:00
16-Mar-09	3	9	CN	08:40	11:40	3:00
16-Mar-09	3	1	GAC	12:40	14:40	2:00
16-Mar-09	3	7	GAC	09:00	12:00	3:00
17-Mar-09	3	2	CN	09:10	12:10	3:00
17-Mar-09	3	4	GAC	13:40	16:40	3:00
17-Mar-09	3	2	CN	13:10	16:10	3:00
17-Mar-09	3	5	GAC	09:40	12:40	3:00
19-Mar-09	3	9	AD	11:20	14:20	3:00
19-Mar-09	3	1	AD	15:00	18:00	3:00
20-Mar-09	3	1	GAC	13:20	15:20	2:00
20-Mar-09	3	1	GAC	11:00	13:00	2:00
20-Mar-09	3	9	GAC	08:20	10:20	2:00
23-Mar-09	3	8	CG	14:29	17:29	3:00
23-Mar-09	3	8	CG	10:29	13:29	3:00
24-Mar-09	3	4	CG	09:30	12:30	3:00
24-Mar-09	3	5	CG	13:30	15:30	2:00
27-Mar-09	3	8	AD	16:05	19:05	3:00
27-Mar-09	3	8	AD	12:05	15:05	3:00
28-Mar-09	3	4	AD	06:30	09:30	3:00
28-Mar-09	3	5	AD	10:35	13:35	3:00
29-Mar-09	3	9	AD	07:10	10:10	3:00
30-Mar-09	3	7	AD	07:15	10:15	3:00
30-Mar-09	3	4	CN	09:15	12:15	3:00
30-Mar-09	3	5	CN	13:40	16:40	3:00
30-Mar-09	3	7	AD	11:15	14:15	3:00
31-Mar-09	3	2	AD	07:10	10:10	3:00

Date	Month	Vantage Point	Observer	Start Time	End Time	Duration
31-Mar-09	3	1	AD	11:00	14:00	3:00
07-Apr-09	4	9	MJA	05:55	08:55	3:00
07-Apr-09	4	2	MJA	10:29	13:29	3:00
09-Apr-09	4	1	MJA	06:05	09:05	3:00
09-Apr-09	4	7	MJA	10:05	13:05	3:00
17-Apr-09	4	4	AM	05:40	08:40	3:00
17-Apr-09	4	5	AM	10:10	13:10	3:00
19-Apr-09	4	1	AM	09:00	12:00	3:00
21-Apr-09	4	4	MJA	10:30	13:30	3:00
22-Apr-09	4	8	MJA	05:35	08:35	3:00
22-Apr-09	4	8	MJA	09:35	12:35	3:00
24-Apr-09	4	7	RD	07:50	10:50	3:00
24-Apr-09	4	9	AM	08:50	11:50	3:00
26-Apr-09	4	5	ED	18:45	21:45	3:00
06-May-09	5	1	MJA	05:15	08:15	3:00
06-May-09	5	7	MJA	09:10	12:10	3:00
07-May-09	5	2	AM	05:40	08:40	3:00
07-May-09	5	2	AM	09:40	12:40	3:00
07-May-09	5	2	MJA	18:05	21:05	3:00
07-May-09	5	9	MJA	13:55	16:55	3:00
11-May-09	5	4	AM	14:30	17:30	3:00
11-May-09	5	5	AM	18:40	21:40	3:00
20-May-09	5	6	AM	15:45	16:45	1:00
21-May-09	5	7	ED	19:35	22:35	3:00
21-May-09	5	1	ED	15:35	18:35	3:00
26-May-09	5	4	AM	05:10	08:10	3:00
27-May-09	5	8	BA	13:00	17:00	4:00
27-May-09	5	8	BA	09:00	12:00	3:00
28-May-09	5	6	AM	16:45	17:45	1:00
30-May-09	5	9	AM	05:00	08:00	3:00
31-May-09	5	5	AM	10:00	13:00	3:00
02-Jun-09	6	4	MJA	15:28	18:28	3:00
02-Jun-09	6	5	MJA	19:25	22:20	2:55
04-Jun-09	6	1	AM	04:00	07:00	3:00
04-Jun-09	6	6	AM	14:30	15:30	1:00
04-Jun-09	6	8	AM	09:45	12:45	3:00
08-Jun-09	6	2	AM	10:30	13:30	3:00
08-Jun-09	6	9	MJA	16:55	19:55	3:00
08-Jun-09	6	6	MJA	15:00	16:05	1:05
09-Jun-09	6	4	AM	07:00	10:00	3:00
15-Jun-09	6	5	AM	04:00	07:00	3:00
15-Jun-09	6	6	AM	08:00	09:00	1:00

Date	Month	Vantage Point	Observer	Start Time	End Time	Duration
21-Jun-09	6	2	AM	03:50	06:50	3:00
21-Jun-09	6	9	AM	08:20	11:20	3:00
23-Jun-09	6	7	GT	17:00	20:00	3:00
23-Jun-09	6	7	GT	20:00	23:00	3:00
24-Jun-09	6	6	AM	14:15	15:15	1:00
25-Jun-09	6	8	GT	04:10	07:10	3:00
25-Jun-09	6	1	GT	07:55	10:55	3:00
05-Jul-09	7	6	AM	09:15	10:15	1:00
08-Jul-09	7	7	AM	08:00	11:00	3:00
08-Jul-09	7	1	AM	04:00	07:00	3:00
10-Jul-09	7	8	AM	04:10	07:10	3:00
10-Jul-09	7	8	AM	08:10	11:10	3:00
12-Jul-09	7	6	AM	14:50	15:50	1:00
15-Jul-09	7	9	AM	15:15	18:15	3:00
15-Jul-09	7	2	AM	19:35	22:35	3:00
19-Jul-09	7	6	AM	12:20	13:20	1:00
20-Jul-09	7	4	AM	04:30	07:30	3:00
20-Jul-09	7	5	AM	09:50	12:50	3:00
23-Jul-09	7	6	AM	13:45	14:45	1:00
24-Jul-09	7	7	AM	19:00	22:00	3:00
24-Jul-09	7	1	AM	15:00	18:00	3:00
27-Jul-09	7	5	LB	19:30	22:30	3:00
27-Jul-09	7	4	LB	15:55	18:15	2:20
28-Jul-09	7	6	AM	12:40	13:40	1:00
28-Jul-09	7	2	AM	08:40	11:40	3:00
28-Jul-09	7	9	AM	04:35	07:35	3:00
05-Aug-09	8	1	GAC	05:15	08:15	3:00
05-Aug-09	8	7	GAC	09:15	12:15	3:00
05-Aug-09	8	6	GAC	13:35	14:35	1:00
06-Aug-09	8	9	GAC	09:00	12:00	3:00
06-Aug-09	8	1	GAC	13:00	15:00	2:00
13-Aug-09	8	9	LB	14:14	17:15	3:01
20-Aug-09	8	1	AM	16:30	17:30	1:00
20-Aug-09	8	2	AM	18:15	21:15	3:00
20-Aug-09	8	6	AM	14:20	15:20	1:00
21-Aug-09	8	5	AM	18:00	21:00	3:00
21-Aug-09	8	4	AM	13:50	16:50	3:00
24-Aug-09	8	6	AM	16:00	17:00	1:00
24-Aug-09	8	7	AM	18:00	21:00	3:00
25-Aug-09	8	5	LB	14:15	17:15	3:00
25-Aug-09	8	4	LB	18:28	21:13	2:45
26-Aug-09	8	8	LB	14:30	17:30	3:00

Date	Month	Vantage Point	Observer	Start Time	End Time	Duration
26-Aug-09	8	8	LB	18:00	19:50	1:50
28-Aug-09	8	6	LB	15:25	16:25	1:00
28-Aug-09	8	2	LB	11:40	14:40	3:00
					Total Duration	1095:16

Details of Flight Activity Records per Species

7.84 Details of observations during vantage point surveys from 2007-09, including species, dates times and durations of flights are shown below in Table 7a.20. Species codes follow the standard BTO notation, as follows:

7.85 BK - black grouse, CA - cormorant, CG - Canada goose, CS - common sandpiper, CU - curlew, GN - goldeneye, GD - goosander, GE - green sandpiper, GJ - greylag goose, GP - golden plover, HH - hen harrier, KT - red kite, L - lapwing, MA - mallard, ML - merlin, MS - mute swan, OC - oystercatcher, PE - peregrine PG - pink-footed goose, RP - ringed plover, SE - short-eared owl, SN - snipe, TU - tufted cuck, UO - unidentified grey goose species, WS - whooper swan.

Table 7a.20: Flight Activity Observations per Species at Galawhistle 2007-09

Date	Vantage Point	Observer	Key number	Time	Species	Number	Time in Flight	Time at PCH
09-Apr-09	1	MJA	2088	08:37	BK	1	15	0
22-Oct-07	1	EMCL	1675	10:24	BK	2	30	0
26-Apr-09	5	ED	2126	19:36	CA	1	120	120
04-Apr-08	6	ED	1806	13:26	CA	2	570	390
30-May-09	9	AM	2176	07:49	CG	10	600	450
07-Jul-08	2	AM	1938	13:55	CS	1	30	0
17-Mar-08	5	MJA	1724	13:43	CU	1	15	0
17-Mar-08	6	MJA	1719	10:35	CU	1	60	60
17-Mar-08	5	MJA	1721	13:14	CU	1	120	90
17-Mar-08	5	MJA	1723	13:31	CU	1	45	0
17-Mar-08	5	MJA	1725	14:01	CU	1	30	0
17-Mar-08	5	MJA	1726	14:01	CU	1	105	0
17-Mar-08	5	MJA	1727	14:01	CU	1	105	0
17-Mar-08	5	MJA	1728	14:01	CU	1	105	0
17-Mar-08	5	MJA	1729	14:04	CU	1	30	0
17-Mar-08	4	AM	1731	09:13	CU	1	30	15
17-Mar-08	4	AM	1732	10:24	CU	1	15	0
17-Mar-08	5	MJA	1722	13:26	CU	1	45	30
04-Apr-08	6	ED	1803	13:02	CU	1	15	0
04-Apr-08	6	ED	1804	13:22	CU	1	45	45
04-Apr-08	6	ED	1805	13:24	CU	1	30	0
04-Apr-08	6	ED	1807	13:48	CU	1	165	165
04-Apr-08	6	ED	1817	14:58	CU	1	15	0
04-Apr-08	6	ED	1818	15:05	CU	2	90	30
04-Apr-08	6	ED	1821	16:07	CU	1	60	0
04-Apr-08	6	ED	1824	16:48	CU	2	180	150
04-Apr-08	6	ED	1814	14:21	CU	1	225	30
04-Apr-08	6	ED	1816	14:53	CU	1	75	0
04-Apr-08	6	ED	1815	14:30	CU	1	30	0
04-Apr-08	6	ED	1808	13:54	CU	1	45	0
04-Apr-08	6	ED	1811	14:13	CU	1	45	15
04-Apr-08	6	ED	1813	14:21	CU	1	60	30
05-Apr-08	5	ED	1795	17:50	CU	1	30	0
05-Apr-08	5	ED	1780	15:11	CU	2	30	0
05-Apr-08	5	ED	1782	15:25	CU	2	90	0
05-Apr-08	5	ED	1784	15:37	CU	1	30	0
05-Apr-08	5	ED	1789	16:03	CU	3	315	180
05-Apr-08	5	ED	1791	16:52	CU	2	60	0
05-Apr-08	5	ED	1792	17:36	CU	1	15	0
05-Apr-08	5	ED	1794	17:48	CU	1	45	30
05-Apr-08	5	ED	1793	17:48	CU	2	90	60
07-Apr-08	5	EMCL	1748	15:07	CU	1	15	0
07-Apr-08	5	EMCL	1739	11:49	CU	1	30	30
07-Apr-08	5	EMCL	1740	12:01	CU	1	45	0
07-Apr-08	5	EMCL	1742	12:50	CU	1	45	45
07-Apr-08	5	EMCL	1743	13:17	CU	1	45	15
07-Apr-08	5	EMCL	1744	13:17	CU	1	30	0
07-Apr-08	5	EMCL	1745	13:22	CU	1	60	0
07-Apr-08	5	EMCL	1737	11:34	CU	1	30	0
07-Apr-08	5	EMCL	1747	14:10	CU	1	15	0
07-Apr-08	5	EMCL	1736	11:31	CU	1	15	0
07-Apr-08	5	EMCL	1746	13:40	CU	1	30	0
07-Apr-08	5	EMCL	1738	11:41	CU	1	15	0
07-Apr-08	5	EMCL	1735	11:30	CU	2	30	0
13-Apr-08	1	ED	1801	14:38	CU	2	390	360
13-Apr-08	2	ED	1796	10:18	CU	1	90	30
13-Apr-08	2	ED	1797	10:21	CU	1	270	45
13-Apr-08	2	ED	1798	11:15	CU	1	30	0
13-Apr-08	2	ED	1799	11:24	CU	2	240	90
18-Apr-08	1	ALB	1778	11:12	CU	1	30	0
20-Apr-08	8	ALB	1773	12:57	CU	1	30	0
20-Apr-08	8	ALB	1776	14:21	CU	1	15	0
20-Apr-08	8	ALB	1774	14:11	CU	1	30	15
20-Apr-08	8	ALB	1775	14:11	CU	1	30	15
21-Apr-08	8	ALB	1766	09:10	CU	1	45	30
21-Apr-08	8	ALB	1767	09:12	CU	1	30	15
21-Apr-08	8	ALB	1768	09:12	CU	1	45	15
21-Apr-08	8	ALB	1769	09:17	CU	1	15	0
21-Apr-08	8	ALB	1770	09:18	CU	1	30	15
21-Apr-08	8	ALB	1771	09:20	CU	1	15	0
21-Apr-08	8	ALB	1772	09:44	CU	1	15	0
22-May-08	5	DG	1905	11:31	CU	1	30	0
22-May-08	5	DG	1908	13:51	CU	1	15	0
22-May-08	5	DG	1902	10:18	CU	2	90	0
22-May-08	5	DG	1903	10:50	CU	1	30	0
22-May-08	5	DG	1906	13:11	CU	1	30	0
22-May-08	5	DG	1904	10:52	CU	2	60	0
22-May-08	5	DG	1907	13:27	CU	1	45	0
26-May-08	6	DG	1888	09:42	CU	1	15	0
26-May-08	6	DG	1889	09:42	CU	1	30	0
26-May-08	5	DG	1891	12:57	CU	1	75	60
26-May-08	5	DG	1892	13:16	CU	1	60	15

Date	Vantage Point	Observer	Key number	Time	Species	Number	Time in Flight	Time at PCH
30-May-08	4	AA	1833	08:47	CU	1	30	0
30-May-08	4	AA	1834	10:27	CU	1	120	120
03-Jun-08	8	MJA	1840	10:20	CU	1	30	0
03-Jun-08	8	MJA	1837	09:27	CU	1	75	60
03-Jun-08	8	MJA	1839	10:12	CU	1	105	75
03-Jun-08	8	MJA	1838	09:27	CU	1	75	60
04-Jun-08	2	MJA	1841	14:25	CU	1	30	0
04-Jun-08	7	MJA	1842	10:07	CU	1	45	0
04-Jun-08	7	MJA	1843	10:57	CU	1	135	45
04-Jun-08	7	MJA	1844	11:20	CU	1	30	30
05-Jun-08	5	ED	1866	17:06	CU	2	300	180
05-Jun-08	5	ED	1858	14:57	CU	2	120	30
05-Jun-08	5	ED	1859	15:41	CU	2	450	390
05-Jun-08	5	ED	1860	15:41	CU	1	225	210
05-Jun-08	5	ED	1861	15:43	CU	1	30	0
05-Jun-08	5	ED	1865	16:35	CU	1	165	135
05-Jun-08	5	ED	1863	16:28	CU	2	210	150
05-Jun-08	2	AC	1845	07:55	CU	1	30	30
05-Jun-08	2	AC	1846	10:16	CU	2	60	0
06-Jun-08	8	DG	1909	11:10	CU	1	15	0
06-Jun-08	8	DG	1910	11:29	CU	2	60	0
06-Jun-08	8	DG	1911	11:39	CU	1	105	60
06-Jun-08	8	DG	1912	12:19	CU	2	60	0
06-Jun-08	8	DG	1913	12:33	CU	1	30	0
06-Jun-08	8	DG	1914	13:01	CU	2	60	0
06-Jun-08	8	DG	1915	14:07	CU	1	15	0
06-Jun-08	8	DG	1916	14:19	CU	1	15	0
06-Jun-08	8	DG	1917	14:21	CU	1	45	0
06-Jun-08	8	DG	1918	14:28	CU	1	30	0
07-Jun-08	2	ED	1870	10:28	CU	2	210	180
07-Jun-08	2	ED	1871	11:02	CU	1	105	90
07-Jun-08	2	ED	1872	11:10	CU	1	30	15
07-Jun-08	7	ED	1875	15:53	CU	4	240	120
08-Jun-08	1	ED	1885	12:23	CU	1	60	45
08-Jun-08	1	ED	1884	12:21	CU	2	60	0
08-Jun-08	1	ED	1883	12:06	CU	1	60	0
17-Jun-08	6	ED	1881	11:36	CU	1	105	30
17-Jun-08	6	ED	1877	09:26	CU	1	330	285
17-Jun-08	6	ED	1878	09:29	CU	4	180	120
20-Jun-08	4	ED	1853	16:39	CU	1	30	0
20-Jun-08	4	ED	1854	17:04	CU	2	120	120
20-Jun-08	4	ED	1855	17:24	CU	1	60	45
20-Jun-08	4	ED	1856	18:03	CU	1	45	0
20-Jun-08	4	ED	1849	15:20	CU	1	15	0
20-Jun-08	4	ED	1852	16:04	CU	1	45	15
20-Jun-08	4	ED	1851	15:59	CU	2	30	0
20-Jun-08	4	ED	1850	15:51	CU	1	300	195
29-Jun-08	5	ED	1897	10:19	CU	1	45	0

Date	Vantage Point	Observer	Key number	Time	Species	Number	Time in Flight	Time at PCH
29-Jun-08	5	ED	1898	10:21	CU	1	45	0
29-Jun-08	5	ED	1896	10:15	CU	1	15	0
29-Jun-08	5	ED	1895	09:55	CU	1	45	0
01-Jul-08	6	ED	1921	15:12	CU	1	150	120
01-Jul-08	6	ED	1920	14:31	CU	1	375	360
01-Jul-08	6	ED	1923	16:19	CU	10	750	450
01-Jul-08	6	ED	1925	16:39	CU	1	150	90
01-Jul-08	6	ED	1926	16:39	CU	1	15	0
02-Jul-08	4	ED	1927	15:17	CU	5	2925	2475
03-Jul-08	5	DG	1934	11:07	CU	1	60	0
03-Jul-08	5	DG	1935	11:08	CU	2	30	0
12-Mar-09	1	GAC	2000	07:46	CU	2	180	180
12-Mar-09	7	GAC	2002	12:09	CU	1	75	75
13-Mar-09	9	GAC	2006	09:28	CU	1	30	0
13-Mar-09	9	GAC	2005	09:22	CU	1	45	15
13-Mar-09	1	GAC	2043	13:02	CU	1	30	15
13-Mar-09	9	GAC	2007	09:58	CU	1	15	0
16-Mar-09	9	CN	1984	09:10	CU	1	180	30
17-Mar-09	5	GAC	2032	12:03	CU	1	180	135
17-Mar-09	5	GAC	2019	10:14	CU	2	240	90
17-Mar-09	5	GAC	2020	10:23	CU	1	45	15
17-Mar-09	5	GAC	2026	10:38	CU	2	210	180
17-Mar-09	5	GAC	2027	10:52	CU	6	4860	2160
17-Mar-09	5	GAC	2028	10:52	CU	2	1020	540
17-Mar-09	5	GAC	2031	11:58	CU	2	180	0
17-Mar-09	5	GAC	2033	12:04	CU	1	60	60
17-Mar-09	5	GAC	2035	12:32	CU	3	810	450
17-Mar-09	4	GAC	2038	13:57	CU	1	75	45
17-Mar-09	4	GAC	2039	15:00	CU	1	60	0
17-Mar-09	4	GAC	2040	15:28	CU	1	135	105
17-Mar-09	5	GAC	2030	11:26	CU	1	120	105
20-Mar-09	9	GAC	2010	08:26	CU	1	60	60
24-Mar-09	5	CG	2082	14:19	CU	1	135	105
28-Mar-09	5	AD	2050	11:18	CU	2	60	0
28-Mar-09	5	AD	2051	12:01	CU	1	30	0
30-Mar-09	5	CN	2045	14:13	CU	2	90	60
07-Apr-09	9	MJA	2072	08:42	CU	1	300	0
07-Apr-09	9	MJA	2071	08:41	CU	1	390	60
09-Apr-09	1	MJA	2086	07:39	CU	1	15	0
09-Apr-09	1	MJA	2087	08:03	CU	1	60	60
09-Apr-09	1	MJA	2089	08:57	CU	1	15	0
17-Apr-09	5	AM	2096	11:14	CU	1	60	45
17-Apr-09	5	AM	2093	10:40	CU	2	150	120
17-Apr-09	5	AM	2095	11:05	CU	2	60	30
17-Apr-09	5	AM	2097	11:49	CU	1	30	30
17-Apr-09	5	AM	2098	11:58	CU	2	60	60
17-Apr-09	5	AM	2099	12:56	CU	4	240	180
17-Apr-09	5	AM	2100	13:04	CU	1	210	210

