Appendix 7-5 – Collision Risk Assessment

Cleanrath Wind Farm

DOCUMENT DETAILS

Client:	**Cleanrath Windfarm Ltd.**
Project Title:	**Cleanrath Wind Farm**
Project Number:	**191223-a**
Document Title:	**Appendix 7-5 – Collision Risk Assessment**
Document File Name:	**191223-a – CRA – 2020.07.28 – F**
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Rev	Status	Date	Author(s)	Approved By
01	Draft	07/05/2020	DN	PC
02	Final	28/07/2020	DN	PC

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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 Cleanrath Wind Farm Site, Co. Cork, henceforth referred to as the Subject Development. The collision risk assessment, prepared by Mr David Naughton (BSc), is based on vantage point watch surveys undertaken at the development site from February 2015 up to and including February 2017 covering a 25-month survey period, consisting of two breeding seasons and two non-breeding seasons, in full compliance with SNH (2017). Surveys were undertaken from three fixed Vantage Point (VP) Locations, (i.e. VP1, VP2 and VP3) between February 2015 and February 2017.

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: Estimation of the number of birds or flights passing through the air space swept by the rotor blades of the wind turbines. Transits are calculated using either the "**Regular** or **Random Flight**" model, depending on flight distribution and behaviour.
- Stage 2: Calculation of the probability of a bird strike occurring. Calculated using a statistical spreadsheet which considers avian biometrics and turbine parameters. This spreadsheet is publicly available on the SNH website. https://www.nature.scot/wind-farm-impacts-birds-calculating-probability-collision

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.

An informal third stage is then applied to the generated outcome of Stage 1 and Stage 2. This third stage is to account for a "real life" scenario, i.e. to account for the avoidance measures taken by each bird species, worked out as percentage applied to the product of stage 1 and 2. This third "informal" stage is often the most important factor of collision risk modelling. For several 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 and continuous studies and literature, precautionary rates have now been increased to 98-99% or higher in most cases and are regularly evolving with further examination of bird behaviour and mortality rates at windfarm sites. The most recently recommended species' avoidance rates can be found at https://www.nature.scot/wind-farm-impacts-birds-guidance-avoidance-rates-guidance.

2. METHODOLOGY

Two forms of collision risk modelling are considered when referencing the Band Model. These are often referred to as the **"Regular Flight Model"** and the **"Random Flight Model"**. The "Regular Flight Model" is generally applied to a suite of flightlines which form a regular pattern such as a commuting corridor between roosting and feeding grounds or migratory routes. As such the "Regular Flight Model" is typically relevant for waterbird species, particularly geese and swans. The "Random Flight Model" is relevant for scenarios whereby no discernible patterns or flight routes can be associated with a species within the study area. Random flights can occur for any species but is most prevalent when examining foraging or hunting flight behaviour.

- **"Random Flight Model"** examines the predicted number of transits through the windfarm by regarding all flights within the viewshed (i.e. a 2km of the vantage point) as randomly occurring. This model therefore assumes that any observed flight could just as easily occur within the windfarm site as without. Any flights recorded as flying within the rotor swept height inside the 2km arc of the vantage point is to be included in the model.
  This model has a number of key assumptions and limitations;

  1. *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.*
  2. *Habitat and bird activity will remain the same over time and be unchanged during the operational stage of the windfarm.*
  3. *All flight activity used in the model occurred within the viewshed area calculated at the lowest swept rotor height. (e.g. if the lowest swept height of the turbine blade is 30m, the viewshed coverage displaying the visibility of the area within the 2km arc at a height of 30m above ground level is used. All flights are assumed to have occurred within this visible area, although many are likely to have been above this. The AVP calculation in the model is therefore highly precautionary as it likely to have been a larger area of coverage for much of the flight activity.*

- **"Regular Flight Model"** examines the predicted number of transits through a cross-sectional area of the windfarm which represents the width of the commuting corridor. A 2-dimesional line represents a "risk window" which is the width of the windfarm plus a 500m buffer of the turbines, multiplied by the rotor diameter. All commuting flights which pass through this risk window, within the swept height of the turbines, are included in collision risk modelling. Any regular flights more than 500m from the turbine layout can be excluded from analysis.
  This model has a number of key assumptions and limitations;

  1. *Firstly, that 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.*
  2. *It is assumed that bird activity is spatially explicit.*
  3. *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).*

More detail on both the Random and Regular Flight Model calculations are publicly available and can be found on the SNH website. https://www.nature.scot/wind-farm-impacts-birds-calculating-theoretical-collision-risk-assuming-no-avoiding-action.

