Appendix 7.2 Collision Risk Modelling

7.1 INTRODUCTION

Collision Risk Modelling (CRM) for target species of conservation concern observed during baseline ornithological monitoring to be active within the rotor sweep area (RSA) of proposed turbines associated with the Letter Wind Farm has been completed. Collision Risk Modelling has been completed to estimate the number of such birds likely to collide with turbines at a proposed wind farm site. The CRM method used follows that set out by Scottish Natural Heritage, referred to as the Band Model (Band et al., 2007).

7.2 CRM DATA INPUTS

The data that provides the input for the CRM comprises:

- The vantage point survey effort and the result of vantage point monitoring completed at two vantage points (VP1 & VP2) for the Letter Wind Farm site between March 2019 and March 2021 as well as between April 2022 and September 2022.
- The proposed turbine parameters for the Letter Wind Farm site. It is noted that at this stage a range in turbine parameters has been set out in the EIAR and associated planning documents. A precautionary approach has been adopted for the CRM and the maximum range, encompassing the largest rotor sweep area, has been used for the turbine parameters inputted into the CRM.
- Bird Biometric data, which comprises bird species length, wingspan and average speed.

7.2.1 TURBINE PARAMETERS

The turbine parameters used for the CRM are set out in **Table 1** below.

Table 1: Turbine Parameters

Turbine Parameter	Metric
No Turbines	4
No. Blades per Turbine	3
Largest Turbine Blade Tip Height	150m
Largest Rotor Diameter	117m

Turbine Parameter	Metric
Largest Rotor Radius	58.5
Largest Hub Height	92m
Blade Height Above Ground	33.5m
Maximum Chord	4m
Mean Pitch of blade	25 degrees
Rotational period (sec/rotation)	4.9 seconds
Turbine Operation Time	85%

7.2.2 BIRD BIOMETRIC DATA

CRM has been completed for kestrel, which was the only target species of conservation concern observed in flight within the rotor sweep area during vantage point monitoring surveys. Biometrics for kestrel are set out in **Table 2** below.

Table 2: Kestrel Biometrics

Biometric	Metric
Length	0.34
Wingspan	0.76
Average Speed	10.1

7.3 VANTAGE POINT SURVEY EFFORT

Surveys commenced in March 2019 and were continued monthly until March 2021, providing 2 years of vantage point surveys. Surveys were completed during both the breeding and non-breeding seasons.

VP1 provided views over turbines T3 and T4 and the surrounding hinterland. VP2 provides views over the turbines T1 and T2.

A minimum of 36 hours surveying was completed at both VP1 and VP2 during each breeding and non-breeding season between March 2019 and March 2021.

Additional vantage point surveys were completed during the 2022 breeding season, between April 2022 and September 2022.

A total number of 195 Hours (or 702,000 seconds) (averaging 39 hours per season) of vantage point surveying was completed from VP1 during the 2019 breeding season, 2019/2020 non-breeding season; 2020 breeding season; 2020/2021 non-breeding season; and the 2022 breeding season.

A total number of 186 Hours (or 669,600 seconds) (Averaging 37.5 hours per season) of vantage point surveying was completed from VP2 during the 2019 breeding season, 2019/2020 non-breeding season; 2020 breeding season; 2020/2021 non-breeding season; and the 2022 breeding season.

7.4 VANTAGE POINT FLIGHT ACTIVITY

The vantage point flight activity recorded for kestrel is set out in **Table 3** below.

Table 3: Vantage Point Activity Results

Species	Viewshed Area VP1 (Ha)	Viewshed Area VP1 (Ha)	Flight Time	FSA Time	% of All VP Survey Time in FSA	RSA Time	% of All VP Survey Time in RSA
Kestrel	293.5	380.5	2265	1927	0.14	460	0.03

7.5 MODEL CALCULATIONS

The stages involved in CRM are as follows:

Stage 1: Vantage point observations of birds flying through the study area are used to calculate the number of birds likely to transit through areas swept by the proposed turbine blades. There are two standard approaches that can be used to calculate the number of bird transits through the rotor sweep area, depending on species and flight behaviour.

Regular flights – this approach can be taken when the bird species makes regular flights through the wind farm, perhaps in a defined direction. For example, this approach is appropriate for geese or swans undertaking daily commuting flights from roost sites to feeding areas.