Date	Vantage Point	Observer	Key number	Time	Species	Number	Time in Flight	Time at PCH
17-Apr-09	5	AM	2101	13:06	CU	1	15	15
17-Apr-09	5	AM	2094	10:44	CU	2	30	0
19-Apr-09	1	AM	2107	10:33	CU	1	165	165
19-Apr-09	1	AM	2106	10:32	CU	1	255	240
19-Apr-09	1	AM	2103	09:05	CU	1	45	45
19-Apr-09	1	AM	2104	09:23	CU	1	30	30
19-Apr-09	1	AM	2105	10:11	CU	1	30	30
22-Apr-09	8	MJA	2079	08:26	CU	1	30	15
22-Apr-09	8	MJA	2080	08:29	CU	1	45	15
22-Apr-09	8	MJA	2091	09:53	CU	1	75	60
22-Apr-09	8	MJA	2077	06:30	CU	1	30	0
22-Apr-09	8	MJA	2078	08:22	CU	2	90	30
22-Apr-09	8	MJA	2076	06:24	CU	1	30	0
24-Apr-09	7	RD	2131	08:31	CU	1	45	45
24-Apr-09	9	AM	2108	09:28	CU	2	90	90
26-Apr-09	5	ED	2122	19:01	CU	1	120	90
26-Apr-09	5	ED	2121	18:58	CU	1	30	0
26-Apr-09	5	ED	2123	19:01	CU	1	120	105
26-Apr-09	5	ED	2124	19:05	CU	1	30	0
26-Apr-09	5	ED	2125	19:13	CU	1	15	0
26-Apr-09	5	ED	2127	19:37	CU	2	30	0
26-Apr-09	5	ED	2128	20:15	CU	2	30	0
06-May-09	1	MJA	2110	05:41	CU	1	15	0
06-May-09	1	MJA	2111	08:03	CU	1	75	75
07-May-09	9	MJA	2114	14:41	CU	1	45	45
07-May-09	9	MJA	2115	14:41	CU	1	15	0
07-May-09	9	MJA	2117	15:30	CU	1	75	60
07-May-09	9	MJA	2118	16:25	CU	1	150	150
07-May-09	9	MJA	2119	16:47	CU	1	45	0
11-May-09	5	AM	2138	18:46	CU	1	45	30
11-May-09	4	AM	2136	16:37	CU	1	45	30
11-May-09	5	AM	2141	19:52	CU	1	105	105
11-May-09	5	AM	2142	20:03	CU	1	15	0
11-May-09	4	AM	2137	17:21	CU	1	30	0
26-May-09	4	AM	2134	06:01	CU	1	15	0
26-May-09	4	AM	2135	07:42	CU	1	30	0
27-May-09	8	BA	2177	09:13	CU	2	150	60
27-May-09	8	BA	2178	10:07	CU	1	30	0
27-May-09	8	BA	2184	13:24	CU	2	90	0
31-May-09	5	AM	2192	12:25	CU	1	15	0
02-Jun-09	5	MJA	2198	20:19	CU	1	15	0
02-Jun-09	4	MJA	2193	16:09	CU	1	75	15
02-Jun-09	5	MJA	2197	20:14	CU	1	15	0
02-Jun-09	5	MJA	2199	20:24	CU	1	30	15
02-Jun-09	5	MJA	2200	20:31	CU	1	15	0
02-Jun-09	5	MJA	2204	20:47	CU	1	45	0
02-Jun-09	5	MJA	2205	21:12	CU	1	15	0
02-Jun-09	5	MJA	2206	21:28	CU	2	60	60

Date	Vantage Point	Observer	Key number	Time	Species	Number	Time in Flight	Time at PCH
02-Jun-09	5	MJA	2196	20:14	CU	1	15	0
04-Jun-09	1	AM	2167	06:55	CU	1	105	105
04-Jun-09	8	AM	2168	11:06	CU	1	60	60
04-Jun-09	1	AM	2164	05:51	CU	1	45	30
04-Jun-09	1	AM	2166	06:42	CU	1	30	0
04-Jun-09	1	AM	2165	06:23	CU	1	30	15
04-Jun-09	1	AM	2161	04:32	CU	1	15	15
04-Jun-09	1	AM	2162	05:15	CU	1	30	30
04-Jun-09	1	AM	2163	05:42	CU	1	30	15
15-Jun-09	5	AM	2155	06:37	CU	1	30	30
15-Jun-09	5	AM	2146	04:16	CU	1	15	0
15-Jun-09	5	AM	2147	04:32	CU	1	30	15
15-Jun-09	5	AM	2148	04:40	CU	1	15	0
15-Jun-09	5	AM	2150	04:57	CU	1	30	30
15-Jun-09	5	AM	2151	05:09	CU	1	45	45
15-Jun-09	5	AM	2152	05:37	CU	1	15	0
15-Jun-09	5	AM	2154	05:54	CU	1	30	15
15-Jun-09	5	AM	2156	06:48	CU	1	15	0
15-Jun-09	5	AM	2157	06:54	CU	1	30	30
15-Jun-09	5	AM	2158	06:55	CU	1	15	15
15-Jun-09	5	AM	2159	06:57	CU	2	120	120
15-Jun-09	5	AM	2153	05:39	CU	1	60	45
21-Jun-09	2	AM	2211	04:59	CU	1	60	15
21-Jun-09	2	AM	2212	06:34	CU	1	45	45
25-Jun-09	8	GT	2219	04:48	CU	1	45	0
04-Apr-08	6	ED	1810	14:03	DN	3	90	90
18-Apr-08	1	ALB	1779	12:14	DN	1	15	0
15-Jan-08	5	MJA	1702	13:12	GD	1	30	0
08-Feb-08	6	MJA	1711	15:04	GD	1	30	0
06-Mar-08	6	MJA	1717	12:23	GD	2	30	0
06-Mar-08	6	MJA	1716	11:38	GD	2	90	0
20-Jan-09	8	MJA	1980	11:37	GD	2	150	60
04-Mar-09	8	GAC	1982	10:41	GD	3	225	180
21-Jun-09	9	AM	2216	10:32	GE	1	60	15
30-Oct-07	6	CW	1682	11:21	GJ	6	540	0
17-Mar-08	6	MJA	1720	10:48	GJ	2	60	0
16-Apr-08	7	LT, GAC	1754	10:11	GJ	70	14700	2100
16-Apr-08	7	LT, GAC	1755	11:07	GJ	46	2070	0
16-Apr-08	7	LT, GAC	1756	11:18	GJ	65	5850	1950
21-Apr-08	8	ALB	1765	07:02	GJ	1	45	15
22-May-08	6	JM	1893	08:15	GJ	2	150	90
29-Nov-08	8	ED	1967	11:28	GJ	5	1200	1200
13-Feb-09	1	AM	2056	09:39	GJ	1	165	45
28-Feb-09	9	AM	1996	15:26	GJ	2	30	0
07-Apr-09	9	MJA	2063	06:35	GJ	3	270	225
07-Apr-09	9	MJA	2070	07:40	GJ	3	225	180
28-Sep-07	5	MJA	1665	14:34	GP	2	30	0
22-Oct-07	7	AA	1684	14:54	GP	20	300	0

Date	Vantage Point	Observer	Key number	Time	Species	Number	Time in Flight	Time at PCH
30-Oct-07	8	MJA	1679	13:46	GP	15	225	0
07-Nov-07	5	CW	1693	13:31	GP	20	600	0
07-Nov-07	4	MJA	1691	13:31	GP	20	300	0
07-Nov-07	4	MJA	1687	11:13	GP	19	855	855
14-Mar-08	2	MJA	1749	10:13	GP	7	525	420
20-Aug-08	1	MJA	1947	12:02	GP	4	240	180
14-Sep-08	7	ED	1959	13:57	GP	3	135	90
21-Sep-08	5	AM	1952	08:52	GP	1	120	15
05-Oct-08	5	AM	1965	12:32	GP	1	60	30
18-Feb-09	4	GAC	1999	13:53	GP	1	15	15
18-Feb-09	4	GAC	1998	13:47	GP	3	90	90
28-Mar-09	4	AD	2052	06:37	GP	31	465	465
07-May-09	2	MJA	2120	20:16	GP	80	2400	0
28-Sep-07	6	ED	1667	12:58	HH	1	105	0
28-Sep-07	6	ED	1668	13:15	HH	1	15	0
28-Sep-07	6	ED	1669	13:21	HH	1	15	0
28-Sep-07	6	ED	1670	14:02	HH	1	90	15
29-Jan-08	2	LT	1703	11:42	HH	1	60	0
29-Jan-08	7	CJR	1705	11:34	HH	1	75	0
29-Jan-08	1	EMCL	1708	12:19	HH	1	90	0
29-Jan-08	1	EMCL	1707	12:18	HH	1	30	0
29-Jan-08	1	EMCL	1706	11:43	HH	1	90	0
16-Apr-08	7	LT, GAC	1757	12:08	HH	1	45	0
17-Apr-08	7	LT	1761	10:51	HH	1	195	45
17-Apr-08	7	LT	1760	10:50	HH	1	30	0
17-Apr-08	7	LT	1762	10:55	HH	1	255	60
17-Apr-08	7	LT	1758	10:04	HH	1	60	45
20-Apr-08	4	ALB	1777	16:34	HH	1	150	0
26-May-08	8	ED	1835	15:56	HH	1	60	60
05-Jun-08	5	ED	1862	16:02	HH	1	630	390
03-Jul-08	8	DG	1939	15:18	HH	1	180	0
27-Aug-08	8	CN	1946	13:58	HH	1	30	0
17-Sep-08	5	CN	1951	14:26	HH	1	120	0
17-Sep-08	2	AM	1953	11:36	HH	1	75	60
17-Sep-08	2	AM	1954	12:35	HH	1	75	60
17-Sep-08	7	AM	1955	08:05	HH	1	30	0
02-Oct-08	8	GAC	1960	10:55	HH	2	780	330
14-Oct-08	2	AM	1964	09:17	HH	1	60	60
20-Oct-08	7	GAC	1962	12:26	HH	1	30	0
28-Feb-09	9	AM	2060	13:24	HH	1	30	15
20-Mar-09	1	GAC	2018	13:18	HH	1	30	0
11-May-09	5	AM	2144	20:38	HH	1	60	0
11-May-09	5	AM	2143	20:30	HH	1	180	0
15-Jul-09	2	AM	2223	21:01	HH	1	45	15
24-Aug-09	7	AM	2235	19:14	HH	1	30	0
21-Dec-08	7	ED	1968	12:24	KT	1	75	75
07-Jun-08	7	ED	1873	14:00	KT	1	150	30
08-Jun-08	1	ED	1886	14:48	KT	1	840	480

Date	Vantage Point	Observer	Key number	Time	Species	Number	Time in Flight	Time at PCH
28-Sep-07	6	ED	1672	14:11	KT	1	765	390
28-Sep-07	6	ED	1671	14:10	KT	1	90	75
04-Jul-08	1	ED	1932	16:36	KT	1	90	60
06-Mar-08	6	MJA	1715	10:48	L.	18	1080	0
05-Apr-08	5	ED	1783	15:34	L.	1	90	60
05-Apr-08	5	ED	1787	15:48	L.	3	135	0
05-Apr-08	5	ED	1781	15:16	L.	1	90	75
05-Apr-08	5	ED	1786	15:47	L.	1	90	45
05-Apr-08	5	ED	1788	16:00	L.	1	45	0
05-Apr-08	5	ED	1790	16:33	L.	1	90	90
05-Apr-08	5	ED	1785	15:37	L.	2	60	0
07-Apr-08	5	EMCL	1734	11:22	L.	1	15	0
07-Apr-08	5	EMCL	1733	11:20	L.	1	30	0
22-May-08	5	DG	1901	09:51	L.	2	90	0
22-May-08	5	DG	1900	09:47	L.	2	90	0
22-May-08	5	DG	1899	09:12	L.	2	90	0
26-May-08	8	ED	1836	18:36	L.	1	30	0
26-May-08	5	DG	1890	12:51	L.	2	60	0
07-Jun-08	7	ED	1874	14:48	L.	4	1080	120
17-Mar-09	5	GAC	2021	10:30	L.	1	120	30
17-Mar-09	5	GAC	2023	10:32	L.	1	120	30
17-Mar-09	5	GAC	2024	10:33	L.	2	360	240
17-Mar-09	5	GAC	2022	10:30	L.	2	360	180
17-Mar-09	5	GAC	2037	12:38	L.	1	120	90
17-Mar-09	5	GAC	2036	12:38	L.	1	90	90
17-Mar-09	5	GAC	2025	10:35	L.	3	360	270
17-Mar-09	5	GAC	2034	12:25	L.	1	75	0
17-Mar-09	5	GAC	2029	10:56	L.	1	120	90
20-Mar-09	9	GAC	2015	09:25	L.	2	60	60
20-Mar-09	9	GAC	2014	09:19	L.	2	150	150
20-Mar-09	9	GAC	2013	09:18	L.	2	150	150
30-Mar-09	5	CN	2046	15:47	L.	1	30	0
11-May-09	5	AM	2139	18:50	L.	3	360	315
31-May-09	5	AM	2191	10:10	L.	1	30	30
15-Jun-09	5	AM	2149	04:41	L.	2	30	0
20-Jul-09	5	AM	2224	10:05	L.	4	240	240
20-Jul-09	5	AM	2225	10:14	L.	1	75	75
27-May-09	8	BA	2181	11:22	MA	4	60	0
14-Dec-08	9	AM	1972	09:57	MA	4	360	360
07-Apr-09	9	MJA	2068	07:10	MA	1	45	0
07-Apr-09	9	MJA	2067	07:10	MA	3	180	0
28-Jul-09	9	AM	2226	05:05	MA	2	30	30
27-May-09	8	BA	2179	10:42	MA	3	45	0
13-Mar-09	9	GAC	2003	09:02	MA	2	150	120
20-Nov-08	1	AM	1973	14:12	MA	2	30	0
30-May-09	9	AM	2175	07:37	MA	2	30	0
27-May-09	8	BA	2182	12:00	MA	4	60	0
28-Feb-09	9	AM	2059	12:22	MA	2	150	150

Date	Vantage Point	Observer	Key number	Time	Species	Number	Time in Flight	Time at PCH
28-Jul-09	9	AM	2228	07:09	MA	1	30	0
07-May-09	9	MJA	2112	14:04	MA	4	120	120
30-May-09	9	AM	2170	05:32	MA	1	30	15
28-Sep-07	6	ED	1673	11:15	ML	1	30	15
09-Nov-07	1	CW	1694	09:24	ML	1	120	0
04-Apr-08	6	ED	1812	14:19	ML	1	75	75
04-Apr-08	6	ED	1822	16:24	ML	1	30	0
05-Apr-08	6	ED	1829	12:32	ML	1	90	30
05-Apr-08	6	ED	1828	12:28	ML	1	60	15
04-Jul-08	1	ED	1933	17:07	ML	1	180	165
04-Jul-08	2	ED	1931	15:23	ML	1	45	30
30-Jul-08	4	ED	1940	13:33	ML	1	15	0
12-Aug-08	4	MJA	1945	11:45	ML	1	30	0
28-Mar-09	4	AD	2053	07:49	ML	1	30	0
27-Jul-09	5	LB	2220	21:06	ML	1	135	105
28-Jul-09	2	AM	2229	08:42	ML	1	60	45
13-Aug-09	9	LB	2231	16:35	ML	1	15	0
13-Aug-09	9	LB	2232	16:43	ML	1	60	30
30-Oct-07	6	CW	1681	10:03	MS	2	120	120
22-Oct-07	1	EMCL	1678	15:36	MS	2	90	0
22-Oct-07	1	EMCL	1677	15:26	MS	2	120	120
22-May-08	6	JM	1894	08:50	OC	1	90	60
26-May-08	6	DG	1887	08:51	OC	2	30	0
20-Jun-08	8	ED	1848	13:03	OC	1	15	0
20-Jun-08	8	ED	1847	11:54	OC	1	15	0
01-Jul-08	6	ED	1922	15:26	OC	2	180	120
28-Feb-09	9	AM	2058	11:52	OC	1	90	90
28-Feb-09	9	AM	1995	15:10	OC	1	15	0
13-Mar-09	9	GAC	2004	09:11	OC	2	120	120
16-Mar-09	9	CN	1987	10:47	OC	1	30	0
16-Mar-09	9	CN	1985	09:14	OC	1	45	0
16-Mar-09	9	CN	1988	15:04	OC	2	90	0
20-Mar-09	9	GAC	2011	08:36	OC	2	60	0
20-Mar-09	9	GAC	2012	09:18	OC	2	90	0
07-Apr-09	9	MJA	2061	06:26	OC	2	30	0
24-Apr-09	9	AM	2109	10:14	OC	1	15	0
07-May-09	9	MJA	2116	15:20	OC	2	30	0
27-May-09	8	BA	2190	14:59	OC	1	480	0
30-May-09	9	AM	2173	07:04	OC	1	15	0
30-May-09	9	AM	2171	05:57	OC	1	30	0
30-May-09	9	AM	2172	06:20	OC	1	30	15
30-May-09	9	AM	2174	07:12	OC	2	90	0
08-Jun-09	9	MJA	2218	19:39	OC	1	15	15
08-Jun-09	9	MJA	2217	17:46	OC	1	15	0
21-Jun-09	9	AM	2215	10:05	OC	2	150	30
21-Jun-09	9	AM	2214	09:53	OC	3	135	135
21-Jun-09	9	AM	2213	08:44	OC	1	30	30
11-Sep-07	1	CJR	1661	10:31	PE	1	45	0

Date	Vantage Point	Observer	Key number	Time	Species	Number	Time in Flight	Time at PCH
28-Sep-07	5	MJA	1666	15:27	PE	1	60	60
22-Oct-07	7	AA	1683	13:35	PE	1	135	135
22-Oct-07	1	EMCL	1676	13:33	PE	1	120	120
23-Oct-07	5	AA	1685	13:12	PE	1	15	15
23-Oct-07	2	EMCL	1674	12:12	PE	1	120	0
07-Nov-07	4	MJA	1690	11:49	PE	1	105	105
07-Nov-07	4	MJA	1689	11:49	PE	1	105	105
07-Nov-07	5	CW	1692	11:57	PE	2	150	120
07-Nov-07	4	MJA	1688	11:22	PE	1	135	135
13-Nov-07	6	CW	1696	10:37	PE	1	180	30
10-Dec-07	1	MJA	1700	11:20	PE	1	75	75
10-Dec-07	1	MJA	1698	10:44	PE	1	165	60
10-Dec-07	1	MJA	1699	10:53	PE	1	540	375
06-Feb-08	5	MJA	1709	13:06	PE	1	15	15
06-Feb-08	5	MJA	1710	11:14	PE	1	45	45
11-Feb-08	1	MJA	1712	12:48	PE	1	255	195
11-Feb-08	7	EMCL	1713	12:28	PE	1	135	60
12-Feb-08	2	EMCL	1714	11:35	PE	1	180	135
06-Mar-08	6	MJA	1718	13:45	PE	1	75	0
18-Mar-08	7	MJA	1730	12:02	PE	1	30	0
04-Apr-08	6	ED	1832	15:23	PE	1	240	30
04-Apr-08	6	ED	1819	15:19	PE	1	60	0
04-Apr-08	6	ED	1823	16:24	PE	1	75	15
04-Apr-08	6	ED	1820	15:23	PE	1	1200	180
04-Apr-08	6	ED	1809	14:01	PE	1	345	330
05-Apr-08	6	ED	1827	11:12	PE	1	90	30
05-Apr-08	6	ED	1830	12:54	PE	1	240	90
05-Apr-08	6	ED	1826	10:57	PE	1	705	525
05-Apr-08	6	ED	1831	13:10	PE	1	315	0
07-Apr-08	5	EMCL	1741	12:30	PE	1	135	90
13-Apr-08	1	ED	1802	15:32	PE	1	135	105
13-Apr-08	1	ED	1800	14:13	PE	1	765	435
17-Apr-08	7	LT	1759	10:16	PE	1	60	45
17-Apr-08	7	LT	1763	11:27	PE	1	30	30
17-Apr-08	7	LT	1764	11:28	PE	1	30	0
05-Jun-08	5	ED	1864	16:32	PE	1	150	120
17-Jun-08	6	ED	1876	09:16	PE	1	90	45
17-Jun-08	6	ED	1879	09:38	PE	1	645	390
17-Jun-08	6	ED	1880	09:52	PE	1	675	300
01-Jul-08	6	ED	1924	16:32	PE	1	105	15
05-Aug-08	7	MJA	1942	11:10	PE	1	45	0
05-Aug-08	7	MJA	1941	10:59	PE	1	75	45
21-Aug-08	7	GAC	1944	08:21	PE	1	30	0
21-Aug-08	8	GAC	1943	11:32	PE	1	60	45
14-Sep-08	7	ED	1958	13:24	PE	1	345	285
20-Oct-08	7	GAC	1961	12:19	PE	1	30	0
09-Jan-09	7	GAC	1971	13:12	PE	1	30	0
13-Feb-09	1	AM	2057	10:25	PE	1	15	0

Date	Vantage Point	Observer	Key number	Time	Species	Number	Time in Flight	Time at PCH
18-Feb-09	7	CN	1981	12:13	PE	1	60	60
25-Feb-09	5	GAC	1983	11:41	PE	1	90	60
13-Mar-09	1	GAC	2042	12:26	PE	2	90	90
17-Mar-09	2	CN	1994	13:40	PE	2	1680	180
17-Mar-09	2	CN	1993	13:38	PE	1	75	60
17-Mar-09	2	CN	1992	13:27	PE	2	180	180
17-Mar-09	2	CN	1991	13:15	PE	2	360	60
17-Mar-09	2	CN	1990	13:10	PE	1	315	135
17-Mar-09	2	CN	1989	10:55	PE	1	180	180
19-Mar-09	1	AD	2054	15:42	PE	1	15	15
20-Mar-09	1	GAC	2016	13:53	PE	1	105	45
20-Mar-09	1	GAC	2017	14:11	PE	1	30	15
30-Mar-09	5	CN	2044	14:03	PE	1	60	0
07-Apr-09	9	MJA	2062	06:34	PE	1	15	15
07-Apr-09	9	MJA	2069	07:28	PE	1	45	30
07-Apr-09	9	MJA	2066	06:56	PE	1	30	0
07-Apr-09	9	MJA	2065	06:52	PE	1	150	150
07-Apr-09	9	MJA	2064	06:52	PE	1	150	150
09-Apr-09	1	MJA	2084	06:33	PE	1	30	15
09-Apr-09	1	MJA	2085	06:33	PE	1	30	15
21-Apr-09	4	MJA	2073	10:40	PE	1	15	0
21-Apr-09	4	MJA	2074	12:40	PE	1	1080	0
21-Apr-09	4	MJA	2075	12:48	PE	1	270	0
07-May-09	9	MJA	2113	14:04	PE	1	90	75
02-Jun-09	4	MJA	2194	17:24	PE	1	360	0
02-Jun-09	4	MJA	2195	17:24	PE	1	360	0
04-Jun-09	8	AM	2169	12:34	PE	1	45	45
05-Aug-09	1	GAC	2230	08:08	PE	1	30	15
24-Aug-09	6	AM	2234	16:10	PE	1	150	75
29-Jan-09	2	AM	2055	12:16	PG	120	10800	1800
27-Sep-07	3	AA	1663	13:33	PG	1	105	0
28-Jan-08	4	MJA	1704	11:05	PG	80	10800	0
27-Sep-07	3	AA	1662	11:39	PG	58	4350	4350
27-Sep-07	3	AA	1664	14:02	PG	15	1350	1350
28-Dec-08	4	AM	1975	09:49	PG	150	9000	0
21-Jun-09	2	AM	2210	04:32	RP	1	15	0
29-Jul-08	6	AA	1950	10:07	SE	1	30	15
09-Nov-07	7	EMCL	1686	13:57	SN	1	120	120
05-Jun-08	5	ED	1867	17:28	SN	5	2550	2475
05-Jun-08	5	ED	1868	17:39	SN	2	210	180
05-Jun-08	5	ED	1869	17:57	SN	2	300	270
20-Jun-08	4	ED	1857	18:46	SN	1	60	45
02-Jul-08	4	ED	1929	16:33	SN	1	60	45
02-Jul-08	4	ED	1928	15:32	SN	1	165	150
03-Jul-08	5	DG	1936	11:37	SN	3	135	45
05-Oct-08	5	AM	1966	12:48	SN	1	15	0
20-Nov-08	2	AM	1974	09:07	SN	1	15	0
14-Jan-09	1	GAC	1977	10:19	SN	1	15	0

Date	Vantage Point	Observer	Key number	Time	Species	Number	Time in Flight	Time at PCH
26-Apr-09	5	ED	2129	21:03	SN	1	30	30
11-May-09	5	AM	2140	19:08	SN	1	15	0
02-Jun-09	5	MJA	2209	22:05	SN	1	390	390
02-Jun-09	5	MJA	2207	21:40	SN	1	1200	1200
02-Jun-09	5	MJA	2203	20:43	SN	1	15	15
02-Jun-09	5	MJA	2202	20:32	SN	1	75	75
02-Jun-09	5	MJA	2201	20:32	SN	1	75	75
02-Jun-09	5	MJA	2208	21:40	SN	1	345	345
15-Jun-09	5	AM	2160	06:59	SN	1	15	0
08-Jul-09	1	AM	2221	05:54	SN	1	15	15
08-Jul-09	1	AM	2222	06:37	SN	1	15	0
28-Jul-09	9	AM	2227	06:13	SN	1	15	0
21-Aug-09	5	AM	2233	18:12	SN	1	15	0
28-Jan-09	9	GAC	1978	14:04	TU	1	30	15
13-Nov-07	6	CW	1697	11:10	UO	33	6930	0
16-Mar-09	9	CN	1986	09:59	UO	50	3000	0
09-Nov-07	1	CW	1695	14:49	WS	8	1440	720
30-Oct-07	6	CW	1680	09:29	WS	5	900	0

Technical Appendix 3 – Peat Assessment

1. Introduction

Infinis Limited (Inifnis) is currently progressing proposals for a wind farm at Galawhistle, near Glenbuck. The site layout includes 22 turbines with associated access tracks, crane hardstanding, a construction compound, a laydown area, an Infinis substation and a ScottishPower substation as well as 4 borrows pits.