In the case of all species observed at the Subject Development Site, flights during the survey period could be classified as randomly distributed flights which could occur anywhere within the given viewsheds. Therefore the "Random Flight Model" was applied to these species to calculate the predicted number of transits through the windfarm site. All flight activity within the subject development site, either within 500m of turbines or not has been assumed as randomly occurring due to the similar nature of habitats in these areas and lack of defined flight patterns.

The steps used to derive the collision mortality risk for each species observed at 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, while flight speeds have been referenced from Alerstam et al. (2007).

3. The product of the number of birds calculated to fly through the turbines in a year multiplied by the collision risk (i.e. 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 2018).

5. This final output after all steps to the model is a real-world estimation of the number of collisions that may occur at the wind farm based on observed bird activity during the survey period.

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 length, depth 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.

Several assumptions were made in the calculation of collision risk for the Subject Development Site. These assumptions are tailored specifically to Subject Development Site and are as follows:

- Birds in flight within the study area recorded within the height band 25m – 175m are assumed to be in danger of collision with the rotating turbine blades. This exceeds the actual risk area for the swept area (i.e. 32.5m – 150m) in order to account for surveyor error.
- Avoidance factors of individual species are those currently recommended by SNH (2018). 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 for species which exhibit both behaviours. 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 for species which exhibit both flapping and gliding flight. For snipe and golden plover only the mean calculations for flapping flights were used.

The turbine and wind farm characteristics for this assessment at the Subject Development Site are presented in Table 1 below.

Table 1 Windfarm Parameters at the Subject Development Site

Wind Farm Component	Parameters
Turbine model	Nordex N117
Number of turbines	9
Blades per turbine rotor (3d model used)	3
Rotor diameter (m)	117
Rotor radius (m)	58.5
Hub height (m)	91
Swept height (m)	32.5 - 150
Mean pitch of blade (degrees)	5
Chord (m) (i.e. depth of blade)	3.6
Speed (Dynamic Operational Range) (m/s)	7.5 – 13.2
Mean Speed (m/s)	10.35
Average Rotational period (s) [60/10.35]	5.80
*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%.

3. RESULTS

Collison estimates were calculated using flight data recorded during vantage point watches at three vantage point locations (VP1, VP2 and VP3) within the study area between February 2015 and February 2017. The target species recorded within the potential collision risk zone included hen harrier, golden plover, peregrine, kestrel, sparrowhawk and snipe. It is acknowledged that the predicted number of transits, and hence predicted rate of collision for snipe may be underestimated, as flight activity for this species is largely crepuscular in nature while the VP survey sample consists of hours during daylight period for the most (Table 1.4, SNH (2017)).

The calculation parameters are outlined in Tables 2 – 8. A fully worked example of the calculation of collision risk for wintering golden plover populations is available in Appendix 1.

Table 2 Subject Development Site VP Survey Effort and Viewshed Coverage

Vantage Point	Visible Area at 25m (hectares)	Risk Area (hectares)	Turbines visible from VP	Total Survey Effort (hrs)
VP1	553	39.25	1	159
VP2	611.6	276.9	8	157
VP3	62.2	60.9	2	159

Table 3 Bird Biometrics (Taken from BTO BirdFacts & Alerstam et al. (2007)) and duration at PCH during VP Surveys

Species	Length (m)	Wingspan (m)	Ave. speed (m/s)	Seconds in flight at PCH (25 - 175m)
Hen Harrier (Winter)	0.48	1.10	9.1	188
Golden Plover (Winter)	0.28	0.72	17.9	25,310
Peregrine	0.42	1.02	12.1	115
Kestrel	0.34	0.76	10.1	2,305
Sparrowhawk	0.33	0.62	10.0	5
Snipe	0.26	0.46	17.1	380

Seconds in flight at PCH is calculated by multiplying the number of birds observed per flight by the duration of the flight spent within the height band 25-175m.

Table 4 Random CRM - Number of Transits per Turbine within the Viewshed of each VP

Species	VP1	VP2	VP3
Hen Harrier (Winter)	1.37	0.03	0
Golden Plover (Winter)	68.00	346.88	235.11
Peregrine	0.64	0	6.18
Kestrel	6.38	2.79	114.31
Sparrowhawk	0	0	0.43
Snipe	0	0	64.84

Table 5 Number of Transits across site per year (Averages calculated from Table 4 Above and adjusted for all 9 turbines)

Species	Average Transits	Transits Across Entire Site (All 9 Turbines) (Average Transits*9)
Hen Harrier (Winter)	0.47	4.2
Golden Plover (Winter)	216.66	1,950.0
Peregrine	2.27	20.4
Kestrel	41.16	370.4
Sparrowhawk	0.14	1.3
Snipe	21.61	194.5

