Technical Appendix 8.1

Ornithological Technical Report

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SCOTTISHPOWER RENEWABLES

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1 INTRODUCTION

1.1 Background

1. Scottish Power Renewables Ltd. (SPR) commissioned a programme of ornithology surveys to inform an Ecological Impact Assessment (EcIA) in support of their proposed Harestanes South Windfarm Extension (the Proposed Development), located approximately 15km north of Dumfries (Central Ordnance Survey Grid Reference: NX 97681 91280). The Proposed Development would be an extension to the existing 68-turbine operational Harestanes Windfarm which is located to the north. The Proposed Development Site (the Site) and its location in relation to the operational Harestanes Windfarm is shown in **EIA Report Figure 1.2 Application Boundary**.

2. A programme of flight activity surveys was undertaken over the 12-month period between September 2019 and August 2020 covering the 2019/20 non-breeding season and 2020 breeding season. A broader suite of targeted breeding bird surveys was also undertaken during the 2020 breeding season, as well as a consultation exercise with ornithological interest groups and relevant land management organisations to gather recent historical data to support the findings of the survey programme. All surveys were carried out in line with Scottish Natural Heritage's (SNH) wind farm bird survey guidance (SNH, 2017)[1].

3. This Ornithological Technical Report provides details of the methods and results of the ornithological field surveys and data consultation exercise conducted to inform the EcIA for the Proposed Development. The report concentrates on target species recorded in and around the Site which fall into at least one of the following categories:

- Birds listed on Annex I of the EU Birds Directive[2];
- Birds listed on Schedule 1 of the Wildlife and Countryside Act 1981 (as amended[3]);
- Birds that are qualifying features of European designated sites of nature conservation importance for birds (i.e. Special Protection Areas (SPAs) and Wetlands of International Importance (Ramsar Sites) in proximity or potentially connected to the Site; and
- Red-listed Birds of Conservation Concern (BoCC) (Eaton et al., 2015)[4].

4. Other species which are typically recognised as being potentially vulnerable to the effects of windfarm developments, but which do not fall under any of the above categories, such as certain wader and waterfowl species were also recorded as target species (e.g. snipe, oystercatcher and mute swan).

5. Sensitive information pertaining to the nest site locations of rare and vulnerable species, particularly those which may be at risk of persecution, has been omitted from this report and is instead presented in the **Appendix 8.2 Ornithological Confidential Appendix.**

[1] SNH (2017). Recommended bird survey methods to inform impact assessment of onshore windfarms. SNH Guidance. SNH, Battleby.
[2] EU Birds Directive: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009L0147
[3] Schedule 1-listed species of the Wildlife and Countryside Act 1981: http://www.legislation.gov.uk/ukpga/1981/69/schedule/1.
[4] 4 Eaton MA, Aebischer NJ, Brown AF, Hearn RD, Lock L, Musgrove AJ, Noble DG, Stroud DA and Gregory RD (2015). Birds of Conservation Concern 4: the population status of birds in the United Kingdom, Channel Islands and Isle of Man. British Birds 108, 708–746.
[5] SNH (2016). Assessing Connectivity with Special Protection Areas (SPAs). Version 3 – June 2016.

1.2 Desk Study and Bird Survey Methods

1.2.1 Desk Study and Consultation

1.2.1.1 Designated Sites

6. A desk study was undertaken at the outset of the survey programme to identify statutory ornithological designated sites of nature conservation interest located within, in close proximity, or potentially connected to the Site.

7. The extent of searches conducted for statutory European/International designated sites (i.e. Special Protection Areas (SPAs) and Wetlands of International Importance (Ramsar Sites)) was dependent on their proximity and/or potential connectivity to the Site. This included direct connectivity, such as via watercourses, or indirect connectivity, such as through the potential use of habitats within the Site by qualifying species of designated sites in the wider surrounding area based on those species recognised foraging/commuting ranges (e.g. as detailed in SNH (2016)[5]). Consequently, searches extended up to 20km from the Site boundary based on the longest recognised commuting distance which is for pink-footed geese and greylag geese; species which are associated with a number of designated sites in Scotland. Searches for all other designated sites with ornithological features of interest (including Sites of Special Scientific Interest (SSSI), National Nature Reserves (NNRs) and Local Nature Reserves (LNRs)) extended to 2km from the Initial Site Feasibility Study Area (see **EIA Report Figure 8.1 Flight Activity Survey Vantage Point Locations and Viewsheds**). Searches were conducted using the following sources:

- SNH Sitelink database website[6];
- Natural England's MAGIC Map application[7]; and
- Joint Nature Conservation Committee (JNCC) website[8].

1.2.1.2 Protected and Notable Species of Conservation Concern

8. To help inform the ornithological survey programme and the EcIA, a consultation exercise was also undertaken to request recent historical records of protected and notable species of conservation concern (i.e. records of target species from the past 10 years (2010-2019 inclusive)) within 2km of the Initial Site Feasibility Study Area: the area identified as being under consideration for the Proposed Development at the outset of the ornithological survey programme (see **EIA Report Figure 8.1: Flight Activity Survey Vantage Point Locations and Viewsheds**). The following land management organisations and ornithological interest groups were consulted for any relevant data they may hold:

- Forestry and Land Scotland (FLS: land owners of the Site);
- Dumfries and Galloway Raptor Study Group (D&GRSG);
- Royal Society for the Protection of Birds (RSPB) Conservation Data Management Unit;
- South West Scotland Environmental Information Centre (SWSEIC); and
- Scottish Ornithologists' Club (SOC) bird recorder Dumfries and Galloway.

9. Data was also made available from the Applicant for the operational Harestanes Windfarm including conditioned post-construction goshawk monitoring survey reports undertaken between 2014 and 2018 inclusive (RPS, 2014[9]; NRP, 2015[10] and Arcus 2016-2018[11]).

[6] SNH Sitelink database website (https://sitelink.nature.scot/home).
[7] Natural England MAGIC Map application website (https://magic.defra.gov.uk/).
[8] JNCC website (http://jncc.defra.gov.uk/).
[9] RPS (2014). Harestanes Wind Farm Year 1 Post-construction Raptor Monitoring Summary Report (Confidential). September 2014.
[10] NRP (2015). Harestanes Wind Farm Report on Ornithological Surveys (Confidential). September 2015.
[11] Arcus (2016-2018). Harestanes Wind Farm Goshawk and Short-eared Owl Monitoring Reports, 2016, 2017 and 2018. October 2016, 2017 and 2018.

10. Data obtained from the above sources was used to inform the field surveys as and when it became available (e.g. to locate recent historical scarce raptor nest sites or black grouse lek sites).

2 Ornithological Field Surveys

11. The ornithology survey programme was developed based on the particular ornithological sensitives which were anticipated to occur in and around the Site and was devised following SNH's survey guidance for assessing onshore wind farms (SNH, 2017)[1].

12. It is important to note that Vantage Point (VP) locations for the flight activity surveys were identified at the outset of the ornithological survey programme when the Proposed Development was represented by an Initial Site Feasibility Study Area. However, once the survey programme was underway, and before the commencement of the breeding season surveys, the Study Area was reduced to a more realistic 'Developable Area' upon which the survey areas for all other surveys were based, as shown in **EIA Report Figure 8.2: Targeted Ornithological Survey Areas**.

2.1.1 COVID-19 Restrictions

13. Due to the rural setting of the Site and the isolated nature of the ornithological surveys it was possible to continue with the majority of surveying and achieve a reasonably large proportion of the scheduled ornithological surveys during the critical early stages of the breeding season. Therefore, it is considered that Covid-19 restrictions have not resulted in any significant limitations to assessing the ornithological baseline within the Study Area.

2.1.2 Flight Activity Surveys

14. These surveys were designed to record the flight activity of birds utilising the airspace over the Site. The data collected allow the total flight activity and bird numbers involved to be estimated over a given timeframe (e.g. breeding season, non-breeding season or year), as well as showing spatial and temporal flight activity patterns. In turn, this information is used to undertake collision risk modelling (CRM) for key species using the standard Band et al. (2007)[12] method, to predict potential mortality rates from collisions.

15. In order to collect flight activity data, surveys are conducted from elevated VPs which offer as wide and as unrestricted a view as possible of the Site and a surrounding buffer of 500m (the Flight Activity Survey Area). For the Site, nine VPs were identified to adequately cover the Flight Activity Survey Area. Combined, these VPs overlook the majority of the Developable Area at rotor height in accordance with SNH guidelines, which for the turbine model under consideration is 50m to 200m above ground level. Details of each of these VP locations are provided in **Table 8.1.1** while their locations, distribution around the Site and 2km and 180° viewsheds from 50m above ground level are illustrated in **EIA Report Figure 8.1: Flight Activity Survey Vantage Point Locations and Viewsheds**.

16. SNH's guidance requires that a minimum of 36 hours of survey effort is carried out at each VP in each relevant survey season (i.e. breeding and non-breeding). Importantly though, it also requires that the minimum required 36 hours of survey effort is captured within the specific breeding and non-breeding seasons of each of the key species/groups of conservation concern which are most likely to occur over or in the vicinity of the site. Based on local knowledge of habitats and ornithological interests associated with the Site and surrounding area, two key species that were identified as likely to be present were red kite and goshawk, the breeding seasons for which are March to July and mid-March to mid-August respectively (SNH, 2014)[13]. Consequently, the flight activity survey programme for Proposed Development was devised to cover the non-breeding season between September 2019 and February 2020 and the breeding season between March and August 2020.

VP Number*	Eastings	Northings	View Angle (degrees)	Location in Relation to the Site
6	297968	590302	0°	Outwith
7	298291	591960	130°	Within
8	298711	594102	135°	Outwith
10	300689	589261	0°	Outwith
11	300742	591302	45°	Within
12	303054	594544	190°	Outwith
13	303106	589909	315°	Outwith
14	304065	592012	280°	Outwith
15	297968	590302	180°	Outwith

* VP numbering reflects that surveys initially covered a much larger area and/or that some original VP locations had to be dropped and replaced following denial of land access.

