Trecelyn Wind Farm
Appendix 9B: Collision Risk Modelling
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1 INTRODUCTION

1.1 This Appendix has been written as a supplement to Chapter 9 Ornithology of the Environmental Statement for the proposed Trecelyn Wind Farm (hereafter referred to as the 'Proposed Development'). It explains the process and results of the Collision Risk Modelling (CRM), which estimates the wind turbine collision risk to select bird species based on flight data from two years of Vantage Point (VP) surveys.

1.2 The CRM methodology is based on Band *et al*. (2007[1]) as recommended by Natural Scotland (previously known as Scottish Natural Heritage (SNH) (SNH 2017[2]). The model requires various data (turbine specification, species biometrics and flight characteristics and data on flights within the Collision Risk Zone (CRZ)) to calculate a theoretical collision rate by season, year and over the lifetime of the project to inform the assessment of potentially significant adverse effects. The ability of species to avoid turbines is also factored in (SNH 2018[3]).

2 METHODOLOGY

2.1 Worst-case parameters for the wind turbine model selected for the Proposed Development and used for the CRM are shown in **Table EDP 2.1**.

Table EDP 2.1: Turbine Dimensions Used in the CRM

Parameter	Value
Model	Vestas V117-4.2MW
Number of Turbines	4
Number of Blades	3
Blade Diameter (m)	117

[1] Band, W., Madders, M. & Whitfield, D.P. (2007) *Developing Field and Analytical Methods to Assess Avian Collision Risk at Wind Farms*. In: de Lucas, M., Janss, G. & Ferrer, M. (eds.) Birds and Wind Farms: Risk Assessment and Mitigation *(pp. 259-275).* Quercus, Madrid.

[2] Scottish Natural Heritage (2017) *Recommended Bird Survey Methods to Inform Impact Assessment of Onshore Wind Farms*. (online) Available at: https://www.nature.scot/sites/default/files/2018-06/Guidance Note - Recommended bird survey methods to inform impact assessment of onshore windfarms.pdf. Last accessed 04/07/22.

[3] Scottish Natural Heritage (2018) *Avoidance Rates for the Onshore SNH Wind Farm Collision Risk Model*. (online) Available at: https://www.nature.scot/sites/default/files/2018-09/Wind farm impacts on birds - Use of Avoidance Rates in the SNH Wind Farm Collision Risk Model.pdf. Last accessed 04/07/22.

Parameter	Value
Blade High Point (m)	145
Blade Low Point (m)	28
Maximum Blade Depth (m)	4
Flight Risk Area (m^2)	603,389
Flight Risk Volume (m^3)	77,980,500

2.2 A total of two VP locations were used, covering a combined area of approximately 320 hectares (ha). This area was calculated by combining the total area visible from each VP and therefore allows for the potential over-representation where these areas overlap. **Table EDP 2.2** shows the number of survey hours per VP location per season.

Table EDP 2.2: Survey Hours per VP Location per Season

Season	Hours per Survey	Number of Surveys	Total Number of Hours per VP Location	Total Number of Hours Surveyed across both VPs
Breeding 2020	3	12	36	72
Non-breeding 2020-21	3	12	36	72
Breeding 2021	3	12	36	72
Non-breeding 2021-22	3	18	54	108*

*Survey effort increased in response to scoping response from Natural Resources Wales (NRW) to increase migratory coverage.

2.3 The CRM was completed separately for breeding (April to August) and non-breeding (September to March) seasons, covering two years from the 2020 breeding season through to the non-breeding season of 2021-22.

2.4 Based on the flight data recorded, target species were selected for CRM. The species that were analysed were grey heron (*Ardea cinerea*), mallard (*Anas platyrhynchos),* herring gull (*Larus argentatus*), lesser black-backed gull (*Larus fuscus*), goshawk (*Accipiter gentilis*), kestrel (*Falco tinnunculus*), osprey (*Pandion haliaetus*), peregrine (*Falco peregrinus*) and red kite (*Milvus milvus*). Owing to the number of raven (*Corvus corax*) and buzzard (*Buteo buteo*) flights recorded within the Survey Boundary and Study Area, and in light of the scoping response from NRW requesting that, subject to results, they not be scoped into of the assessment, these species were also subject to CRM despite their favourable conservation status.