Table 6 Collision Risk Workings (Both Flapping and Gliding Flights took the average Collision Risk Percentage between upwind and downwind)

Species	Flapping Flight	Gliding Flight	Collision Risk [(Flapping + Gliding)/2]
Hen Harrier (Winter)	7.0%	6.8%	6.9%
Golden Plover (Winter)	5.3%	N/A	5.3%
Peregrine	6.2%	5.9%	6.1%
Kestrel	6.0%	5.8%	5.9%
Sparrowhawk	5.9%	5.8%	5.8%
Snipe	5.0%	N/A	5.0%

*Table 7 Collision Probability assuming no Avoidance (Transits*Collision Risk)*

Species	Transits Across Entire Site	Collision Risk	Collisions/year (No Avoidance)
Hen Harrier (Winter)	4.2	6.9%	0.29
Golden Plover (Winter)	1,950.0	5.3%	102.69
Peregrine	20.4	6.1%	1.24
Kestrel	370.4	5.9%	21.92
Sparrowhawk	1.3	5.8%	0.76
Snipe	194.5	5.0%	9.74

Table 8 Collision Probability using Avoidance Rates outlined in SNH (September 2018 V2)

Species	Collisions /year	Collisions /25 Years	Avoidance factor (%)	Note
Hen Harrier (Winter)	0.003	0.07	99%	Winter/Passage (Sep-Feb)
*Golden Plover (Winter)	2.054	51.35	98%	Winter/Passage (Sep-Apr)
Peregrine	0.025	0.62	98%	All year
Kestrel	1.096	27.41	95%	All year
Sparrowhawk	0.015	0.38	98%	All year
*Snipe	0.195	4.87	98%	All year

*Assumed to be active 25% of the night as well as daylight hours per SNH guidance accounting for Swan/Geese and Wader activity. 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.

Kestrel and Golden Plover flights are strongly associated with certain sections of the site (spatially structured) than the flight activity observed for other species. As can be seen in Table 4 above, some areas of the site had a higher number of predicted transits, and hence a higher collision mortality rate. The predicted number of collisions per year provided for Golden Plover and Kestrel in Table 8 above is averaged across the entire windfarm site (i.e. 9 turbines). For these two species, flight activity is confined to certain sections of the site; therefore (potential) collision risk is likely to be higher is these areas.

Table 9 and Table 10, below, outline the ratio of transits/transits per turbine per VP viewshed, and the ratio of predicted collision per viewshed, respectively. As can be seen from both tables the highest number of predicted transits, and hence collisions, are associated with the areas with the most observed flight activity, as provided in Vantage Point Figures in Appendix 7-4. The viewshed areas and turbines within each VP survey area can be seen in Figures 7-2, 7-2-1 – 7-2-3 in Chapter 7 of the EIAR.

Table 9 Number of Transits per VP Viewshed Area

Species	Predicted Transits	VP1 Viewshed	VP2 Viewshed	VP3 Viewshed
Golden Plover	No. of Bird Transits through Viewshed	68.00	2,775.02	470.22
	No. of Bird Transits per Turbine within Viewshed	68.00	346.88	235.11
Kestrel	No. of Bird Transits through Viewshed	6.38	22.31	228.62
	No. of Bird Transits per Turbine within Viewshed	6.38	2.79	114.31

Table 10 Spatial Breakdown of Areas of Highest Collision Risk or Golden Plover and Kestrel

Species	% of Total Collisions / Year - VP1 Viewshed	% of Total Collisions / Year – VP2 Viewshed	% of Total Collisions / Year – VP3 Viewshed
Golden Plover	10.46%	53.37%	36.17%
Kestrel	5.17%	2.26%	92.57%

BIBLIOGRAPHY

Alerstam, T., Rosen M., Backman J., G P., Ericson P & Hellgren O. 2007. *Flight Speeds among Bird Species: Allometric and Phylogenetic Effects.* PLoS Biol, 5, 1656-1662. DOI:10.1371/journal.pbio.0050197

Band, W., Madders, M. and Whitfield, D.P. (2007). *Developing field and analytical methods to assess avian collision risk at wind farms. In: Birds and wind power: risk assessment and mitigation.* M. De Lucas, G.F.E. Janss and M. Ferrer, Eds.: 259-275. Quercus, Madrid.

Chamberlain, D.E., Rehfisch, M.R., Fox, A.D., Desholm, M., Anthony, S.J. 2006*. The effect of avoidance rates on bird mortality predictions made by wind turbine collision risk models.* Ibis 148: 198–202.

Cramp, S. (1993) *Handbook of the Birds of the Western Palaearctic.* Oxford University Press, Oxford.