Table 8.1.1: Flight Activity Survey VP Locations Covering the Site

17. Additional flight activity survey effort for migratory waterfowl during the autumn and spring passage periods was not considered to be necessary as the Site is not known to be located in an area which is expected to be regularly used or overflown during these specific migration periods. This was supported by the findings of Mitchell (2012)[14] who demonstrated that the core foraging areas of geese associated with the nearest SPAs (identified in Section 3.1) are located well away from the Site with only a small proportion of birds heading in the direction of the Site to forage around the lower Water of Ae valley. The non-requirement of survey effort for migratory waterfowl was accepted by SNH and RSPB in their responses to an interim bird survey report (WSP, 2020)[15] submitted following the completion of 10-months of survey effort, which included the survey findings from the full 2019/20 non-breeding season including the autumn and spring migratory periods[16, 17].

18. Survey effort was spread throughout the daytime period where daylight hours best represent temporal flight activity patterns. Each survey was undertaken by a single observer in good conditions (i.e. visibility of at least 2km). Weather and visibility conditions were recorded on an hourly basis including information on wind strength and direction, precipitation and cloud cover.

19. Non-breeding season effort was carried out by RPS, while the breeding season surveys were conducted by WSP. All VP watches were limited to a maximum of three hours duration by any single observer, with a minimum of half an hour break between any two consecutive VP surveys. Simultaneous VPs were not carried out where one observer's VP position was located within another surveyor's viewshed. That said, the Site is highly active both in terms of forestry activities and recreational activities, including walking and mountain biking. Therefore, birds associated with the Site and their behaviour is expected to be highly habituated to human activities.

20. During each VP watch surveyors continuously scanned the airspace within the 2km, 180° viewshed arc of the respective VP location using the naked eye as well as binoculars to record all target bird species. Although a viewshed radius of 2km was used to record all species, observations of birds located outside of this radius (e.g. flocks of large, easily detectable birds) were also recorded to provide additional context.

[12] Band, W, Madders, M, & Whitfield, D.P. (2007) Developing field and analytical methods to assess avian collision risk at wind farms. In: Janss, G, de Lucas, M & Ferrer, M (eds.) Birds and Wind Farms. Quercus, Madrid.
[13] SNH (2014). Breeding season dates for key breeding species in Scotland (https://www.nature.scot/sites/default/files/2017-07/A303080%20-%20Bird%20Breeding%20Season%20Dates%20in%20Scotland.pdf).
[14] Mitchell, C. 2012. Mapping the distribution of feeding Pink-footed and Iceland Greylag Geese in Scotland. Wildfowl & Wetlands Trust /SNH Report, Slimbridge. 108pp.
[15] WSP (2020). Harestanes Extension (South) Wind Farm Interim Ornithological Technical Report. July 2020.
[16] Letter from Crispin Hill, SNH Operations Officer (Forth & Southern Scotland) in response to Harestanes Extension (South) Wind Farm Interim Ornithological Technical Report, dated 04 August 2020.
[17] Letter from Ed Tooth, Conservation Officer (Scottish Lowlands and Southern Uplands) in response to Harestanes Extension (South) Wind Farm Interim Ornithological Technical Report, dated 13 August 2020.

21. Once a bird or flock was detected, it was observed until it had landed or flown out of sight. The paths of all observed flights (flight lines) were drawn directly onto 1:10,000 OS maps while the following associated flight data was also recorded:

- flight start time;
- species (where identification was uncertain, observations were identified to species group level at a minimum);
- number of birds/flock size;
- flight duration;
- bird(s) occupancy at one of up to six height bands above ground level[18] for each 15 second flight time interval; and
- behaviour (including territorial or nesting behaviour).

22. In addition to flights by target species, the presence and behaviour of any other notable species which may be potentially vulnerable to the effects of wind turbines (so-called secondary species) was also recorded.

23. Two hundred and sixteen flight activity surveys were undertaken over and around the Site between September 2019 and August 2020 totalling of 648 hours of survey effort. Thirty-six hours of survey effort was undertaken at each VP during both the 2019/20 non-breeding season and 2020 breeding season in accordance with SNH's minimum requirements with effort being evenly distributed throughout the seasons as much as possible.

24. **Table 8.1.2** presents a summary of the flight activity survey effort undertaken between September 2019 and August 2020, further details of which are provided in **Annex 1, Table A1**.

2.1.2.1 Collision Risk Modelling

25. The Collision Risk Modelling (CRM) methodology followed that described by Band et al. (2007)[12] which is recommended by SNH, further details of which are provided in **Annex 8.2**. This involves a three-step process:

- **Stage 1**: using flight activity survey results as a sample to estimate the number of flights likely to take place at rotor height during a certain period of time (usually either a year or during the breeding or non-breeding season), then calculate what proportion of these would take place within the total rotor swept area of the wind farm, assuming no avoidance actions, thus placing a bird at risk of collision.
- **Stage 2**: calculate the probability that, if a flight does pass within the rotor swept area of a turbine, that bird would be struck by a rotating blade. This probability is multiplied by the number of at-risk flights estimated in Stage 1.
- **Stage 3**: account for the birds' likely ability to avoid colliding with turbines in the vast majority of occasions, by behavioural actions either close to individual rotors or by avoiding the wind farm as a whole. This avoidance rate (typically 98% and up to 99.8% for geese - SNH 2018[19]) is then multiplied by the figure calculated at Stage 2 to give an overall estimate of collision rate.

26. For each target species recorded in sufficient numbers (i.e. three or more "at risk" flights as defined in **Annex 8.2**) at the Proposed Development, separate collision rates for the breeding and non-breeding season (where relevant) were predicted using either a directional or non-directional (random) version of the model. The choice of model for each target species was based on its pattern of flight behaviour within the study area. The directional model is appropriate when a species tends to move across the windfarm area in a particular direction. This type of flight behaviour is characteristic of species on migration or making regular movements between feeding and roosting sites and SNH advocates using it for groups such as geese, swans, divers 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.

VP Location	Monthly Survey Effort per VP												
	2019				2020								Total Effort
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr*	May	Jun	Jul	Aug	
VP 6	3	9	6	6	6	6	6	3	9	6	6	6	72
VP 7	3	9	6	6	6	6	6	0	9	6	9	6	72
VP 8	3	9	6	6	6	6	6	0	9	6	9	6	72
VP 10	3	9	6	6	6	6#	6	0	9	9	0~	12	72
VP 11	3	9	6	6	6	6	6	0	9	9	6	6	72
VP 12	3	9	6	6	6	6#	6	6	6	6	6	6	72
VP 13	3	9	6	6	6	6	6	0	9	9	6	6	72
VP 14	3	9	6	6	6	6	6	3	9	6	6	6	72
VP 15	0+	6	9	9	6	6	6	6	6	0^	12	6	72
Total Effort	24	78	57	57	54	54	54	18	75	57	60	60	648

* Reduced survey effort in April reflects Covid-19 related access restrictions. Deficiencies incurred in April were made up in May and June where total survey effort for those months is proportionately higher.
# Survey effort at VPs 10 and 12 in February was conducted on 01 March as a result of postponements due to persistent bad weather.
+ No survey effort was completed at VP15 in September as it was only established in October following denial of access to a previous VP identified to cover the corresponding airspace.
^ Survey effort at VP15 in June was missed due to a survey scheduling error. This missed effort was caught up in July.
~ Survey effort at VP10 in July was missed due to land access restrictions. This missed effort was caught up in August.

Table 8.1.2 – Summary of Flight Activity Survey Effort

27. The Risk Zone within which birds were considered to be at risk of collision was taken to be the area enclosed by the tips of the outermost turbine rotors, plus a 500m buffer to allow for surveyor error when mapping flight lines, in line with SNH guidance[1].

2.1.3 Scarce Breeding Raptor Surveys

28. The Developable Area plus a surrounding buffer of 2km was surveyed for scarce breeding raptors between March and July 2020. The scarce breeding raptor survey area is shown in **EIA Report Figure 8.2: Targeted Ornithological Survey Areas**.

29. Survey protocols broadly followed the standard methodologies for assessing raptor populations set out by Hardey *et al*. (2013)[20] and Gilbert et al. (1998)[21]. The surveys involved an initial scoping visit in March followed by four rounds of survey visits undertaken thereafter to determine presence, territory occupation and breeding success. Covering this period encompassed the time of year when activity can be highest and species presence is most likely to be detected.

30. The scoping visit in March and the initial surveys in April and May predominantly involved VP watches overlooking the extensive forestry of the Developable Area as well as other areas of suitable breeding raptor habitat in the surrounding area such open moorland and small stands of woodland. The purpose of these surveys was to detect

[18] Height bands applied varied between RPS during the non-breeding season (Height Bands 1 = <20m, 2 = 20-40m, 3 = 40-100m, 4 = 100-150m, 5 = 150-200m, 6= 200m+) and WSP during the breeding season (Height Bands 1 = <50m, 2 = 50-250m, 3 = 250m+) due to indicative turbine specifications being made available for the breeding season. For collision risk modelling, non-breeding season flight activity data will be adapted to identify proportionate flight time in the relevant overlapping height bands.

[19] SNH (2018). Use of Avoidance Rates in the SNH Wind Farm Collision Risk Model. SNH, September 2018 v2. https://www.nature.scot/sites/default/files/2018-09/Wind%20farm%20impacts%20on%20birds%20-%20Use%20of%20Avoidance%20Rates%20in%20the%20SNH%20Wind%20Farm%20Collision%20Risk%20Model.pdf.
[20] Hardey et al. (2013). Raptors. A Field Guide for Surveys and Monitoring. SNH, Inverness
[21] Gilbert, G., Gibbons D.W., and Evans, J. (1998). Bird Monitoring Methods. RSPB, Sandy.

early breeding season display activity, particularly by species such as goshawk and hen harrier. Thereafter, surveys primarily involved walkovers focussing effort in areas previously identified with concentrations of raptor activity as well as other areas of suitable nesting habitat such as heather moorland, craggy rock faces, cliffs and steep sided burns. The locations of recent historical nest sites provided by consultees were also inspected during the walkover surveys. The locations of any nest sites or nesting/territorial activity by raptors was recorded, as were any sightings and signs of activity (e.g. prey remains, faecal splashing, plucking posts and pellets).

31. All observations of raptor species and sightings of any associated field signs and the locations of flight lines were mapped using standard BTO symbols and activity codes. The grid references of any target raptor nest sites (regardless of activity status) were also recorded. In doing so, care was taken not to disturb occupied nest sites and all surveyors held a Schedule 1 survey licence issued by SNH.

32. **Annex 8.1, Table A2** presents the scarce breeding raptor survey effort during the 2020 breeding season.