2.5 Target species flight heights were recorded at 15 second intervals. Based on the worst-case turbine specifications at the outset of the Project, the following core height bands were used during the first year of surveys:

- <30m;
- 30–180m (CRZ); and
- 180m.

2.6 For the second year of surveys, additional height band increments were recorded in 15m increments to allow some flexibility should the turbine specification change. However, for the purposes of the CRM, a precautionary approach has been adopted and the CRZ has been considered to be 30-180m despite the final turbine specification only having a CRZ of 28-145m. The additional 35m included at the upper height of the CRZ is considered to more than compensate for the 2m shortfall at the lower blade height, particularly given that recording heights are based on subjective human estimates.

2.7 In addition, to adopt an even more precautionary stance given the lower turbine height, an additional CRM was run in parallel with the standard approach. This precautionary approach adds the time that all birds spent flying in the height band immediately below the CRZ (0-30m flight band in year 1 and 15-30m flight band in year 2 – this additional height band was only introduced in year 2) into the time seen flying at CRZ height.

2.8 As none of these species were flying across the Survey Boundary or Study Area in any sort of regular way, the 'Random Model' technique was used. The model takes into account the time that birds of each species were observed flying at the height of the turbine rotors (CRZ), as well as the time in which birds could be active, i.e. the number of daylight hours per month.

2.9 The Band (2007) model is a two-stage process. The first stage uses the flight data recorded on the VP survey, as set out in **Table EDP 2.3**, to estimate the number of birds flying through the areas swept by the turbine rotor blades per year.

Table EDP 2.3: Flight Observations for Stage 1 of CRM

Species	Season	Total Observed Time(s)	Available Hours for Flight Activity	Time at CRZ Height(s) (30-180m)	Time at Precautionary CRZ Height(s) (0-180m Year 1/15-180m Year 2)
Buzzard	Breeding 2020 (April-August)	4650	2351.19	1950	2385
	Non-breeding 2020-21 (September-March)	2835	2130.25	1890	2070
	Breeding 2021 (April-August)	3420	2351.19	3105	3195
	Non-breeding 2021-22 (September-March)	3885	2130.25	2535	2700

Species	Season	Total Observed Time(s)	Available Hours for Flight Activity	Time at CRZ Height(s) (30-180m)	Time at Precautionary CRZ Height(s) (0-180m Year 1/15-180m Year 2)
Goshawk	Breeding 2020 (April-August)	0	2351.19	0	0
	Non-breeding 2020-21 (September-March)	0	2130.25	0	0
	Breeding 2021 (April-August)	45	2351.19	45	45
	Non-breeding 2021-22 (September-March)	300	2130.25	300	300
Grey Heron	Breeding 2020 (April-August)	30	2351.19	15	30
	Non-breeding 2020-21 (September-March)	0	2130.25	0	0
	Breeding 2021 (April-August)	45	2351.19	0	30
	Non-breeding 2021-22 (September-March)	150	2130.25	150	150
Herring Gull	Breeding 2020 (April-August)	990	2351.19	690	915
	Non-breeding 2020-21 (September-March)	90	2130.25	0	0
	Breeding 2021 (April-August)	1995	2351.19	1440	1755
	Non-breeding 2021-22 (September-March)	0	2130.25	0	0