As part of these proposals, Infinis have commissioned RPS Planning and Development (RPS) to undertake a Peat Stability Risk Assessment for the proposed wind farm.

This document outlines the RPS methodology for peat stability risk assessment, along with the analysis performed and results obtained. The outcome of this assessment is presented in mapping and tabular form, identifying areas assessed as having a risk of a peatslide occurring. This has been further developed to assess the implications of the development on the baseline (or naturally occurring) risks.

RPS believe this technical assessment is appropriate for informing the EIA and planning process in that all the relevant matters have been identified in scale and location and mitigation measures discussed. However this does not constitute a detailed engineering design, and detailed site investigations and geotechnical assessments will be required prior to and during construction activities.

1.1 History of Peat Failure

A peatslide occurs when a portion of the peat mass becomes detached and flows downhill, usually as blocks of solid peat rafted on a slurry of semi-liquid peat. Other material such as bedrock, drift and vegetation is often included.

The causes and frequency of peatslides are only partially understood. Peatslides are known to occur naturally; however, due to the remote nature of most peatland areas the frequency of naturally occurring peatslides is unknown, although they are believed to be relatively rare events.

There have been a number of documented events relating to peatslides in the UK and Ireland, including:

- A peat slide event at Knochnageeha, Kerry, Republic of Ireland in 1896, killed 8 people;
- An event Castle Garde in County, Limerick, Republic of Ireland in 1708 killed 21 people;
- High velocity peatslides, similar to flow slides, have been observed to have moved at between 3 and 8 m/s (Straduff, County Sligo, Republic of Ireland, in 1984). However, these types of events have tended to be restricted to raised bog areas;
- Peatslide failures were triggered by an intense rainstorm in September 2003 at Channerwick, Shetland Islands. The rainstorm was part of a slow moving front which pushed south-eastwards across Scotland overnight. Anecdotal evidence indicates an average intensity of 33mm/hr. The intensity of the storm resulted in widespread flooding of the burns and the initiation of rapid peatslides. The latter developed into hillside debris flows with long run-outs, causing widespread damage to roads and other infrastructure. The peatslides occurred on slopes with angles between approximately 7° and 25° It was also noted that the summer of 2003 had been unusually dry, as had the previous summer and winter. It is possible that desiccation and cracking of the peat was a contributory factor to the peatslides;
- The intense rainstorm which triggered the Channerwick slides was also found to be the primary cause of multiple peatslides on the slopes of the Dooncarton and Barnachuille mountains in County Mayo. The exceptional rainfall was of such intensity as to overwhelm natural drainage systems in the peat and underlying weathered rock, thereby mobilising sections of overburden through buoyancy and gravitational forces; and
- In October 2003 at Derrybrien, County Galway, Republic of Ireland, a 2.5km strip of land, with a volume of around 450,000m^3, slipped downslope. Investigations concluded that construction activities related to a 71 turbine wind farm development were likely to have been a contributory factor. Damage was caused to forestry, farmland, roads and an important salmonid river.

In recent years, assessment of peatslide risk at wind farm sites has come to the fore, largely as a consequence of the peatslide event at the Derrybrien Wind farm site. The investigation into the causes of this peatslide found that there was a combination of contributory physical factors in the area where the slide occurred, including a zone of weak peat and a natural drainage channel, and activity associated with the construction of the wind farm. Key recommendations of the investigation report were:

- That no concentrated loads, such as excavated material from turbine foundation excavations, shall be placed on marginally stable ground;
- That concentrated water flow onto the peat slopes and unstable excavations are to be avoided;
- That construction should be supervised on a full time basis by qualified and experienced geotechnical personnel;
- That ongoing ground investigation work should continue with regular monitoring of specialist movement detection equipment, site roads and other works;
- That modified construction work practices which do not adversely affect existing stability, are to be adopted; and
- That a robust drainage plan is to be developed.

1.2 Objectives

This assessment is in accordance with the current Scottish Government guidance (2006) [1]. This is a guidance document designed to address the requirement for peat stability assessments as part of The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 1999 (EIA Regulations). It determines hazard rankings in terms of significant and non-significant risks which for the purposes of this assessment should be considered to relate to significance tests under the EIA Regulations.

This study therefore comprises a generally non-intrusive investigation that has been compiled based on available information, a review of the existing peat stability assessment and a subsequent site reconnaissance exercise including a peat depth survey. The main objectives of this assessment are as follows:

- Carry out a desk based study of the site with regard to peat stability;
- Undertake a reconnaissance and assessment of the site within the vicinity of the proposed Development and surrounding area;
- Identify possible areas of peat across the study area and assess the risk of instability within these deposits at the present time; and
- Provide recommendations for further work or specific construction methodologies to suit ground conditions at the study area to mitigate against any potential peat instability risk.

[1] Peat Landslide Hazard and Risk Assessments, Best Practice Guide for Proposed Electricity Generation Developments. December 2006

This assessment has been carried out in general accordance with the guidance given in the Scottish Government document[1].

1.3 Scope of Work

The Peat Stability Assessment is based on a site reconnaissance and observations made in the study area together with an examination of published information including digital British Geological Survey (BGS) data, published soils maps, aerial photography, topographic maps, historical Ordnance Survey (OS) maps and the peat depth information that was collected during the original peat stability assessment.

1.4 Proposed Construction Works

The following construction activities are understood to be required for the proposed Development:

- Excavation of bedrock at 4 borrow pits for site access tracks and foundations;
- Construction of site access and internal site infrastructure;
- Excavation of cable trenches adjacent to site tracks;
- Development of temporary construction compound and laydown areas;
- Excavation for construction of 22 turbine foundations and adjacent crane hardstandings; and
- Development and construction of substations.

2. Methodology

2.1 Desktop Study

In order to gather baseline information, a desktop survey was undertaken in order to:

- Describe surface water hydrology, including watercourses and springs;
- Collect historic hydrological flow and flooding data for the immediate area and mainstream watercourses;
- Collect water quality from the Scottish Environment Protection Agency (SEPA);
- Collect information relating to recreation and fisheries;
- Collate soil, geological and hydrogeological information;
- Collate information relating to ground stability of the site;
- Identify any areas of recent and/or historic peat failures from aerial photography; and
- Collate any published information relating to peat failures that have occurred in the area of the site.

Information sources that were utilised to gain an understanding of the nature of peat included:

- BS 5930 Code of Practice for Site Investigations;
- Carling, P.A. (1986) *Peat Slides in Teesdale and Weardale, Northern Pennines, July 1983: Descriptions and failure mechanisms.* Earth Surface Processes and Landforms, 11, pp193-207;
- Dykes, A.P. and Warburton, J. (2006) *Mass movements in peat: a formal classification scheme.* Geomorphology
- Evans, M. & Warburton, J., (2007). *Geomorphology of Upland Peat: Erosion, Form and Landscape Change,* Blackwell Publishing Ltd;
- Forestry Commission (2000), Forests and Peatland Habitats Guideline Note;
- Holden, J. & Burt, T.P. (2003). *Hydrological studies on blanket peat: the significance of the acrotelm-catotelm model.* Journal of Ecology 91(1): 86-102;
- Holden, J. and Burt, T.P. (2003) *Hydraulic conductivity in upland blanket peat: measurement and variability.* Hydrological Processes, 17 (6). 1227-1237;
- Holden, J. and Burt, T.P. (2002) *Infiltration, runoff and sediment production in blanket peat catchments: implications of field rainfall simulation experiments.* Hydrological Processes, 16 (13). 2537-2557;
- Holden, J. and Burt, T.P. (2002) *Piping and pipeflow in a deep peat catchment.* Catena, 48 (3). 163-199;
- L S Blake, (1998), Civil Engineers Reference Book;
- Scottish Government (2006) *Peat Landslide Hazard and Risk Assessments, Best Practice Guide for Proposed Electricity Generation Developments*;
- Scottish Natural Heritage (SNH), (1985) *Bogs: The Ecology, Classification and Conservation of Ombrotrophic Mires*;
- Warburton, J. Holden, J. & A, J, Mills (2004). *Hydrological Controls of Surficial Mass Movements in Peat,* Earth Science Reviews 67: 139 – 156; and
- Wilson, P. and Hegarty, C. (1993) *Morphology and causes of recent peat slides on Skerry Hill, Co Antrim, Northern Ireland.* Earth Surface Processes and Landforms, 18, pp593-601.

The review of site specific information consisted of examining available geological, hydrological and hydrogeological data and reports. These included:

- Flood Estimation Handbook (FEH) CD-ROM;
- SEPA River Basin Management Plan (RBMP) interactive map (*gis.sepa.org.uk/*)
- 1:50,000 British Geological Survey (BGS) digital data;
- Macaulay Institute, Soil Survey of Scotland, 1:50,000 Provisional Soil Map (1985), Hawick and Eskdale (sheet 79) and part of the Cheviot Hills (Sheet 80);
- 1: 625,000 Hydrogeological Map of Scotland;
- Bedrock Aquifers Map (2004), SEPA;
- Superficial Aquifers Map (2004), SEPA;
- Aerial Photography;
- Digital Terrain Model (DTM); and
- River Annan District Salmon Fishery Board, http://www.annanfisheryboard.co.uk/.

2.2 Site Investigation

The main aims of the site reconnaissance survey were to verify the information gathered during the desk-based study and to record targeted peat depth information associated with the planned location of the site infrastructure. The site layout can be viewed in Figure 1. RPS carried out an initial site investigation on the 13th and 14th May 2009.

During the initial site walkover, notes were taken regarding topography, vegetation cover, hydrology, drainage and the presence of peat. A peat depth hand probing exercise was also carried out in order to confirm and/or identify areas of peat and give a general indication of how the deposits, where present, vary in depth across the site.

A secondary site investigation was carried out on the 11th and 12th of August 2009 following the finalisation of the site layout. The purpose of this investigation was to carry out targeted peat probing in the areas of site infrastructure.

Peat depths across the site can be derived from a number of possible approaches such as linear transects or area sampling.

For the purposes of this assessment, peat probing was carried out using a peat probing rod with a maximum length of 8m within areas of the site that will be affected by the development.

Peat probing locations were predefined and uploaded onto a handheld GPS (Garmin GPSmap 60CSx) to ensure accuracy of the probing locations. If additional probing locations were required as a result of encountering deep peat on site[2]; the locations were recorded using the handheld GPS.

Peat samples were also retrieved from each turbine location and a number of locations across the site using a hand soil auger. The purpose of obtaining samples was to help gain an understanding of the underlying peat. The samples provided the following information:

- An indication of the nature of the peat, described as fibrous, semi-fibrous or amorphous; and
- A qualitative visual observation of the moisture content in the peat samples obtained with the auger. Observations on the nature of the peat were made using the Von Post Scale of Humification. An example of the Von Post Scale is provided in an annex to this report.

Photographs were also taken during the site visit to record the site features and a number of the peat probing locations. The data collected from the peat probing exercise is provided in an annex to this report.

3. Desktop Study

3.1 Rainfall

Chapter 8 details the rainfall at the site based on the nearby MetOffice rainfall gauging stations at Auchincruive and Eskdalemuir. The site is subject to relatively high levels of rainfall (long term annual average of between 984mm and 1634mm). Peat slides are considered more likely to occur during very wet rainfall events immediately following periods of low rainfall during which the peat matrix has become weakened by drying effects. The rainfall data indicates that the site infrequently suffers low rainfall, and the risk of peat slide may therefore expected to be reduced at the site.

3.2 Surface Water Hydrology

Surface Water Hydrology
Hydrologically the proposed wind farm site lies in the watershed of two catchments; the Douglas Water to the north, south east and the River Ayr to the south west. The numerous watercourses within the site and immediately downstream have been divided into their respective sub-catchments, based on the topography and the Flood Estimation Handbook (FEH) CD-ROM.

Douglas Water Catchment
The majority of the on-site watercourses discharge into the Douglas Water via the Galawhistle Burn, Monks Water and the Podowrin Burn.

Galawhistle Burn
The Galawhistle Burn has its headwaters rising from Little Auchinstilloch and Meikle Auchinstilloch. Due to the presence of the open cast coal site, the majority of these headwaters and minor tributaries have had their courses altered by man-made diversion channels. These channels are designed to significantly reduce the volume of water flowing into the open cast coal site.

As a result of these artificial channels, a large number of headwaters had no flow at the time of the hydrology site visits. The headwaters are characteristic of upland, moorland/heath watercourses, situated in shallow v-shaped valleys.

From NGR NS 76067 30974 onwards, the Galawhistle Burn reverts back to its natural state and continues to flow east in a well established v-shaped valley, with distinct natural terraces between Meikle Auchinstilloch and Hareshaw Hill. The channel ranges from approximately 0.5m – 1.0m in width with much of the channel having little or no in-stream vegetation. Meanders are also an important feature of the Galawhistle Burn, with extensive evidence of the erosive and depositional features that occur as a result. Pool and riffle sequences are also a dominant characteristic of the Galawhistle Burn.

The Galawhistle Burn continues to flow east until its confluence with the Monks Water at NGR NS 77193 31041.

The riparian zone is dominated by grasses and appears to be stable for much of its length. No in-stream, artificial or natural obstructions compromising river continuity of the Galawhistle Burn were observed during the site investigation.

Monks Water
The Monks Water has headwaters that rise from Meikle Auchinstilloch and Wedder Hill in the vicinity of the Cumberhead forestry plantation. The headwaters are characteristic of upland, moorland/heath watercourses.

The Monks Water continues to flow in a south-west direction before its confluence with the Galawhistle Burn. Upstream of this confluence the channel width ranges between 0.5m – 1.5m, with much of the channel having little or no in-stream vegetation. Pool and riffle sequences are characteristic of the Monks Water. The development of pool and riffle sequences is usually through a combination of scour and deposition, organised spatially to give a more or less regular spacing between each sequence. Meanders are also an important feature of the watercourse, with evidence of the initial stages of meander formation and cut-offs present.

After its confluence with the Galawhistle Burn at NGR NS 77193 31041 the Monks Water flows in a south, south-east direction through open rough grassland used for livestock grazing. The channel increases in width, ranging between 1.5m – 3.0m with very little in-stream vegetation.

The riparian zone of the Monks Water is dominated by mosses and grasses with evidence of slumping and poaching by livestock along various stretches of its course. In areas of slumping no evidence of peat or peaty soils were visible in the failure scar.

Podowrin Burn
The Podowrin Burn is situated along the eastern periphery of the site and rises between Wedder Hill and Hagshaw Hill. The burn flows in a general south-west direction at the base of the aforementioned hills. The burn begins to flow in a south-east direction between Avermarks Hill and Arrarat Hill and continues to do so until it reaches Low Broomerside Hill (NGR NS 79661 29144). From this point the watercourse abruptly changes direction and starts to flow in a south-west direction until it discharges into the Douglas Water at NGR NS 78962 28156.

River Ayr Catchment
The remainder of the on-site watercourses discharge into the River Ayr via the Hareshaw Burn, Ponesk Burn and Glenbuck Loch.

[2] For pragmatic purposes, areas of deep peat are considered to be equal to or greater than 1.5m.

The headwaters of the Hareshaw Burn rise between the two summits of Hareshaw Hill and flow in a general south-south west direction until the watercourse reaches the extents of the mine workings. From approximately NGR NS 758 296 the watercourse changes direction and flows in a south-west direction for approximately 600m before it is picked up by Stottencleugh Burn at NGR NS 75313 29056.

The headwaters of the Hareshaw Burn are characteristic of upland mainly surface-water fed, moorland/heath watercourses. The riparian zone of the lower reaches is dominated by small corridors of mixed forestry.

Glenbuck Loch is a man-made loch created in 1802 to secure water supplies for the cotton mills that once existed at Catrine. The loch is fed by the Stottencleugh Burn whose headwaters rise in the vicinity of Sclanor Hill. As shown in Photograph 8.6, the northern extents of the loch are surrounded by the steep slopes of Hareshaw Hill with much of the banks dominated by small forestry plantations. The loch discharges into the River Ayr at NGR NS 75393 28757.

The site access is located within the catchment of the Ponesk Burn. The Ponesk Burn flows into the River Ayr, immediately south of the A70. The route of the Ponesk Burn is the result of a diversion approximately 25 years a go for the mining of the Ponesk Open Cast Coal Site (OCCS). In its lower reaches the burn flows in a straight channel with hard engineered banks.

3.3 Soils

The distribution of the soils across the site is dependant upon the geology, topography and drainage regime of the area. The site soils consist predominantly of blanket peat, peaty gley soils of the Glenalmond and Rowanhill Associations and peaty podzols of the Ettrick, and Glenalmond Associations. Areas of brown forest soils of the Ettrick and Glenalmond Associations are found within the valleys of some of the watercourses. A minor area of non-calcerous gley soils belonging to the Ettrick Association is also located to the south of the site. The main soil types are listed below in relation to their dominance on site:

- Blanket Peat – organic material that has remained wet to the surface. They also contain a huge store of carbon and are an important component of the carbon budget for Scotland;
- Peaty Gleys – slowly permeable, seasonally waterlogged clay-like soils with a peaty surface horizon;
- Peaty Podzols – leached soils with a peaty surface layer. The drainage of these soils is dependant on the level of leaching. Peaty podzols are normally free draining however where strong leaching has occurred sufficient deposition of iron and aluminium in the lower soil horizons may cement the material into a hard impermeable later, or ironpan, resulting in waterlogging of the profile above. The product of this is a soil intermediate between podzol and gley;
- Brown Forest Soils – are well drained with brownish subsoils where iron oxides created through weathering processes are bonded to silicate clays. The texture and fertility of the soil is dependant upon the nature of the parent material and the degree of alteration it has undergone. Under natural conditions the soils would form under broadleaf forest which promotes rapid decomposition of plant residue and subsequent recycling of plant nutrients; and
- Non-calcerous Gleys – are developed under conditions of intermittent or permanent waterlogging. These soils are naturally poorly drained and support grassland based agriculture.

Peat is a soft to very soft, highly compressible, highly porous organic material that can consist of up to 90 – 95% water, with 5 – 10% solid material[3]. Unmodified peat consists of three layers; a surface layer of peat, known as the top mat and consists of living vegetation such as herbaceous plants, grasses and mosses. The second layer or acrotelm[4] which can be up to 1m thick can be highly permeable and receptive to rainfall. Decomposition of organic matter within the acrotelm occurs aerobically and rapidly[5]. The acrotelm generally has a high proportion of fibrous material and often forms a crust in dry conditions.

A third layer, or catotelm, lies beneath the acrotelm and forms a stable colloidal substance which is generally impermeable. As a result the catotelm usually remains saturated with little groundwater flow.

Due to the dominance of peat and peaty soils across the site, a series of peat depth exercises were carried out. The results of the peat probing exercise and site investigation are presented in Section 4.

3.4 Geology

Superficial Geology

The BGS 1:50 000 digital superficial geology data for the site (shown in Figure 2) indicates that the majority of the site is underlain by deposits of Devensian Till call Diamicton. Diamicton is characterised by being very poorly sorted with larger sedimentary grains set in a matrix of fine grains.

There are also isolated areas of peat overlying the till deposits that are situated on the tops and slopes of the surrounding hills, such as Meikle Auchinstilloch, Wedder Hill and Hareshaw Hill.

Areas of alluvium and alluvial fan deposits (comprised of clay, silt, sand and gravel) are found within the valleys of some of the watercourses.

Solid Geology

As shown in Figure 3, the BGS 1:50 000 data indicates that the solid geology underlying the site mainly comprises sandstones from the Lanark Group, Inverclyde Group, Dungavel Group and Monks Water Group. The Lanark Group sandstones form the Swanshaw Sandstone Formation, part of the Old Red Sandstone Supergroup, and are described as medium grained and moderately well sorted. The Inverclyde group sandstones form the Kinneswood Formation and are described as fine-to medium-grained, weakly cemented, and are variously coloured red, brown, yellow or white. The Dungavel group sandstones form the Plewlands Sandstone Formation, which are described as greyish brown, micaceous and cross-bedded fluviatile sandstones. Finally the Monks Water Group forms the Quarry Arenite Formation which is described as medium- and coarse-grained sandstone often containing intraclast fragments of red shale.

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[3] Warburton, J., Holden, J., Mills, A.M., (2004) *Hydrological Controls of Surficial Mass Movements in Peat.* Earth-Science Reviews 67, 139-156

[4] Is the upper layer of the peat bog, in which organic matter decomposes aerobically and rapidly.

[5] M, Evans, J, Warburton (2007) *Geomorphology of Upland Peat: Erosion, Form and Landscape Change*, Blackwell Publishing Ltd;

To the northern and southern edges of the site there are outcrops of Greywacke Conglomerate belonging to the Lanark Group and the Greywacke Conglomerate Formation. In addition to greywacke it contains pebbles of quartz, jasper and chert.