2.1.4 Lekking Black Grouse Surveys

33. The Developable Area plus a surrounding buffer of 1.5km was surveyed to determine the presence or likely absence of lekking black grouse. The survey protocol followed the methodology detailed in Gilbert et al. (1998)[21]. The lekking black grouse survey area is shown in **EIA Report Figure 8.2: Targeted Ornithological Survey Areas**.

34. A habitat suitability assessment was undertaken in March from flight activity surveys and through drive-arounds. Thereafter, two rounds of surveys were conducted between late March and mid-May 2020 and involved walkovers covering all areas of suitable habitat (e.g. areas of short grassland such as in-bye pastures or moorland particularly near young or sparse forest edges). Surveys were undertaken around sunrise up to approximately two hours after dawn in dry and calm conditions with good visibility. Surveyors sought to cover all areas to within 500m in search of lekking male black grouse and attending females. Any identified leks were observed from suitable vantage points to avoid disturbance and the number of males (not just displaying birds) and females seen in the lekking area were recorded on each visit. The grid reference and details of any observations or signs of black grouse were also recorded. Leks located 200m or more apart were considered to be separate.

35. **Annex 8.1, Table A3** presents the lekking black grouse survey effort between late March and mid-May 2020.

2.1.5 Breeding Nightjar Surveys

36. The Developable Area plus a surrounding buffer of 500m was surveyed to determine the presence or likely absence of breeding nightjar. The survey protocol followed the methodology detailed in Gilbert *et al.* (1998)[21]. The breeding nightjar survey area is shown in **EIA Report Figure 8.2: Targeted Ornithological Survey Areas**.

37. Assessments of potentially suitable breeding nightjar habitat were undertaken in April and May during other surveys and when travelling in and around the Site to other survey destinations. Thereafter, two rounds of surveys were undertaken between June until mid-July involving walkovers covering all areas of suitable habitat (e.g. areas of heathland, clearfell and/or young forestry plantations). Surveys were undertaken in dry and calm conditions from around dusk and extended to approximately two and a half hours after sunset.

38. During each survey, surveyors tried to get to within 100m of all points, subject to safe access (clear-felled areas were not traversed in the dark for health and safety reasons), listening out for churring (singing) nightjar. The locations of any detected churring males were marked on a map with registrations for simultaneously churring males being joining with a dotted line denoting two separate territories. Any non-simultaneous churring heard from two locations and up to 30 seconds apart were recorded as different males if the two were more than 400m apart, otherwise they were recorded as the same male that had moved.

39. **Annex 8.1, Table A4** presents the breeding nightjar survey effort undertaken between June and mid-July 2020.

2.1.6 Moorland Breeding Bird Surveys

40. These surveys sought to determine the assemblage of breeding birds and the locations of breeding territories for all species of conservation concern and covered all areas of open moorland within the Developable Area and a surrounding buffer of 500m, as shown in **EIA Report Figure 8.2: Targeted Ornithological Survey Areas**. They followed a modified version of the Brown and Shepherd methodology (Brown and Shepherd, 1993)[22] as summarised in Gilbert et al. (1998)[21] and involved four rounds of surveys undertaken between April and July in line with the methods of Calladine et al. (2009)[23], as recommended by SNH (2017)[1].

41. During each visit the surveyors followed transect routes covering the survey area to within at least 250m of all parts of open moorland. This distance was considered sufficient to detect most species expected to occur on the open moorland habitats of the survey area, particularly breeding waders of conservation concern such as golden plover, curlew or lapwing.

42. The behaviour of all birds seen or heard during the surveys was recorded on large-scale maps using standard BTO coding and notation. Survey visits were undertaken in good, clear weather conditions (wind less than Beaufort force 5). **Annex 8.1, Table A5** presents summarised details of the moorland breeding bird surveys undertaken between April and July 2020.

43. All breeding bird survey records were entered into ArcView Geographic Information System (GIS) software. These were then analysed in order to identify the minimum number of probable or confirmed breeding territories for all target species (territory analysis was not carried out for non-target species). For wading birds, this was done following the methods of Brown and Shepherd (1993)[22] whereby breeding territories were assigned on the basis of at least one registration of birds engaging in territorial behaviour including displaying, singing or alarm calling, distraction displays, territorial disputes or the detection of eggs, nests or young. Where possible, simultaneous registrations of birds displaying such behaviour were used to identify different territories. Where this was not possible, such registrations which were from the same survey visit and were within 500 m of each other (200 m for dunlin) were assumed to be associated with the same territory, while registrations beyond this distance from one another were considered to be from separate, neighbouring territories. For registrations from different survey visits, birds within 1,000m of each other (500m for dunlin) were assumed to be from with the same territory.

44. For all other species, territories were assigned following the CBC methods described in Gilbert et al. (1998)[21] and Bibby et al. (2007)[24]. This either involves the identification of clusters of registrations of birds of the same species displaying breeding characteristics (e.g. singing, alarm calling, nest building, mating) or food provisioning in the same general area over successive survey visits (probable breeding), or the discovery of an active nest (e.g. containing eggs or chicks) (confirmed breeding). Given that the surveys comprised four visits over the breeding season, the minimum requirement for a cluster, and hence a probable breeding territory, to be defined was at least two registrations conforming to the above criteria recorded on separate survey visits conducted at least ten days apart.

45. Based on the territory analysis procedure detailed above, the estimated number of breeding territories held by target species was identified within the entire survey area and within the proposed development site itself.

[22] Brown, A.F. and Shepherd, K, B. (1993). A method for censusing upland breeding waders. Bird Study, 40: 189-195
[23] Calladine, J., Garner, G., Wernham, C. & Thiel, A. (2009). The influence of survey frequency on population estimates of moorland breeding birds. Bird Study, Volume 56, Issue 3.
[24] Bibby C., Burgess N., Hill D. and Mustoe S. (2007). Bird Census Techniques, 2nd Edition, Academic Press, London.

3 DESK STUDY AND BIRD SURVEY RESULTS

3.1 Desk Study Results

3.1.1 Designated Sites

46. Two internationally designated sites of ornithological interest were identified within 20km of the Site boundary. Details of each of these sites are presented in **Table 8.1.3** while their locations and distribution in relation to the Site are shown in **EIA Report Figure 8.3: Ornithological Designated Sites and Natural Heritage Zone**.

Site	Distance from Site	Qualifying Interest
Castle Loch, Lochmaben SPA and Ramsar Site	9.5km	Non-breeding: pink-footed goose
Upper Solway Flats and Marshes SPA and Ramsar Site	17.5km	Non-breeding: bar-tailed godwit, cormorant, curlew, dunlin, golden plover, goldeneye, grey plover, knot, lapwing, oystercatcher, pink-footed goose, pintail, redshank, ringed plover, scaup, shelduck, Svalbard barnacle goose, waterfowl assemblage, whooper swan Passage: ringed plover
		Non-breeding: bar-tailed godwit, curlew, knot, oystercatcher, pink-footed goose, pintail, redshank, scaup, Svalbard barnacle goose

Table 8.1.3 – International Designated Sites within 20km of the Proposed Development

47. The Site Boundary does not physically overlap with any internationally or nationally designated sites. The nearest designated site, Castle Loch, Lochmaben, lies approximately 9.5km southeast of the Site Boundary and is designated for its non-breeding population of pink-footed goose. The Upper Solway Flats and Marshes lies approximately 17.5km south of the Site Boundary and is designated for non-breeding populations of wading and waterfowl species, most notably of which is pink-footed goose due to their potential connectivity with the Site.

48. There are no non-statutory designated sites with ornithological interests within 2km of the Site.

3.1.2 Protected and Notable Species of Conservation Concern

49. The following provides an overview of the data obtained from previous development studies and through the consultation exercise. Nest site locations for rare and vulnerable species of conservation concern have been withheld and are provided in **Appendix 8.2: Ornithological Confidential Appendix**.

3.1.2.1 Data from Operational Harestanes Windfarm

50. Ornithological surveys to inform the EcIA for the operational Harestanes Windfarm were undertaken in 2002 and 2003. The Ornithological Technical Appendix of the Harestanes Wind Farm Environmental Statement (ES) (Scottish Power, 2004)[25] identifies the following;

- **Goshawk**: two territories were located within 2km of the operational Harestanes Wind Farm site with a third approximately 5km away. Post-construction monitoring reports from 2014 to 2018[10, 11, 12] identified two of these to be located within 2km of the Site, although one of these sites was found to be unoccupied in 2018.
- **Peregrine**: two territories within 2km of the operational Harestanes Windfarm site, with at least one being apparently occupied in 2003.
- **Hen harrier**: up to two territories within 2km of the operational Harestanes Windfarm site, with at least one being apparently occupied in 2003.
- **Short-eared owl**: one pair were reported to have bred within the operational Harestanes Windfarm site in 2003.
- **Barn owl**: four occupied nest sites all of which were located over 2km from the operational Harestanes Windfarm site.
- **Black grouse**: three territories were identified in proximity to the operational Harestanes Windfarm site, all of which were located to the north and hence over 5km from the Site.
- **Golden plover** and **curlew** territories were located on the open moorland habitats surrounding the operational Harestanes Windfarm site.

3.1.2.2 Forestry and Land Scotland

51. FLS provided records of target raptor nest sites in and around the Initial Site Feasibility Study Area from 2019. These included:

- **Goshawk**: four nest sites; one within the Initial Site Feasibility Study Area and three within 2km (one to the north, one to the west and the other to the south west). Two of the three goshawk nest sites provided were consistent with those reported in the Ornithological Technical Appendix of the Harestanes Wind Farm ES[25].
- **Red kite**: one nest site within 2km to the south west of the Initial Site Feasibility Study Area.
- **Barn owl**: four nest sites; two within the Initial Site Feasibility Study Area and two within 2km to the west.
- **Black grouse**: various undated records of black grouse were provided in and around the Initial Site Feasibility Study Area, however, only one related to an apparently well attended lekking site, located approximately 1.7km to the north west.