Species	Season	Total Observed Time(s)	Available Hours for Flight Activity	Time at CRZ Height(s) (30-180m)	Time at Precautionary CRZ Height(s) (0-180m Year 1/15-180m Year 2)
Kestrel	Breeding 2020 (April-August)	150	2351.19	60	150
	Non-breeding 2020-21 (September-March)	870	2130.25	570	840
	Breeding 2021 (April-August)	150	2351.19	30	135
	Non-breeding 2021-22 (September-March)	705	2130.25	585	675
Lesser Black-backed Gull	Breeding 2020 (April-August)	780	2351.19	525	615
	Non-breeding 2020-21 (September-March)	45	2130.25	45	45
	Breeding 2021 (April-August)	2385	2351.19	1320	2160
	Non-breeding 2021-22 (September-March)	165	2130.25	120	120
Mallard	Breeding 2020 (April-August)	30	2351.19	0	30
	Non-breeding 2020-21 (September-March)	0	2130.25	0	0
	Breeding 2021 (April-August)	30	2351.19	0	30
	Non-breeding 2021-22 (September-March)	120	2130.25	75	90

Species	Season	Total Observed Time(s)	Available Hours for Flight Activity	Time at CRZ Height(s) (30-180m)	Time at Precautionary CRZ Height(s) (0-180m Year 1/15-180m Year 2)
Osprey	Breeding 2020 (April-August)	0	2351.19	0	0
	Non-breeding 2020-21 (September-March)	0	2130.25	0	0
	Breeding 2021 (April-August)	0	2351.19	0	0
	Non-breeding 2021-22 (September-March)	180	2130.25	60	45
Peregrine	Breeding 2020 (April-August)	540	2351.19	210	345
	Non-breeding 2020-21 (September-March)	180	2130.25	105	165
	Breeding 2021 (April-August)	750	2351.19	450	465
	Non-breeding 2021-22 (September-March)	555	2130.25	390	435
Raven	Breeding 2020 (April-August)	1770	2351.19	660	1620
	Non-breeding 2020-21 (September-March)	2265	2130.25	0	1995
	Breeding 2021 (April-August)	3390	2351.19	255	2820
	Non-breeding 2021-22 (September-March)	4230	2130.25	1395	3330

Species	Season	Total Observed Time(s)	Available Hours for Flight Activity	Time at CRZ Height(s) (30-180m)	Time at Precautionary CRZ Height(s) (0-180m Year 1/15-180m Year 2)
Red Kite	Breeding 2020 (April-August)	990	2351.19	1110	720
	Non-breeding 2020-21 (September-March)	0	2130.25	1665	0
	Breeding 2021 (April-August)	495	2351.19	2115	405
	Non-breeding 2021-22 (September-March)	1830	2130.25	2715	1635

2.10 The flight risk area is defined as the area bounded by the extent of the outer-most turbines, plus a buffer of 58.5m, in order to include the turbine blade radius. The flight risk volume is this area multiplied by the diameter of the turbine blades.

2.11 The area of visibility was calculated using QGIS Geographic Information System (GIS) software, using a viewshed of 180° from each of the two VP locations, limited to a radius of 2km. It covers the area visible 25m above ground level, assuming an observer height of 1.75m, a woodland height of 18m, and a 5m digital terrain model.

2.12 The second stage then estimates the probability of these birds actually being hit by the moving rotors. The results of this stage can be seen in **Table EDP 2.4**. This stage uses data of bird wingspan and body length (BTO 2022[4]) and flight speeds (Alerstam *et al*. 2007[5] and Bruderer & Boldt 2001[6]), which can be seen in **Table EDP 2.5**. Where these two data sources listed different flight speeds, the slower one was used in order to assume a worst-case scenario.

2.13 These two stages are multiplied together to produce an estimate of bird casualties over a year, assuming that birds will take no measures to avoid collisions.

[4] British Trust for Ornithology (2022) *Birdfacts* (online) Available at: https://www.bto.org/understanding-birds/birdfacts. Last accessed 04/07/22.

[5] Alerstam T., Rosén M., Bäckman J., Ericson P.G.P., Hellgren, O. (2007). *Flight Speeds among Bird Species: Allometric and Phylogenetic Effects*. PLoS Biol 5(8): e197. DOI:10.1371/journal.pbio.0050197.

[6] Bruderer, B. & Boldt, A. 2001. Flight characteristics of birds 1: radar measurement of speeds. Ibis 143 (2): 178-204.

