APPENDIX 7-5

COLLISION RISK ASSESSMENT DOCUMENT

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1. INTRODUCTION

This document outlines the methodology used to assess the collision risk for birds at the Proposed Development Site. The collision risk assessment is based on vantage point surveys undertaken at the wind farm study area from April 2019 to March 2021. This represents a 24-month survey period, consisting of two breeding seasons and two winter seasons, which is in full compliance with NatureScot (previously Scottish Natural Heritage) guidance (SNH, 2017). Surveys were undertaken from two fixed vantage points.

Collision risk is calculated using a mathematical model to predict the number of birds that may be killed by collision with moving wind turbine rotor blades. The modelling method used in this collision risk calculation is known as the Band Model (Band *et al.,* 2007) and has been used in a number of studies on bird collision with wind turbines (e.g. Chamberlain *et al.,* 2006; Drewitt and Langston, 2006; Fernley *et al.,* 2006; Madders and Whitfield, 2006). Note that these are theoretical predictions, therefore results must be interpreted with a degree of caution.

Two stages are involved in the Band Model. First, the number of bird transits through the air space swept by the rotor blades of the wind turbines per year is estimated. Then the collision risk for a bird passing through the rotor blades is calculated using a mathematical formula. The product of these provides a theoretical annual collision mortality rate. Finally, a bird avoidance rate is applied to the collision mortality rate to account for birds attempting to avoid collision. This final collision mortality rate informs the assessment of impacts of the wind turbine on birds.

2. METHODOLOGY

2.1 The Band Model

The Band Model is used to predict the number of bird collisions that might be caused by a wind turbine. It uses species-specific information on bird biometrics, flight characteristics and the expected amount of flight activity, along with turbine-specific information on hub height, rotor diameter, pitch and rotational speed. The turbine will be 104m at hub height, with 3 blades of a diameter of 162m, giving a maximum rotor height of 185m and a minimum rotor height 23m. The model makes a number of assumptions on the turbine design and on biometrics of birds:

1. Birds are assumed to be of a simple cruciform shape.
2. Turbine blades are assumed to have length, depth and pitch angle, but no thickness.
3. Birds fly through turbines in straight lines.
4. Bird flight is not affected by the slipstream of the turbine blade.

- Because the model assumes that no action is taken by a bird to avoid collision, it is recognised that the collision risk figures derived are purely theoretical and represent worst case estimates.

Two forms of collision risk modelling are outlined by Band *et al.* (2007): a **"Regular Flight Model"** and the **"Random Flight Model"**. A Regular Flight Model is generally applied to situations where flightlines form a regular pattern. This may occur, for example, when birds are using a wind farm site as a commuting corridor between roosting and feeding grounds or migratory routes, as is often observed in geese and swans. The Random Flight Model generally applied to situations where flightlines form no discernible patterns or routes. This is often observed, for example when raptors are in foraging or hunting flights.

The Regular Flight Model predicts the number of transits through a cross-sectional area of a wind farm which represents the width of the commuting corridor. A "risk window" is identified: a 2-dimensional line the width of a wind farm to a 500m buffer of the turbines, multiplied by the rotor diameter. All commuting flights which pass through this risk window within the rotor swept height (potential collision height; PCH) are included in collision risk modelling. Any regular flights more than 500m from the turbine layout can be excluded from analysis. There are a number of key assumptions and limitations:

- The turbine rotor swept area is 2-dimensional, i.e. there is a single row of turbines in the windfarm. This represents all turbines within the commuting corridor accounted for by a single straight-line.
- Bird activity is spatially explicit.
- Birds in an observed flight only cross the turbine area once and do not pass through the cross-section a second time (or multiple times).
- Habitat and bird activity will remain the same over time and be unchanged during the operational stage of the windfarm.
- All flight activity used in the model occurred within the viewshed area.