In the area of the existing colliery road, construction compound and laydown area the site is dominated by undivided cyclic sedimentary rocks with areas of limestone. The undivided cyclic sedimentary rocks are part of the Limestone Coal Formation which comprises sandstone, siltstone and mudstone in repeated cycles. The siltstone and mudstone are usually grey to black while the sandstone is usually fine- to medium- grained and off-white to grey. Coal seams are common and may exceed 0.3m in thickness. The limestone rocks are part of the Lower Limestone formation. The limestones are nearly all marine and fossiliferous and are pale to dark grey in colour.

The site is also heavily faulted with a number of faults traversing the site.

3.5 Hydrogeology

Hydrogeological Units

The Hydrogeological Map of Scotland[6] indicates that the site is dominantly underlain by Carboniferous: Westphalian rocks in which groundwater flow is dominantly in fissures and other discontinuities. These aquifers are comprised of cyclical deposits of mudstones, siltstones, fine-grained sandstones, seatclays and coals. Large volumes of water have been pumped from mine workings in the past but water supply boreholes have not been developed because yields are low and water quality poor.

Areas in the vicinity of the main access track and north east of the site are underlain by highly productive aquifers of the Carboniferous rocks of the Dinantian and Namurian. Groundwater is dominantly in fissures and other discontinuities. The oldest strata of Dinantian age consist of medium-grained sandstones, with subordinate mudstones, siltstones and limestones. Borehole yields in the oldest strata are generally moderate and not greater than 10l/s. The highest strata consists of sandstones, mudstones and occasional thin coals with borehole yields generally less than 10l/s and exceptionally 20l/s.

A minor area to the south east of the site is underlain by Silurian and Ordovician rocks that are generally impermeable and with groundwater except at shallow depths. Any groundwater is confined to near surface cracks and joints.

Groundwater Flow in the Superficial Deposits

In 2004, SEPA in conjunction with the BGS produced a series of maps to gain a better understanding of the hydrogeological properties of superficial and bedrock aquifers in Scotland. The superficial aquifer map indicates that the superficial aquifers underlying the are dominated by intergranular flow with low productivity (0.1 - 1l/s)[7]. In the western extent of the site there are areas where groundwater flow in the superficial deposits is dominated by intergranular flow with high productivity (>10/s)[7].

[6] BGS (1988), Hydrogeological Map of Scotland, 1:625,000

[7] A, M, MacDonald, D, F, Ball and B, É, O, Dochartaigh (2004), A GIS of aquifer productivity in Scotland: explanatory notes, Groundwater Systems and Water Quality Programme Commissioned Report CR/04/04/047N

In areas dominated by Till, groundwater movement is likely to be restricted due to the mixture of clay through cobbles generally having a low permeability. However, weathered horizons or thick lenses of sand and gravel are likely to have slightly higher permeability and support small groundwater flows.

The groundwater regime that operates in peat is complex and very variable over short distances. Groundwater flow is considered to be more active within the acrotelm layer and to be more static within the deeper lower permeability catotelm layer. However, the presence of naturally occurring "peat-pipes" and desiccation cracks within peat facilitates the rapid movement of water, similar to the presence of major fractures in bedrock formations. Minor groundwater flow is also likely to occur at the boundary between the peat and superficial deposits.

Due to the nature of the constituents that make up Alluvium, groundwater movement is likely to be less restricted within the river valleys.

Groundwater Flow in the Bedrock

The Bedrock Aquifer map produced by SEPA indicates that the bedrock aquifers underlying the site are dominated by intergranular-fracture flow with moderate productivity (1-10l/s)[7].

Groundwater Vulnerability

The Water Framework Directive (WFD) policed by SEPA through the Water Environment and Water Services (Scotland) Act 2003, is intended to protect all groundwater, including that which is not exploited for supply and providing baseflow to surface watercourses. Part of the implementation of the WFD has involved assessing the vulnerability of groundwater to pollution and SEPA has published an assessment of groundwater vulnerability in Scotland[8]. The methodology for the assessment determines the vulnerability of the groundwater based upon the permeability of the bedrock, type of groundwater flow (intergranular flow or fracture flow) and the type and thickness of the superficial deposits. The underlying superficial aquifers are dominated by intergranular flow with low productivity, whilst the bedrock aquifers are dominated by fracture flow with low productivity. The Groundwater Vulnerability Map of Scotland classes the site as 'Vulnerable' (4a) and (4b). The vulnerability classification can be attributed to the transmission of rainfall and runoff from the surface to groundwater and the subsequent ease of movement of pollutants through the fracture dominated rocks. This assessment is based on the generic consideration of soil and rock types and does not indicate that the risks to individual sources are high.

3.6 Topography and Slope

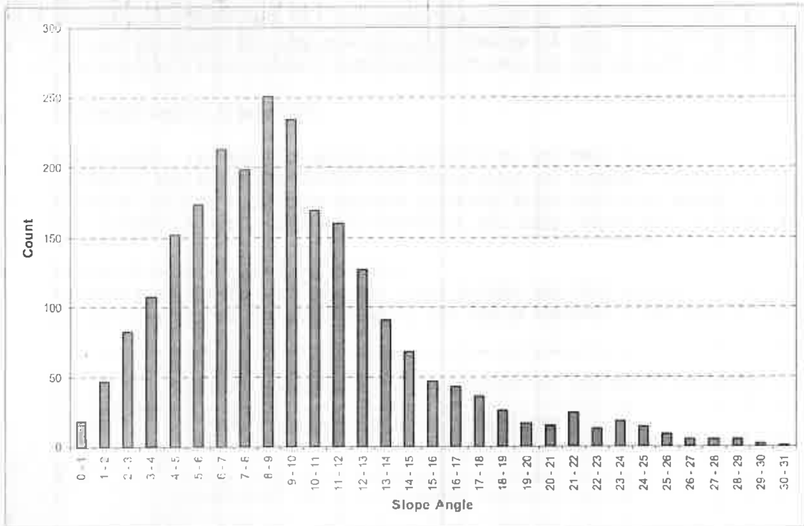
Using Digital Terrain Model (DTM) data, elevation and slope angle maps were created for the proposed Wind Farm, these are shown in Figure 4. The topography of the site ranges from a low of 234m Above Ordnance Datum (AOD) at the site entrance adjacent to the A70 to a high of 467m AOD on the summit of Hareshaw Hill. The valleys of the watercourses are situated around 270m – 300m AOD.

The slope angle map enabled the identification of high slope angles and significant breaks in slope. Breaks in slope were identified using DTM data, cross-sections, the OS data and professional judgement. As can be seen on Figure 5 and due to the nature of the topography on site, the

[8] Development of a Groundwater Vulnerability Screening Methodology for the Water Framework Directive, Scotland and Northern Ireland Forum For Environmental Research, Project WFD 28 Final Report 2004

infrastructure is located on varied gradients. The site infrastructure located on the south facing slope of Meikle Auchinstilloch is located on gradients between 6° and 10°. The gradient of Hareshaw Hill varies from between 2° and 6° in the lower valleys, and up to >14° in the vicinity of the summit. The majority of the site infrastructure located in this area appears to be located on gradients between 6° and 10°. The gradient to the west of the site, in the vicinity of Wedder Hill and Arrarat Hill is steep with the west facing valleys having significant areas of slopes greater than 14°. Generally the site infrastructure in this area is located on slopes of between 2° and 14°.

Graph 2 Slope Angle Histogram



3.7 Aerial Photography Interpretation

Interpretation of Aerial Photography was undertaken in order to assess and identify evidence of existing and historical peat instability.

A site wide interpretation of the site area was undertaken. The following list of features was used as a basis for the interpretation to identify possible locations of existing and historical peat instability or areas that may be susceptible to instability in the future:

- Possible extension and/or compressior features;
- Areas of historical failure scars and debris;
- Evidence of peat creep;
- Areas with apparently poor drainage;
- Areas with concentrations of surface drainage networks; and
- Steeply incised stream cuttings with adjacent deposits of recorded peat.

From the digital aerial photography interpretation (API), 18 localities were identified as being of interest and worthy of inspection during the site investigations. Many of these areas were identified as possible historical instability or identified as areas being susceptible to future instability. These features, together with brief notes on why they were identified during the aerial photography interpretation are provided in Table 1. The location of the identified localities are also provided in Figure 5.

Table 1 Features identified during the Aerial Photography Interpretation (API) and Desk Study

ID	Features Identified During Aerial Photography Interpretation (API) and Desk Study
1	Mottled surface and dark ridges on aerial photography suggest that erosion or peat instability features may be present.
2	Extensive scarps along route of Monks Water. Potential for slope failure features already being present.
3	Extensive scarps along route of Monks Water. Potential for slope failure features already being present.
4	Extensive scarps along route of Monks Water. Potential for slope failure features already being present.
5	Equally spaced linear drainage features. Implies that artificial drainage has been installed on site. Features appear to drain into main artificial drainage that flows into tributary of Galawhistle Burn.
6	Aerial photography suggests that the valley of the watercourse is situated in a gully with steep embankments. Potential for instability features to be present.
7	Dark ridges present on aerial photography. Possible area of peat creep.
8	Equally spaced artificial linear drainage features.
9	Equally spaced artificial linear drainage features.
10	Extensive long drainage feature that does not appear in OS basemaps. Suggest that the feature is artificial.
11	Dark ridges present on aerial photography. Possible area of peat creep.
12	Equally spaced artificial linear drainage features.
13	Aerial photography suggests that the valley of the watercourse is situated in a gully with steep embankments. Potential for instability features to be present.
14	Aerial photography suggests that the valley of the watercourse is situated in a gully with steep embankments. Potential for instability features to be present.
15	Extensive artificial drainage feature present on slope of Hareshaw Hill. It is likely that this feature was created as part of the historic mine workings
16	Equally spaced artificial linear drainage features. Evidence of extensive scarps and hummocky ground
17	Large extent of historic open cast mine workings. Possible area for peat instability features to be present due to the removal of bedrock, soils and peat and also from storage of overburden.
18	Evidence of scars around southern and western slopes of Arrarat Hill with upslope crescent scarps. May be evidence of historical failure in this area.

Details of the site investigation that followed from the aerial photography interpretation are provided in Section 4.

3.8 BGS Ground Stability Information

The BGS also provides 1:50,000 digital data relating to ground stability in the form of the GeoSure national data set. These datasets provide geological information about potential ground movement or subsidence that can help inform planning decisions. Datasets available for the Galawhistle Wind Farm are detailed below.

Compressible Ground

The compressible ground dataset refers to types of ground, which may contain layers of soft material like clay or peat. These may compress if loaded by overlying structures, or if the groundwater level changes, potentially resulting in depression of the ground and disturbance of foundations.

The dataset provides information on four divisions of compressible strata found in the proposed Development area. Table 2 provides a breakdown of these divisions.

Table 2 Compressible Ground Divisions

Category	Description
A	Compressible strata are not thought to be present
C	Compressibility and uneven settlement potential may be present. Land use should consider specifically the compressibility and variability of the site
D	Compressibility and uneven settlement hazards are probably present. Land use should consider specifically the compressibility and variability of the site.
E	Highly compressible strata present. Significant constraint on land use depending on thickness

As shown in Figure 6, the majority of the site is overlying strata that is not thought to be compressible (Category A). Sections of the access track and Turbines 3, 10, 12, 15 and 22 are located on highly compressible strata (E).

The majority of the proposed Development lies within areas less sensitive to compression. However, the site investigation included the areas, particularly in the locale of Turbines 3, 10, 12, 15 and 22 and associated access track where there the underlying strata is more susceptible to compression. The results of the site investigation are detailed in Section 4.

Landslide (Slope Instability)

The landslide hazard dataset categorises the ground into the potential for slope instability, taking into account particular slope characteristics, specifically solid and superficial geology, gradient, source of water, drainage and man-made constructions, combining to cause the slope to become unstable.

The dataset provides information on four divisions of instability found in the proposed Development area. Table 3 provides a breakdown of these divisions.

Table 3 Landslide (Slope Instability) Divisions

Category	Description
A	Slope instability problems are not thought to occur but consideration to potential problems of adjacent areas impacting the site should always be considered
B	Slope instability problems are not likely to occur but consideration to potential problems of adjacent areas impacting the site should always be considered
C	Slope instability problems may be present or anticipated. Site investigations should consider specifically the slope stability of the site
D	Slope instability problems are probably present or have occurred in the past. Site investigations should consider specifically the slope stability of the site

As shown on Figure 6, the majority of the site is situated on ground that has been classed as not likely to have instability problems (Category B). However, Turbines 10, 12, 18 and 22 are located on ground where slope instability problems may be present or anticipated (Category C) and small sections of track are located in Category D.

The majority of the proposed wind farm is situated on ground less susceptible to instability. However, the site investigation included the areas, particularly in the locale of infrastructure mentioned above where slope instability problems may arise from the proposed wind farm. The results of the site investigation are detailed in Section 4.

4. Site Investigation

Following the desk-based study, a series of site investigations were carried out to verify the information gathered during the desk based study and to determine the peat depth across the site. An initial site investigation was carried out on the 13th and 14th of May 2009 to help determine the depth of peat across the site. The peat probing was carried out in a grid pattern, with the results helping to inform the site layout. A secondary peat depth survey was also carried out on the 11th and 12th of August 2009. Targeted peat probing was carried out in all areas of proposed infrastructure.

During both site investigations, a site walkover was also carried out to gain a better understanding of the site topography and hydrology and to determine the extent of any peat instability indicators that may be present.

4.1 Peat Depths

Table 4 provides a summary of the peat depths that were recorded during the site investigation. An indicative peat depth map is provided in Figure 7 and also shows the distribution of the peat depths recorded during the site investigation.

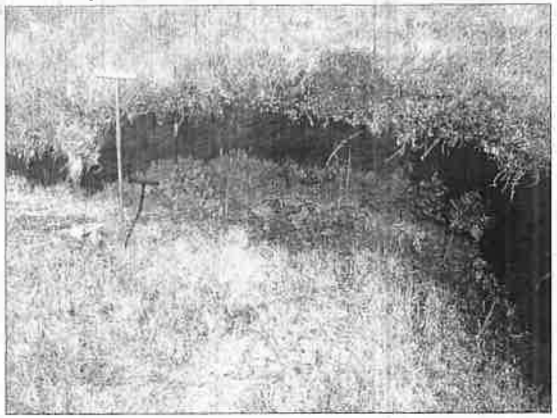
Table 4 Summary of recorded peat depths (m)

Peat Depth Range (m)	Peat depth categorisation	Results	% of Points
<0.25	Shallow	34	12.9
0.25-0.75	Moderate	139	52.3
0.75-1.5	Deep	81	30.8
>1.5	Very Deep	9	3.4
TOTAL		263	100

The table indicates that peat depth across the site ranges from <0.25m to <1.5m, with minor areas of peat in the depth range of >1.5m. 52.3% of the total probing points fall within the 'Moderate' peat depth category, with only 12.9% in the 'Shallow' peat depth category.

An aerial photography review of the proposed development area has been undertaken, detailing the areas of proposed windfarm infrastructure.

Photograph 1 Example of peat depth at Galawhistle Wind Farm



The photograph indicates the peat depth as the peat probe to the left of the photograph has a length of 1m, with the subdivisions every 0.1m. The depth of peat in this area did not exceed 1m.

Details of additional photographs that were taken during the site investigation are provided in Appendix 3.

4.2 Surface Hydrology and Artificial Drainage

Research has shown that peat instability can be triggered along natural drainage lines or in association with artificial drainage[3]. Watercourses need to be considered because in times of considerable rainfall, leading to increased surface water runoff, water levels could rise rapidly and potentially affect the stability of the surrounding peat. During the site investigation, watercourses were examined to determine if peat instability features were present within 10m either side of the watercourse.

Areas of limited drainage, such as blanket bog, are also considered more susceptible to instability than better drained areas due to higher groundwater tables.

Water can also be concentrated into zones of potential instability by networks of artificial drainage. Should these ditches be partly infilled and vegetated it is also likely that they will act as a store of water from upslope rather than facilitating the rapid removal of water. A number of man-made drainage ditches were noted across the site. The ditches all discharge into natural watercourses and it is likely that they were created for agricultural purposes, as part of a moorland gripping scheme or for potential forestry use.

Examples of the geomorphology of the surface hydrology and artificial drainage encountered during the site investigation are provided in Appendix 3.

4.2 Subsurface Hydrology

Within peat, groundwater is considered to actively flow within the higher permeability acrotelm layer and to be more static within the low permeability catotelm layer. The presence of peat pipes within either horizon can however transport a significant volume of water through a peat mass and can potentially represent a significant risk of peat failure. No evidence of peat pipes or similar subsurface hydrological features were recorded during the site investigation.

4.3 Evidence of Wind and Water Erosion

Peat hags can provide an indication of past and current peat erosion and site drainage. Evidence of potential wind erosion was noted south of the summit of Hareshaw Hill, in the vicinity of Turbine 10.

Photograph 2 Evidence of potential wind erosion features in the vicinity of Turbine 10

The features identified above were also evident on the digital Aerial Photography (API ID 1).

In the saddle between Hareshaw Hill and the minor summit to the south, in the vicinity of Turbine 10, the geomorphology of the environment is conducive to water erosion. It is possible that the geomorphology of this area has been formed as a result of wind and water erosion focussed in the vicinity of Hareshaw Hill in the minor saddle to the south. It is likely that this is a long term and ongoing process.

Photograph 3 Evidence of water erosion in the vicinity of Turbine 10

It is likely that the geomorphological features highlighted in Photograph 2 and Photograph 3 are inexorably linked as wind and water erosion would be more powerful within the saddles.

4.4 Existing/Historical Failure

The presence of existing failure scars in a development area may indicate local site conditions conducive to future peat instability[1].

Although differences exist between specific types of peat mass movement there are four main morphological elements common in rapid peat mass movements:

1. A source zone consisting of a single or multiple, often crescentic scar areas (defined by an upslope head scarp);
2. A zone of peat debris dominated by large rafts of peat, and smaller blocks arranged in blockfields and clusters;
3. A runout track with abundant abraded and fractured peat blocks, a trail of peat slurry and uprooted vegetation. This is often bounded by distinct levees and peat blocks; and
4. Secondary features adjacent to the main failure showing evidence of both tension and compression within the peat, including both extension and rupture tension cracks and compression ridges[5].

Rapid peat mass movements tend to occur on short timescales of seconds and hours, however due to its nature, peat is also susceptible to slow movement over longer timescales. Longer term peat mass movement can be identified by the presence of tension cracks or compression ridges.

Aerial photographic evidence of peat failure was noted to the south and west of Arrarat Hill, with crescentic scars running along a line approximately 600m in length. The photographs showed possible scars running downslope, with head scarps present. They may indicate relict failures that may not be that evident on the site. However, these features are potentially signs of unstable ground.

4.5 Incipient Failure

Incipient failures usually indicate where a failure may be due to occur. Tension cracks, bulging and compression ridges can often be the precursors to a larger failure. No evidence of tension cracks, bulges or any other indicators of potential instability were recorded during the site investigation.

5. Peat Stability Risk Assessment

86.8% of the recorded peat depths were greater than 0.25m. Combined with features conducive to peat instability which have been established prior to construction, a baseline scenario can be established. Implications of the proposed construction methodologies can then be incorporated into the design and construction process.

This peat stability assessment is based on an examination of available topographic data, aerial photography, radar data, observations made during the site investigation and an assessment of peat depth across the site.

The key objectives of this section of the assessment are:

- Identify existing, historical and/or potential areas of instability across the site; and
- Ensure that the proposed Development does not result in an unacceptable risk to peat stability.

The following section provides information on the history of peatslides, factors influencing peat stability, potential consequences of such an event and the RPS methodology for determining the risk of peat failures within each of the denoted hazard zones.

5.1 Factors Controlling Peat Stability

Peat failures are caused by a combination of preparatory and triggering factors. Preparatory factors act to reduce the stability of peat in the medium to long term, whereas triggering factors act to initiate slope failures. Slope failures may be slow or rapid, with a limited or extensive spatial extent[1].

The main preparatory factors that are relevant for this site include:

- Increase in the peat mass from natural accumulation or increases in water content;
- Loss of surface vegetation and associated tensile strength; and
- Alteration to the hydrological regime due to the installation of artificial drainage channels.

The main triggering factors for peat instability that are relevant for this site include:

- High intensity and prolonged rainfall, especially in drier periods. Rainfall is not a controllable factor, however the assessment considers the potential effects of heavy rainfall at the site; and
- Peat extraction and peat loading are potential risks from construction, operation and decommissioning working practices. Both can be mitigated through best practice working methodologies.

5.2 Consequences of Peat Failure

A key part of the risk assessment process is to identify the potential scale of peat failure, should it occur, and identify the potential environmental effects as well as the receptors of such an event.

The affects of peat failures are felt locally, both in the long and short term, but they also have wider off-site implications[5].

Peat failure in the area of the proposed Wind Farm would affect the following key receptors:

- The proposed wind farm, including infrastructure and turbines;
- Site workers and plant (risk of injury/death or damage to plant);

- Land based and aquatic ecological effects (damage to habitats);
- Effects on the quality of on-site and downstream watercourses;
- Site drainage (blocked drains/ditches leading to localised flooding and/or erosion);
- Designated sites;
- Visual amenity (scarring of landscape); and
- Sites of archaeological significance.

5.3 Risk Assessment Methodology

The level of risk allocated to a particular area relates to the presence of peat, the likelihood of failure occurring (the hazard) and the consequences of such a failure (the exposure). The risk assessment discussed in the following sections is based on a scoring system, where the hazard and exposure scores are multiplied to produce a final risk score.

The following sections detail the methodologies for determination of the appropriate hazard and exposure scores.

5.4 Hazard Determination

The current guidance on peat landslide hazard and risk assessments provides a clear mechanism for determining the risk of development on peat. However, specific guidance on determining the level of hazard is not presented e.g. for peat depth, and in these instances professional judgement has been applied. Hazard determination within this assessment is therefore based on the combination of a number of factors, including:

- Peat Depth;
- Slope Angle/Gradient;
- Site Hydrology; and
- Observations made during the site investigation with regards to existing, historic and incipient peat failures.

Peat Depth

The depth of peat present is a major factor in the potential for failure as well as having an effect on the potential scale of a peat failure.

Failure may be facilitated through weak layers within the peat which may exist as a result of hydrological factors, or possibly as a result of the nature of the peat deposits themselves. The nature of the interface between the distinct layers within a peat mass is defined by peat depth and hydrology.

The formation of the three peat layers described in Section 3.4 is dependant upon peat depth. Thin deposits (<0.5m) are less likely to have a catotelm, and are likely to consist of a top mat and immature acrotelm. As such, with inherent strength influenced by the density of vegetation fibres present with peat mass, peat thickness of less than 0.5m are not reported to have failed catastrophically.

