

Technical Appendix 6.2

Collision Risk Modelling

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1 Collision Risk Modelling Report

1.1 Introduction

- 1.1.1 ITP Energised (now SLR) was appointed by the Applicant to undertake collision risk modelling using data taken from their ornithological surveys (as commissioned by the Applicant) in support of a proposed renewable energy development north of Muirkirk (the 'Proposed Development'). In order to assess the likely impacts of the Proposed Development on the local bird population, analysis for the potential collision risk has been undertaken on target species as defined in **Technical Appendix 6.1**. The analysis has been undertaken using the turbine layout and development boundary, as displayed in **Technical Appendix 6.2: Figure 1**, and a candidate turbine specification as outlined in **Table 1**.

Table 1 – Candidate Turbine - Nordex N163 at 4.8MW

Table Heading	Heading
Number of turbines	18
Rotor Diameter	163 m
Hub Height	148.5 m (1 turbine @ 118.5 m)
Rotor Sweep	67-230 m (1 turbine @ 37-200 m)
Max chord	4.15
Pitch	Variable (use 6 degrees)
Rotation period	7.45 sec (Blades will rotate at approximately 6.1 – 10.1 revolutions per minute - average =8.1)
Turbine 'lifetime'	40 years

Site Description

- 1.1.2 The Proposed Development is split into two main development areas, with the wind turbines located within the northern development area (Dungavel Forest), and the solar, BESS and substation located within the southern development area (Netherwood) - refer to **Figure 1.2** (EIA Report Volume 2).
- 1.1.3 The northern development area, which is the only section relevant to the collision risk modelling is located within the western part of Dungavel Forest, directly to the west and south of the operational Dungavel and Kype Muir Extension Wind Farms, within South Lanarkshire.

1.2 Collision Risk Modelling

- 1.2.1 Band *et al.* (2007) described a method by which field data on bird flight activity can be gathered and used to crudely quantify the likelihood of collisions with turbines: the 'Band' Collision Risk Model (CRM). This method is more suitable for some species than others (Madders & Whitfield, 2006). For example, fast moving raptors like merlin and most songbirds are difficult to detect beyond a distance of a few hundred metres and nocturnal species are difficult to detect at all. As a result, it is rarely possible to generate reliable estimates of flight activity for these species and collision risk is best determined qualitatively.
- 1.2.2 The Band CRM has recently been modified and an updated version released by NatureScot in December 2024 (NatureScot, 2024). The updated approach builds on previous models developed by Band *et al.* (2007) and Band (2000) and does not change the single transit probability calculation but adds the other stages of the model, to standardise these calculations. The approach is intended to provide collision risk estimates that are comparable across different wind farms (NatureScot, 2024).



Data Collection and Species Selection

- 1.2.3 Surveys were undertaken over the northern development area from four Vantage Points ('VPs') between April 2022 and February 2024 (VP9-VP12) with a total of 144 hours undertaken at VPs 9-11 and 72 hours at V12. This time period constitutes two complete years of survey VP9-11 and one full year for VP12. The VP locations were used across the survey period and the VPs are shown along with the viewsheds in **Figure 6.1** (EIA Report Volume 2).
- 1.2.4 A total of 12 target species were recorded from the VP surveys and recorded activity is summarised below in Table 2. All the survey flights were recorded onto ArcGIS and the data entered into an excel spreadsheet and further analysed in order to select all the flights which were recorded at least in part at potential collision height ('PCH') within the 2 km viewshed of the VP. PCH is the height between the low and high points of the rotor sweep of the turbine blades, as shown for the differing turbine sizes in **Table 1**, all flights and the total number of individuals recorded at PCH within the viewshed of the VP are displayed below in **Table 2**.
- 1.2.5 The collision risk modelling was completed using all the flights recorded during the VP surveys and the 2 km viewsheds (180 arc in front of the VP locations at PCH) and this methodology creates an average collision figure which covers the entire area covered by the viewsheds. A summary of the results showing all target species is detailed below in **Table 2** which shows:-
- the total number of flights recorded for the whole northern development area;
 - the total number of birds recorded for the whole northern Development area;
 - The total number of full and / or in-part flights at PCH, defined as between 67 m-230 m (adjusted to 37-200 m for Turbine 17);
 - 'At-risk' flight seconds, *i.e.* number of birds x at-risk seconds; and
 - Whether the species was taken forward for forward for CRM;