3.1.2.3 Dumfries and Galloway Raptor Study Group

52. D&GRSG provided the following records:

- **Goshawk**: three territories; one within the Initial Site Feasibility Study Area and two within 2km (one to the west and the other to the south west), all of which corresponded with nest site locations provided by FLS (above). However, only one of these nest sites corresponded with those reported in the Ornithological Technical Appendix of the Harestanes Wind Farm ES[25]. Two of the territories were occupied in 2019 while the third was most recently monitored in 2017 when it too was occupied with all pairs successfully rearing chicks in these years.
- **Red kite**: one nest site within 2km south southwest of the Initial Site Feasibility Study Area which broadly corresponded with the nest site location provided by FLS (above). This nest site was occupied and successfully reared chicks in 2019.
- **Barn owl**: six sites; one located within the Initial Site Feasibility Study Area and the other five located within the surrounding 2km buffer. Only two of these nest sites were found to have been occupied in 2019.

3.1.2.4 RSPB

53. The only records provided by RSPB were of two individual black grouse from 2011; one of a non-lekking male located approximately 1.4km to the south of the Initial Site Feasibility Study Area and the other of a female located within 1km to the north of the Initial Site Feasibility Study Area.

3.1.2.5 Dumfries and Galloway Local Bird Recorder

54. The local bird recorder did not respond to the data request.

[25] ScottishPower (2004). Harestanes Wind Farm Environmental Statement (and associated Ornithological Technical Appendix). Prepared for CRE Energy, A ScottishPower company.

3.1.2.6 South West Scotland Environmental Information Centre

55. SWSEIC provided recent historical records for various target species within 2km of the Initial Site Feasibility Study Area, all of which were observational sightings records (i.e. no nest, roost or lek site records). These are summarised as follows;

- **Goshawk**: seven records located over and around the southern parts of the Initial Site Feasibility Study Area (over the Forest of Ae and adjacent open ground).
- **Red kite**: four records over the open ground to the south and south east of the Initial Site Feasibility Study Area, around Parkland and Courance.
- **Peregrine**: four records over the open ground to the east and south west of the Initial Site Feasibility Study Area, around Courance and Gledenholm.
- **Hen harrier**: one record to the south west of the Initial Site Feasibility Study Area (south west of Ae).
- **Barn owl**: eleven records associated with locations to the south west and south east of the Initial Site Feasibility Study Area, near Ae and Courance.
- **Whooper swan**: five records of flocks comprising between 22 and 64 birds to the south east of the Initial Site Feasibility Study Area, near Courance.
- **Pink-footed goose**: four records; two of flocks comprising between 560 and 800 birds to the south east of the Initial Site Feasibility Study Area, near Courance, the other two records near Ae having no count data associated with them.
- **Greylag goose**: six records of up to eight birds to the south of the Initial Site Feasibility Study Area, Parkgate.
- **Golden plover**: a single record of a single bird to the south of the Initial Site Feasibility Study Area, near Parkgate.
- **Curlew**: a single record of a single bird to east of the Initial Site Feasibility Study Area, near Courancehill/Tawnaze Hill.
- **Lapwing**: three records of up to two birds to the east and south west of the Initial Site Feasibility Study Area, near Courancehill/Tawnaze Hill and Ae.
- **Whimbrel**: a single record of four birds to the south east of the Initial Site Feasibility Study Area, near Courance.
- **Common crossbill**: twenty-five records of birds associated with the Forest of Ae.

56. SWSEIC also provided various records of other comparatively common and widespread breeding and wintering species of conservation concern such as house sparrow, grey partridge, linnet, cuckoo, fieldfare, redwing and brambling.

3.2 Ornithological Field Survey Results

3.2.1 Flight Activity Surveys

57. A total of 160 flights by 12 target species were recorded over and around the Site between September 2019 and August 2020. **Table 8.1.4** presents a summary of the flight activity survey results, full details of which are provided in **Annex 8.3, Table A6**. **EIA Report Figures 8.4a: Flight Activity Survey Results: Raptors (Non-breeding Season) and 8.4b: Flight Activity Survey Results: Raptors (Breeding Season)** show the distribution of target raptor flight activity during the non-breeding and breeding season respectively, while **EIA Report Figures 8.5: Flight Activity Survey Results: Waterfowl and 8.6: Flight Activity Survey Results: Waders** show the distribution of target waterfowl and wading bird species flight activity. **Table 8.1.4** also presents the number of flights, constituent number of birds and their cumulative duration which passed through the Windfarm Polygon[26] at potential collision height (PCH) and hence were "at risk" of collision with the wind turbines.

58. **Goshawk** was the most frequently recorded species with 77 flights comprising 86 individuals with birds being recorded in every month of the survey programme. There were however distinct peaks of activity in early autumn (September to October: 20 flights representing 26.0%) and late winter/early spring (February to March: 25 flights representing 32.5%), with these periods reflecting juvenile dispersal and pre-breeding display activity respectively. Flight activity was distributed around the entire Site, particularly during the non-breeding season. There was however a distinct concentration of activity in the southern/central part of the survey area along the Glenkiln Burn throughout the year, but particularly during the breeding season.

Species	Total No. of Flights	Total Constituent No. of Birds	Cumulative Flight Duration (sec)	No. of "At Risk" Flights	Constituent No. of Birds "At Risk"	Cumulative Flight Duration "At Risk" (sec)
Goshawk	77	86	9870	8	9	1110.45
Pink-footed goose	25	2220	3360	2	152	120
Red Kite	18	19	3270	0	0	0
Hen harrier	10	10	1515	1	1	50
Snipe	8	8	195	0	0	0
Lapwing	7	10	275	0	0	0
Greylag goose	4	23	285	1	13	22.5
Golden plover	3	54	180	1	18	30
Merlin	2	2	135	0	0	0
Oystercatcher	4	4	75	0	0	0
Peregrine	1	1	60	0	0	0
Whooper swan	1	1	75	0	0	0

Table 8.1.4 – Summary of Flight Activity Survey Results (September 2019 - August 2020)

59. **Pink-footed geese** were the second most frequently recorded species with 25 flights comprising 2220 individuals. Flights occurred throughout the non-breeding season (i.e. from late September to mid-March) with the majority of flights (all but three) occurring during either the autumn (nine flights, comprising 1347 individuals) or spring passage periods (13 flights, comprising 635 individuals). Flights were generally in a north-south or south-northward direction respectively reflecting longer distance migratory flights to and from core overwintering sites as opposed to daily commuting movements between traditional roosting and foraging sites.

60. **Red kites** were also frequently recorded with 18 flights, comprising 19 individuals, the majority of which occurred during the breeding season over the open agricultural habitats and along the forest edges outside of the Site to the south and east. There were no flights over the central forested parts of the Site.

61. **Hen harriers** were only recorded during the non-breeding season with 10 flights involving 10 individuals comprising both genders and all age classes (i.e. adult and juvenile birds). Flight activity was concentrated over the forestry in the eastern part of the Site and the adjacent open moorland and agricultural land.

62. The remaining eight target species were recorded infrequently with no more than eight flights being recorded. These were:

- **Snipe**: eight flights involving eight individuals, all of which were located in agricultural and moorland habitats out with the Site;
- **Lapwing**: seven flights involving nine individuals, all of which were located in agricultural habitats outwith the Site;
- **Greylag goose**: four flights involving 23 individuals passing over and around the Site;

[26] The Windfarm Polygon is defined in Annex 8.2 and is the area enclosed by the tips of the outermost turbine rotors.

- **Oystercatcher**: four flights involving four individuals to the south west of the Site;
- **Golden plover**: three flights on the same day, each comprising what were presumably the same 18 individuals (i.e. 54 'individuals' in total), located over the moorland and forest edge to the north of the Site;
- **Merlin**: two flights involving two individuals, both occurring during the breeding season with one passing over the southern-central part of the Site and the other passing over the agricultural land to the south;
- **Peregrine**: one flight involving a single individual passing over the Site during the breeding season; and
- **Whooper swan**: one flight involving a single individual flying down the Water of Ae valley during the non-breeding season.

3.2.1.1 Collision Risk Modelling

63. As detailed in the methods section, in order for CRM results to be meaningful a minimum of three "at risk" flights are required. The flight activity survey results therefore meant that there were only sufficient at-risk flights to undertake CRM for goshawk. A summary of the output from the CRM based on the recorded goshawk flight activity is presented in **Table 8.1.5** below.

Species	Recommended Avoidance Rate	Number of Predicted Collisions per Year	Time Predicted for One Collision to Occur
Goshawk	98%	0.3	3 years

Table 8.1.5 – Collision Risk Modelling Output

Scarce Breeding Raptor Surveys

64. **EIA Report Figure 8.7: Scarce Raptor Survey Results** shows the distribution of scarce breeding raptor survey observations, as well as notable incidental observations made during other surveys and or travel in and around the site. Compared to the high levels of flight activity by goshawk, and to a lesser extent red kite, recorded during the breeding season flight activity surveys, relatively few sightings of scarce raptors were recorded during the surveys.

65. The few goshawk flights which were recorded were observed around the forest edge around the Developable Area and wider 2km survey buffer. No sightings were made within the core area of activity in the southern-central part of Developable Area recorded through the flight activity surveys. Nonetheless, two active goshawk nests were located within the scarce raptor survey area at the beginning of July; one to the north of the Site, notably within the operational Harestanes Windfarm site, and the other to the south of the Site. The latter of these two nest sites was closely associated with the Glenkiln Burn valley where a large proportion of the goshawk flights were recorded during the flight activity surveys, and so were probably reflective of activity by the pair associated with this territory. These nest sites were within approximately 1km of two of the recent historical nest site locations provided by FLS and so it is considered highly likely that these are alternative nest sites for the associated pairs. Both of these nest sites are located outwith the Developable Area and over 1km from the nearest indicative turbine locations. Details regarding the locations of these two nest sites are provided in **Appendix 8.2: Ornithological Confidential Appendix.**

66. The limited number of red kite flights were observed over the open agricultural habitats and along the forest edges outside of the Site to the south and north east. No active red kite nest sites, or of any other target raptor species were identified despite intensive searches at and around the recent historical nest site locations provided by the Applicant, FLS and D&GRSG, although old, disused nests had been located at several of these locations. This includes active barn owl nests associated with nest site locations provided by consultees; some of which were found to have been damaged or were apparently no longer suitable. There was however an incidental observation of two juvenile barn owls in shelter belt woodland near Kirkland Farm, to the south west of the Site and it was assumed that a nest site was located nearby. There were also incidental observations/detections of a barn owl and long-eared owls seen and/or heard during the nightjar surveys in the eastern and western parts of the nightjar survey area. The long-eared owl records in particular suggested that this species had bred within the forest during the season.

3.2.2 Lekking Black Grouse Surveys

67. No black grouse (lekking birds or incidental sightings) were recorded (seen or heard) during any of the surveys undertaken.