Peat probing was undertaken as part of the site investigation and the results are discussed in greater detail in Sections 4.1. The results clearly indicate that the site is dominated by moderate (0.25 – 0.75m) and deep peat (0.75 – 1.5m) with minor pockets of very deep (>1.5m) peat also found in isolated localities. The distribution of the peat depths as well as an indicative peat depth map is provided in Figure 7.

As part of the hazard determination process, peat depth divisions are allocated a risk score depending on the depth of the peat. The hazard scores for peat depths are summarised in Table 5.

Table 5 Allocation of Hazard Determination Scores for Peat Depths

Peat Depth (m)		Hazard Determination Score
Shallow	0 – 0.25	1
Moderate	0.25 – 0.75	2
Deep	0.75 – 1.5	3
Very Deep	>1.5	4

In the Scottish context, blanket peat can be up to 5m deep or more, but generally is not much more than 2m to 3m deep and often much less. Peat depth categories were chosen in the context of wind farm construction i.e. peat depths of 1.5m represent approximately the cut-off between cut-and-fill and floating track construction. Similarly, the practicalities of constructing turbine foundations in peat greater than 2.5m deep make this a less attractive option.

Slope Angle/Gradient

The limiting factor governing the formation of thick peat deposits is topography. Peat tends to be deepest in closed depressions and in the case of blanket peat, peat deposits thin as the slope angle increases. On steeper slopes, thick continuous peat deposits are unlikely to be present as the drainage conditions are such that peat cannot form[5].

As part of the hazard determination process, slope angle divisions are allocated a risk score. The hazard scores for slope angle are summarised in Table 6.

Table 6 Allocation of Hazard Determination Scores for Slope Angles

Slope Angle (°)		Hazard Determination Score
Flat	0 – 2	1
Shallow	2 – 6	2
Moderate	6 – 10	3
Steep	10 – 14	4
Very Steep	>14	5

Site Hydrology

Sites of peat failure share several common characteristics, which predispose them to failure. These pre-requisites all relate to hillslope hydrology either directly or indirectly:

- A peat layer overlying an impervious or very low permeability clay or mineral base;
- A convex slope or a slope with a break of slope at its head;
- Proximity to local drainage either from seepage, groundwater flow, flushes, pipes and streams; and
- Connectivity between surface drainage and the peat/impervious base interface[3].

Peat slides initiated along natural drainage lines or in association with artificial drainage often brought about by mining activity or agricultural practices[3].

The site investigation determined that the majority of the site is well-drained with boggy diffuse drainage features noted amongst the headwaters of the watercourses.

It was also established that areas of the site were traversed by a series of man-made drainage ditches. The ditches all discharge into natural watercourses and it is likely that they were created for agricultural purposes, as part of a moorland gripping scheme or for potential forestry use.

Artificial drainage ditches have the potential to instigate peat instability for a number of reasons:

- The removal of peat at the break of slope can decrease the support on the upslope peat mass and potentially cause the peat to fail;
- Exceedance of the critical level of pore water pressure on the upslope peat mass during heavy and/or intense rainfall; and
- Liquifaction of the basal peat by increased water content.

The site investigation also established that there was no evidence of peat pipes or other subsurface hydrological features present within the site.

The relative hazard scoring for this factor, as shown in Table 7 is based on the visual observations carried out during the site investigation.

Table 7 Allocation of Hazard Determination Scores for Surface Hydrological Characteristics

Site Hydrological Characteristics	Hazard Determination Score
Well drained site with no hydrological factors present that can influence instability	1
Boggy, stream heads, diffused drainage	2
Saturated with standing water - blanket bog	3
Artificial drainage and/or blocked drainage paths	4

Presence of existing, historic and incipient failure features

Aerial photography indicated the possible presence of past failure scars on the west and southern slopes of Arrarat Hill. These scars were not evident during the site visit, but they may represent features of potentially unstable ground.

The rationale behind the coring for this hazard factor is based on how the presence of existing failure scars or evidence of incipient failure in a development area may indicate local site conditions conducive to future peat instability[1].

The relative hazard scoring for this factor, as shown in Table 8 is based on the visual observations carried out during the site investigation.

Table 8 Allocation of Hazard Determination Scores based on the presence of pre-failure indicators

Presence of existing, historic and incipient failure features present	Hazard Determination Score	
	Yes	No
One or a combination of pre-failure indicators of instability present within risk area	5	1

Parameter Combination
The relative risk rating system used represents a principally qualitative method of assessing the risk of instability. The alternative quantitative evaluation of Factor of Safety (FoS) of a particular peat slope presents difficulties due to the spatial variations in the factors included. However it is recognised that should areas of 'Substantial' and 'Serious' risk be identified, detailed intrusive ground investigations are recommended to help determine the extent of the risk area and to potentially provide micro-siting opportunities for the site infrastructure.

The risk ratings derived from Table 9 are adapted from the current guidance[1] and also are based on the combination of the four parameters mentioned above. The scores for the dominant conditions found within the risk areas are multiplied together to help determine the level of hazard.

Table 9 Hazard Determination Scale

Scale	Parameter Combination	Probability of Occurrence	Score Ranges (from multiplication of hazard determination scores)
5	Almost Certain	>1 in 3	120 - 400
4	Probable	1 in 10 – 1 in 3	61 - 120
3	Likely	1 in 10^2 – 1 in 10	21 - 60
2	Unlikely	1 in 10^7 – 1 in 10^2	11 - 20
1	Negligible	<1 in 10^7	1 -10

Worked examples for determining the level of hazard are provided below:

WORKED EXAMPLE 1
The following conditions dominate example risk area 1:
Peat Depth = 1.5m – 2.5m x Slope Angle = 6° - 10° x Boggy Stream with diffused drainage x No evidence of pre-failure indicators present on site

3 x 2 x 2 x 1 = 12

Hazard Score = UNLIKELY (2)

WORKED EXAMPLE 2
The following conditions dominate example risk area 2:
Peat Depth = >2.5 x Slope Angle = 2° - 6° x Saturated with standing water, blanket bog x No evidence of pre-failure indicators present on site

4 x 3 x 3 x 1 = 36

Hazard Score = LIKELY (3)

WORKED EXAMPLE 3
The following conditions dominate example risk area 3:
Peat Depth = <0.5 x Slope Angle = >14° x Artificial drainage and/or blocked drainage paths x Evidence of pre-failure indicators present

1 x 5 x 4 x 5 = 100

Hazard Score = PROBABLE (4)

5.5 Exposure Determination

The level of exposure is based on professional judgement, taking into account the level of impact on the environment, the potential project and the on-site infrastructure.

Table 10 Exposure Determination Scale

Scale	Parameter Combination	Impact
5	Extremely High Impact	100% of project/surrounding environment
4	Very High Impact	10% - 100%
3	High Impact	4% - 10%
2	Low Impact	1% - 4%
1	Very Low Impact.	<1% of project/surrounding environment

5.6 Risk Ranking

Using the scales provided in Table 9 and Table 10, it is possible to assign a hazard ranking for each zone by multiplying the Hazard and Exposure score, as shown in Table 11.

Table 11 Risk Ranking Matrix

Exposure						
	5	5	19	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
	Hazard					

Following the multiplication of the Hazard and Exposure scores the risk ranking for each zone will be between 1 and 25. This score will help to target specific mitigation measures to ensure that the stability of the on-site peat is not compromised by the proposed Development.

A breakdown of the risk rankings and suggested actions are detailed below:

- 1 – 4 (Insignificant) – Project should proceed with monitoring and mitigation of peat landslide hazards at these locations as appropriate;
- 5 – 10 (Significant) – Project may proceed pending further investigation to refine assessment and mitigate hazard through relocation or re-design at these locations;
- 11 – 16 (Substantial) – Project should not proceed unless hazard can be avoided or mitigated at these locations, without significant environmental impact, in order to reduce hazard ranking to significant or less; and
- 17 – 25 (Serious) – Avoid project development at these locations.

5.7 Summary of Assessment and Ranking

For the purposes of this assessment, the site has been divided into different hazard zones or areas (denoted A to S). The first point of determining the hazard zones used the FEH CD-ROM, taking into consideration the topographical boundaries imposed by the catchments present across the site.

Additional information used to determine the hazard zone boundaries included the following factors:

- Peat Depth;
- Location of sensitive receptors; and
- Evidence of current, historic and incipient failure.

This division of the study site into hazard zones resulted in some infrastructure lying on the boundary of two or more hazard zones. In these cases, the hazard was assessed separately for each zone, and the proposed infrastructure was assessed within each of the construction risk assessments.

Surface water hydrology is considered the most sensitive receptor as peat failures can have detrimental effects on the quality and quantity of surface water, as well as disrupting the ecological status of the watercourses.

The risk assessment firstly considers the baseline risk associated with the site (the site in its natural, undeveloped condition). In view of the proposed Development to be constructed, and in consideration of the proposed site layout, a further assessment is also made to identify the hazards associated with the likely construction works that will be carried out.

The results of the qualitative risk assessment are presented in an annex to this report. The detailed results summarises the dominant features that are present within each hazard zone and the likely effects these will have on the stability of the peat. The baseline risk and the associated risk as a result of wind farm construction activities is also provided in Figure 7.

The construction activities and associated potential risks to peat stability include:

- Access track construction – cut road construction will result in the removal of peat that can reduce support given to the upslope peat mass. This can also result in hydrological discontinuity in the peat body, by encouraging the rapid removal of water within the peat. Floating road construction can compact peat and therefore restrict groundwater movement;
- Wind farm drainage can create preferential pathways for surface and groundwater movement, which can disrupt the hydrological properties of peat. This has the potential to increase the likelihood of saturation and/or drying out of the peat mass;
- Excavations associated with wind farm construction (e.g. turbine foundations, borrow pits and substation foundations) can disrupt the hydrological properties of peat and cause the peat to dry out. The removal of peat will also reduce the support given to the upslope peat mass; and
- Peat/soil stockpiles stored incorrectly on slopes can increase the pressure on the peat mass and reduce stability.

The list above is a brief summary of the likely construction activities that can have an effect on the stability of peat. Further details regarding the specific construction activities that can have an influence on the stability of peat is provided in an annex to this report.

6. Construction Approach and Mitigation Measures

6.1 Introduction

The risk of instability across the site due to the construction of the proposed Development is likely to be higher than the baseline risk if adequate control and mitigation measures are not put into place. However, through the implementation of mitigation measures the risks will be minimised.

The presence of watercourses, other sensitive habitats and topography should be taken into consideration when considering the location of site infrastructure.

The site desktop study and site investigation identified peat depths across the site varying from <0.5m to 5.2m. The peat depth exercise has established that the peat underlying the proposed infrastructure rarely exceeds 1.5m in depth. To minimise the potential for peat instability there will be no 'floating road' construction in any areas of the site.

Any construction activity relating to or undertaken in the vicinity of watercourses (including any watercrossings etc) should be carried out in general accordance with relevant SEPA Pollution Prevention Guideline, The Water Framework Directive (WFD), The Water Environment and Water Services (Scotland) Act 2003 (WEWS) and the Controlled Activities Regulations (CAR) 2005 which came into effect in April 2006.

6.2 Mitigation Measures

General

Micro-siting of infrastructure will ensure that no construction or storage or takes place within 50m of areas identified to represent historic failures.

The design and construction of the wind farm development should be developed to avoid triggering instability. Prior to undertaking construction on site, a detailed and intrusive investigation will be undertaken, including trial pitting and boreholes. This will be used to inform detailed geotechnical designs for each turbine location, access track, borrow pit, laydown area and the construction compound. This will take into consideration the location-specific mechanical characteristics of the peat deposits and morphology of the underlying strata (i.e. till or bedrock).

All excavations in peat will be risk assessed to inform these location specific mitigation measures. Slope stability upslope and downslope of the excavation will be monitored during construction where moderate or deeper peat thicknesses exist. This will include pre-construction through to post construction monitoring of peat stability using ground monitoring pegs, groundwater standpipes and rainfall monitoring. The relationship between rainfall and groundwater monitoring should be assessed over a rolling month period. Where there has been a period of low rainfall reflected in reduced groundwater levels, there may be a need to cease works in these areas.

A suitably qualified person will oversee all works in areas with peat present. This person will maintain a geotechnical risk register on the site to log assessments, design plans and monitoring results. Construction staff will be made aware of peat stability during the site induction to raise awareness of best practice, location specific restrictions, peat instability indicators and emergency procedures. Deeper areas of peat within the vicinity of the development will be identified by physical demarcation with instruction to site personnel to avoid the identified areas or minimise the requirement for construction activities in these locations, where practical.

Whenever practical, arisings from excavations will not be stored on the adjacent peat. This would increase the potential for slides to occur in these areas. Excavations should not be left open in areas of elevated susceptibility, especially where this may undercut the peat slope above. Drainage of surface waters, either by natural watercourse or by drainage ditches, should be diverted away from any construction activities in areas of elevated peat slide risk.

Design and construction of a suitable drainage system for the proposed Development will be required. This should take the form of Sustainable Urban Drainage Systems[9] (SUDS) and should allow the free drainage without significant alteration of the hydrological regime of the site.

Restoration of the borrow pits will entail the sequential replacement of material with subsoil/peat layers placed on the exposed layer followed by the topsoil/peat from stored material from the initial excavation or from other excavations on the site (e.g. arisings from the construction of turbine base). Depending on the effectiveness of the restoration following an appropriate period of time to allow the seedbank to naturally reseed, the topsoils can be reseeded with a seed mix to be agreed with SNH.

[9] The Water Environment (Controlled Activities)(Scotland) Regulations 2005, A Practical Guide, SEPA – *"If the surface water runoff is from areas constructed after 1 April 2007 or from a construction site operated after 1 April 2007, these sites must be drained by a Sustainable Urban Drainage System (SUDS). The only exceptions are (i) if the runoff is from a single dwelling and its curtailage and (ii) the discharge is to coastal water."*

7. Post Mitigation Hazard Risk

Following the implementation of the mitigation and construction methodologies presented above, the effect of the proposed Development on the peat resource present on site is expected to be negligible.

Table 13 provides a summary of the risks of peat failure in each of the hazard zones following the implementation of site specific mitigation measures and construction methodologies.

8. Conclusions and Recommendations

8.1 Conclusions

This report has fulfilled the objectives and scope of works set out in Sections 1.1 and 1.2, respectively. From the information gathered it is concluded that:

The study site is predominantly covered by areas of moderate peat, with some small areas of deeper peat present on shallow slopes and within depressions. The study area consists predominantly of sandstones overlain with discontinuous layers of glacial till and peat.

The site has been significantly modified through the incision of peat with artificial drainage across the area. These ditches are mainly overgrown and appear to be relatively old features associated with historic anthropogenic activities. Despite the presence of these features, there is no evidence of peat slide within the study area.

As a result of the information presented in this report, the construction risk assessment has determined that the majority of the hazard zones have a 'Significant' risk rating.

With the implementation of mitigation measures, it is considered that any changes in the baseline risk as a result of construction activities will be negligible.

8.2 Recommendations

This peat stability assessment has been based on desk study research, observations made during the site investigation and results from the peat probing exercise. It is recommended that prior to construction, a detailed and intrusive investigation is carried out, taking into account the findings of this report.

The intrusive works should be designed in such a way that the investigation of peat stability is focused, in particular, on locations identified by this assessment as representing a 'Significant' risk as well as providing adequate coverage for the remainder of the site. The aim of the intrusive investigation would be to further develop the peat stability risk assessment of the site. It is recommended that such intrusive investigations should include the following elements:

- Trial pitting at turbine, hardstanding and borrow pit locations and at suitable intervals along the proposed access track route with the purpose of providing detailed descriptions of the physical properties of the underlying peat;
- Boreholes at suitable locations across the site to identify the nature of the peat/substrate boundary; and
- Recovery of peat samples and the underlying substrate material for subsequent geotechnical laboratory testing for shear strength and moisture content.

Supervision of the intrusive works should be undertaken by suitably qualified and experienced personnel.

All intrusive works will be carried in accordance with industry standards and guidance.

Figures

Phase 1 Peat Depths

ID	Easting	Northing	Depth (m)
14	276518	629342	1.9
15	276513	629377	0.9
16	276525	629417	1.6
17	276523	629420	0.3
18	276624	629870	1.0
A10	277300	632003	1.3
A11	277600	631697	0.3
A12	277300	631697	0.6
A13	277000	631697	0.8
A14	276700	631697	0.5
A20	276631	629786	0.3
A22	276638	629588	0.4
A25	276400	631397	0.7
A26	276700	631397	0.7
A27	277000	631397	1
A28	277300	631397	0.6
A29	277600	631397	0.3
A30	277900	631397	0.9
A31	278200	631097	1.1
A32	277900	631097	1
A33	277600	631097	0.6
A34	277300	631097	0.4
A35	277000	631097	0.9
A36	276700	631097	0.6
A37	276400	631097	0.4
A38	276400	630797	0.9
A39	276700	630797	1.8
A40	277000	630797	1.4
A41	277300	630797	0.1
A42	277600	630797	0.6
A43	277900	630797	0.5
A44	278200	630797	1.0
A45	277900	630497	1.5
A46	277600	630497	0.5
A47	277300	630497	0.6
A48	277000	630497	0.5
A49	276700	630497	0.6
A50	276400	630497	0.6
A51	276400	630197	0.9
A52	276700	630197	0.5
A53	277000	630197	0.2
A54	277300	630197	0.3
A55	277600	630197	0.9
A57	277900	629897	1.5
A58	277600	629897	0.6
A59	277293	629897	0.2
A60	277000	629897	0.4
A61	276700	629897	1.6

ID	Easting	Northing	Depth (m)
A62	276400	629897	1.0
A63	276100	629897	0
A64	276093	629597	0.1
A65	276400	629597	0.7
A66	276700	629597	0.2
A67	277006	629597	0.4
A74	277737	630963	0.8
A76	277293	629297	0.5
A77	277000	629297	0.5
A78	276700	629297	0.6
A85	277874	630481	0.25
T04	277908	630111	1.0
T04E	277930	630111	0.7
T04N	277907	630134	0.8
T04S	277909	630088	0.9
T04W	277885	630110	1.2
T05	277860	630480	1.3
T05E	277883	630480	1.1
T05N	277861	630503	1.2
T05S	277861	630457	1.0
T05W	277838	630478	0.8
T06	277746	630796	0.4
T06E	277769	630795	0.6
T06S	277747	630774	0.6
T06W	277725	630795	0.4
T07	278035	631222	1.4
T07E	278059	631224	1.6
T07N	278033	631246	1.6
T07S	278036	631198	1.9
T07W	278011	631221	1.2
T08	277711	631556	1.3
T08E	277733	631555	1.1
T08N	277708	631579	1.2
T08S	277711	631532	0.9
T08W	277688	631555	0.9
T09	277330	630880	0.3
T09E	277352	630878	0.3
T09N	277326	630901	0.1
T09S	277326	630861	0.3
T09W	277301	630878	0.3
T10	276677	629326	0.5
T10E	276694	629325	0.5
T10N	276673	629346	0.4
T10S	276672	629304	0.2
T10W	276651	629325	1.1
T11	276386	629669	0.9
T11E	276406	629667	0.6
T11N	276383	629687	0.6
T11S	276383	629646	0.5
T11W	276363	629668	0.7
T12	276480	630018	1.2

ID	Easting	Northing	Depth (m)
T12E	276497	630018	0.2
T12N	276476	630039	1.1
T12S	276474	629996	1.1
T12W	276454	630017	1.0
T13	276312	630336	0.5
T13E	276330	630333	0.8
T13N	276306	630358	1.0
T13S	276310	630315	0.9
T13W	276286	630334	0.7
T14	276764	630496	0.8
T14E	276787	630496	0.5
T14N	276761	630518	0.7
T14S	276764	630475	0.6
T14W	276740	630494	0.7
T15	276386	630711	0.9
T15E	276406	630709	0.8
T15N	276385	630731	0.8
T15S	276385	630685	0.8
T15W	276361	630712	0.7
T16	276648	631459	0.7
T16E	276665	631459	0.5
T16N	276644	631481	0.8
T16S	276648	631435	0.5
T16W	276624	631457	0.6
T17	277162	631504	1.0
T17E	277180	631503	0.6
T17N	277159	631524	0.8
T17S	277161	631483	1.1
T17W	277137	631505	0.6
T18	277449	631817	0.8
T18E	277468	631816	0.6
T18N	277448	631838	0.5
T18S	277449	631793	0.5
T18W	277424	631819	0.7
T19	276789	631184	0.7
T19E	276809	631182	0.4
T19N	276787	631203	0.8
T19S	276787	631162	0.8
T19W	276764	631182	0.5
T20	277608	631207	0.5
T20E	277626	631205	0.5
T20N	277602	631227	0.4
T20S	277606	631182	0.5
T20W	277583	631203	0.5
T21	276879	630866	0.6
T21E	276897	630866	0.8
T21N	276876	630887	1.0
T21S	276879	630844	1.2
T21W	276854	630865	0.8
T22	278220	630958	0.5
T22E	278240	630957	0.5

ID	Easting	Northing	Depth (m)
T22N	278219	630980	0.4
T22S	278220	630935	0.4
T22W	278199	630959	0.6
TO6N	277745	630819	0.5

Phase 2 Peat Depths

ID	Easting	Northing	Depth (m)
A01	275334	630622	<0.1
A02	275431	630646	<0.1
A03	275524	630683	<0.1
A04	275615	630723	<0.1
A05	275671	630806	<0.1
A06	275761	630850	<0.1
A07	275858	630874	<0.1
A08	276008	630860	<0.1
A09	276059	630771	0.2
A10	276090	630624	<0.1
A11	276100	630475	<0.1
A12	276091	630325	<0.1
A13	276044	630182	<0.1
A14	276074	630035	<0.1
A15	276223	630022	0.3
A16	276373	630015	0.8
A17	276468	63001[illegible]	0.35
A18	276560	629972	0.8
A19	276605	629883	0.7
A21	276645	629687	0.2
A23	276626	629488	0.3
A24	276385	629672	0.6
A25	276440	629755	0.7
A26	276524	629808	0.7
A27	276596	629789	0.3
A28	276163	630213	2.0
A29	276243	630272	0.7
A30	276325	630330	0.5
A31	276401	630394	0.3
A32	276494	630433	0.4
A33	276592	630451	0.45
A34	276690	630473	0.4
A35	276788	630488	0.5
A36	276881	630871	0.6
A37	276783	630848	0.5
A38	276687	630820	1.2
A39	276591	630792	0.7
A40	276499	630754	1.1
A41	276403	630726	0.9
A42	276307	630697	0.9
A43	276232	630631	1.3
A44	276157	630564	0.8
A45	276724	631156	0.2
A46	276779	631239	0.4