The Random Flight Model predicts the number of transits through a wind farm while assuming that all flights within the vantage point viewshed are randomly occurring, i.e. any observed flight could just as easily occur within a wind farm site as outside it. All flights within PCH inside the viewshed are included in the model. There are a number of key assumptions and limitations:

- Bird activity is not spatially explicit, i.e. activity is equal throughout the viewshed area and this is equal to activity in the windfarm area.

- Habitat and bird activity will remain the same over time and be unchanged during the operational stage of the windfarm.

- All flight activity used in the model occurred within the viewshed area calculated at the lowest swept rotor height.

More detail on both the Random and Regular Flight Model calculations are available from SNH: https://www.nature.scot/wind-farm-impacts-birds-calculating-theoretical-collision-risk-assuming-no-avoiding-action. In the case of the Proposed Development, eight species recorded in flight in the Wind Farm Site were randomly distributed. Therefore a Random Flight Model was conducted for these species. A Regular Flight Model was not conducted for any species, as no regular flight corridors were evident.

2.2 Modelling Process

The steps used in the Band Model to derive the collision mortality rate for each species observed at a wind farm site are outlined below.

- Stage 1: Estimate the number of bird transits through the air space swept by the rotor blades of the wind turbines. Transits are calculated using either the "Regular" or "Random" flight model (Band *et al.,* 2007), depending on flight distribution and behaviour – for the Proposed Development a Random Flight Model was conducted for all species.

- Stage 2: Calculate the collision risk for an individual bird flying through a rotating turbine blade. Collision risk is calculated using a formula which incorporates the number of bird transits (Stage 1), individual species' biometrics, individual species' flight speed and style, and the proposed turbine parameters. This formula is publicly available on the SNH website: https://www.nature.scot/wind-farm-impacts-birds-calculating-probability-collision. Biometrics are available from the British Trust of Ornithology (BTO, 2021) and flight speeds are available from Alerstam *et al.* (2007). For species that can both flap and glide, the mean of the collision risk for flapping and for gliding flight is taken.

  - The product of the number of birds transits per year multiplied by the collision risk provides an annual collision mortality rate. Note that this is the worst-case scenario for collision mortality, as it assumes that birds flying towards the turbines make no attempt to avoid them.

  - To account for birds attempting to avoid collision, an avoidance factor is applied to the annual collision mortality rate. This corrects for the ability of the birds to detect and manoeuvre around the turbines. Avoidance rates are available from SNH (2018). Bird avoidance rates are generally 98-99% or higher for most species, based on empirical evidence, targeted studies and literature reviews, and continue to be updated following further studies of bird behaviour and mortality rates at wind farm sites.

The final annual collision risk corrected for avoidance is a "real-world" estimation of the number of collisions that may occur at a wind farm, based on observed bird activity during the vantage point survey period.

2.3 Turbine specifications

Birds in flight within the viewshed at height bands of 10-25m, 25-175m and >175m above ground level have been included in the collision risk model. The turbine specifications used in the model are available in Table 7-5-1.

Table 7 – 5 – 1 Turbine specifications

Wind Farm Component	Scenario Modelled
Turbine model	Vestas V162
Number of turbines	9
Blades per turbine rotor	3
Rotor diameter (m)	162
Rotor radius (m)	81
Hub height (m)	104
Swept height (m)	23-185
Pitch of blade (degrees)	6
Maximum chord (m) (i.e. depth of blade)	4.5
Rotational period (s)	6.74
*Turbine operational time (%)	85

*This operational period of 85% is referenced from a report by the British Wind Energy Association (BWEA) (2007) which identifies the standard operational period of the wind turbines in the UK to be roughly 85%.

2.4 Ornithological Receptors

The species of conservation concern recorded during surveys at the Wind Farm Site were:

- Peregrine Falcon;
- Lapwing;
- Black-headed Gull;
- Mallard;
- Teal;
- Snipe;
- Kestrel;
- Buzzard;
- Sparrowhawk.

A CRM was conducted for each of these species. It is assumed that waterbirds are active for 25% of the night along with daylight hours (as per SNH guidance) and this is accounted for in the model.