3.2.3 Breeding Nightjar Surveys

68. No nightjar were recorded (seen or heard) during any of the surveys undertaken.

3.2.4 Moorland Breeding Bird Surveys

69. A total of 46 species were recorded within the survey area of which 14 were target species. **Table 8.1.6** presents a list of the target species recorded and the estimated number of breeding territories held by those species while their distribution within the survey area is shown in **EIA Report Figure 8.8: Breeding Bird Territories**. The full list of species recorded during the moorland breeding bird surveys is presented in **Annex 8.3, Table A7**. The surveys identified that the pastoral agricultural land, open moorland and associated forest edge habitats of the survey area support an assemblage of breeding birds which is typical of these habitats.

70. Of the 14 target species recorded, only red kite and barn owl were Annex I and/or Schedule 1 listed species, neither of which were found to be holding breeding territories within the survey area. The remaining 12 target species were either red-listed and/or SBL species.

Species	Conservation Status			Presence/Min. No. of Breeding Territories within the Survey Area
	EU Annex I	WCA Sch. 1	BoCC Red-list	
Barn owl		✓		Present (pellets detected only)
Cuckoo			✓	1
Curlew			✓	1
Grey wagtail			✓	Present
Lapwing			✓	1
Lesser redpoll			✓	Present
Linnet			✓	2
Mistle thrush			✓	Present
Red kite	✓	✓		Present
Skylark			✓	13
Snipe			✓	2
Song thrush			✓	2
Spotted flycatcher			✓	Present
Tree pipit			✓	1

Table 8.1.6 – Target Species Recorded during Moorland Breeding Bird Surveys (April and July 2020)

ANNEX 8.1: Ornithological Survey Details

Date	VP	Surveyor*	Start time	End time	Duration (hrs)
26/09/19	6	TB	16:35	19:35	03:00
27/09/19	11	TB	11:10	14:10	03:00
27/09/19	14	TB	15:00	18:00	03:00
27/09/19	7	PC	15:45	18:45	03:00
29/09/19	8	AR	10:30	13:30	03:00
29/09/19	9	AR	14:40	17:40	03:00
29/09/19	13	PC	14:50	17:50	03:00
30/09/19	12	TB	10:45	13:45	03:00
30/09/19	10	TB	15:00	18:00	03:00
15/10/19	8	TB	10:20	13:20	03:00
15/10/19	8	TB	13:50	16:50	03:00
16/10/19	7	TB	12:15	15:15	03:00
16/10/19	7	TB	15:45	18:45	03:00
17/10/19	6	TB	07:20	10:20	03:00
17/10/19	10	GM	10:45	13:45	03:00
17/10/19	6	TB	10:50	13:50	03:00
17/10/19	10	GM	14:15	17:15	03:00
18/10/19	11	GM	07:10	10:10	03:00
18/10/19	11	GM	10:40	13:40	03:00
21/10/19	13	TB	08:15	11:15	03:00
21/10/19	13	TB	11:45	14:45	03:00
22/10/19	12	TB	09:05	12:05	03:00
22/10/19	12	TB	12:35	15:35	03:00
23/10/19	14	TB	07:30	10:30	03:00
23/10/19	14	TB	11:00	14:00	03:00
25/10/19	8	TB	07:35	10:35	03:00
25/10/19	7	PH	08:15	11:15	03:00
25/10/19	6	PH	11:55	14:55	03:00
26/10/19	10	PH	07:50	10:50	03:00
26/10/19	14	PH	11:45	14:45	03:00
28/10/19	11	GM	14:30	17:30	03:00
29/10/19	12	GM	07:30	10:30	03:00
29/10/19	13	GM	11:25	14:25	03:00
30/10/19	15	PC	10:30	13:30	03:00
30/10/19	15	PC	14:00	17:00	03:00
07/11/19	15	TB	12:45	15:45	03:00
08/11/19	12	TB	09:30	12:30	03:00
08/11/19	12	TB	13:00	16:00	03:00
12/11/19	7	GM	08:05	11:05	03:00
12/11/19	7	GM	11:35	14:35	03:00
14/11/19	10	GM	09:45	12:45	03:00
14/11/19	10	GM	13:15	16:15	03:00
15/11/19	14	TB	09:00	12:00	03:00
15/11/19	14	TB	12:30	15:30	03:00
21/11/19	8	TB	09:25	12:25	03:00
21/11/19	8	TB	12:55	15:55	03:00
22/11/19	6	TB	09:45	12:45	03:00
22/11/19	6	TB	13:15	16:15	03:00
25/11/19	11	TB	09:55	12:55	03:00
25/11/19	11	TB	13:25	16:25	03:00
26/11/19	13	TB	08:55	11:55	03:00
26/11/19	13	TB	12:25	15:25	03:00
27/11/19	15	TB	07:40	10:40	03:00
27/11/19	15	TB	11:10	14:10	03:00
05/12/19	7	TB	07:55	10:55	03:00
05/12/19	7	TB	11:25	14:25	03:00
06/12/19	6	AR	09:00	12:00	03:00
06/12/19	11	PC	09:05	12:05	03:00
06/12/19	6	AR	12:30	15:30	03:00
06/12/19	11	PC	12:35	15:35	03:00
10/12/19	15	TB	13:15	16:15	03:00
10/12/19	15	TB	13:15	16:15	03:00
11/12/19	10	GM	08:20	11:20	03:00
11/12/19	10	GM	11:50	14:50	03:00
13/12/19	15	GM	09:15	12:15	03:00
13/12/19	15	GM	12:45	15:45	03:00
23/12/19	8	PC	09:35	12:35	03:00
23/12/19	13	GM	09:40	12:40	03:00
23/12/19	8	PC	13:05	16:05	03:00
23/12/19	13	GM	13:10	16:10	03:00
31/12/19	14	AR	09:05	12:05	03:00
31/12/19	12	PC	09:20	12:20	03:00
31/12/19	14	AR	12:35	15:35	03:00
31/12/19	12	PC	12:50	15:50	03:00
03/01/20	7	PC	08:30	11:30	03:00
03/01/20	7	PC	12:00	15:00	03:00
17/01/20	8	PC	08:50	11:50	03:00
17/01/20	12	TB	09:00	12:00	03:00
17/01/20	8	PC	12:20	15:20	03:00
17/01/20	12	TB	12:30	15:30	03:00
20/01/20	11	GM	07:55	10:55	03:00
20/01/20	11	GM	11:25	14:25	03:00
22/01/20	15	GM	10:10	13:10	03:00
22/01/20	14	TB	10:30	13:30	03:00

Date	VP	Surveyor*	Start time	End time	Duration (hrs)
22/01/20	15	GM	13:40	16:40	03:00
22/01/20	14	TB	14:00	17:00	03:00
26/01/20	6	TB	10:40	13:40	03:00
26/01/20	6	TB	14:10	17:10	03:00
29/01/20	13	GM	08:25	11:25	03:00
29/01/20	13	GM	11:55	14:55	03:00
30/01/20	10	TB	10:45	13:45	03:00
30/01/20	10	TB	14:15	17:15	03:00
04/02/20	8	TB	10:55	13:55	03:00
04/02/20	8	TB	14:25	17:25	03:00
07/02/20	7	PC	08:30	11:30	03:00
07/02/20	7	PC	12:00	15:00	03:00
10/02/20	11	TB	09:00	12:00	03:00
10/02/20	11	TB	12:30	15:30	03:00
11/02/20	15	TB	08:55	11:55	03:00
11/02/20	15	TB	12:25	15:25	03:00
17/02/20	13	TB	07:05	10:05	03:00
17/02/20	13	TB	10:35	13:35	03:00
21/02/20	6	TB	11:30	14:30	03:00
21/02/20	6	TB	15:00	18:00	03:00
23/02/20	14	TB	09:00	12:00	03:00
23/02/20	14	TB	12:30	15:30	03:00
01/03/20	12	AR	09:15	12:15	03:00
01/03/20	10	PC	09:20	12:20	03:00
01/03/20	12	AR	12:45	15:45	03:00
01/03/20	10	PC	12:50	15:50	03:00
10/03/20	14	IG	10:50	13:50	03:00
10/03/20	14	IG	14:20	17:20	03:00
11/03/20	10	IG	09:15	12:15	03:00
11/03/20	10	IG	12:45	15:45	03:00
12/03/20	6	IG	07:35	10:35	03:00
12/03/20	15	RW	07:35	10:35	03:00
12/03/20	13	GS	07:45	10:45	03:00
12/03/20	6	RW	11:15	14:15	03:00
12/03/20	13	GS	11:15	14:15	03:00
12/03/20	15	IG	11:15	14:15	03:00
16/03/20	7	IG	10:50	13:50	03:00
16/03/20	7	IG	14:20	17:20	03:00
19/03/20	11	GS	10:45	13:45	03:00
19/03/20	11	GS	14:15	17:15	03:00
20/03/20	8	RW	09:15	12:15	03:00
20/03/20	8	RW	12:45	15:45	03:00
30/03/20	12	RW	11:00	14:00	03:00

Date	VP	Surveyor*	Start time	End time	Duration (hrs)
30/03/20	12	RW	14:30	17:30	03:00
09/04/20	14	RW	11:15	14:15	03:00
17/04/20	12	RW	07:55	10:55	03:00
22/04/20	6	RW	07:50	10:50	03:00
22/04/20	15	TB	09:00	12:00	03:00
27/04/20	15	TB	07:40	10:40	03:00
28/04/20	12	RW	12:10	15:10	03:00
01/05/20	14	GM	14:20	17:20	03:00
04/05/20	11	GM	13:05	16:05	03:00
04/05/20	11	GM	16:35	19:35	03:00
05/05/20	7	GM	11:05	14:05	03:00
05/05/20	7	GM	14:35	17:35	03:00
06/05/20	12	GM	10:10	13:10	03:00
06/05/20	12	GM	13:40	16:40	03:00
07/05/20	8	GM	07:35	10:35	03:00
07/05/20	8	GM	11:05	14:05	03:00
12/05/20	10	TB	10:45	13:45	03:00
12/05/20	10	TB	14:15	17:15	03:00
12/05/20	7	GM	17:05	20:05	03:00
13/05/20	14	GM	07:45	10:45	03:00
13/05/20	13	TB	07:50	10:50	03:00
13/05/20	14	GM	11:15	14:15	03:00
13/05/20	13	TB	11:20	14:20	03:00
13/05/20	8	GM	15:10	18:10	03:00
20/05/20	6	TB	05:25	08:25	03:00
20/05/20	13	TB	08:55	11:55	03:00
21/05/20	6	RW	11:25	14:25	03:00
21/05/20	11	GM	11:35	14:35	03:00
21/05/20	6	RW	14:55	17:55	03:00
28/05/20	10	GM	19:10	22:10	03:00
29/05/20	15	RW	07:20	10:20	03:00
29/05/20	15	RW	10:50	13:50	03:00
01/06/20	8	GM	11:25	14:25	03:00
01/06/20	8	GM	14:55	17:55	03:00
02/06/20	11	GM	15:30	18:30	03:00
03/06/20	7	GM	11:30	14:30	03:00
03/06/20	13	TB	14:45	17:45	03:00
03/06/20	7	GM	15:00	18:00	03:00
03/06/20	13	TB	18:15	21:15	03:00
09/06/20	11	PC	06:30	09:30	03:00
09/06/20	11	PC	10:00	13:00	03:00
11/06/20	10	GM	05:15	08:15	03:00
12/06/20	12	PC	06:40	09:40	03:00