ID	Easting	Northing	Depth (m)
A47	276823	631329	0.45
A48	276803	631427	0.65
A49	276729	631494	0.4
A50	276629	631493	0.4
A51	276532	631467	0.5
A52	277175	631516	0.2
A53	277256	631559	0.7
A54	277351	631611	0.45
A55	277345	631801	0.4
A56	277442	631827	0.3
A57	277542	631824	0.3
A58	277591	631655	0.5
A59	277632	631584	1.0
A60	277734	631515	0.8
A61	277732	631433	0.75
A62	277836	631334	0.2
A63	277833	631343	0.9
A64	278018	631350	1.4
A65	277727	631305	<0.1
A66	277651	631240	0.1
A67	277534	631165	<0.1
A68	277522	631087	0.5
A69	277449	631135	0.7
A70	277449	631003	0.3
A71	277338	630882	0.3
A72	277747	631163	0.6
A73	277736	631063	1.0
A75	277731	630864	0.2
A76	277735	630764	0.3
A77	277829	630731	0.3
A78	277921	630769	0.2
A79	278037	630820	0.6
A80	278076	630893	0.5
A81	278136	630973	1.4
A82	278179	631063	0.3
A83	277754	630639	0.5
A84	277832	630551	0.5
A86	277833	630382	0.5
A87	277851	630284	0.4
A88	277836	630188	0.4
A89	277820	630089	0.9
A90	277811	629989	1.1
A91	277828	629891	0.9
A92	277934	629826	0.55
A93	277937	629789	1.6
A94	278031	629754	0.3
A95	278136	629665	0.5
A96	278142	629569	1.0
A97	278177	629713	0.4
A98	278244	629639	0.4
A99	278273	629543	0.3

ID	Easting	Northing	Depth (m)
B01	278302	629447	0.5
B02	278326	629350	0.5
B03	278359	629256	0.6
B04	276333	630251	0.7
B05	276412	630254	1.0
B06	276541	629741	0.5
B07	276555	629668	0.5
B08	278080	629679	1.2
B09	278004	629703	1.3
B10	277827	630369	0.4
B11	277761	630389	<0.1
B12	277817	631187	0.4
B13	277910	631260	1.1
B14	277800	631263	0.7

Von Post Scale of Humification

Symbol	Description
H1	Completely undecomposed peat which, when squeezed, releases almost clear water. Plant remains easily identifiable. No amorphous material present.
H2	Almost entirely undecomposed peat which, when squeezed, releases clear or yellowish water. Plant remains still easily identifiable. No amorphous material present.
H3	Very slightly decomposed peat which, when squeezed, releases muddy brown water, but from which no peat passes between the fingers. Plant remains still identifiable, and no amorphous material present.
H4	Slightly decomposed peat which, when squeezed releases very muddy dark water. No peat is passed between the fingers but the plant remains are slightly pasty and have lost some of their identifiable features.
H5	Moderately decomposed peat which, when squeezed, releases very "muddy" water with a very small amount of amorphous granular peat escaping between the fingers. The structure of the plant remains is quite indistinct although it is still possible to recognize certain features. The residue is very pasty.
H6	Moderately highly decomposed peat with a very indistinct plant structure. When squeezed, about one-third of the peat escapes between the fingers. The residue is very pasty but shows the plant structure more distinctly than before squeezing.
H7	Highly decomposed peat. Contains a lot of amorphous material with very faintly recognizable plant structure. When squeezed, about one-half of the peat escapes between the fingers. The water, if any is released, is very dark and almost pasty.
H8	Very highly decomposed peat with a large quantity of amorphous material and very indistinct plant structure. When squeezed, about two-thirds of the peat escapes between the fingers. A small quantity of pasty water may be released The plant material remaining in the hand consists of residues such as roots and fibres that resist decomposition.

Symbol	Description
H9	Practically fully decomposed peat in which there is hardly any recognizable plant structure. When squeezed it is a fairly uniform paste.
H10	Completely decomposed peat with no discernible plant structure. When squeezed, all the wet peat escapes between the fingers.

Peat Stability Risk Assessment Results

Area A

Influences and Factors	Description	Scoring
Baseline Risk		
Peat Depth	8 peat probes in area – all with depths <0.1m. • The area is dominated by shallow peat (<0.25m).	1
Topography/ Gradient	The topography of the area crosses the line of a ridge running north-west/ south-east from Sclenor Hill. The highest point is 345m Above Ordnance Datum (AOD). The topography slopes down from this peak to a low of 250m adjacent to the A7. • The gradient of the area is dominated by slopes of between 0° - 6° with minor areas of 10° - 14°.	2
Evidence of peat failure	No evidence of existing, historic or incipient peat failure	1
Surface Hydrology	Well drained area with no indications of boggy or standing water. Artificial drainage exists along the track.	1
Baseline Hazard Scale	Dominance of shallow peat depths on well drained slopes with no evidence of instability	1 (Negligible)
Baseline Exposure Scale	Potential to impact on environmentally sensitive watercourses	3 (High)
Baseline Risk Ranking		3 (Insignificant)
Construction Risk		
Construction Elements	Laydown area; Construction compound; and 5.5km of proposed access track including 4.2km upgrading of existing track.	
Construction Hazard Scale	Construction activities occurring in area dominated by shallow peat/peaty soils on uninterrupted slopes Construction activities include: • Access track construction (cut road construction is likely due to dominance of shallow peat); and • Construction activities associated with the construction compound and laydown area. The removal of peat associated with construction activities can reduce stability on the upslope peat mass and alter the surface and sub-surface hydrology. Peat/soil stockpiles can increase the sheer stress on the peat mass and increase the likelihood of failure.	
Construction Exposure Scale	Potential to impact on environmentally sensitive watercourses	
Construction Risk Ranking		3 (Insignificant)

Area B

Influences and Factors	Description	Scoring
Baseline Risk		
Peat Depth	One peat probe in area with a depth of 0.4m. The area has been highly modified and comprises semi-improved neutral and improved grassland pasture.	2
Topography/ Gradient	The topography is dominated by the southern slopes of Meikle Auchinstilloch reaching from 300m to 360m AOD and moderate gradients of 6° – 10°.	3
Evidence of peat failure	No evidence of existing, historic or incipient peat failure	1
Surface Hydrology	A minor stream head and trackside drainage are present with the Galawhistle Burn at the bottom of the slope.	2
Baseline Hazard Scale	Moderate peat depths on rolling terrain	2 (Unlikely)
Baseline Exposure Scale	Potential to impact on environmentally sensitive watercourse	3 (High)
Baseline Risk Ranking		6 (Significant)
Construction Risk		
Construction Elements	Borrow Pit; ScottishPower Substation; Infinis Substation; and 0.53km of proposed access track (all existing track).	
Construction Hazard Scale	Peat in this area is dominated by moderate depths. Construction activities are also occurring on moderate slopes.. Construction activities include: • Access track construction (an existing track exists, which will be upgraded); and • Construction activities associated with one borrow pit and two substation areas. The removal of peat associated with construction activities can reduce stability on the upslope peat mass and alter the surface and sub-surface hydrology.	
Construction Exposure Scale	Potential to impact on environmentally sensitive watercourse and disrupt construction activities	
Construction Risk Ranking		6 (Significant)

Area C

Influences and Factors	Description	Scoring
Baseline Risk		
Peat Depth	23 peat probes carried out, with the recorded peat depths from 0.2m to 1m, with the shallowest peat depths recorded along the access track. 17 of the probes were in moderate peat (0.25 – 0.75m) with five in deep peat.	2
Topography/ Gradient	The topography of this area is determined by the lower slopes of Meikle Auchinstilloch, running down to the Galawhistle Burn. Slope angles are dominated by moderate slopes (6°-10°) with some areas of steep areas nearby to Turbine 16.	4
Evidence of peat failure	No evidence of existing, historic or incipient peat failure.	1
Surface Hydrology	Blanket bog present in areas with headwaters present.	3
Baseline Hazard Scale	Moderate and shallow peat depths in area with steep slopes.	3 (Likely)
Baseline Exposure Scale	Potential to impact on environmentally sensitive watercourses.	3 (High)
Baseline Risk Ranking		9 (Significant)
Construction Risk		
Construction Elements	Turbines 16 and 19 1.3km access track including 0.5km upgrade of existing track.	
Construction Hazard Scale	Topography of Area C is moderate to steep sloping ground, with varying peat depths. Construction activities will occur in areas with moderate peat depth and Turbine 16 is on steep sloping ground. Turbine 19 is on moderate to deep peat and shallow gradient. Construction activities include: • Access track construction (cut road construction is likely due to the presence of peat <1m); and • Construction activities associated with two turbines. The removal of peat associated with construction activities can reduce stability on the upslope peat mass and alter the surface and sub-surface hydrology. Peat/soil stockpiles can increase the sheer stress on the peat mass and increase the likelihood of failure.	
Construction Exposure Scale	Potential to impact on environmentally sensitive watercourse and disrupt construction activities	
Construction Risk Ranking		9 (Significant)

Area D

Influences and Factors	Description	Scoring
Baseline Risk		
Peat Depth	A total of 20 peat probes were carried out in this area. These varied between 0.2m and 1.3m with 14 probes identifying moderate peat depths (0.25m – 0;75m) and 6 classified as deep (0.75 – 1.5m).	2
Topography/ Gradient	The topography is dominantly on moderate slopes (6°-10°), with some shallow areas upslope, downslope and in the vicinity of Turbine 17.	3
Evidence of peat failure	No evidence of existing, historic or incipient peat failure.	1
Surface Hydrology	Boggy ground with wet heath and blanket bog predominant in the area. The headwaters of the Monks Water run through the downslope extent of the area.	3
Baseline Hazard Scale	Dominance of moderate peat on sloping terrain.	**2 (Unlikely)**
Baseline Exposure Scale	Potential to impact on environmentally sensitive watercourse.	3 (High)
Baseline Risk Ranking		**6 (Significant)**
Construction Risk		
Construction Elements	Two turbines (17 and 18); and 1.3km of proposed access track including 0.6km of upgrade to existing track..	
Construction Hazard Scale	Topography of Area D is rolling, with varying peat depths. However, construction activities will occur in an area with moderate slope. Turbine 18 and associated access crosses well drained acid grassland and Turbine 17 is located on moderate peat. Construction activities include: • Access track construction; and • Construction activities associated with turbines and access track. The removal of peat associated with construction activities can reduce stability on the upslope peat mass and alter the surface and sub-surface hydrology. Peat/soil stockpiles can increase the sheer stress on the peat mass and increase the likelihood of failure. Volume and location of construction activities are unlikely to significantly alter the baseline hazard	**2 (Unlikely)**
Construction Exposure Scale	Potential to impact on environmentally sensitive watercourse and disrupt construction activities	3 (High)
Construction Risk Ranking		**6 (Significant)**

Area E

Influences and Factors	Description	Scoring
Baseline Risk		
Peat Depth	A total of 19 peat probes were carried out in this area. These ranged from <0.1m to 1.4m, with the majority (13) being in deep peat (0.75m – 1.5m)	3
Topography/ Gradient	Topography across the selected area was dominated by shallow gradients (2°-6°) gradients with areas of flat ground (0°-2°) on the lower slopes of Hareshaw Hill in the north.	2
Evidence of peat failure	No evidence of existing, historic or incipient peat failure.	1
Surface Hydrology	Predominantly boggy ground with flushes, the Galawhistle Burn and one of its headland tributaries.	3
Baseline Hazard Scale	Moderate peat deposits on terrain that has shallow gradients, with boggy habitat and flushes.	2 (Unlikely)
Baseline Exposure Scale	Potential to impact on environmentally sensitive headwaters and watercourses.	3 (High)
Baseline Risk Ranking		**6 (Significant)**
Construction Risk		
Construction Elements	Turbine 15 and 21; and 0.7km of new access track.	
Construction Hazard Scale	Construction activities are occurring in areas of moderate peat depths, shallow gradients and boggy ground. Construction activities include: • Access track construction (cut road construction is likely due to dominance of moderate peat); and • Construction activities associated with two turbines. The removal of peat associated with construction activities can reduce stability on the upslope peat mass and alter the surface and sub-surface hydrology. Peat/soil stockpiles can increase the sheer stress on the peat mass and increase the likelihood of failure.	
Construction Exposure Scale	Potential to impact on environmentally sensitive watercourses and disrupt construction activities.	
Construction Risk Ranking		6 (Significant)

Area F

Influences and Factors	Description	Scoring
Baseline Risk		
Peat Depth	A total of 27 peat probes were carried out in this area. • 12 of these recorded peat depths within the moderate peat depth category (0.25m – 0.75m) • 11 of these recorded peat depths within the deep peat depth category (0.75m – 1.5m); and • 2 peat probes fall within the very deep peat depth category (>1.5m). The assessment assumes that peat in this area is dominated by moderate depths.	3
Topography/ Gradient	The topography of the area is dominantly moderate (6°-10°) gradients with one small area of steep (10°-14°).	3
Evidence of peat failure	No evidence of existing, historic or incipient peat failure.	1
Surface Hydrology	There are no watercourses within the area, although there are a number of artificial drainage channels some of which have formed flush habitat in the west, adjacent to the opencast. The area is dominated by blanket bog habitat.	4
Baseline Hazard Scale	Dominance of moderate peat on rolling terrain, with artificial drainage channels.	3 (Likely)
Baseline Exposure Scale	Potential to impact on environmentally sensitive watercourses.	3 (High)
Baseline Risk Ranking		**9 (Significant)**
Construction Risk		
Construction Elements	Turbines 15 and 13; and 1.5km of proposed new access track.	
Construction Hazard Scale	Construction activities in areas of moderate peat depths, moderate gradients and artificial drainage; Construction activities include: • Access track construction; and • Construction activities associated with turbine areas. The removal of peat associated with construction activities can reduce stability on the upslope peat mass and alter the surface and sub-surface hydrology. Peat/soil stockpiles can increase the sheer stress on the peat mass and increase the likelihood of failure.	
Construction Exposure Scale	Potential to impact on environmentally sensitive watercourses and disrupt construction activities.	
Construction Risk Ranking		**9 (Significant)**

Area G

Influences and Factors	Description	Scoring
Baseline Risk		
Peat Depth	35 peat probes in this area • 4 probes recorded shallow peat depths <0.25m; • 13 probes recorded moderate peat depths (0.25m – 0.75m); • 12 probes recorded deep peat depths (0.75m – 1.5m); and • 1 probes with a depth of 2m, in very deep peat. The area is dominated by moderate to deep peat depths.	3
Topography/ Gradient	The topography of this area is dominated by the north and west slopes of Hareshaw Hill. The gradient generally ranges from moderate (6°-10°) through to very steep (>14°) with small areas where the turbines will be sited being shallow ground (2°-6°). The site is dominated by a steep gradient.	4
Evidence of peat failure	No evidence of existing, historic or incipient peat failure.	1
Surface Hydrology	The site investigation established that several artificial drainage ditches have been installed on the west facing slopes of Hareshaw Hill. The area is dominated by marshy grassland with blanket bog habitat also present.	4
Baseline Hazard Scale	Moderate peat depths on steep and very steep gradients in a well drained area with areas of artificial drainage.	3 (Likely)
Baseline Exposure Scale	Potential to impact on environmentally sensitive watercourses.	3 (High)
Baseline Risk Ranking		9 (Significant)
Construction Risk		
Construction Elements	Turbines 11, 12 and 13; Metmast; Borrow pit; and 1.7km of proposed new access track.	
Construction Hazard Scale	Construction activities in areas of moderate peat depths, steep, well drained gradients with extensive evidence of artificial drainage. Construction activities include • Access track construction; and • Construction activities associated with borrow pit and three turbines. The removal of peat associated with construction activities can reduce stability on the upslope peat mass and alter the surface and sub-surface hydrology. Peat/soil stockpiles can increase the sheer stress on the peat mass and increase the likelihood of failure.	
Construction Exposure Scale	Potential to impact on environmentally sensitive watercourses and disrupt construction activities.	
Construction Risk Ranking		9 (Significant)

Area H

Influences and Factors	Description	Scoring
Baseline Risk		
Peat Depth	18 peat probes were recorded in this area: • 3 probes recorded shallow peat depths <0.25m; • 9 probes recorded moderate peat depths (0.25m – 0.75m) and • 6 probes recorded deep peat depths (0.75m – 1.5m). The area is dominated by moderate peat depths.	2
Topography/Gradient	The gradient in this area ranges from 2° to >14°, with the dominant gradient being steep 10°-14°.	4
Evidence of peat failure	No evidence of existing, historic or incipient peat failure.	1
Surface Hydrology	The lower slopes of the area appear to be well drained, although there are areas of boggy ground and flushes present.	4
Baseline Hazard Scale	Moderate peat depths on steep slopes with artificial drainage.	3 (Likely)
Baseline Exposure Scale	Potential to impact on environmentally sensitive watercourses.	3 (High)
Baseline Risk Ranking		**9 (Significant)**
Construction Risk		
Construction Elements	Turbines 12 and 14; and 0.2km of proposed new access track.	
Construction Hazard Scale	Construction activities in areas of moderate peat depths on moderate, well drained gradients with no evidence of artificial drainage nearby construction sites. Construction activities include • Construction of turbines 3 and 5; and • Access track construction. The removal of peat associated with construction activities can reduce stability on the upslope peat mass and alter the surface and sub-surface hydrology. Peat/soil stockpiles can increase the sheer stress on the peat mass and increase the likelihood of failure.	
Construction Exposure Scale	Potential to impact on environmentally sensitive watercourses and disrupt construction activities.	
Construction Risk Ranking		**9 (Significant)**

Area I

Influences and Factors	Description	Scoring
Baseline Risk		
Peat Depth	23 peat probes were undertaken in this area: • 14 probes recorded moderate peat depths (0.25m – 0.75m); • 3 probes recorded deep peat depths (0.75m – 1.5m); and • 3 probes recorded very deep peat (>1.5m). The site is dominated by moderate to deep peat depths.	2
Topography/ Gradient	The site is dominated by the rolling hillside of Hareshaw Hill, with gradients varying from shallow (2°-6°) to very steep (>14°) in some areas, although the site is dominated by a steep gradient (10°-14°).	4
Evidence of peat failure	No evidence of existing, historic or incipient peat failure.	1
Surface Hydrology	Wet heathland habitat on the upper slopes with flushes associated with headwaters feeding the Monks Water present.	2
Baseline Hazard Scale	Shallow to moderate peat depths on steep gradients with some very steep areas and headwaters with associated flushes extending through the site.	2 (Unlikely)
Baseline Exposure Scale	Potential to impact on environmentally sensitive watercourses.	3 (High)
Baseline Risk Ranking		6 (Significant)
Construction Risk		
Construction Elements	Turbine 10; Borrow pit; and 0.9km of proposed new access track.	
Construction Hazard Scale	Area is dominated by moderate peat depths with construction activities on steep and very steep, well drained slopes. Construction activities include • Activities associated with the construction of one turbine and a borrow pit; and • Access track construction. The removal of peat associated with construction activities can reduce stability on the upslope peat mass and alter the surface and sub-surface hydrology. Peat/soil stockpiles can increase the sheer stress on the peat mass and increase the likelihood of failure.	
Construction Exposure Scale	Potential to impact on environmentally sensitive watercourses and disrupt construction activities.	
Construction Risk Ranking		6 (Significant)

Area J

Influences and Factors	Description	Scoring
Baseline Risk		
Peat Depth	2 Peat probes were carried out in this area, both recording peat depths of 0.5m.	2
Topography/ Gradient	Steep gradients dominate this area with some moderate slopes present.	4
Evidence of peat failure	No evidence of existing, historic or incipient peat failure.	1
Surface Hydrology	Wet heathland habitat with flushes present along headwaters feeding into the Monks Burn.	2
Baseline Hazard Scale	Moderate peat depths on steep gradients with no evidence of historic slumping.	2 (Unlikely)
Baseline Exposure Scale	Potential to impact on environmentally sensitive watercourses.	3 (High)
Baseline Risk Ranking		6 (Significant)
Construction Risk		
Construction Elements	No works proposed in this area	
Construction Hazard Scale	NA	
Construction Exposure Scale	NA	
Construction Risk Ranking		NA

Area K

Influences and Factors	Description	Scoring
Baseline Risk		
Peat Depth	2 peat probes were undertaken in this area, recording peat depths of 0.5 and 0.6m.	2
Topography/ Gradient	The site is dominated by the rolling northern slopes of Strawberry Hill with shallow gradients (2°-6°) near the summit and very steep slopes (>14°) down to the Monks Water.	3
Evidence of peat failure	No evidence of existing, historic or incipient peat failure.	1
Surface Hydrology	In areas of the saddle between Strawberry Hill and Arrarat wet marshy grassland surrounds a headwater which feeds into the Monks Water. Blanket bog habitat exists in the south of the site.	3
Baseline Hazard Scale	Moderate peat depths on shallow to very steep gradients and headwaters with associated marshy grassland.	2 (Unlikely)
Baseline Exposure Scale	Potential to impact on environmentally sensitive watercourses.	3 (High)
Baseline Risk Ranking		6 (Significant)
Construction Risk		
Construction Elements	Turbine 1;and 0.2km of proposed new access track.	
Construction Hazard Scale	Area is dominated by moderate peat depths with construction activities on shallow, marshy slopes. Construction activities include • Activities associated with the construction of one turbine; and • Access track construction. The removal of peat associated with construction activities can reduce stability on the upslope peat mass and alter the surface and sub-surface hydrology. Peat/soil stockpiles can increase the sheer stress on the peat mass and increase the likelihood of failure.	
Construction Exposure Scale	Potential to impact on environmentally sensitive watercourses and disrupt construction activities.	
Construction Risk Ranking		6 (Significant)

Area L

Influences and Factors	Description	Scoring
Baseline Risk		
Peat Depth	5 peat probes were undertaken in this area, recording peat depths of 0.2, 0.3, 0.5, 0.6 and 0.5m.	2
Topography/ Gradient	The site is dominated by the steep western slopes of Arrarat Hill with very steep gradients (>14°) down to the Monks Water.	5
Evidence of peat failure	No evidence of existing, historic or incipient peat failure.	5
Surface Hydrology	The main slopes of the area are well drained acid grassland, with some flushes draining the hillside. Boggy areas are present near the summit.	2
Baseline Hazard Scale	Moderate peat depths on very steep gradients with flushes present in several areas.	[illegible]
Baseline Exposure Scale	Potential to impact on environmentally sensitive watercourses.	3 (High)
Baseline Risk Ranking		12 (Substantial)
Construction Risk		
Construction Elements	0.1km of proposed new access track. Turbine 2	
Construction Hazard Scale	Area is dominated by moderate peat depths with construction activities on shallow, well drained slopes. Construction activities include • Activities associated with the construction of one turbine; and • Access track construction. The removal of peat associated with construction activities can reduce stability on the upslope peat mass and alter the surface and sub-surface hydrology. Peat/soil stockpiles can increase the sheer stress on the peat mass and increase the likelihood of failure. The turbine location will be micr

osited up the slope into Area N if areas of unstable ground are dentified within 50m of the proposed location. | **2 (Unlikely)** |
| Construction Exposure Scale | Potential to impact on environmentally sensitive watercourses and disrupt construction activities. | 3 (High) |
| ***Construction Risk Ranking***
Due to the extent and location of works Construction Risk Ranking is assessed to be significant before mitigation is included. | | **6 (Significant)** |