Table EDP 2.4: Calculation of Collision Probabilities for Birds Passing Through Area Swept by Rotor Blades

Species (in flapping flight)	Collision Probability Upwind (%)	Collision Probability Downwind (%)	Mean (%)
Buzzard	18.1	11.4	14.8
Goshawk	21.0	14.2	17.6
Grey Heron	22.3	15.6	19.0
Herring Gull	17.3	10.7	14.0
Kestrel	18.2	11.4	14.8
Lesser Black-Backed Gull	18.2	11.5	14.9
Mallard	13.2	6.9	10.1
Osprey	19.0	12.3	15.7
Peregrine	16.5	9.9	13.2
Raven	16.2	9.6	12.9
Red Kite	18.6	11.9	15.3

Note: upwind and downwind probabilities are different due to wind speed affecting time taken to pass through the area swept by the rotor blades. These are therefore combined to give an average collision probability.

2.14 In reality, birds will avoid collisions if possible, so this assumption is unrealistic. Therefore SNH (2018[7]) have calculated avoidance rates based on observations of different species in the field, which are then applied to the bird collision risk estimate to provide a more realistic estimate. Furness (2019[9]) updated the avoidance rates of herring gull and lesser black-backed gull. The avoidance rates used are shown in **Table EDP 2.5**.

Table EDP 2.5: Bird Biometrics and Avoidance Rates

Species	Body Length (m)	Wingspan (m)	Assumed Flight Speed (m/s)	Avoidance Rate (%)
Buzzard	0.54	1.20	11.6	98.0
Goshawk	0.55	1.10	9.7	98.0
Grey Heron	0.94	1.85	11.2	98.0
Herring Gull	0.6	1.44	12.8	99.5
Kestrel	0.34	0.76	10.1	95.0
Lesser Black-Backed Gull	0.58	1.42	11.9	99.5
Mallard	0.62	0.98	18.5	98.0
Osprey	0.6	1.70	11.4	98.0
Peregrine	0.42	1.02	12.1	98.0
Raven	0.64	1.35	14.3	98.0

[7] Scottish Natural Heritage (2018) *Avoidance Rates for the Onshore SNH Wind Farm Collision Risk Model*. (online) Available at: https://www.nature.scot/sites/default/files/2018-09/Wind farm impacts on birds - Use of Avoidance Rates in the SNH Wind Farm Collision Risk Model.pdf. Last accessed 04/07/22.

[9] Furness, R.W. (2019) *Avoidance rates of herring gull, great black-backed gull and common gull for use in the assessment of terrestrial wind farms in Scotland*. Scottish Natural Heritage Research Report No. 1019.

Species	Body Length (m)	Wingspan (m)	Assumed Flight Speed (m/s)	Avoidance Rate (%)
Red Kite	0.63	1.85	12.0	99.0

3 LIMITATIONS AND ASSUMPTIONS

3.1 The CRM assumes that the turbines will be operational at all times, and therefore accounts for the worst-case scenario. In reality, mechanical faults/maintenance and low wind speed will likely mean that operational time is more like 85-90%. If the rotors are not spinning, this would result in lower numbers of bird collisions than projected here.

3.2 Of the 324 total hours of VP surveys, a total of five hours, or 1.5%, were undertaken in poor visibility (<1km), and a total of 21 hours were undertaken in moderate visibility (1-2km). Therefore, a total of 8.0% of surveys were undertaken in less than optimal visibility conditions. In reality, this is an over estimation of reduced visibility, as visibility is recorded four times on survey sheets: at the start, and for the first, second, and third hours.

3.3 No data was available on the wind turbine blade pitch angle which is used in the collision risk calculations. It was left as the default value of 30°. Band (2012[10]) considers 25-30° to be a reasonable assumption for a typical large turbine.

3.4 No data was available for the rotation period of the wind turbines, so this was left at the default value of 2.97 seconds per rotation (20.2 rotations per minute).