Date	VP	Surveyor*	Start time	End time	Duration (hrs)
12/06/20	12	PC	10:10	13:10	03:00
16/06/20	10	GM	12:25	15:25	03:00
16/06/20	10	GM	15:55	18:55	03:00
17/06/20	14	GM	14:40	17:40	03:00
17/06/20	14	GM	18:10	21:10	03:00
19/06/20	6	RW	06:30	09:30	03:00
19/06/20	6	RW	11:55	14:55	03:00
27/06/20	13	TB	11:30	14:30	03:00
02/07/20	12	GM	14:40	17:40	03:00
02/07/20	12	GM	18:10	21:10	03:00
09/07/20	7	GM	13:50	16:50	03:00
09/07/20	8	GM	17:30	20:30	03:00
10/07/20	14	GM	10:10	13:10	03:00
10/07/20	14	GM	13:40	16:40	03:00
15/07/20	11	GM	05:05	08:05	03:00
15/07/20	11	GM	08:35	11:35	03:00
16/07/20	8	GM	14:35	17:35	03:00
16/07/20	15	PC	15:15	18:15	03:00
16/07/20	8	GM	18:05	21:05	03:00
16/07/20	15	PC	18:45	21:45	03:00
21/07/20	6	GM	12:05	15:05	03:00
21/07/20	6	GM	15:35	18:35	03:00
23/07/20	13	GM	14:15	17:15	03:00
23/07/20	13	GM	17:45	20:45	03:00
24/07/20	7	GM	04:10	07:10	03:00
24/07/20	7	GM	07:40	10:40	03:00
28/07/20	15	GM	13:00	16:00	03:00
28/07/20	15	GM	16:30	19:30	03:00
03/08/20	7	GM	14:20	17:20	03:00
03/08/20	7	GM	17:50	20:50	03:00
06/08/20	13	TB	07:30	10:30	03:00
06/08/20	13	TB	11:00	14:00	03:00
07/08/20	14	TB	07:45	10:45	03:00
07/08/20	6	RW	08:35	11:35	03:00
07/08/20	14	TB	11:15	14:15	03:00
07/08/20	6	RW	12:10	15:10	03:00
09/08/20	11	PC	08:45	11:45	03:00
09/08/20	8	GM	11:55	14:55	03:00
09/08/20	11	PC	12:15	15:15	03:00
09/08/20	8	GM	15:25	18:25	03:00
11/08/20	12	GM	10:50	13:50	03:00
11/08/20	12	GM	14:20	17:20	03:00
15/08/20	15	RW	10:10	13:10	03:00
15/08/20	15	RW	13:20	16:20	03:00
20/08/20	10	TB	08:40	11:40	03:00
20/08/20	10	TB	12:10	15:10	03:00
24/08/20	10	TB	09:25	12:25	03:00
24/08/20	10	TB	12:55	15:55	03:00

Table A1 – Flight Activity Survey Effort (September 2019 - August 2020)

* Surveyors: AR: Andrew Russell; GM: Gus McNab; GS, Graham Sparshott: IG: Iain Gilmore; PH: Phil Higginson; PC: Pete Carroll; RW: Robbie Watt; TB: Tony Bowman.

Month	Date	Surveyor#	Start Time	End Time	Duration (hh:mm)*
March	11.03.20	RW	08:30	16:00	05:30
April	20.04.20	RW	07:30/ 14:30	10:30/ 17:30	00.45
	21.04.20	GM	10:10/ 13:20	13:10/ 16:20	06:00
	22.04.20	RW	11:30	17:30	02:00
	23.04.20	GM	10:30	13:30	03:00
	27.04.20	GM	11:05	17:35	06:30
	28.04.20	GM	07:00	09:00	02:00
		TB	10:30	13:30	01:00
		RW	13:45	16:45	00:20
May	01.05.20	GM	10:50	13:50	03:00
	05.05.20	TB	10:00	16:00	06:00
	06.05.20	TB	10:30	16:30	06:00
	21.05.20	TB	11:25/ 14:30	14:25/ 17:30	06:00
	25.05.20	GM	11:30	17:30	06:00
	26.06.20	GM	09:30	15:40	06:10
		TB	10:45	16:45	02:00
	27.05.20	RW	08:00	15:00	00:50
	28.05.20	TB	08:45	14:45	00:45
June	02.06.20	GM	09:00	15:05	06:05
	12.06.20	RW	08:00	15:00	01:50
	25.06.20	GM	13:55	20:20	01:25
	27.06.20	TB	15:00	18:00	03:00
July	08.07.20	GM	10:30/ 14:35	14:20/ 17:45	07:00
		PC	13:15	18:00	04:45
	29.07.20	GM	12:00	18:00	06:00

Table A2 – Scarce Breeding Raptor Survey Effort (March - July 2020)

Surveyors: GM: Gus McNab; PC: Pete Carroll; RW: Robbie Watt; TB: Tony Bowman.
* There are several instances where the survey start and end times do not correspond to the survey duration. This is due to those particular surveys covering a wider area which extended beyond the 2km scarce breeding

raptor survey area and so not all survey effort during those surveys was directly applicable to the Proposed Development. Consequently, a representative proportion of the total survey duration relevant to that covering the survey area has been presented.

Date	Surveyor#	Sunrise Time	Start Time	End Time	Duration (hh:mm)*
09.04.20	RW	06:24	05:30	08:30	03:00
17.04.20	RW	06:05	05:00	08:00	03:00
24.04.20	RW	05:48	05:15	07:15	02:00
27.04.20	TB	05:41	05:10	06:40	00:20
13.05.20	RW	05:09	04:30	07:30	00:20
14.05.20	TB	05:07	04:45	06:45	02:00
21.05.20	GM	04:55	03:55	07:55	04:00

Table A3 – Lekking Black Grouse Survey Effort (late March - mid May 2020)

Surveyors: GM: Gus McNab; RW: Robbie Watt; TB: Tony Bowman.

* There are several instances where the survey start and end times do not correspond to the survey duration. This is due to those particular surveys covering a wider area which extended beyond the 1.5km lekking black grouse survey area and so not all survey effort during those surveys was directly applicable to the Proposed Development. Consequently, a representative proportion of the total survey duration relevant to that covering the survey area has been presented.

Date	Surveyor#	Sunset Time	Start Time	End Time	Duration (hh:mm)*
17.06.20	GM	21:57	22:10	01:05	02:55
25.06.20	GM	21:58	22:20	00:55	02:35
02.07.20	GM	21:56	22:15	00:55	02:40
16.07.20	GM	21:43	22:00	00:40	02:40
	PC	21:43	22:05	00:35	01:40
16.07.20	GM	21:32	21:50	00:25	02:35

Table A4 – Breeding Nightjar Survey Effort (June – mid July 2020)

Surveyors: GM: Gus McNab; PC: Pete Carroll; RW: Robbie Watt.
* There are instances where the survey start and end times do not correspond to the survey duration. This is due to those particular surveys covering a wider area which extended beyond the 0.5km nightjar survey area and so not all survey effort during those surveys was directly applicable to the Proposed Development. Consequently, a representative proportion of the total survey duration relevant to that covering the survey area has been presented.

Month	Date	Surveyor#	Start Time	End Time	Duration (hh:mm)
April	09.04.20	RW	08:30	10:30	02:00
	17.04.20	RW	11:00	13:00	02:00
May	14.05.20	TB	07:00	10:00	03:00
	21.05.20	GM	08:30/ 09:55	09:45/ 10:40	02:00
June	11.06.20	GM	08:30/ 09:35/ 11:35/ 12:40	09:15/ 11:20/ 12:25/ 14:20	05:00
July	08.07.20	GM	08:30/ 09:25	09:10/ 10:30	01:45
		PC	08:45	13:15	04:30

Table A5 – Moorland Breeding Bird Survey Effort (April - July 2020)

Surveyors: GM: Gus McNab; PC: Pete Carroll; RW: Robbie Watt; TB: Tony Bowman.

ANNEX 8.2: METHODS FOR COLLISION RISK MODELLING

Methods for Collision Risk Modelling

71. This section contains details of the methods used for the estimation of turbine collision rates. All of the mapped flight data were collated in a GIS (ArcView v10), with each flight's attributes (e.g. date, number of birds, vantage point recorded) included in an attribute table. These data were used in collision risk models to predict the number of birds that would collide with the turbines of the Proposed Development based on the proposed design specification (hub height - 125 m, blade radius - 75 m) during each season or year.

Choice of Directional or Non-Directional Models

72. CRM followed the method of Band et al. (2007)[12]. For each target species for which sufficient flights were recorded at PCH within the Windfarm Polygon (plus a 500m buffer - see below), a seasonal or annual collision rate was predicted using either a directional or non-directional collision risk model. Three was taken to be the minimum number of individual 'at-risk' flight events required to justify undertaking CRM. The choice of model for each target species was based on its pattern of flight behaviour within the study area.

73. The directional model is appropriate when the flights of a species are predominantly regular, directional, transits across the wind farm area. This type of flight behaviour is characteristic of species on migration or making regular movements between feeding and roosting sites, as is frequently the case for groups such as geese, swans, divers and ducks.