Area M

Influences and Factors	Description	Scoring
Baseline Risk		
Peat Depth	2 peat probes were undertaken in this area, recording peat depths of 0.6m and 0.9m.	2
Topography/ Gradient	The site is located on the peak of Arraral Hill at 428m AOD and with shallow gradients (2°-6°).	2
Evidence of peat failure	No evidence of existing, historic or incipient peat failure.	1
Surface Hydrology	The area is on blanket bog with no drainage noted.	3
Baseline Hazard Scale	Moderate peat depths on shallow gradients.	2 (Unlikely)
Baseline Exposure Scale	Potential to impact on environmentally sensitive watercourses.	3 (High)
Baseline Risk Ranking		6 (Significant)
Construction Risk		
Construction Elements	Turbine 3;and 0.3km of proposed new access track.	
Construction Hazard Scale	Area is dominated by moderate peat depths with construction activities on shallow slopes. Construction activities include • Activities associated with the construction of one turbine; and • Access track construction. The removal of peat associated with construction activities can reduce stability on the upslope peat mass and alter the surface and sub-surface hydrology. Peat/soil stockpiles can increase the sheer stress on the peat mass and increase the likelihood of failure.	
Construction Exposure Scale	Potential to impact on environmentally sensitive watercourses and disrupt construction activities.	
Construction Risk Ranking		6 (Significant)

Area N

Influences and Factors	Description	Scoring
Baseline Risk		
Peat Depth	20 peat probes were undertaken in this area; • 8 probes recorded moderate peat (0.25m – 0.75m); • 11 probes recorded deep peat (0.75m – 1.5m); and • 1 probe recorded very deep peat (>1.5m). The area is dominated by deep peat depths.	3
Topography/ Gradient	The area is located on the eastern slopes of Arrarat Hill with shallow gradients (2°-6°) near the ridge and steep slopes (10°-14°) down to the Podowrin Burn.	4
Evidence of peat failure	No evidence of existing, historic or incipient peat failure.	1
Surface Hydrology	The area overlies blanket bog and dry heath with evidence of artificial drainage noted.	4
Baseline Hazard Scale	Moderate peat depths on steep slopes of blanket bog.	3 (Likely)
Baseline Exposure Scale	Potential to impact on environmentally sensitive watercourses.	3 (High)
Baseline Risk Ranking		9 (Significant)
Construction Risk		
Construction Elements	Turbine 2 and 5;and 1.1km of proposed new access track.	
Construction Hazard Scale	Area is dominated by moderate peat depths with turbine construction activities on shallow slopes, although track construction crosses steep slopes of moderate peat. Construction activities include • Activities associated with the construction of two turbines; and • Access track construction. The removal of peat associated with construction activities can reduce stability on the upslope peat mass and alter the surface and sub-surface hydrology. Peat/soil stockpiles can increase the sheer stress on the peat mass and increase the likelihood of failure.	
Construction Exposure Scale	Potential to impact on environmentally sensitive watercourses and disrupt construction activities.	
Construction Risk Ranking		9 (Significant)

Area O

Influences and Factors	Description	Scoring
Baseline Risk		
Peat Depth	20 peat probes were undertaken in this area; • 11 probes recorded moderate peat (0.25m – 0.75m); and • 8 probes recorded deep peat (0.75m – 1.5m). The area is dominated by moderate to deep peat depths.	3
Topography/ Gradient	The area is located on the southern slopes of Wedder Hill with shallow gradients (2°-6°) near the ridge and moderate slopes (6°-10°) down to the Podowrin Burn.	3
Evidence of peat failure	No evidence of existing, historic or incipient peat failure.	1
Surface Hydrology	The area overlies blanket bog and wet heath with no drainage noted. The headwaters of the Podowrin Burn are at the eastern edge of the area.	3
Baseline Hazard Scale	Moderate peat depths on moderate slopes of blanket bog.	3 (Likely)
Baseline Exposure Scale	Potential to impact on environmentally sensitive watercourses.	3 (High)
Baseline Risk Ranking		9 (Significant)
Construction Risk		
Construction Elements	Turbine 22 and 5;and 0.7km of proposed new access track.	
Construction Hazard Scale	Area is dominated by moderate peat depths with construction activities on shallow slopes. Turbine 22 is on moderate peat and turbine 5 is on deep peat. Construction activities include • Activities associated with the construction of one turbine; and • Access track construction. The removal of peat associated with construction activities can reduce stability on the upslope peat mass and alter the surface and sub-surface hydrology. Peat/soil stockpiles can increase the sheer stress on the peat mass and increase the likelihood of failure.	
Construction Exposure Scale	Potential to impact on environmentally sensitive watercourses and disrupt construction activities.	
Construction Risk Ranking		9 (Significant)

Area P

Influences and Factors	Description	Scoring
Baseline Risk		
Peat Depth	6 peat probes were undertaken in this area; • 4 probes recorded moderate peat (0.25m – 0.75); and • 1 probe recorded deep peat (>1.5m) The area is dominated by moderate peat depths.	2
Topography/ Gradient	The area is located on the south-western slopes of Wedder Hill with very steep gradients (>14°) near the ridge and steep slopes (10°-14°) down to the Monks Water.	5
Evidence of peat failure	No evidence of existing, historic or incipient peat failure.	1
Surface Hydrology	The area is generally well drained dry heath, with two headwaters feeding into the Monks Water. The ridge is overlain with blanket bog.	3
Baseline Hazard Scale	Moderate peat depths on very steep slopes with some areas of blanket bog and two headwaters of the Mons Water..	3 (Likely)
Baseline Exposure Scale	Potential to impact on environmentally sensitive watercourses.	3 (High)
Baseline Risk Ranking		9 (Significant)
Construction Risk		
Construction Elements	Turbine 5;and 0.4km of proposed new access track	
Construction Hazard Scale	Area is dominated by moderate peat depths with construction activities on steep slopes. Construction activities include • Activities associated with the construction of one turbine; and • Access track construction. The removal of peat associated with construction activities can reduce stability on the upslope peat mass and alter the surface and sub-surface hydrology. Peat/soil stockpiles can increase the sheer stress on the peat mass and increase the likelihood of failure.	
Construction Exposure Scale	Potential to impact on environmentally sensitive watercourses and disrupt construction activities.	
Construction Risk Ranking		9 (Significant)

Area Q

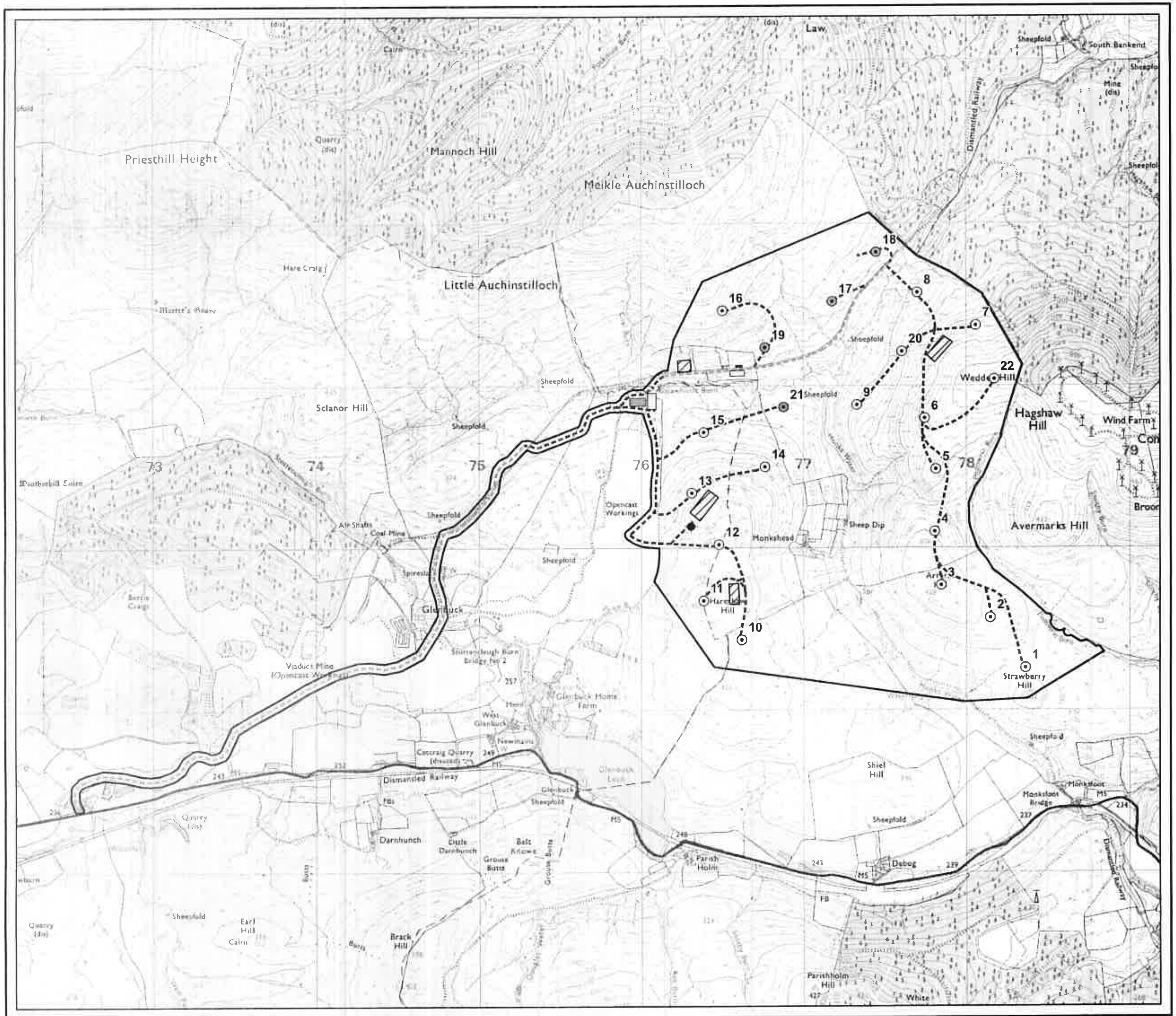
Influences and Factors	Description	Scoring
Baseline Risk		
Peat Depth	8 peat probes were undertaken in this area; • 4 probes recorded moderate peat (0.25m – 0.75m); and • 3 probes recorded deep peat (>1.5m); • The area is dominated by moderate to deep peat depths.	3
Topography/ Gradient	The area is located on the northern slopes of Wedder Hill and is dominated with moderate gradients (6°-10°) with some shallow (2°-6°) and steep slopes (10°-14°) present.	3
Evidence of peat failure	No evidence of existing, historic or incipient peat failure.	1
Surface Hydrology	The area is overlain with blanket bog with flushes present feeding the headwaters of the Monks Water. Artificial drainage exists around the flush habitat.	4
Baseline Hazard Scale	Moderate peat depths on moderate slopes dominated by blanket bog with flushes feeding into the Monks Water.	3 (Likely)
Baseline Exposure Scale	Potential to impact on environmentally sensitive watercourses.	3 (High)
Baseline Risk Ranking		9 (Significant)
Construction Risk		
Construction Elements	Turbine 7;and C.1km of proposed new access track.	
Construction Hazard Scale	Area is dominated by moderate peat depths with construction activities on steep slopes. Construction activities include • Activities associated with the construction of one turbine; and • Access track construction. The removal of peat associated with construction activities can reduce stability on the upslope peat mass and alter the surface and sub-surface hydrology. Peat/soil stockpiles can increase the sheer stress on the peat mass and increase the likelihood of failure.	
Construction Exposure Scale	Potential to impact on environmentally sensitive watercourses and disrupt construction activities.	
Construction Risk Ranking		9 (Significant)

Area R

Influences and Factors	Description	Scoring
Baseline Risk		
Peat Depth	39 peat probes were undertaken in this area; • 7 probes recorded shallow peat (<0.25m); • 28 probes recorded moderate peat (0.25m – 0.75m); and • 4 probes recorded deep peat (C.75m – 1.5m). The area is dominated by moderate peat depths.	2
Topography/ Gradient	The area is located on the lower western slopes of Wedder Hill and is dominated with moderate gradients (6°-10°) with areas of steep slopes (10°-14°) also present.	4
Evidence of peat failure	No evidence of existing, historic or incipient peat failure.	1
Surface Hydrology	The area mainly comprises well drained grassland with some areas of wet heath and blanket bog. Several flushes are present on the hillside, feeding down to the Monks Water. Evidence of artificial drainage was recorded.	4
Baseline Hazard Scale	Moderate peat depths on moderate to steep slopes dominated by wet heathland with flushes feeding into the Monks Water.	3 (Likely)
Baseline Exposure Scale	Potential to impact on environmentally sensitive watercourses.	3 (High)
Baseline Risk Ranking		**9 (Significant)**
Construction Risk		
Construction Elements	Turbine 6, 9 and 20; Borrow pit; and 1.7km of proposed new access track.	
Construction Hazard Scale	Area is dominated by shallow to moderate peat depths with turbines on moderate peat. Construction activities include • Activities associated with the construction of three turbines and one borrow pit; and • Access track construction. The removal of peat associated with construction activities can reduce stability on the upslope peat mass and alter the surface and sub-surface hydrology. Peat/soil stockpiles can increase the sheer stress on the peat mass and increase the likelihood of failure.	
Construction Exposure Scale	Potential to impact on environmentally sensitive watercourses and disrupt construction activities.	
Construction Risk Ranking		**9 (Significant)**

Area S

Influences and Factors	Description	Scoring
Baseline Risk		
Peat Depth	13 peat probes were undertaken in this area; • 3 probes recorded moderate peat (0.25m – 0.75m); and • 9 probes recorded deep peat (0.75m – 1.5m): The area is dominated by deep peat depths.	3
Topography/ Gradient	The area is located on the lower northern slopes of Wedder Hill and is dominated with moderate gradients (6°-10°) with some areas of steep slopes (10°-14°) and shallow slopes (2°-6°) also present.	3
Evidence of peat failure	No evidence of existing, historic or incipient peat failure.	1
Surface Hydrology	The area mainly comprises blanket bog with several flushes around headwaters of the Monks Water. Evidence of artificial drainage present.	4
Baseline Hazard Scale	Moderate peat depths on moderate to steep slopes dominated by blanket bog with flushes feeding into the Monks Water.	3 (Likely)
Baseline Exposure Scale	Potential to impact on environmentally sensitive watercourses.	3 (High)
Baseline Risk Ranking		9 (Significant)
Construction Risk		
Construction Elements	Turbine 8; and 0.7km of proposed new access track.	
Construction Hazard Scale	Area is dominated by deep peat depths with construction activities on moderate slopes, although a small section of access track is on steep slopes. Construction activities include • Activities associated with the construction of one turbine; and • Access track construction. The removal of peat associated with construction activities can reduce stability on the upslope peat mass and alter the surface and sub-surface hydrology. Peat/soil stockpiles can increase the sheer stress on the peat mass and increase the likelihood of failure.	
Construction Exposure Scale	Potential to impact on environmentally sensitive watercourses and disrupt construction activities.	
Construction Risk Ranking		**9 (Significant)**



Key

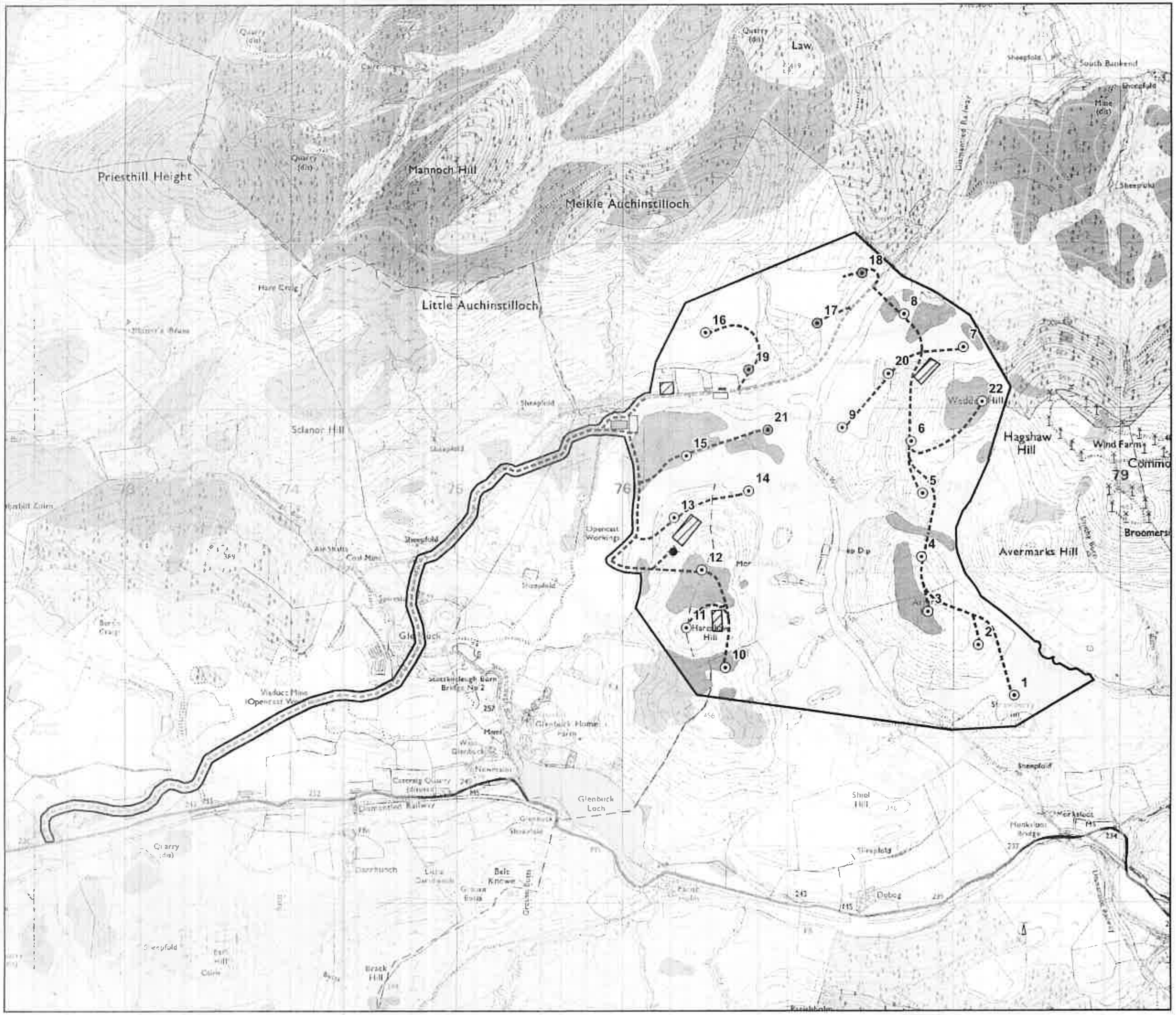
- Site Boundary
- **Turbine Layout**
- **Hub Height (m)**
  - 69
  - 80
- **Access Tracks**
  - Existing
  - New
- Laydown Area
- Construction Compound
- Infinis Substation
- ScottishPower Substation
- Permanent Met Mast
- Borrow Pit

Site Layout

Figure 1

Galawhistle Wind Farm Technical Appendix X

<<SGP5889>> <<Infinis Galawhistle>> <<J:\SGP 5889 Infinis Galawhistle\GIS\MXD files\PER\SGP5889_Fig1_SiteLayout>>



infinis

RPS

Key

Site Boundary

Turbine Layout

Hub Height (m)

69

80

Access Tracks

Existing

New

Infinis Substation

Laydown Area

Construction Compound

ScottishPower Substation

Permanent Met Mast

Borrow Pit

Superficial Geology

Alluvium

Glaciofluvial Deposits

Peat

Till, Devensian

Scale 1:22,000 @ A3

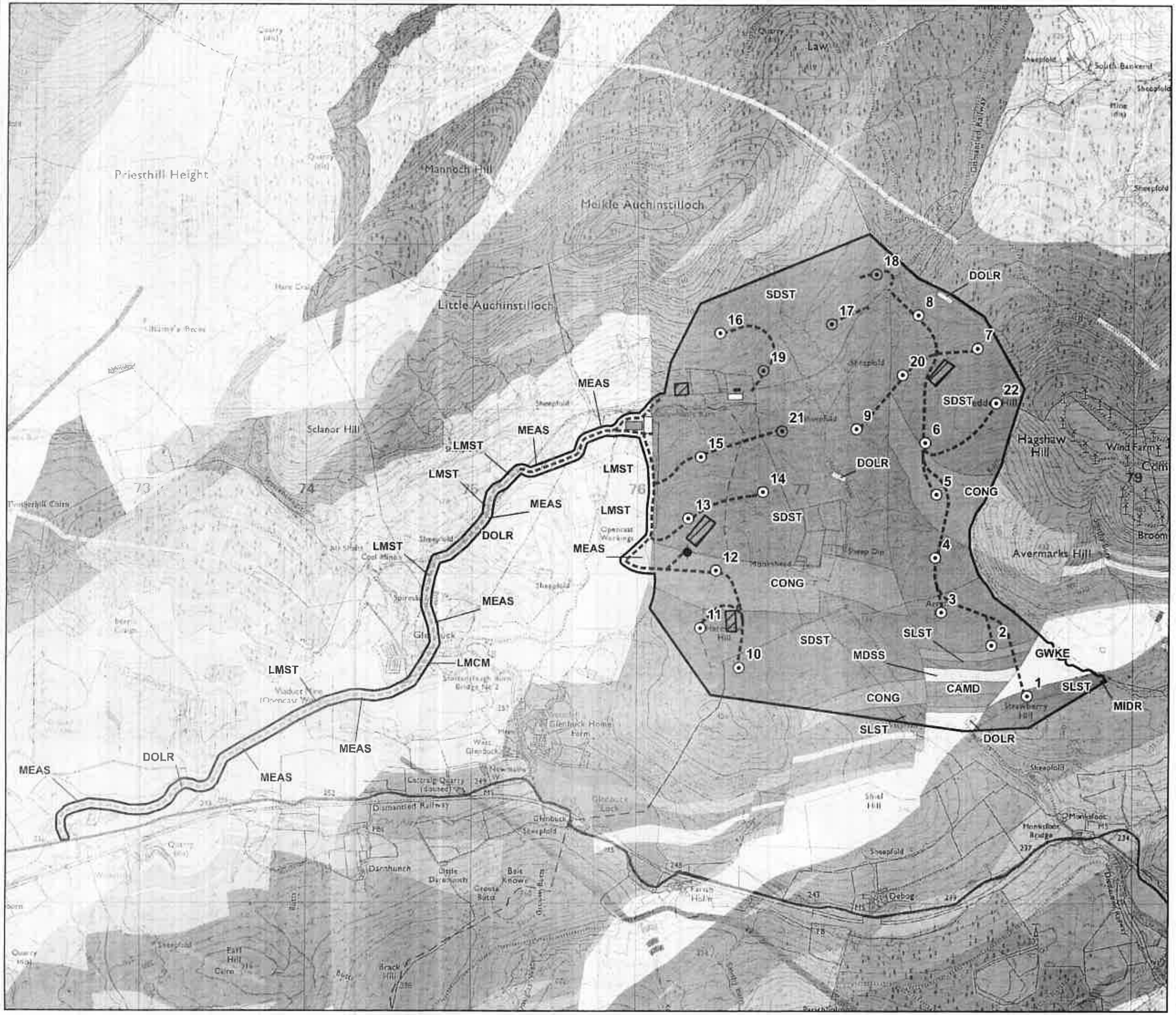
0 0.2 0.4 0.8 km

N

Superficial Geology

Figure 2

Galawhistle Wind Farm
Technical Appendix X



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RPS

Key

- Site Boundary

Turbine Layout

Hub Height (m)