Random flights – this approach can be used for birds such as raptors which occupy a recognised territory and vantage point observations have led to some understanding of the distribution of flights within the study area. It is assumed that all flights recorded are randomly occurring i.e., they are as likely to occur within the wind farm site as outside it.

The vantage point monitoring completed for the Letter Wind Farm did not record any regular flightlines through the wind farm site. Therefore, the random flight approach has been used to calculate the number of birds likely to fly through the rotor sweep areas at the wind farm site. The following steps set out the approach to determining the number of transits per turbine per viewshed and then the average transits per turbine.

Step 1: Probability of a Kestrel Flying through the RSA

The proportion of time that a kestrel spent in flight within the RSA was calculated by first dividing the time that this species was observed within the RSA by the survey monitoring time completed from each vantage point. This calculated T1. T1 was then divided by the extent of the survey area that was visible from the vantage point i.e., the viewshed area. This provided the flight area per viewshed, denoted as 'F'.

To calculate the proportion of time spent within the RSA per vantage point 'F' was multiplied by the area occurring within a 500m buffer distance of the turbines occurring within the viewshed. This calculated 'T2'.

To calculate the occupancy 'n' of the risk area, the number of hours kestrel is assumed to be present all year has been calculated. This is based on an assumption that kestrel is active for 12 hours per day during the breeding season and 8 hours per day during the non-breeding season. This amounts to a total of 2,928 hours year, based on a breeding season of 183 days and a non-breeding season of 183 day. The occupancy 'n' is then calculated by n = T2 / 2928.

The next step is to calculate the flight risk volume of the turbines within each viewshed. This is calculated by multiplying the area occurring within a 500m buffer distance of the turbines occurring within the viewshed by the rotor diameter. The flight risk volume is denoted as 'Vw'.

The next step is to calculate the volume swept by the rotors 'Vr'. This is calculated using the following equation: Vr = no. turbines in viewshed * πr^2 * (max chord 'd' + bird length 'l').

The next step is to calculate the bird occupancy 'b' of the rotor swept area, in seconds. This is calculated by the following equation: b = n * (Vr/Vw) * 3,600.

The next step is to calculate the time taken for a bird to fly through the rotors of 1 turbine, denoted as 't3'. This is calculated as follows: t3 = (d + l)/v, where v is the average speed of a kestrel as per Table 2 above.

The number of bird transits through the rotors of one turbine during the survey period, denoted as 'N' is then calculated as follows: N = b / t3. The calculation is then adjusted for the maximum annual turbine operation time, denoted as 'No' which is assumed to be 85% i.e. No = N * 0.85.

To then convert this to the number of transits per year, denoted as Ny, No is multiplied by the total number of survey months, denoted as 'sm' and divided by 12 i.e., Ny = (No/sm) *12.

The number of transits per turbine within each viewshed, denoted as 'Nvs1'or 'Nvs2' is then calculated by multiplying Ny by the number of turbines in the VP1 and VP2 viewsheds e.g., Nvs1 = Ny/2.
Applying these calculations to the VP1 and VP2 the total number of transits per turbine within each viewshed was calculated to be **0.56** and **0.04** for VP1 and VP2 viewsheds respectively. This provides an average number of transits per turbine across the proposed wind farm site (ANvs) of **0.3**. Given that the proposed wind farm will comprise 4 no. turbines the average transits across the wind farm site (ANws) is calculated to be **1.2**.

Step 2: Probability of Collision with Turbine Rotors

The next stage of the CRM is to calculate the probability of a kestrel colliding with the turbine rotors. The probability of a bird colliding with a turbine blade when making a transit through a rotor depends on a number of estimations that include the avoidance rate assigned for the bird species, as provided by SNH, the shape of the bird and the nature of the bird flight through the rotors which is taken to be in a straight line.

For the calculation of the probability of a collision the kestrel biometrics for wingspan and speed and length are used, whilst the turbine parameters for no. of blades, maximum chord and pitch, rotation period and rotor diameter are used.

A probability, ρ (r, φ), of collision for a bird at radius r from the hub and at a position along a radial line that is at angle φ from the vertical is calculated. This probability is then integrated over the entire rotor disc, assuming that the bird transit may be anywhere at random within the area of the disc.

