
Mynydd Fforch Dwm Wind Farm
Naturalis Energy Developments Ltd
Appendix 10.2: Collision Risk Model Analysis



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1 INTRODUCTION

- 1.1.1 This Technical Appendix has been prepared to accompany **Chapter 10: 'Ornithology'** of the Environment Statement ('ES') for the proposed Mynydd Fforch Dwm Wind Farm (hereafter 'Proposed Development').
- 1.1.2 It presents the details and results of collision mortality risk calculations, completed to inform the assessment for the Proposed Development upon ornithological interests.
- 1.1.3 This Technical Appendix is supplementary to **Appendix 10.1** in Volume 3 of the ES, and which provides full details of ornithological field surveys which have been undertaken to inform this analysis.

2 METHODOLOGY

2.1 Background

- 2.1.1 The NatureScot collision risk model (CRM) (Band *et al.*, 2007) has been used to estimate the collision mortality risk to target species.
- 2.1.2 The CRM calculates collision mortality risks in three stages:
 - Stage 1: the estimation of the number of birds passing through the rotor swept volume of the wind farm, based on observed Vantage Point (VP) flight activity data;
 - Stage 2: the estimation of collision likelihood i.e. the probability of a bird flying through a rotor being hit, based on bird and wind farm parameters and whereby all collisions are assumed to be fatal. This provides an estimate of how many fatal collision could occur, in theory, should birds take no avoiding action; and
 - After multiplying Stage 1 and Stage 2 an avoidance factor is then applied i.e. whereby it is assumed birds take action to avoid collision.

2.2 Wind Farm Parameters

- 2.2.1 The Proposed Development comprises seven turbines, split between the areas known as Mynydd Fforch Dwm ('MFD'), which consist of four turbines, in the east and Mynydd Blaenafon ('MB'), consisting of two turbines in the west.
- 2.2.2 The turbines in MFD comprise four turbines of 200m maximum tip height, 125m hub height, and 150m maximum rotor diameter.
- 2.2.3 The turbines in MB comprise two turbines of 180m maximum tip height, 105m hub height, , and 150m maximum rotor diameter.
- 2.2.4 For the purposes of analysis, CRM is carried out separately for MFD and MB, principally given the varying turbine specifications. For MFD, the flight risk volume (Vw) is based on a buffer constructed around the individual turbine locations with a radius of 290m (area = 127.2ha) and a height at least equal to the rotor diameter (150m). For MB, the Vw is based on a 290m buffer around individual turbine locations with a radius of 290m (area = 58.54ha) and a height at least equal to the rotor diameter (150m).
- 2.2.5 Turbine parameters are summarised in **Table 2.1**. The parameters are presented for MFD and MB. The proposed turbine is either the 'V150 – Vestas or N149 – Nordex' but given the lack of available specification for all parameters for these turbine types, specification for a comparable candidate

turbine (the 'Vestas V164-8.0') is used where parameters for the Proposed Development's turbines are not available. Where uncertainty arises, precautionary parameters have been used.

Table 2.1: Turbine parameters.

Parameter	MFD	MB	Unit
Size of Wind Farm (290m turbine buffer)	127.2	58.54	ha
No. of rotors	4	2	-
No. of blades	3	3	-
Height to tip	200	180	metres
Hub height	125	105	metres
Rotor diameter	150	150	metres
Rotor radius	75	75	metres
Max chord	4.2	4.2	metres
Pitch	15	15	degrees
Rotation period	5.7	5.7	seconds
Downtime	15	15	%

2.3 Viewsheds

- 2.3.1 Target species flight activity data for use in analysis has been obtained from one VP (VP1) during VP flight activity surveys between March 2019 and February 2020, and March 2021 and February 2022 for MFD (two full years), and from one VP (VP2) during VP flight activity surveys between March 2021 and February 2022 for MB (one full year).
- 2.3.2 The visible area for VP1 has been calculated using an observer height of 1.5m and a 20m vertical offset above the ground, and for VP2 has been calculated using an observer height of 1.5m and a 10m vertical offset above the ground. The extent of the visible area that could be seen from each VP location was confirmed prior to the commencement of surveys.
- 2.3.3 **Table 2.2** presents the visible areas of each viewshed and that which falls within the "study area" constructed using a 290m buffer around the turbines for the purpose of analysis, for each area, with a viewshed radius of 2km.

Table 2.2: VP locations and viewshed visible areas.