74. A non-directional model is more appropriate where the flights of a particular species represent more general usage of the airspace in and around the wind farm area and are not predominantly regular transits through the site. This is usually the case where birds have breeding or hunting territories that are 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.

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

    a) across a two-dimensional risk area, or 'Risk Window' 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

    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

76. 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, referred to as the Wind Farm Polygon (WP), plus a 500m buffer to allow for a degree of surveyor error when mapping flight lines in the field. Any bird flying within the WP at PCH was considered to be "at risk" of passing through the airspace swept by a turbine rotor (i.e. a rotor transit).

77. Within the WP, the estimation of flight activity through the rotor-swept airspace differs between directional and non-directional models.

78. For the directional model, the number of rotor transits was calculated as follows:

    1) A 'Risk Window' 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, taken as the distance between the upper and lower rotor swept heights.

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

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

79. For the non-directional model, flight activity is calculated in terms of overall time within the Risk Volume (as opposed to the number of flights through the Risk Window). Thus, the ratio of the Rotor-swept Volume to the Risk Volume is used, where; (i) Risk Volume is defined as the volume of airspace at PCH above the WP (i.e. the area of the WP x the diameter of the rotors); and (ii) Rotor-swept Volume is defined as the total volume of air swept by all of the rotors in the wind farm (determined for an individual rotor as the area swept multiplied by the thickness of the rotor blades).

The Modelling Process

Stage 1

80. The first stage of the modelling process can be summarised as follows:

For the Directional Model - Estimation of the Number Rotor Transits

81. For each target species, the data from the VP surveys were used to estimate the total number of flights through the airspace swept by the proposed wind farm's rotors, during the appropriate season. This total was extrapolated from the overall numbers at which "at risk" birds were recorded moving through the proposed wind farm area. This was achieved using GIS features which enabled the 'clipping' of flights within the WP to determine those 'at-risk', based on which VP they were recorded from.

82. The number of birds observed flying through the Risk Window was totalled across the season or year, for each of the VPs used. For a bird or flock to be considered "at risk" it had to satisfy three conditions:

    1) Occur within the flight recording height bands which reflected turbine height, or actual PCH, which for the proposed turbine design is 50-200m above ground.
        - As noted in the methods section, the flight recording height bands varied between the breeding and non-breeding season surveys. Those applied during the breeding season reflected actual PCH as indicative turbine design specifications were provided (i.e. Height Bands 1 = <50m, 2 = 50-200m, 3 = 200m+), but during the non-breeding season a range of height bands were used to accommodate various turbine design options from the outset of the survey programme (i.e. Height Bands 1 = <20m, 2 = 20-40m, 3 = 40-100m, 4 = 100-150m, 5 = 150-250m, 6= 250m+). Therefore, the identification of flights, and flight time, recorded during the non-breeding season was adjusted to reflect actual PCH by multiplying the number of birds in each of the two height bands that were only partially encompassed by PCH by the proportion of the height bands that were within actual PCH. Thus, for the proposed turbine design the number of birds recorded within non-breeding season Height Band 3 were multiplied by 0.83 (i.e. 5/6) and that within Height Band 5 by 0.5 (i.e. 1/2).

    2) Pass over the survey WP at any point.
    3) Occur within 2 km of the VP at some point.

83. The Risk Window was measured as the distance between the outermost turbine rotors that would be facing a bird (i.e. perpendicular) on its typical orientation through the proposed wind farm. For the purposes of assigning flights to the Risk Window, a 500m buffer extending from the turbine rotor tips was included. This buffer mitigates against a degree of observer error when drawing flightlines on the map in the field. However, the actual length of the Risk Window (without a buffer) was used when calculating collision risk.

84. For each VP the rate at which birds were recorded flying through the Risk Window (the flux of birds) was determined, by calculating the number of birds per hour per km2 of the Risk Window observed within the viewshed.

85. The flux rates for each VP were then weighted to account of the difference in survey effort between them (where survey effort was defined as the product of survey time at the VP and the area of the WP within the viewshed of the VP). The weight for a VP was calculated as its proportion of the total survey effort made from all VPs. This weight was then applied to the un-weighted flux for each VP (unweighted flux * weight).

86. The weighted flux values for each VP were then summed to give the total flux through the proposed wind farm during the surveys.

87. The flux of "at risk" birds through the wind farm during the period of interest was extrapolated from the total flux rate, by multiplying the rate by the total length of the Risk Window in metres, and the total number of minutes that the species was considered to be potentially active during the period (including a 25% nocturnal activity rate for geese and other wildfowl).

88. The area of the Risk Window was determined, to allow calculation of the proportion of the Risk Window that would be rotor-swept within the proposed wind farm. It was calculated as the width of the Risk Window perpendicular to the average flight direction of the species within the site, multiplied by the height of the rotors. The width of the proposed wind farm in this instance is measured between the outermost rotors (tip to tip, with no buffer).

89. The rotor-swept area was determined as the square of the rotor blade length multiplied first by π, and then by the number of turbines proposed for the site.

90. The total number of birds expected to fly through the rotors during the period, was then estimated by multiplying the number flying through the Risk Window by the proportion of the Risk Window that was rotor swept.

91. This figure was then taken forward to Stage 3 of the process (see below).

For Non-directional Model - Estimating the Number of Rotor Transits

92. As described above, for the non-directional model, collision risk is regarded as a function of the time spent within the rotor-swept volume. The Stage 1 calculation for this model is described below.

93. For each target species, the total amount of time that the species was observed flying within the Risk Volume during the period of interest was determined separately for each of the VPs (referred to as the VP occupancy totals).

94. For a bird (or flock) to be considered within the survey Risk Volume it had to satisfy three conditions:

    1) Occur within the flight recording height bands which reflected turbine height, or actual PCH (with the same corrections applied as for the directional model, above).
    2) Pass over the survey WP at any point.
    3) Occur within 2km viewshed of the VP at some point.

95. The VP occupancy totals were each converted to a rate, per unit effort (seconds per hour per km^2) and were then weighted to account for differences in survey effort between the VPs, in the same way as for the directional model (see above). Weighted values were then summed to give the overall occupancy rate of the proposed wind farm during the surveys.

96. The total occupancy of the survey Risk Volume during the period of interest was extrapolated from the overall occupancy rate, by multiplying the rate by the size of the Risk Area and the total number of minutes that the species was potentially active during the period.

97. The Risk Volume was determined by multiplying the area of the WP by the diameter of the rotors.

98. The rotor-swept volume of the proposed wind farm was determined as: N*πr2*(d+L), where N is the number of turbines, d is the width of the rotor blades at their widest point and L is the body length (in metres) of the bird species for which collision risk is being calculated.

99. The total occupancy of the rotor-swept volume during the period was then calculated by multiplying the occupancy of the Risk Volume by the proportion of the Risk Volume that was rotor-swept. The number of rotor transits was then estimated by dividing the total occupancy of the rotor-swept volume by the average time taken by the species to make one rotor transit (with transit time estimated from (d+L)/s, where d is the depth of the rotor swept area (m), L is the length of the species (m), and s is the average flight speed of the species (m/s)).

100. This figure was then taken forward to Stage 3 of the process (see below).

Stage 2

101. The probability was calculated that a bird of the species for which collision risk is being estimated would 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 and of various turbine-specific. The calculation is facilitated by use of a spreadsheet supplied by SNH (2000)[27]. The relevant species biometrics and turbine parameters were entered into this spreadsheet which then calculated the probability of collision. Average flight speed values for goshawk were taken from Kane et al (2015)[28], with other taxonomic data taken from Cramp (1998)[29] or BTO BirdFacts (12)[30].

Stage 3

102. The predicted number of collisions per season (breeding or non-breeding), or per year, was first calculated under the assumptions that the birds take no action to avoid the turbine rotors, and that turbines are operational all of the time. This was calculated as:

No. of birds flying through Rotor swept Area/Volume x Probability of collision

- i.e. (Stage 1 x Stage 2)

This estimate was then adjusted on the basis of the following factors:

    i. that turbines would not be operational all of the time, with the standard assumption of 85% operational time used; and
    ii. a range of plausible avoidance rates applied from 98 – 99.8%, with emphasis placed upon the rate that is recommended for the species of interest by SNH (SNH, 2018)[19].

[27] SNH (2000). Windfarms and birds: Calculating a theoretical collision risk assuming no avoiding action. SNH Guidance Note Series (https://www.nature.scot/sites/default/files/2017-09/Guidance%20Note%20-%20Windfarms%20and%20birds%20-%20Calculating%20a%20theoretical%20collision%20risk%20assuming%20no%20avoiding%20action.pdf).

[28] Kane, S.A.; Fulton, A.H. and Rosenthal, S.J. (2015). When hawks attack: animal-borne video studies of goshawk pursuit and prey-evasion strategies. Journal of Experimental Biology. 218(2): 212–222. (https://jeb.biologists.org/content/jexbio/218/2/212.full.pdf).

[29] Cramp S 1998. Cramp's the complete birds of the Western Palearctic. Oxford: Optimedia, Oxford University Press.

[30] British Trust for Ornithology (BTO) BirdFacts website 2012 (http://www.bto.org/about-birds/birdfacts).

