Collision Risk Assessment

Proposed Meenbog Wind Farm, Co. Donegal

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1 INTRODUCTION

This document has been prepared by McCarthy Keville O'Sullivan Ltd. to assess the collision risk for birds at the proposed Meenbog Wind Farm, Co. Donegal. The collision risk assessment, prepared by Mr Stephen Corrigan (BSc), is based on vantage point watch surveys undertaken at the site of the proposed development from April 2015 up to and including September 2017 covering the required full two years of survey.

Collision risk is calculated using a mathematical model to predict the numbers of individual birds, of a particular species, that may be killed by collision with moving wind turbine rotor blades. The modelling method used in this collision risk calculation follows Scottish Natural Heritage (SNH) guidance which is sometimes referred to as the Band Model (Band *et al*. (2007).

Two stages are involved in the model:

- Stage 1: Determination of the number of birds or flights passing through the air space swept by the rotor blades of the wind turbines

- Stage 2: Calculation of the probability of a bird strike occurring.

The product of Stage 1 and Stage 2 gives a theoretical annual collision mortality rate on the assumption that birds make no attempt to avoid colliding with turbines.

The Band model has been the subject of academic assessment (e.g. Chamberlain et al., 2005 & 2006, Madders & Whitfield 2006, Drewitt & Langston 2006, Fernley, Lowther & Whitfield 2006) and its results must be interpreted with a degree of caution.

For a number of years, SNH advocated a highly precautionary approach, recommending a value of 95% as an avoidance rate (Band et al., 2007). However, based on empirical evidence precautionary rates have now been increased to 98-99% or higher in most cases.

2 METHODOLOGY

The steps used to derive the collision risk for the proposed development according to the Band Model are outlined below:

1. Stage 1 (Band): the model uses observations of birds flying through the study area during vantage point surveys to calculate the number of birds estimated to fly through the proposed turbines blade swept areas.
2. Stage 2 (Band): the model calculates the collision risk for an individual bird flying through a rotating turbine blade. The collision risk depends on the species biometrics and flight behaviour. Bird biometrics are available from the British Trust of Ornithology (BTO) online bird collision risk guidance.
3. The product of the number of birds calculated to fly through the turbines in a year and the risk that a bird doing so will collide with the moving blades gives the worst-case scenario for collision mortality. The worst-case scenario assumes that birds flying towards the turbines make no attempt to avoid them.
4. An avoidance factor is applied to the results to account for avoidance of the turbines by birds in flight. This corrects for the ability of the birds to detect and manoeuvre around the turbines. Avoidance rates are available from SNH online bird collision risk guidance (SNH 2016).
5. Finally, a figure for the average downtime of the turbines is applied. This accounts for wind speeds unsuitable for turbine rotation and maintenance downtime (in the case of the subject site, maintenance downtime has been taken at 80%). The final output is a real-world estimation of the number of collisions that may occur at the wind farm.

The Band Method makes a number of assumptions on the biometrics of birds and the turbine design. These are:

- Birds are assumed to be of a simple cruciform shape
- Turbine blades are assumed to have width and pitch angle, but no thickness
- Birds fly through turbines in straight lines
- 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.

A number of assumptions were made in the calculation of collision risk for the proposed Meenbog Wind Farm. These assumptions are tailored specifically to the proposed Meenbog Wind Farm and are as follows:

- Birds in flight within the study area at heights between 25m and 175m are assumed to be in danger of collision with the rotating turbine blades. This is a precautionary approach as the lower extent of the swept area of the turbine blades will be 30.5m.
- Avoidance factors of individual species are those currently recommended by SNH 2016. An avoidance factor is applied to the results to account for avoidance of the turbines by birds in flight. This corrects for the ability of the birds to detect and manoeuvre around the turbines.
- No preference was taken for birds using flapping or gliding flight through the study area. In the calculation of the percentage risk of collision for a bird flying through a rotating turbine, the mean of the worst-case scenario (*i.e.* a bird flying upwind through a turbine using flapping flight whilst the turbine is at its

fastest rotation speed) and the best-case scenario (*i.e.* a bird flying downwind through a rotating turbine using a gliding flight whilst the turbine at its slowest rotation speed) has been used.

- VP18 was added to the site in May 2016 to ensure full coverage of the site. As 17 months of surveys were carried out from this VP it does not reach the full two-year standards for SNH. This is accounted for in the model as bird transits are calculated separately for each vantage point. VP18 covers only one winter season of potential migratory bird's activity. To account for this transits on site are calculated encompassing the entire site and calculated considering only VP's where migratory bird activity was recorded. The difference in the resulting data in shown to be negligible.

The Collision Risk Assessment (CRA) also makes assumptions on the turbine specifications, such as rotor diameter and rotational speed. Because the final choice of turbine will not be known until a competitive tendering process is completed, the worst-case scenario is assumed. The worst-case scenario is a combination of the maximum collision risk area (affected by hub height and rotor blade length), maximum number of turbines proposed and minimum turbine downtime. The turbine and wind farm characteristics for the purposes of this assessment at the proposed Meenbog Wind Farm are presented in Table 2.1.