Area	VP	Grid Reference	Visible Area (ha)
			Within 290m turbine buffer
MFD	1	SS 82861 97535	83.37
MB	2	SS 80768 97785	40.8

2.4 VP Flight Activity Data

- 2.4.1 Survey effort (hours) completed at each VP location between March 2019 and February 2020, and March 2021 and February 2022, is summarised in **Table 2.3** (note VP1 at MFD was surveyed across the entire two-year survey period, while VP2 was surveyed at MB in Year 2 only).
- 2.4.2 Full details of field survey effort and target species flight activity recorded presented in **Appendix 10.1** in Volume 3 of the ES and illustrated in **Figures 10.5a-b** in Volume 2 of the ES.

Table 2.3: VP flight activity survey effort summary.

VP	2019										2020		Year 1 Total
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
1	9	6	12	6	6	6	6	6	6	6	6	6	81
VP	2020										2021		Year 2 Total
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
1	9	6	12	6	6	6	6	6	6	6	6	6	81
2	9	6	12	6	6	6	6	6	6	5	6	6	80

2.5 ‘At Collision Risk’ Flight Activity

- 2.5.1 ‘At collision risk’ flight activity for use in analysis was identified as those target species flights recorded within 290m of the turbines and flying at collision risk height (e.g. between 50-220m for MFD and 30-180m for MB).
- 2.5.2 For MFD, the tip height (200m) is used as the upper limit of the collision risk height, while the lower limit of the collision risk height (50m) is derived from the lower rotor sweep. Bird flights at height bands 2 (HT2) and 3 (HT3) (thus occurring at a height of 30-150m+) are regarded as ‘at collision risk’ given tip height exceeds the highest height band.
- 2.5.3 For MB, the tip height (180m) is used as the upper limit of the collision risk height, while the lower limit of the collision risk height (30m) is derived from the lower rotor sweep. Bird flights at height bands 2 (HT2) and 3 (HT3) (thus 30-150m+) are regarded as ‘at collision risk’ given tip height exceeds the highest height band.
- 2.5.4 Collision mortality risks have only been estimated for those species with four, or more, ‘at collision risk’ flights, over any one survey year. Accordingly, only the flight activity of red kite has been subject to detailed analysis.
- 2.5.5 Collision risks for target species with the number of ‘at collision risk’ flights below this number can be reasonably concluded as inconsequential at any population level, without the requirement for detailed analysis.
- 2.5.6 Details of ‘at collision risk’ flight activity of other target species are provided in **Annex 1**.
- 2.5.7 ‘At collision risk’ flight activity recorded during the survey period for red kite which were analysed using the NatureScot CRM (Band *et al.*, 2007) is summarised in **Table 2.4**. Analysis was undertaken for both Year 1 and Year 2 for MFD and in Year 2 for MB.

Table 2.4: “At collision risk” flight activity.

Species	Total No. of Flights (Total No. of Birds)			Total Time at Collision Risk Height (secs) as Derived from CRM Analysis (secs) ¹		
	MFD Area Year 1	MFD Area Year 2	MB Area Year 2	MFD Area Year 1	MFD Area Year 2	MB Area Year 2
Red kite	18 (19)	13 (16)	11 (11)	1,765	1,230	1,210

2.6 Target Species Parameters

- 2.6.1 The parameters used to calculate the collision probability calculations for red kite are presented in **Table 2.5**. The results of the collision probability calculations are provided in **Annex 2**.

Table 2.5: Target species parameters.

Parameters are taken from Urquhart and Whitfield (2016), which is a recommended source of this information as stated in NatureScot guidance (2018).

Species	Length (m)	Wingspan (m)	Flight Speed (m/s)	Collision Probability (%) ²	Avoidance Rate (%)	Occupancy
Red kite	0.65	1.65	11.0	7.2	99	All year

¹ Total time at risk multiplied by the number of birds.

² See **Annex 2**.

3 COLLISION RISK ANALYSIS

3.1 Approach

3.1.1 Only flight activity of red kite has been subject to detailed.

3.1.2 The following information has used in analysis:

- Wind farm area (290m turbine buffer) for MFD and MB, respectively: 127.2ha and 58.54ha;
- Assumed daylight flying hours (potential): 4475.1 and 4464.1³ respectively in Year 1 and 2 (based on all year species occupancy) based on a latitude of 51.663878; and
- Downtime: 15%.