2.5 Calculation Parameters

The calculation parameters for the vantage points are outlined in Table 7-5-2. Bird biometrics are presented in Table 7-5-3. Table 7-5-4 presents the model input values for the random model: bird seconds in flight at PCH observed from the vantage points during the relevant survey period. Bird seconds in flight at PCH is calculated by multiplying the number of birds observed per flight by the duration of the flight spent within PCH (PCH = the three height bands 10-25m, 25-175m and >175m).

Table 7- 5 - 2 Survey effort and viewshed coverage

Vantage Point	Visible Area at 25m	Risk Area	Turbines visible	Total Survey Effort
VP1	640.281ha	281.842ha	5	144 hours
VP3	441.215ha	210.555ha	5	144 hours

Table 7 – 5 – 3 Bird biometrics

Species	Body Length(m)	Wingspan(m)	Flight Speed(m/s)
Peregrine Falcon	0.42	1.02	20.7
Lapwing	0.3	0.84	11.9
Black-headed Gull	0.36	1.05	11.9
Mallard	0.58	0.9	20.8
Teal	0.36	0.61	19.7
Snipe	0.26	0.46	17.1
Kestrel	0.34	0.76	10.1
Buzzard	0.54	1.2	13.3
Sparrowhawk	0.33	0.62	10

Table 7 – 5 – 4 Model input values

Species	Model	Period	Input value
Peregrine Falcon	random	All	1,006
Lapwing	random	Winter	206,909
Black-headed Gull	random	Breeding	77,176
Black-headed Gull	random	Winter	262[1]
Mallard	random	All	1,021
Teal	random	Winter	64
Snipe	random	Winter	464
Kestrel	random	All	6,253
Buzzard	random	All	15,150
Sparrowhawk	random	All	884

The avoidance rates applied to the collision risk were: 98% for peregrine, merlin, lapwing, black-headed gull, mallard, teal, snipe, buzzard and sparrowhawk; and 95% for kestrel.

[1] *Note: Black-headed gull flights BH006 – BH010 were omitted from the CRM as they were predictably associated/concentrated in an area of habitat over 500m from the nearest turbine on a single day, and therefore not random in nature.*

3. RESULTS AND DISCUSSION

The predicted number of transits per year and the collision risk is presented in Table 7-5-5, along with the final predicted number of collisions per year. Note that for birds that both flap and glide, the average collision risk percentage between flapping and gliding is taken.

Table 7 – 5 – 5 Results of CRM

Species	Survey Period	Model	Transits	Collision Risk			Collision Rate			Estimated Collisions Over Lifetime of Wind Farm	One Bird Collision
				flapping	gliding	overall	without avoidance	avoidance factor	with avoidance		
Peregrine Falcon	All	random	161.6	4.6%	4.33%	4.46%	7.21	98%	**0.144**	4.33 birds	7 years
Lapwing	Winter	random	16446.7	4.64%	no gliding flight	4.64%	763.5	98%	**15.27**	458.1 birds	<1 year
Black-headed Gull	Breeding	random	9684.6	4.93%	4.74%	4.83%	467.85	98%	**9.357**	280.71 birds	<1 year
Black-headed Gull	Winter	random	25.4	4.93%	4.74%	4.83%	1.23	98%	**0.025**	0.74 birds	41 years
Mallard	All	random	180.6	4.77%	no gliding flight	4.77%	8.61	98%	**0.172**	5.17 birds	6 years
Teal	Winter	random	10.3	4.28%	no gliding flight	4.28%	0.44	98%	**0.009**	0.26 birds	114 years
Snipe	Winter	random	57.5	4.1%	no gliding flight	4.1%	2.36	98%	**0.047**	1.41 birds	21 years
Kestrel	All	random	453.8	4.94%	4.85%	4.89%	22.2	95%	**1.11**	33.3 birds	1 year
Buzzard	All	random	1477.1	5.38%	5.18%	5.28%	77.97	98%	**1.559**	46.78 birds	1 year
Sparrowhawk	All	random	51.7	4.87%	4.81%	4.84%	2.5	98%	**0.05**	1.5 birds	20 years

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