Scottish Natural Heritage have made available a spreadsheet to aid the calculation of these probabilities (http://www.snh.gov.uk/planning-and-development/renewable-energy/onshore-wind/bird-collisionrisks-guidance/). For a full explanation of the calculation methods see Band *et al.,* (2007).

The collision probability calculated for kestrel is **8.4%**.

A collision probability of 8.4% and an average of 1.2 transits across the rotor swept area of the wind farm site per year, the collision rate per year, assuming no avoidance will be **0.1**.

The SNH have assigned an avoidance rate of 95% for kestrel. Applying this avoidance rate the collision rate per year will be **0.005**.

Given that the operation phase of the proposed wind farm will be 40 years, the collision rate for kestrel over the lifetime of the wind farm will be **0.2** collision per year.

7.6 CRM EXAMPLE CALCULATIONS

Table 4 provides the results of the calculations for kestrel for VP1.

Table 4: CRM Step 1 Calculations for VP1

Parameter			CRM Step 1 Calculations			
Parameters	**Code**	**Parameter Value**	**Model Calculation Steps**	**Unit**	**Formula**	**Value**
Survey area visible from VANTAGE POINT	**avvp**	293.5	Proportion of time between 30 - 135m	T1	Bobs/s	0.00060
Survey Time at VP1 All year (seconds)	**s**	702000	Flight Activity per visible unit of area	F	T1/avvp	0.00000
Bird Observation Time at 30 - 135m	**Bobs**	420	proportion of time in risk area	T2	F*FRA	0.00023
Rotor Radius (m)	**r**	58.5	bord occupancy of risk area	n	T2*Ba	0.66720
Rotor Diameter (m)	**D**	117	risk volume (area of risk*rotor diameter	Vw	(FRA*D) *10000	130,787,396.72447
Max chord width of turbine blade (m)	**d**	4	actual volume of air swept by rotors	Vr	x*(Pi*r2*(d+l))	93,321.41818
No. turbines in viewshed of VP1	**x**	2	bird occupancy of rotor swept area (seconds)	b	(n*(Vr/Vw)) *3600	1.71385
Bird length (m)	**l**	0.34	time taken for bird to pass through rotors (seconds)	T3	(d+l)/v	0.42970
Average flight Speed of Kestrel	**v**	10.1	number of birds passes through the rotor in the survey period	N	b/t2	3.98846
500m buffer of turbines within viewshed (Flight Survey Area) (Ha)	**FRA**	111.7841	Total transit adjusted for max annual turbine operation time (85%)	No	N*0.85	3.39019

Parameter			CRM Step 1 Calculations			
Parameters	**Code**	**Parameter Value**	**Model Calculation Steps**	**Unit**	**Formula**	**Value**
Availability of species activity during survey periods (hours)	**Ba**	2928	Number of transits per year	Ny	(No/M) *12	1.13006
Months of Surveying	**M**	36	Number of transits per turbine within VP1	Nvs	Ny/x	**0.56503**

Table 5 provides the calculations for the average transits per turbine within each viewshed and the average transits per turbine across the wind farm site.

Table 5: Calculation of No. of Kestrel Transit per Turbine Across the Wind Farm Site

Parameter	Unit	Calculated Value
No. Transits per turbine within VP1 viewshed	Nvs1	0.56
No. Transits per turbine within VP1 viewshed	Nvs2	0.04
Average no. transits per turbine for both VPs	ANvs	0.3
No. transits per turbine across the wind farm site	ANws	1.2

Table 6 provides the calculations for the collision risk, with avoidance, without avoidance per year and over the 40-year lifetime of the wind farm.

Table 6: Calculated Collision Risk for Kestrel

Parameter	Unit Code	Formula	Value
Collision Probability	CP	from SNH Table	8.40%
Transits	T	from CRM Step 1	1.217103
Collision rate/year assuming no avoidance	CRnv	T/CP	0.102237
Avoidance Rate	AR	from SNH	95%
Collision rate/year assuming avoidance	CRv	CRnv*5%	0.005112
Collision rate over 40-year period	CR40	CRv*40	0.204473