4 RESULTS

4.1 The results of the CRM, showing seasonal, annual and longer-term collision risks, are shown in **Table EDP 4.1**.

[10] Band, B. (2012). *Using a Collision Risk Model to Assess Bird Collision Risks for Offshore Wind Farms*. Report by British Trust for Ornithology (BTO). Report for The Crown Estate. (online) Accessed at https://www.bto.org/sites/default/files/u28/downloads/Projects/Final_Report_SOSS02_Band1ModelGuidance.pdf. Last accessed 25/08/22.

Table EDP 4.1: Projected Seasonal, Annual, and Longer-Term Collision Risk for Standard and Precautionary Approaches

Activity Season	Predicted Collisions	Standard			Precautionary		
		Year 1	Year 2	Average	Year 1	Year 2	Average
Buzzard							
Breeding Season (April-August)	Predicted collisions per year	0.17	0.30	0.24	0.21	0.31	0.26
	Predicted collisions over 30 years	5.15	9.00	7.08	6.30	9.26	7.78
Non-breeding Season (September-March)	Predicted collisions per year	0.15	0.15	0.15	0.17	0.16	0.16
	Predicted collisions over 30 years	4.53	4.36	4.44	4.96	4.73	4.84
Annual Total	Predicted collisions per year	0.32	0.45	0.39	0.38	0.47	0.42
	Predicted collisions over 30 years	9.68	13.36	11.52	11.26	13.99	12.62
Goshawk							
Breeding Season (April-August)	Predicted collisions per year	0.00	0.00	0.00	0.00	0.00	0.00
	Predicted collisions over 30 years	0.00	0.13	0.06	0.00	0.13	0.06
Non-breeding Season (September-March)	Predicted collisions per year	0.00	0.02	0.01	0.00	0.02	0.01
	Predicted collisions over 30 years	0.00	0.52	0.26	0.00	0.52	0.26
Annual Total	Predicted collisions per year	0.00	0.02	0.01	0.00	0.02	0.01
	Predicted collisions over 30 years	0.00	0.65	0.32	0.00	0.65	0.32
Grey Heron							
Breeding Season (April-August)	Predicted collisions per year	0.00	0.00	0.00	0.00	0.00	0.00
	Predicted collisions over 30 years	0.05	0.00	0.02	0.10	0.11	0.10
Non-breeding Season (September-March)	Predicted collisions per year	0.00	0.00	0.00	0.00	0.00	0.00
	Predicted collisions over 30 years	0.00	0.08	0.04	0.00	0.08	0.04
Annual Total	Predicted collisions per year	0.00	0.00	0.00	0.00	0.01	0.00
	Predicted collisions over 30 years	0.05	0.08	0.06	0.10	0.19	0.14

Activity Season	Predicted Collisions	Standard			Precautionary		
		Year 1	Year 2	Average	Year 1	Year 2	Average
Herring Gull							
Breeding Season (April-August)	Predicted collisions per year	0.02	0.04	0.03	0.02	0.06	0.04
	Predicted collisions over 30 years	0.48	1.24	0.86	0.63	1.68	1.16
Non-breeding Season (September-March)	Predicted collisions per year	0.00	0.00	0.00	0.00	0.00	0.00
	Predicted collisions over 30 years	0.00	0.00	0.00	0.00	0.00	0.00
Annual Total	Predicted collisions per year	0.02	0.04	0.03	0.02	0.06	0.04
	Predicted collisions over 30 years	0.48	1.24	0.86	0.63	1.68	1.16
Kestrel							
Breeding Season (April-August)	Predicted collisions per year	0.01	0.01	0.01	0.03	0.03	0.03
	Predicted collisions over 30 years	0.35	0.19	0.27	0.87	0.85	0.86
Non-breeding Season (September-March)	Predicted collisions per year	0.10	0.07	0.09	0.15	0.09	0.12
	Predicted collisions over 30 years	2.98	2.12	2.55	4.39	2.58	3.49
Annual Total	Predicted collisions per year	0.11	0.08	0.10	0.18	0.12	0.15
	Predicted collisions over 30 years	3.33	2.31	2.82	5.26	3.43	4.35
Lesser Black-backed Gull							
Breeding Season (April-August)	Predicted collisions per year	0.01	0.04	0.02	0.01	0.07	0.04
	Predicted collisions over 30 years	0.36	1.13	0.74	0.42	1.96	1.19
Non-breeding Season (September-March)	Predicted collisions per year	0.00	0.00	0.00	0.00	0.00	0.00
	Predicted collisions over 30 years	0.03	0.05	0.04	0.03	0.05	0.04
Annual Total	Predicted collisions per year	0.01	0.04	0.02	0.01	0.07	0.04
	Predicted collisions over 30 years	0.39	1.18	0.78	0.45	2.01	1.23