Drewitt, A. & Langston, R. (2006). *Assessing the impacts of wind farms on birds.* Ibis 148 p.29-42

Fernley, J., Lowther, S. & Whitfield P. 2006. *A Review of Goose Collisions at Operating Wind Farms and Estimation of the Goose Avoidance Rate.* Unpublished Report by West Coast Energy, Hyder Consulting and Natural Research.

Madders, M. & Whitfield, P.D. (2006). *Upland Raptors and the Assessment of Wind Farm Impacts.* Ibis (2006), 148, 43-56.

Whitfield, D.P. & Urquhart, B. (2015). *Deriving an avoidance rate for swans suitable for onshore wind farm collision risk modelling.* Natural Research Information Note 6. Natural Research Ltd, Banchory, UK.

Scottish Natural Heritage (SNH) (2018*). Use of Avoidance Rates in the SNH Wind Farm Collision Risk Model.* Available at https://www.nature.scot/wind-farm-impacts-birds-use-avoidance-rates-snh-wind-farm-collision-risk-model

British Trust of Ornithology (BTO) online BirdFacts. Available at https://www.bto.org/about-birds/birdfacts

https://www.timeanddate.com/sun/

APPENDIX 1

WORKED EXAMPLE OF COLLISION RISK CALCULATION (RANDOM FLIGHT MODEL – GOLDEN PLOVER (WINTER))

Stage 1 (Transits through rotors per year) [Using figures from VP1 Column]

Table 11 Standard Measurements (Specific to Golden Plover, Windfarm Site, Turbines modelled & VP1)

Description	Value	Units
Survey area visible from VP (Hectares) [At 32.5m]	Avp	553
Survey Time at VP1 September – April (secs) (Winter Months)	s	378,000
Bird observation time at PCH 25m – 175m (secs)	PCH	3,600
Rotor Radius (metres)	r	58.5
Rotor Diameter (metres)	D	117
Chord width of turbine blade (metres)	d	3.96
No. of turbines in viewshed of VP1	x	1
Bird length in metres (golden plover) [Taken from BTO online)	l	0.28
Ave. Flight speed of golden plover (m/s) [Allerstam et al. 2007]	v	17.9
500m buffer of turbines within viewshed, i.e. Area of Risk (Hectares)	Arisk	39.25
Availability of species activity during survey period (hours) [Daylight hours]	Ba	7,844.67

Table 12 CRM Stage 1 Calculations using Standard Measurements in Table 1

Description	Value	Formula	Units
Proportion of time in flight 25m – 175m	t1	s/PCH	0.00952381
Flight activity per visible unit of area	F	t1/Avp	1.72E-05
Proportion of time in risk area	Trisk	F*Arisk	0.0006760
Bird occupancy of risk area	n	Trisk*Ba	5.3027348
Risk volume (Area of risk*Rotor Diameter)	Vw	(Arisk*D)*10,000	45922500
Actual volume of air swept by rotors	o	X*(Pi*r2(d+l))	45585.57755
Bird occupancy of rotor swept area (seconds)	b	3600*(n*(o/Vw))	18.94978771
Time taken for bird to pass through rotors (seconds)	t2	(d+Bl)/v	0.236871508
Number of bird passes through the rotor in the survey period	N	b/t2	80.00028302
Total transits adjusted for max annual Turbine Operation Time (85% in this case)	Tn	N*0.85	68.00
Number of transits per turbine within viewshed of VP1	**TnT1**	**Tn/x**	**68.00**

Table 13 CRM Stage 1 Calculations – Number of transits through windfarm

Description	Value	Formula	Units
Number of transits per turbine with viewshed of VP1	TnT1	Tn/x	68.00
Number of transits per turbine with viewshed of VP2	TnT2	Tn/x	346.88
Number of transits per turbine with viewshed of VP3	TnT3	Tn/x	235.11
Average transits per turbine for all VPs	ATnT	(TnT1+TnT2+TnT3) /3	216.66
Predicted number of transits through windfarm site (All 9 turbines)	T	ATnT*9	1,949.96

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

1,949.96

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 golden plover was taken to be 0.28 metres and the wingspan 0.72 metres. The flight velocity of the bird is assumed to be 17.9 metres per second. The chord of the blades is taken to be 3.96 metres, variable pitch is assumed to be 5 degrees and the average rotation cycle is taken to be 5.80 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 these calculations for all species are shown in Table 8 above.

Collision Probability*

5.0%

*This is calculated using the SNH collision risk probability model at https://www.nature.scot/wind-farm-impacts-birds-calculating-probability-collision

Collisions per year

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

102.69

The annual theoretical collision rate assuming 98% avoidance (102.69*0.02)

2.05

Theoretical collision rate assuming 98% avoidance across the operational period of the windfarm (2.05*25)

51.35