ANNEX 8.3: ORNITHOLOGICAL SURVEY RESULT DETAILS

Date	Time	VP	Observer*	Species	No. of Birds	Flight duration (secs)
29/09/19	13:00	8	AR	Goshawk	1	195
29/09/19	16:48	13	PC	Snipe	1	45
30/09/19	12:22	12	TB	Hen harrier	1	15
30/09/19	12:43	12	TB	Pink-footed goose	300	90
30/09/19	12:45	12	TB	Pink-footed goose	85	15
30/09/19	13:21	12	TB	Pink-footed goose	120	150
30/09/19	13:41	12	TB	Pink-footed goose	32	90
30/09/19	15:47	10	TB	Pink-footed goose	37	30
30/09/19	16:39	10	TB	Pink-footed goose	120	150
17/10/19	12:28	10	GM	Goshawk	1	30
17/10/19	12:36	10	GM	Goshawk	1	60
17/10/19	12:40	10	GM	Goshawk	2	120
17/10/19	12:43	10	GM	Goshawk	2	285
17/10/19	12:43	10	GM	Goshawk	2	240
17/10/19	13:11	10	GM	Goshawk	1	90
17/10/19	13:23	10	GM	Goshawk	1	75
17/10/19	13:27	10	GM	Goshawk	1	120
17/10/19	13:39	10	GM	Goshawk	1	45
17/10/19	13:42	10	GM	Goshawk	3	240
17/10/19	14:27	10	GM	Goshawk	1	60
17/10/19	14:33	10	GM	Goshawk	2	105
17/10/19	15:01	10	GM	Pink-footed goose	465	180
17/10/19	16:02	10	GM	Goshawk	1	60
18/10/19	12:57	11	GM	Pink-footed goose	170	120
21/10/19	09:27	13	TB	Snipe	1	30
21/10/19	13:31	13	TB	Red kite	1	105
21/10/19	14:10	13	TB	Goshawk	1	60
22/10/19	10:51	12	TB	Greylag goose	13	45
23/10/19	09:00	14	TB	Goshawk	1	270
23/10/19	12:12	14	TB	Snipe	1	15
23/10/19	12:23	14	TB	Pink-footed goose	18	180
23/10/19	13:36	14	TB	Hen harrier	1	825
25/10/19	08:55	7	PH	Whooper swan	1	75
26/10/19	09:07	10	PH	Greylag goose	6	90
29/10/19	08:18	12	GM	Hen harrier	1	165
30/10/19	11:10	15	PC	Goshawk	1	195
30/10/19	12:08	15	PC	Red kite	1	165
14/11/19	10:27	10	GM	Red kite	1	45
14/11/19	11:12	10	GM	Goshawk	1	15
14/11/19	11:21	10	GM	Hen harrier	1	30
14/11/19	11:36	10	GM	Goshawk	1	30
14/11/19	13:48	10	GM	Goshawk	1	150
15/11/19	09:59	14	TB	Hen harrier	1	120
15/11/19	10:13	14	TB	Hen harrier	1	30
15/11/19	11:29	14	TB	Hen harrier	1	180
06/12/19	10:27	11	PC	Goshawk	1	90
11/12/19	08:46	10	GM	Goshawk	1	135
11/12/19	09:02	10	GM	Goshawk	1	210
11/12/19	09:57	10	GM	Goshawk	1	120
11/12/19	11:08	10	GM	Goshawk	2	45
23/12/19	13:21	13	GM	Goshawk	1	60
23/12/19	15:26	13	GM	Goshawk	1	75
31/12/19	13:09	14	AR	Goshawk	1	105
03/01/20	10:59	7	PC	Goshawk	1	150
03/01/20	11:22	7	PC	Goshawk	1	60
03/01/20	11:28	7	PC	Goshawk	1	120
17/01/20	10:04	8	PC	Pink-footed goose	110	120
17/01/20	14:36	8	PC	Goshawk	1	120
22/01/20	10:37	14	TB	Pink-footed goose	36	30
26/01/20	14:17	6	TB	Goshawk	1	90
29/01/20	08:52	13	GM	Pink-footed goose	92	105
29/01/20	09:37	13	GM	Hen harrier	1	90
29/01/20	09:37	13	GM	Hen harrier	1	15
29/01/20	10:46	13	GM	Snipe	1	45
29/01/20	13:06	13	GM	Hen harrier	1	45
30/01/20	15:57	10	TB	Goshawk	1	45
10/02/20	10:50	11	TB	Goshawk	1	225
10/02/20	15:01	11	TB	Goshawk	1	150
17/02/20	07:39	13	TB	Greylag goose	2	60
23/02/20	09:13	14	TB	Goshawk	1	165
23/02/20	14:45	14	TB	Goshawk	1	210
01/03/20	10:25	10	PC	Goshawk	1	375
01/03/20	10:28	10	PC	Goshawk	1	195
01/03/20	11:06	10	PC	Goshawk	1	30
10/03/20	16:42	14	IG	Red kite	1	270
11/03/20	09:34	10	IG	Pink-footed goose	24	135
11/03/20	10:02	10	IG	Pink-footed goose	70	75

Date	Time	VP	Observer*	Species	No. of Birds	Flight duration (secs)
11/03/20	10:04	10	IG	Goshawk	1	90
11/03/20	10:06	10	IG	Peregrine	1	60
11/03/20	10:27	10	IG	Goshawk	1	135
11/03/20	10:40	10	IG	Goshawk	1	165
11/03/20	11:17	10	IG	Goshawk	1	150
11/03/20	11:50	10	IG	Goshawk	2	270
11/03/20	11:50	10	IG	Goshawk	1	240
11/03/20	11:53	10	IG	Goshawk	1	60
11/03/20	13:18	10	IG	Merlin	1	15
11/03/20	13:36	10	IG	Goshawk	1	120
11/03/20	14:01	10	IG	Goshawk	1	60
11/03/20	14:07	10	IG	Goshawk	1	90
11/03/20	14:51	10	IG	Goshawk	1	15
11/03/20	14:58	10	IG	Goshawk	1	165
11/03/20	15:02	10	IG	Pink-footed goose	57	180
12/03/20	08:01	13	GS	Greylag goose	2	90
12/03/20	09:11	13	GS	Pink-footed goose	33	75
12/03/20	09:44	13	GS	Pink-footed goose	51	225
12/03/20	09:50	13	GS	Pink-footed goose	44	255
12/03/20	10:04	15	RW	Pink-footed goose	45	300
12/03/20	10:15	13	GS	Goshawk	1	150
12/03/20	11:22	15	IG	Pink-footed goose	10	90
12/03/20	11:35	13	GS	Red kite	1	405
12/03/20	11:45	13	GS	Pink-footed goose	45	195
12/03/20	12:10	13	GS	Pink-footed goose	33	90
12/03/20	12:13	13	GS	Pink-footed goose	75	240
12/03/20	12:22	6	RW	Pink-footed goose	88	75
19/03/20	15:15	11	GS	Goshawk	1	330
19/03/20	15:24	11	GS	Merlin	1	120
19/03/20	15:55	11	GS	Goshawk	1	105
19/03/20	16:16	11	GS	Goshawk	1	30
30/03/20	12:39	12	RW	Golden plover	18	15
30/03/20	14:46	12	RW	Golden plover	18	150
30/03/20	15:03	12	RW	Golden plover	18	15
09/04/20	11:19	14	RW	Pink-footed goose	60	165
09/04/20	12:31	14	RW	Goshawk	1	15
09/04/20	12:33	14	RW	Goshawk	1	45
22/04/20	10:12	15	TB	Red kite	1	60
22/04/20	10:24	6	RW	Snipe	1	15
04/05/20	15:08	11	GM	Goshawk	1	75
07/05/20	11:53	8	GM	Goshawk	1	45
12/05/20	11:58	10	TB	Lapwing	1	15
12/05/20	12:18	10	TB	Lapwing	1	15
12/05/20	14:52	10	TB	Lapwing	1	45
12/05/20	15:08	10	TB	Lapwing	1	30
13/05/20	10:40	14	GM	Goshawk	1	270
13/05/20	13:26	14	GM	Goshawk	2	90
13/05/20	15:24	8	GM	Goshawk	1	165
13/05/20	16:03	8	GM	Goshawk	1	225
20/05/20	08:14	6	TB	Red kite	1	60
21/05/20	11:34	6	RW	Lapwing	3	45
21/05/20	17:52	6	RW	Oystercatcher	1	15
29/05/20	08:30	15	RW	Red kite	1	30
29/05/20	11:08	15	RW	Oystercatcher	1	15
29/05/20	11:24	15	RW	Red kite	1	30
29/05/20	12:10	15	RW	Red kite	1	15
01/06/20	13:05	8	GM	Goshawk	1	60
11/06/20	06:17	10	GM	Goshawk	1	30
16/06/20	13:29	10	GM	Lapwing	2	45
16/06/20	14:55	10	GM	Lapwing	1	80
16/06/20	16:42	10	GM	Goshawk	1	120
17/06/20	16:51	14	GM	Goshawk	1	150
17/06/20	19:26	14	GM	Goshawk	1	60
19/06/20	07:11	6	RW	Snipe	1	15
19/06/20	14:01	6	RW	Snipe	1	15
19/06/20	14:05	6	RW	Snipe	1	15
16/07/20	15:39	15	PC	Red kite	1	150
16/07/20	16:12	15	PC	Red kite	2	105
16/07/20	16:21	15	PC	Red kite	1	600
16/07/20	16:42	8	GM	Red kite		270
16/07/20	17:50	15	PC	Oystercatcher	1	30
16/07/20	18:12	15	PC	Oystercatcher	1	15
24/07/20	08:33	7	GM	Goshawk	1	15
07/08/20	12:40	6	RW	Goshawk	1	15
09/08/20	12:45	11	PC	Goshawk	1	180
11/08/20	11:21	12	GM	Goshawk	1	150
17/08/20	14:04	15	RW	Red kite	1	45
24/08/20	09:52	10	TB	Red kite	1	180
24/08/20	11:33	10	TB	Goshawk	1	285

Table A6 – Details of Flight Activity Survey Records

* Surveyors: AR: Andrew Russell; GM: Gus McNab; GS, Graham Sparshott: IG: Iain Gilmore; PH: Phil Higginson; PC: Pete Carroll; RW: Robbie Watt; TB: Tony Bowman.

Species	EU Annex I	WCA Sch. 1	Red-listed BoCC
Blackbird			
Blackcap			
Barn owl		✓	
Blue tit			
Buzzard			
Carrion crow			
Chaffinch			
Chiffchaff			
Cuckoo			✓
Common gull			
Curlew			✓
Green woodpecker			
Grey wagtail			✓
Great tit			
Garden warbler			
House Martin			
Jackdaw			
Lapwing			✓
Lesser black-backed gull			
Lesser redpoll			✓
Linnet			✓
Magpie			
Meadow pipit			
Mistle thrush			✓
Nuthatch			
Pied wagtail			
Raven			
Red grouse			
Red kite	✓	✓	
Redstart			
Robin			
Rook			
Sand martin			
Siskin			
Skylark			✓
Snipe			✓
Song thrush			✓
Spotted flycatcher			✓
Stock dove			
Stonechat			
Swallow			
Tree pipit			✓

Table A7 – Moorland Breeding Bird Survey Species List and Species of Conservation Concern

Harestanes South Windfarm Extension Project Team

ScottishPower Renewables
9th Floor ScottishPower Headquarters
320 St Vincent Street
Glasgow
G2 5AD

HarestanesSouthWindfarm@scottishpower.com



www.scottishpowerrenewables.com

SCOTTISHPOWER
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