Activity Season	Predicted Collisions	Standard			Precautionary		
		Year 1	Year 2	Average	Year 1	Year 2	Average
Mallard							
Breeding Season (April-August)	Predicted collisions per year	0.00	0.00	0.00	0.00	0.00	0.00
	Predicted collisions over 30 years	0.00	0.00	0.00	0.06	0.14	0.10
Non-breeding Season (September-March)	Predicted collisions per year	0.00	0.00	0.00	0.00	0.01	0.00
	Predicted collisions over 30 years	0.00	0.14	0.07	0.00	0.17	0.09
Annual Total	Predicted collisions per year	0.00	0.00	0.00	0.00	0.01	0.00
	Predicted collisions over 30 years	0.00	0.14	0.07	0.06	0.31	0.19
Osprey							
Breeding Season (April-August)	Predicted collisions per year	0.00	0.00	0.00	0.00	0.00	0.00
	Predicted collisions over 30 years	0.00	0.00	0.00	0.00	0.00	0.00
Non-breeding Season (September-March)	Predicted collisions per year	0.00	0.00	0.00	0.00	0.00	0.00
	Predicted collisions over 30 years	0.00	0.08	0.04	0.00	0.08	0.04
Annual Total	Predicted collisions per year	0.00	0.00	0.00	0.00	0.00	0.00
	Predicted collisions over 30 years	0.00	0.08	0.04	0.00	0.08	0.04
Peregrine							
Breeding Season (April-August)	Predicted collisions per year	0.02	0.04	0.03	0.03	0.04	0.04
	Predicted collisions over 30 years	0.52	1.22	0.87	0.85	1.26	1.05
Non-breeding Season (September-March)	Predicted collisions per year	0.01	0.02	0.01	0.01	0.02	0.02
	Predicted collisions over 30 years	0.23	0.64	0.44	0.37	0.71	0.54
Annual Total	Predicted collisions per year	0.03	0.06	0.04	0.04	0.06	0.06
	Predicted collisions over 30 years	0.75	1.86	1.31	1.22	1.97	1.59

Activity Season	Predicted Collisions	Standard			Precautionary		
		Year 1	Year 2	Average	Year 1	Year 2	Average
Raven							
Breeding Season (April-August)	Predicted collisions per year	0.11	0.22	0.16	0.15	0.29	0.22
	Predicted collisions over 30 years	3.16	6.59	4.87	4.60	8.79	6.70
Non-breeding Season (September-March)	Predicted collisions per year	0.14	0.17	0.15	0.17	0.21	0.19
	Predicted collisions over 30 years	4.29	4.97	4.63	5.14	6.27	5.70
Annual Total	Predicted collisions per year	0.25	0.39	0.31	0.32	0.50	0.41
	Predicted collisions over 30 years	7.45	11.56	9.50	9.74	15.06	12.40
Red Kite							
Breeding Season (April-August)	Predicted collisions per year	0.03	0.01	0.02	0.03	0.02	0.03
	Predicted collisions over 30 years	0.93	0.39	0.66	1.02	0.63	0.82
Non-breeding Season (September-March)	Predicted collisions per year	0.00	0.04	0.02	0.00	0.05	0.03
	Predicted collisions over 30 years	0.00	1.30	0.65	0.00	1.53	0.76
Annual Total	Predicted collisions per year	0.03	0.05	0.04	0.03	0.07	0.06
	Predicted collisions over 30 years	0.93	1.69	1.31	1.02	2.16	1.58