3.1.3 **Table 3.1** presents collision mortality risk estimates for red kite, with detailed analysis presented in **Annex 3**.

3.1.4 On the basis of the approach to identifying 'at collision risk' flight activity the results of analysis are considered to be precautionary.

3.1.5 Collision mortality risk estimates calculated using the NatureScot CRM (Band *et al.*, 2007) should also not be concluded as the number of bird deaths that will occur as a result of the Proposed Development but are an indication of the level of risk of collision.

Table 3.1: CRM Analysis results.

Species	Avoidance Rate (%)	Area	Annual Collision Mortality			Years for One Death		
			Year 1	Year 2	Average	Year 1	Year 2	Average
Red kite	99	MFD MB	0.159 ⁴ n/a	0.238 0.085	0.199 n/a	6.303 n/a	4.195 11.72 0	5.249 n/a

3.1.6 Year 2 results determined that combined the annual collision mortality risk for the Proposed Development is (0.238 for MFD + 0.085 for MB) = 0.323.

3.1.7 The annual collision mortality estimate for MFD in Year 1 was lower than the estimate for the same area in Year 2. It is therefore considered that using the Year 2 estimates and combining these for the MFD and MB areas, provide a worst-case scenario in terms of annual collision mortality for the Proposed Development for use in subsequent assessment.

³ Potentially active hours have been calculated using latitude of 51.663878 as per Forsythe *et al.* (1995) and based on annual occupancy for red kite. Higher potential daylight flight hours in Year 1 due to it being a leap year.

⁴ Annual collision mortality rates for adult birds only (i.e. excluding juvenile birds) is 0.156, so a minimal difference.

4 REFERENCES

- Band, W., Madders, M. and Whitfield, D.P. (2007). *Developing field and analytical methods to assess avian collision risk at wind farms*. In De Lucas, M., Janss, G. and Ferrer, M. (eds) 'Birds and Wind Power'.
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ANNEX 1 – “AT RISK” FLIGHT ACTIVITY

Table A1-1 present “at risk” flight activity for target species recorded during the survey period (March 2019 – February 2020 and March 2021 – February 2022; the number of birds, total flight duration and time spent at collision height (HT2 – HT3 for MB and MFD) and below (HT1 for MB and MFD) collision risk height is presented. Note, of these, only red kite was recorded in sufficient number “at collision risk” height and considered appropriate for CRM Analysis to be carried out.

Table A1-1: Target species “at risk” flight activity (Wind Farm Area: 290m) – MFD (VP1) and MB (VP2) are presented.

Survey Year	Date	VP	Species	No. of Birds	Start Time (24hrs)	Total Flight Duration (secs) ⁵	Total Time Spent (secs) ⁶		
							HT1	HT2	HT3
MFD Area									
1	26/03/2019	1	Red kite	1	08:40	200	50	50	100
1	15/04/2019	1	Red kite	1	15:04	170	45	125	0
1	15/04/2019	1	Red kite	1	16:10	100	30	70	0
1	31/05/2019	1	Red kite	1	12:43	40	0	40	0
1	31/05/2019	1	Red kite	1	12:46	40	25	15	0
1	31/05/2019	1	Red kite	1	13:50	20	0	5	15
1	27/06/2019	1	Red kite	1	08:30	30	0	30	0
1	16/07/2019	1	Red kite	1	14:29	30	0	30	0
1	15/10/2019	1	Red kite	2	13:20	150	0	150	0
1	15/10/2019	1	Red kite	1	13:23	20	0	20	0
1	15/10/2019	1	Red kite	1	13:27	170	0	170	0
1	21/11/2019	1	Red kite	1	14:20	210	30	180	0
1	21/11/2019	1	Red kite	1	14:42	330	45	285	0

⁵ Total time multiplied by the number of birds.

⁶ Total time multiplied by the number of birds.