- 69
- 80

Access Tracks

- Existing
- New
- Laydown Area
- Construction Compound
- Infinis Substation
- ScottishPower Substation
- Permanent Met Mast
- Borrow Pit

Solid Geology

- Dolerite (DOLR)
- Limestone (LMST)
- Limestone, Mudstone and Calcareous Mudstone (LMCM)
- Undivided Cyclic Sedimentary Rocks (MEAS)
- Microdioritic-Rock (MIDR)
- Calcareous Mudstone (CAMD)
- Conglomerate (CONG)
- Greywacke (GWKE)
- Mudstone, Siltstone and Sandstone (MDSS)
- Sandstone (SDST)
- Siltstone (SLST)

Scale 1:22,000 @ A3

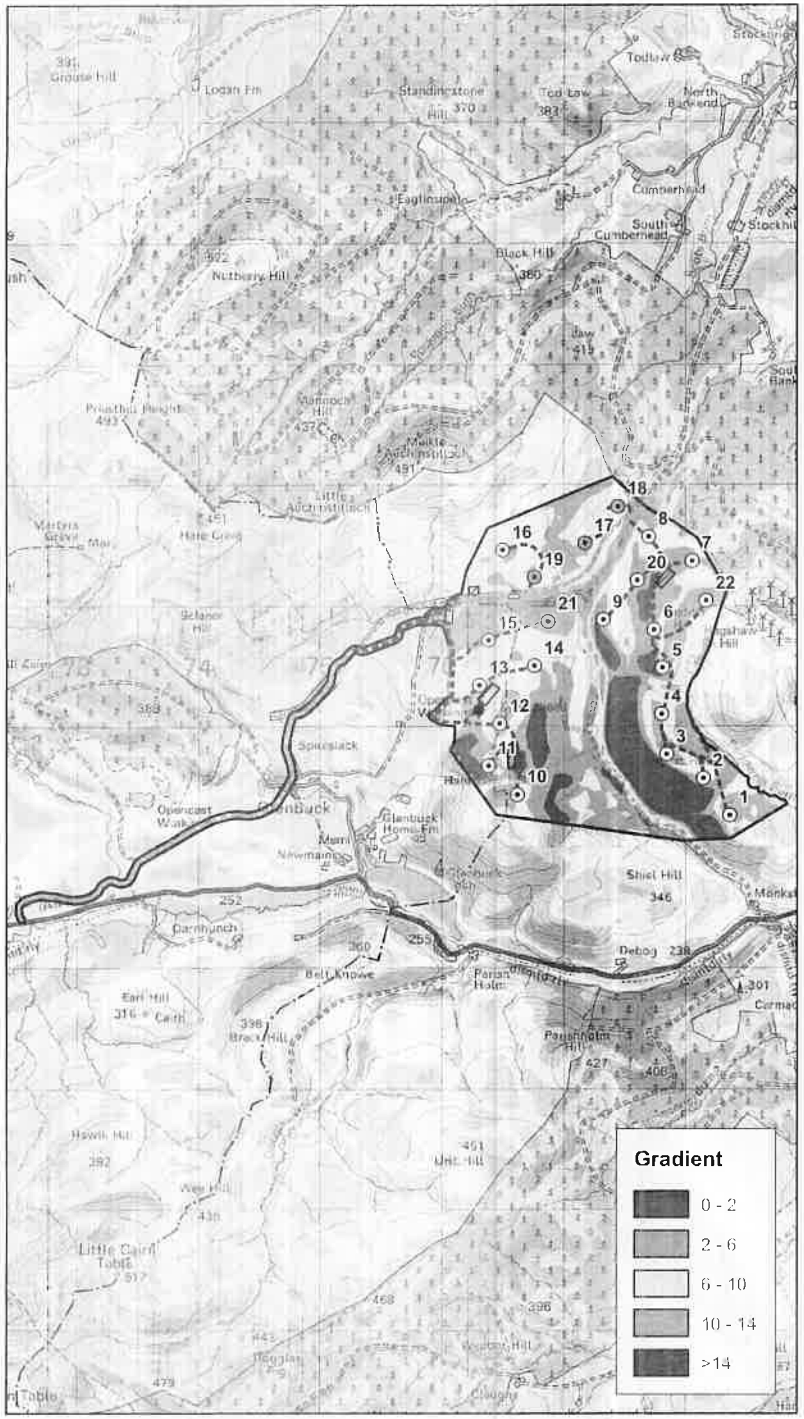
0 0.2 0.4 0.8 km

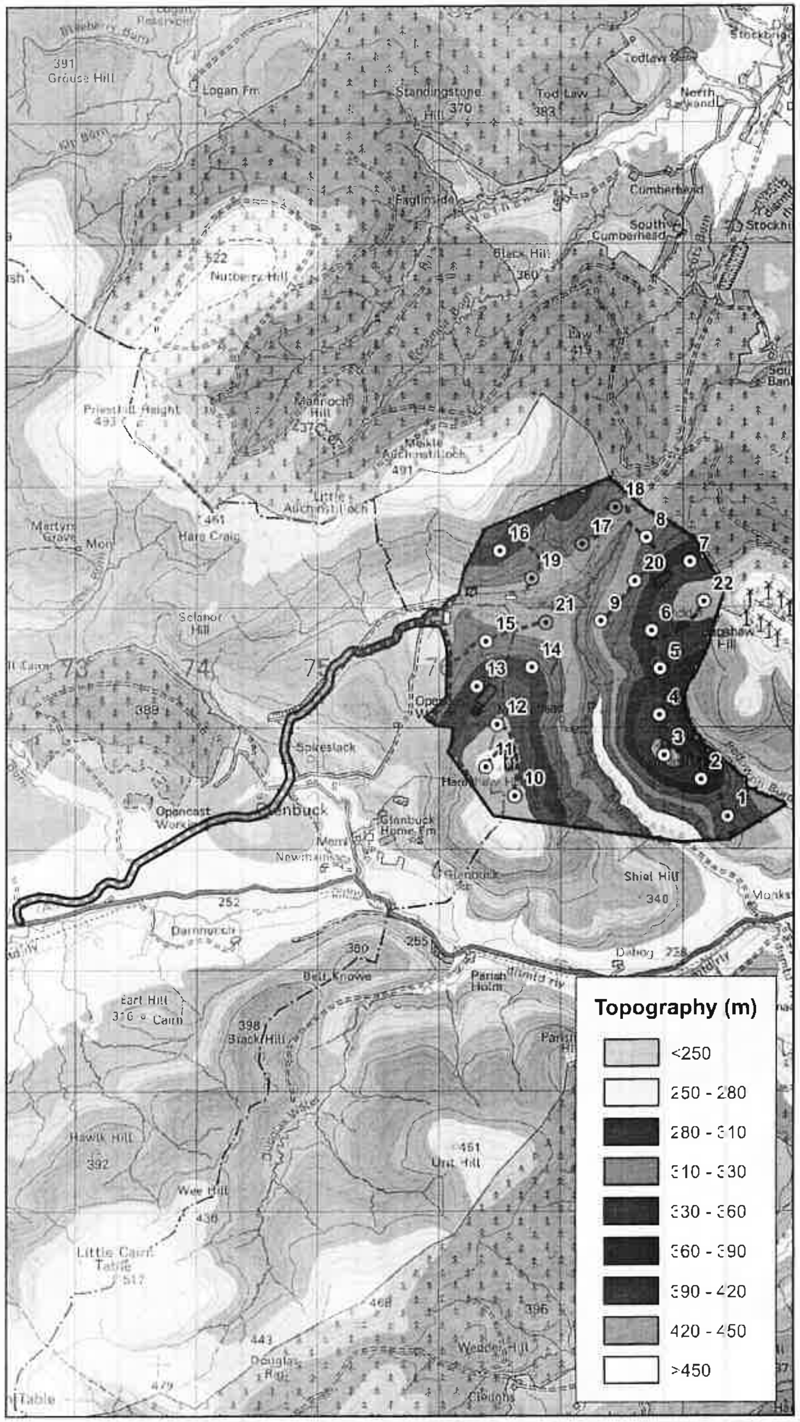
N

Solid Geology

Figure 3

Galawhistle Wind Farm
Technical Appendix X





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Key

Site Boundary

Turbine Layout

Hub Height (m)

69

80

Access Tracks

Existing

New

Laydown Area

Construction Compound

Infinis Substation

ScottishPower Substation

Permanent Met Mast

Borrow Pit

Scale 1:42,000 @ A3

0 0.45 0.9 1.8 km

N

Topography and Gradient

Figure 4

Galawhistle Wind Farm
Technical Appendix X

infinis RPS

Key

Site Boundary

Aerial Photography Interpretation Locations

Scale 1:12,375 @ A3

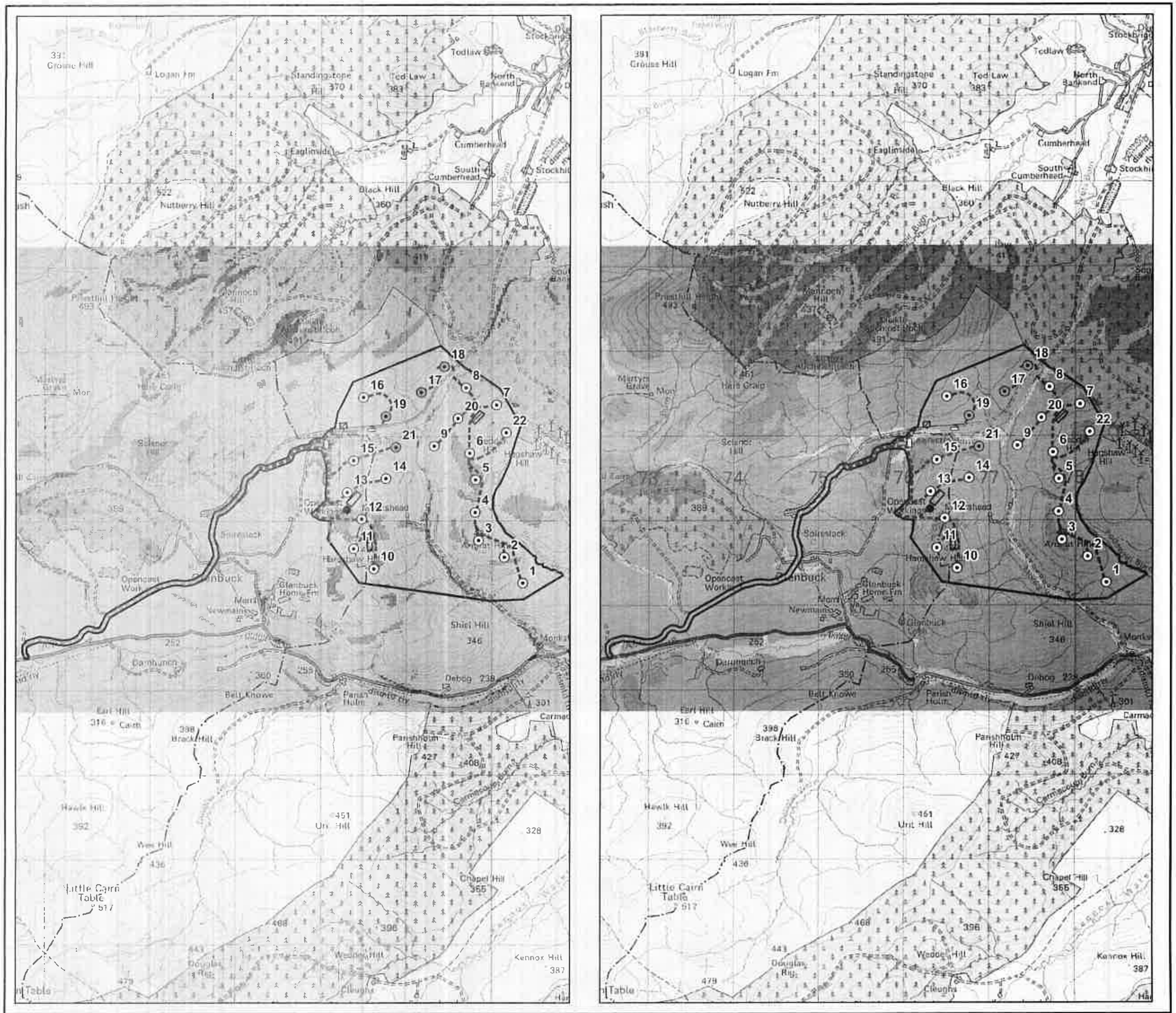
0 0.125 0.25 0.5 km

N

Aerial Photography Interpretation

Figure 5

Galawhistle Wind Farm Technical Appendix X



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Key

Site Boundary

Turbine Layout

Hub Height (m)

69

80

Access Tracks

Existing

New

Laydown Area

Construction Compound

Infinis Substation

ScottishPower Substation

Permanent Met Mast

Borrow Pit

Slope Instability

A

B

C

D

Compressible Strata

A

C

D

E

Scale 1:42,000 @ A3

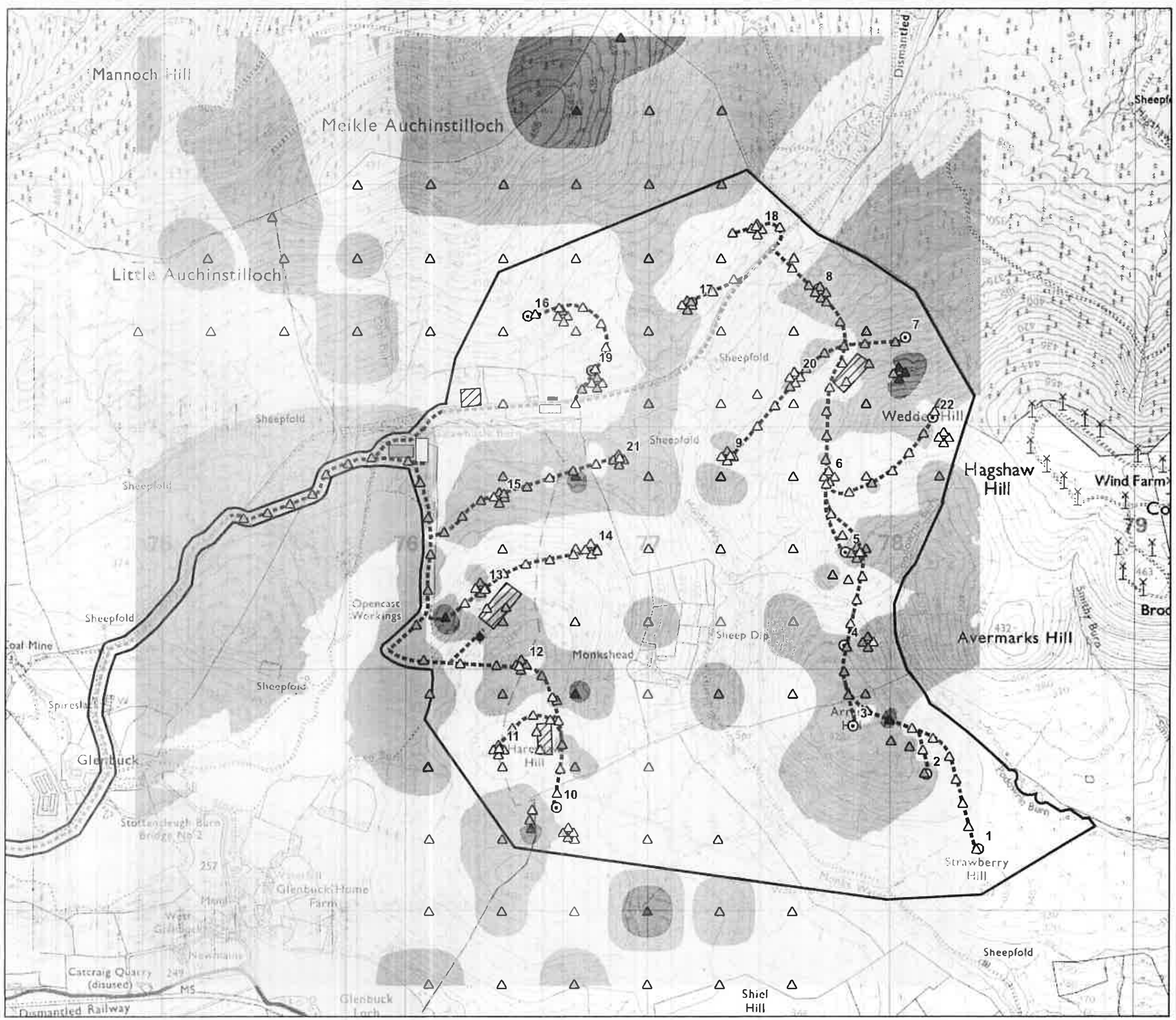
0 0.3 0.6 1.2 km

N

BGS GeoSure

Figure 6

Galawhistle Wind Farm Technical Appendix X



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Key

Site Boundary

Turbine Layout
Hub Height (m)

69

80

Access Tracks

Existing

New

Laydown Area

Construction Compound

Infinis Substation

ScottishPower Substation

Permanent Met Mast

Borrow Pit

Recorded Peat Depths
Depth (m)

0 - 0.25 (shallow)

0.25 - 0.75 (moderate)

0.75 - 1.5 (deep)

>1.5 (very deep)

Scale 1:15,000 @ A3

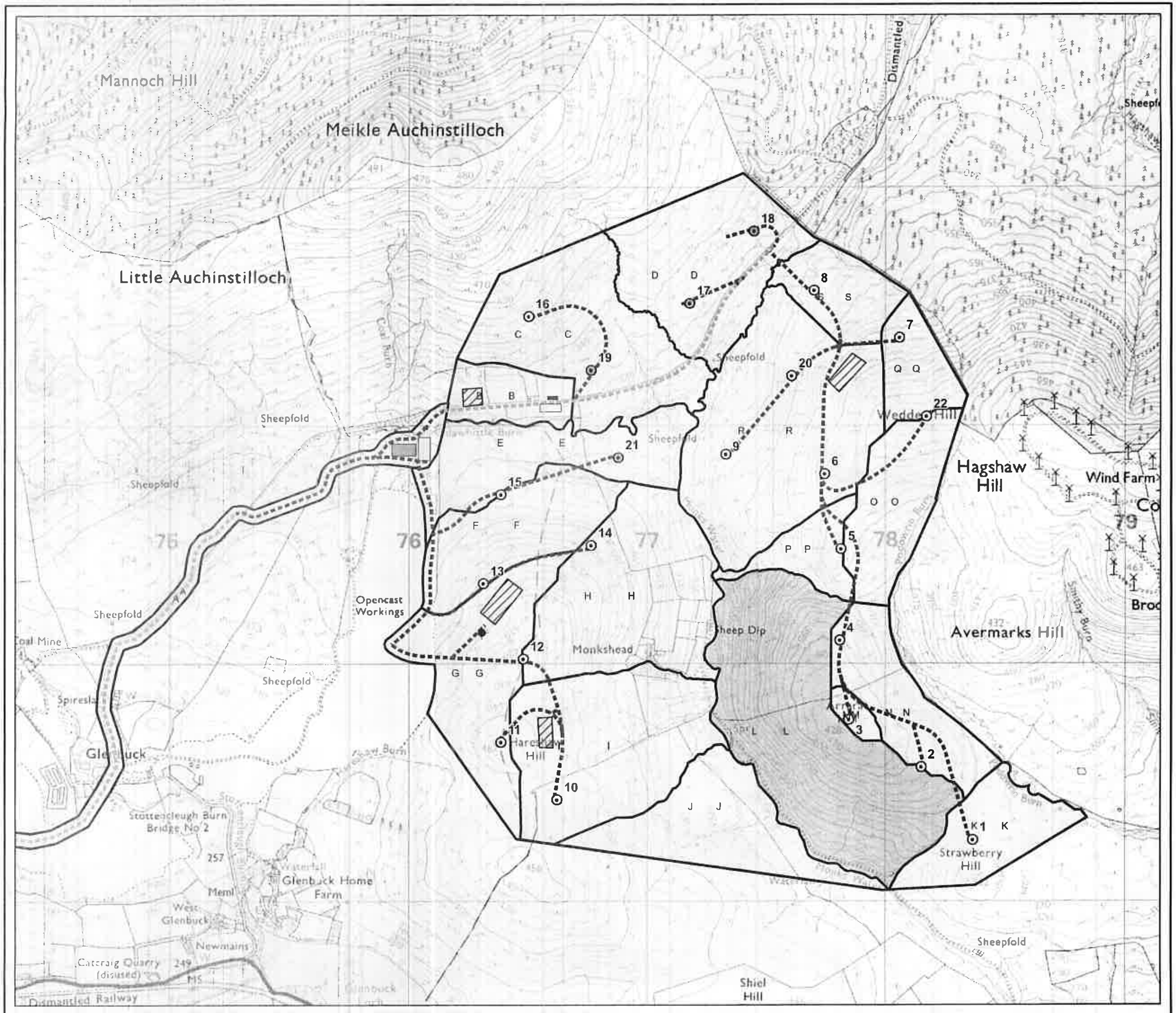
0 0.125 0.25 0.5 km

N

Indicative Peat Depth

Figure 7

Galawhistle Wind Farm
Technical Appendix X



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Key

Site Boundary

Turbine Layout

Hub Height (m)

69

80

Permanent Met Mast

Access Tracks

Existing

New

Laydown Area

Construction Compound

Infinis Substation

ScottishPower Substation

Borrow Pit

Risk Zones

Baseline Risk Ranking

Serious

Substantial

Significant

Insignificant

Scale 1:15,000 @ A3

0 0.125 0.25 0.5 km

N

Baseline Risk Ranking

Figure 8

Galawhistle Wind Farm Technical Appendix X

infinis