Table 2 – Target Species Recorded

Species	Flights	Individuals	Flights 'at-risk'	Flight seconds 'at-risk'	Taken forward for CRM
Common Sandpiper	2	2	0	-	NO
Curlew	7	8	2	14.4	YES
Golden Plover	3	13	3	1,300	YES
Goshawk	4	4	1	10.4	YES
Greylag Goose	2	15	1	99.8	NO*
Hen Harrier	1	1	0	-	NO
Osprey	1	1	1	176	YES
Peregrine	2	2	2	373	YES
Pink-footed Goose	19	884	15	74,460.2	NO*
Red Kite	4	4	3	280.2	YES
Woodcock	1	1	0	-	NO
Whooper Swan	1	12	1	573.3	NO*

* CRM not carried out for these species as not considered linked to a SPA/Ramsar/SSSI population.

- 1.2.6 A total of three species (common sandpiper, hen harrier and woodcock) were recorded during VP surveys but had no 'at-risk' flight seconds over the 2-year period are not considered to be affected by collision risk with the proposed turbines (**Table 2**). Pink-footed goose were recorded on 19 occasions 'at-risk' but as a very common species on migration and not linked to a protected site,



greylag geese were recorded twice and whooper swan once, these species were not taken forward for collision risk modelling.

1.3 Methods

- 1.3.1 Collision risk has been calculated based as an average figure for the area covered by the viewsheds (**Technical Appendix 6.2: Figure 1**) and based on a layout of 18 wind turbines of the specifications outlined in **Table 1**. It should be noted that the resultant figures provide an average for the site as a whole and do not allow for the potential of configuring a layout in order to minimise the impacts of the proposed turbines.
- 1.3.2 The predicted level of collision mortality is based on results obtained from a collision risk model which uses flight activity data, species' parameters and turbine specifications to obtain a collision rate as outlined in NatureScot guidance (NatureScot, 2024).
- 1.3.3 The guidance also outlines bird biometrics including bird length and wingspan as well as flight speeds and recommended avoidance rates which are inputs into the model and the figures for the species carried forward for collision risk in this assessment are outlined in **Table 3** below.
- 1.3.4 Data on bird flight speed and biometrics were taken from Alerstam *et al.* (2007) and the published avoidance rates were used (SNH 2017).
- 1.3.5 Detailed data on survey dates, times and weather can be found in **Appendix 6.1: Annex A: Table A1**. For reference, all target flights are presented in **Technical Appendix 6.2 Figure 2**.

Table 3 – Target Species Bird Biometrics

Species Name	Bird length (m)	Wingspan (m)	Flight speed (m/s)	Avoidance Rate (%)
Curlew	0.55	0.90	16.3	98
Golden Plover	0.28	0.72	13.7	98
Goshawk	0.55	1.5	13.0	98
Osprey	0.56	1.58	13.0	98
Peregrine	0.42	1.02	16.0	98
Red Kite	0.63	1.85	13.0	99

1.4 Results

- 1.4.1 Six species were taken forward for collision risk modelling, and the results are summarised in **Table 4** below.

Table 4 - Collision Risk Modelling Results

Species Name	Collisions - Non- breeding season	Collisions - Breeding season	Collisions - Annual	Collisions - Scheme Lifetime (40 years)	Years per collision
Curlew	0	<0.01	<0.01	n/a	n/a
Golden Plover	0.03	0.01	0.04	1	25
Goshawk	0	<0.01	<0.01	n/a	n/a
Osprey	0	0.01	0.01	0.25	100
Peregrine	<0.01	0.01	0.01	0.25	100
Red Kite	<0.01	0	<0.01	n/a	n/a

1.5 Species Accounts

The workings for each species are displayed below.