Table 2.1 Turbine and wind farm characteristics

Wind Farm Component	Scenario Modelled
Assumed turbine model	Vestas V126 Wind turbine
Number of turbines	19
Blades per turbine rotor (3d model used)	3
Rotor diameter (m)	126
Rotor radius (m)	63
Hub height (m)	93.5
Swept height (m)	30.5-156.5
Mean pitch of blade (degrees)	40
Maximum chord (m)	4
Average rotational period (s)	5.40
Turbine operational time (%)	80%

3 RESULTS

Collison risks were calculated using flight data recorded during vantage point watches at four vantage point locations (VP1-VP4) within the study area between April 2015 and September 2017 and one vantage point (VP18) between May 2016 and September 2017. The target species recorded within the potential collision risk zone included buzzard, kestrel, sparrowhawk, hen harrier, and golden plover.

The calculation parameters are outlined in Tables 3.1 & 3.2 & 3.3. A worked example of the calculation of collision risk for Buzzard is available in Appendix 1.

Table 3.1 Summary of collision risk modelling parameters for Vantage Points at Meenbog Wind Farm

Vantage Point	Visible Area (ha)	Risk Area (ha)	Turbines visible from VP	Total Survey Effort (hrs)	Survey Effort Migratory Birds (hrs)
VP01	536.7	232.8	4	184.00	75.00
VP02	374.6	297.9	5	172.75	71.00
VP03	395.2	402.5	7	182.00	73.00
VP04	300.2	269.1	4	186.00	72.00
VP18	259.9	325.5	6	110.00	36.00

Table 3.2 Summary of collision risk modelling parameters for target species at Meenbog Wind Farm

Species	Length (m)	Wingspan (m)	Ave. speed (m/s)	Seconds in flight 25 > X > 175 m
Kestrel	0.34	0.76	10.1	244
Sparrowhawk	0.33	0.62	10	35
Buzzard	0.54	1.2	13.3	4041
Hen Harrier	0.48	1.10	9.1	130
Golden Plover	0.28	0.72	17.9	750

Table 3.3 Summary table of collision risk modelling at Meenbog Wind Farm

Species	Collisions/yr Active VP's	Collisions/yr Entire Site	Avoidance factor (%)	Note
Kestrel	0.0249	0.0237	95	All year
Sparrowhawk	0.0009	0.0055	98	All year
Buzzard	0.242	0.242	98	All year
Hen Harrier	0.0101	0.0069	98	All year
Golden Plover*	0.0656	0.0624	98	(October to March) Migratory

*** Golden Plover, assumed to be active 25% of the night as well as daylight hours per CIEEM guidance (Cathrine et al 2017). This is calculated as a portion of the length of night for the survey period provided by www.timeanddate.com and is added to available hours for activity of the species per year.**

3.1 Further Assessment with Regard to Hen Harrier

In 2016 SNH published a guidance document (Wind farm proposal on afforested sites) which provides suggested methods for assessing post-felling collision risk. In relation to the current proposal, the following assessment method was deemed to be the most suitable given the nature of the site and the data available:

- Using forest plans and flight activity data:

A data request was sent to Coillte with the aim of obtaining their forestry plans for the wind farm site. It was then possible to use the forest management plan to work out how the proportion of open, replanted and maturing areas within the forest will vary over time, when compared to the proportions at the time surveys are carried out. This was then combined with the flight activity recorded during survey to predict how site suitability and therefore flight activity may change during the lifetime of the wind farm.

The review of the forestry plans revealed that the average area of suitable Hen Harrier habitat across the windfarm site over the 30 year operational lifetime of the windfarm is 294.6 ha which equates to 33.3% of the windfarm site. This is similar to the levels encountered during the 2015-2017 survey period (i.e. 258.3ha which equates to 29.2 %). Therefore no significant changes in the availability of suitable habitat or flight activity during the lifetime of the wind farm are anticipated.

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Appendix 1

Worked Example of Collision Risk Calculation - Buzzard

Stage 1a (Transits through rotors per year)

The worked example below demonstrates the calculation of transits for a single vantage point in Stage 1a. The same methodology is used to calculate the transits of all vantage points. The average transits for the site are then calculated following the methodology outlined in Stage 1b.