Survey Year	Date	VP	Species	No. of Birds	Start Time (24hrs)	Total Flight Duration (secs) ⁵	Total Time Spent (secs) ⁶		
							HT1	HT2	HT3
1	21/11/2019	1	Red kite	1	14:50	270	30	240	0
1	12/02/2020	1	Red kite	1	10:14	45	0	45	0
1	12/02/2020	1	Red kite	1	10:59	100	40	60	0
1	12/02/2020	1	Red kite	1	12:52	140	65	75	0
1	12/02/2020	1	Red kite	1	12:59	200	140	60	0
MFD Area									
2	07/04/2021	1	Red kite	2	12:35	120	60	60	0
2	09/05/2021	1	Red kite	1	15:41	150	45	105	0
2	06/07/2021	1	Red kite	1	09:21	90	0	90	0
2	06/07/2021	1	Goshawk	1	14:03	90	15	75	0
2	06/07/2021	1	Red kite	1	14:29	60	0	60	0
2	21/09/2021	1	Red kite	1	12:32	480	90	285	105
2	21/09/2021	1	Peregrine	1	13:30	135	45	30	60
2	12/10/2021	1	Red kite	1	12:25	60	0	60	0
2	12/10/2021	1	Red kite	1	14:41	45	0	0	45
2	12/10/2021	1	Merlin	1	14:43	45	15	30	0
2	10/02/2022	1	Red kite	1	10:16	30	0	30	0
2	10/02/2022	1	Red kite	1	10:49	60	15	30	15
2	10/02/2022	1	Red kite	1	13:32	90	30	60	0
2	10/02/2022	1	Red kite	2	13:39	210	60	90	60
2	10/02/2022	1	Red kite	2	14:14	180	120	60	0
2	10/02/2022	1	Red kite	1	14:28	105	30	60	15

Survey Year	Date	VP	Species	No. of Birds	Start Time (24hrs)	Total Flight Duration (secs) ⁵	Total Time Spent (secs) ⁶		
							HT1	HT2	HT3
MB Area									
2	17/03/2021	2	Red kite	1	13:58	60	0	60	0
2	17/03/2021	2	Red kite	1	14:39	240	0	60	180
2	06/04/2021	2	Red kite	1	10:37	90	0	90	0
2	06/04/2021	2	Red kite	1	11:30	30	0	30	0
2	07/07/2021	2	Red kite	1	11:00	75	60	15	0
2	26/08/2021	2	Red kite	1	11:48	180	60	90	30
2	26/08/2021	2	Red kite	1	11:48	235	15	30	190
2	26/08/2021	2	Red kite	1	12:08	180	15	165	0
2	16/09/2021	2	Red kite	1	15:28	60	15	45	0
2	11/02/2022	2	Red kite	1	13:02	105	30	75	0
2	11/02/2022	2	Red kite	1	14:02	150	0	60	90

ANNEX 2 – COLLISION PROBABILITY CALCULATIONS

Red kite

K: [1D or [3D] (0 or 1)	1	Calculation of alpha and p(collision) as a function of radius									
No. Blades	3	Upwind:							Downwind:		
Max Chord	4.2	m	r/R	c/C	α	collide	contribution	collide		contribution	
Pitch (degrees)	15		radius	chord	alpha	length	p (collision)	from radius r	length	p (collision)	from radius r
Bird Length	0.65	m	0.025	0.575	5.32	21.82	1.00	0.00125	20.57	0.98	0.00123
Wingspan	1.65	m	0.075	0.575	1.77	7.69	0.37	0.00276	6.44	0.31	0.00231
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.06	5.55	0.27	0.00332	4.02	0.19	0.00241
			0.175	0.860	0.76	4.84	0.23	0.00405	2.97	0.14	0.00249
Bird speed	11	m/sec	0.225	0.994	0.59	4.44	0.21	0.00478	2.28	0.11	0.00245
Rotor Diam	150	m	0.275	0.947	0.48	3.69	0.18	0.00485	1.63	0.08	0.00214
Rotation Period	5.70	sec	0.325	0.899	0.41	3.15	0.15	0.00489	1.19	0.06	0.00185
			0.375	0.851	0.35	2.80	0.13	0.00503	0.95	0.05	0.00170
			0.425	0.804	0.31	2.54	0.12	0.00517	0.80	0.04	0.00162
			0.475	0.756	0.28	2.33	0.11	0.00530	0.69	0.03	0.00156
Bird aspect ratio: β	0.39		0.525	0.708	0.25	2.15	0.10	0.00540	0.69	0.03	0.00174
			0.575	0.660	0.23	1.99	0.10	0.00547	0.75	0.04	0.00206
			0.625	0.613	0.21	1.85	0.09	0.00552	0.79	0.04	0.00235
			0.675	0.565	0.20	1.72	0.08	0.00554	0.81	0.04	0.00262
			0.725	0.517	0.18	1.60	0.08	0.00554	0.83	0.04	0.00287
			0.775	0.470	0.17	1.49	0.07	0.00552	0.83	0.04	0.00309
			0.825	0.422	0.16	1.38	0.07	0.00547	0.83	0.04	0.00329
			0.875	0.374	0.15	1.29	0.06	0.00539	0.83	0.04	0.00346
			0.925	0.327	0.14	1.20	0.06	0.00529	0.81	0.04	0.00360
			0.975	0.279	0.14	1.11	0.05	0.00517	0.80	0.04	0.00373
Overall p(collision) =						Upwind	9.6%	Downwind	4.9%		
						Average	7.2%				