Survey area visible of Vantage Point viewshed in hectares (Avp)

536.7

Survey Time (secs) / Bird observation time at 25-175m (secs)

662400	855

Proportion of time between 25 – 175m (t1)
(obs time/survey time) = 0.0012908

Flight activity of buzzard per visible unit of area (F) is given by the proportion of observed time at potential collision height (t1) divided by the survey area visible of VP03 (Avp)
F=t1/Avp

2.74E-06

The 500m buffer of the turbines located within the viewshed of the vantage point give the area of risk in ha (Arisk)

232,8

Proportion of time in risk area (Trisk) is given by the flight activity per ha (F) multiplied by the risk area (Arisk)
Trisk = F*Arisk

0.0008526

Availability of species activity during survey period in hours (BA)

13575.33

The bird occupancy of the risk area (n) is given by the proportion of time in risk area (Trisk) multiplied by the hours available for the bird in the survey period (Ba)
n=Trisk*Ba

11.57423875

The risk volume (Vw) is given by the area of risk multiplied by the diameter of the swept area of the rotors
Vw= Arisk*rotor diameter

293328000

Max chord width (d)	No. of turbines (x)	Bird length in m (l)
4	4	0.54

The actual volume of air swept by rotors (o) is provided by
o= x*(piR^2(d+l))

226436.6994

The bird occupancy of the rotor swept area (b) is provided by the bird occupancy of the risk area (n) multiplied by the actual volume of air swept by rotors (o) divided by the risk volume (Vw)) in units of seconds/year)
b= 3600(n((o/Vw))

32.16534635

Time for bird to pass through rotors (t2) is provided by (the maximum chord width (d) plus the legth of the bird (l)) divided the typical flight speed of the bird (v)

t2= (d+Bl)/v

0.341353383

The number of bird passes through rotor in the survey period (N) is calculated as the bird occupancy of the rotor swept area (b) divided by the time for the bird to pass through the rotors (t2)

N= b/t2

94.22887808

Total transits adjusted for maximum operation of the turbine (Tn) is then calculated in this case it will be given as 80%.

Tn= N*0.8

75.38

Total transits in a year is calculated by dividing the total transits adjusted for maximum operation of the turbine (Tn) by the number of months surveyed (M) and multiplying the result by 12 to give a standard year's transits (TnY)

(Tn/M)*12=TnY

30.15

The number of transits per turbine within the viewshed of a vantage point is calculated by dividing the total transits in a year (TnY) by the number of turbines within the viewshed (x) to give (TnT).

TnY/x=TnT

7.54

Stage 1b (Calculating average transits per turbine)

Average transits per turbine (ATnT) is calculated by averaging the number of transits per turbine (TnT) within the viewshed of each vantage point.

$(TnT_1+TnT_2+TnT_3+TnT_4+TnT_5)/5$

7.21

To then calculate the number of transits across the windfarm (T) the average number of transits per turbine (ATnT) is multiplied by the total number of turbines present within the windfarm (Tx).

T=ATnT*Tx

137.055522

Transits through rotors for the species in a one year period across the site

137.055522

Stage 2 (Collision probability)

Calculation of the probability of the birds colliding with the turbine rotors

The probability of a bird colliding with the turbine blades when making a transit through a rotor depends on a number of estimated factors. These factors include the avoidance factor 98% – the ability of birds to take evasive action when coming close to wind turbine blades.

In the calculations, the length of a buzzard was taken to be 0.54 metres and the wingspan 1.2 metres. The flight velocity of the bird is assumed to be 13.3 metres per second. The maximum chord of the blades is taken to be 4 metres, variable pitch is assumed to be 40 degrees and the average rotation cycle is taken to be 5.40 seconds per rotation, depending on wind conditions.

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 (SNH) have made available a spreadsheet to aid the calculation of these probabilities. For a full explanation of the calculation methods see Band *et al*. (2007). The results of the calculations are shown in Table 1.3.

This is calculated using the SNH collision risk probability model at
http://www.snh.gov.uk/planning-and-development/renewable-energy/onshore-wind/bird-collision-risks-guidance/

Collision probability

8.8%

Collisions per year

The annual theoretical collision rate assuming no avoidance = T*Collision probability

12.10

The annual theoretical collision rate assuming 98% avoidance

0.24

Using previous flight activity as a surrogate for future hen harrier activity

Calculation of flight activity October 2013-September 2014 against May 2015-September 2017) to advise on the comparative collision risk of Hen Harrier in the area between the two survey periods.

Sum up the number of hen harrier flights in each survey period

Oct 13/Sep 14	60	X1
April 15/Sep 17	5	X2

Sum up the number of survey hours in each survey period

Oct 13/Sep 14	309	Y1
April 15/Sep 17	724.75	Y2

Find the ratio of survey hours between the two survey periods.
Y1/Y2 = R1

42.6%

Find the comparative number of flights from May 2015 – September 2017 (X2) when multiplied by the ratio of survey hours between the two survey periods (R1)

X2*R1=F1

2.13

Find the ratio of flights October 2013-September 2014 (X1) against May 2015 – September 2017 when accounted for the ratio of survey hours (F1) to give the comparative level of activity (F2)
X1/F1=F2

28.169

Multiply the comparative level of activity (F2) against the estimated number of collisions across the 30-year lifespan of the windfarm calculated from the survey period May 2015 to September 2017 (C1) to give the comparative number of collisions per year (CC1)
F2*C1=CC1

0.2845

Calculate the estimated collisions across the operational lifetime of the windfarm
CC1*30

8.535