ANNEX 3 – COLLISION RISK MODEL ANALYSIS

Red kite (Year 1) – MFD

VP	Watch data			Flying time (s)	Flying time hahr-1	Weighted flying time ha hr ⁻¹	
	Area (ha)	Time (hrs)	HaHr	Risk height	Risk height	Weighting	Risk height
1	83.37	81.0	6752.97	755.08	0.0000310594	1.0000000000	0.0000310594
Totals	83.37	81.0	6752.97	755.08	0.0000310594	1.0000000000	0.0000310594
Mean activity hr ⁻¹ in wind farm				WIND FARM DATA			
Risk height	0.00395	0.3951%		Wind farm area (ha)	127.20		
Daylight hours			4475.1				
Downtime			15	0.85		D	150.0
Vw =			190800000			L + d	4.85
Vr =			342653	No. of turbines	4	R	75
Vr/Vw =			0.0017959				
Speed			11				
Vw Occupancy =			17.680	63648.1			
Vr Occupancy =			0.032	114.3			
Transit time =			0.441				
Transits =			259.246				
Collision probability from NatureScot sheet			0.072				
Collisions with no avoidance			18.666				
Collisions with 99% avoidance			0.187				
Collisions with 99% avoidance & downtime			0.159				
Years for 1 death			6.303				

Red kite (Year 2) – MFD

VP	Watch data			Flying time (s)	Flying time hahr-1	Weighted flying time ha hr ⁻¹	
	Area (ha)	Time (hrs)	HaHr	Risk height	Risk height	Weighting	Risk height
1	83.37	81.0	6752.97	1137.31	0.0000467824	1.0000000000	0.0000467824
Totals	83.37	81.0	6752.97	1137.31	0.0000467824	1.0000000000	0.0000467824
Mean activity hr ⁻¹ in wind farm				WIND FARM DATA			
Risk height	0.00595	0.5951%		Wind farm area (ha)	127.20		
Daylight hours			4464.1				
Downtime			15	0.85		D	150.0
Vw =			190800000			L + d	4.85
Vr =			342653	No. of turbines	4	R	75
Vr/Vw =			0.0017959				
Speed			11				
Vw Occupancy =			26.565	95632.6			
Vr Occupancy =			0.048	171.7			
Transit time =			0.441				
Transits =			389.522				
Collision probability from NatureScot sheet			0.072				
Collisions with no avoidance			28.046				
Collisions with 99% avoidance			0.280				
Collisions with 99% avoidance & downtime			0.238				
Years for 1 death			4.195				

Red kite (Year 2) – MB

VP	Watch data			Flying time (s)	Flying time hahr-1	Weighted flying time ha hr ⁻¹	
	Area (ha)	Time (hrs)	HaHr	Risk height	Risk height	Weighting	Risk height
2	40.80	80.0	3264.00	393.50	0.0000334880	1.0000000000	0.0000334880
Totals	40.80	80.0	3264.00	393.50	0.0000334880	1.0000000000	0.0000334880
Mean activity hr ⁻¹ in wind farm				WIND FARM DATA			
Risk height	0.00196	0.1960%		Wind farm area (ha)	58.54		
Daylight hours			4464.1				
Downtime			15	0.85		D	150.0
Vw =			87810000			L + d	4.85
Vr =			171326	No. of turbines	2	R	75
Vr/Vw =			0.0019511				
Speed			11				
Vw Occupancy =			8.751	31504.9			
Vr Occupancy =			0.017	61.5			
Transit time =			0.441				
Transits =			139.415				
Collision probability from NatureScot sheet			0.072				
Collisions with no avoidance			10.038				
Collisions with 99% avoidance			0.100				
Collisions with 99% avoidance & downtime			0.085				
Years for 1 death			11.720				