CURLEW

CRM input vales

CURLEW			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Transfer to XL Sheet	VP	Flight Time	0	0	0	156	58	99	30	0	0	0	0	0	343
		CRH flight time	0	0	0	0	0	14.4	0	0	0	0	0	0	14.4
		% time CRH													4.198251
	A = VP Area km2	hours													
VP9	5.75	hours	6	12	12	12	12	12	12	24	12	12	12	6	144
		t - seconds	21600	43200	43200	43200	43200	43200	43200	86400	43200	43200	43200	21600	
		b flight seconds	0	0	0	0	0	44	30	0	0	0	0	0	
		Da = b / (t x A) m-2	0	0	0	0	0	0.000177	0.000121	0	0	0	0	0	
VP10	6.06	hours	6	12	12	12	12	12	12	24	12	12	12	6	144
		t - seconds	21600	43200	43200	43200	43200	43200	43200	86400	43200	43200	43200	21600	
		b flight seconds	0	0	0	156	0	0	0	0	0	0	0	0	
		Da = b / (t x A) m-2	0	0	0	0.000596	0	0	0	0	0	0	0	0	
VP11	5.56	hours	6	12	12	12	12	12	12	24	12	12	12	6	144
		t - seconds	21600	43200	43200	43200	43200	43200	43200	86400	43200	43200	43200	21600	
		b flight seconds	0	0	0	0	58	55	0	0	0	0	0	0	
		Da = b / (t x A) m-2	0	0	0	0	0.000241	0.000229	0	0	0	0	0	0	
VP12	5.99	hours	6	6	0	6	6	6	6	12	6	6	6	6	72
		t - seconds	21600	21600	0	21600	21600	21600	21600	43200	21600	21600	21600	21600	
		b flight seconds	0	0	0	0	0	0	0	0	0	0	0	0	
		Da = b / (t x A) m-2	0	0	0	0	0	0	0	0	0	0	0	0	
		Da Average	0	0	0	0.000149	6.04E-05	0.000102	3.02E-05	0	0	0	0	0	

[illegible]

Results Sheet 1 CRM Results - Curlew



GOLDEN PLOVER

CRM – Input values

GOLDEN PLOVER			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Transfer to XL Sheet	VP	Flight Time	0	0	0	1064	0	0	0	336	0	0	0	0	1400
		CRH flight time	0	0	0	963.5	0	0	0	336	0	0	0	0	1299.5
		% time CRH													92.82143
	A = VP Area km2	hours													
VP9	5.75	hours	6	12	12	12	12	12	12	24	12	12	12	6	144
		t - seconds	21600	43200	43200	43200	43200	43200	43200	86400	43200	43200	43200	21600	
		b flight seconds	0	0	0	0	0	0	0	336	0	0	0	0	
		Da = b / (t x A) m-2	0	0	0	0	0	0	0	0.000676	0	0	0	0	
VP10	6.06	hours	6	12	12	12	12	12	12	24	12	12	12	6	144
		t - seconds	21600	43200	43200	43200	43200	43200	43200	86400	43200	43200	43200	21600	
		b flight seconds	0	0	0	944	0	0	0	0	0	0	0	0	
		Da = b / (t x A) m-2	0	0	0	0.003606	0	0	0	0	0	0	0	0	
VP11	5.56	hours	6	12	12	12	12	12	12	24	12	12	12	6	144
		t - seconds	21600	43200	43200	43200	43200	43200	43200	86400	43200	43200	43200	21600	
		b flight seconds	0	0	0	120	0	0	0	0	0	0	0	0	
		Da = b / (t x A) m-2	0	0	0	0.0005	0	0	0	0	0	0	0	0	
VP12	5.99	hours	6	6	0	6	6	6	6	12	6	6	6	6	72
		t - seconds	21600	21600	0	21600	21600	21600	21600	43200	21600	21600	21600	21600	
		b flight seconds	0	0	0	0	0	0	0	0	0	0	0	0	
		Da = b / (t x A) m-2	0	0	0	0	0	0	0	0	0	0	0	0	
		Da Average	0	0	0	0.001026	0	0	0	0.000169	0	0	0	0	

[illegible]

Results Sheet 2 CRM Results - golden plover



Goshawk

CRM – Input values

GOSHAWK			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Transfer to XL Sheet		Flight Time	0	0	0	60	0	39	0	0	77	107	0	0	283
		CRH flight time	0	0	0	0	0	0	0	0	10.4	0	0	0	10.4
		% time CRH													3.674912
	A = VP Area km2	hours													
VP9	5.75	hours	6	12	12	12	12	12	12	24	12	12	12	6	144
		t - seconds	21600	43200	43200	43200	43200	43200	43200	86400	43200	43200	43200	21600	
		b flight seconds	0	0	0	0	0	0	0	0	0	107	0	0	
		Da = b / (t x A) m-2	0	0	0	0	0	0	0	0	0	0.000431	0	0	
VP10	6.06	hours	6	12	12	12	12	12	12	24	12	12	12	6	144
		t - seconds	21600	43200	43200	43200	43200	43200	43200	86400	43200	43200	43200	21600	
		b flight seconds	0	0	0	0	0	0	0	0	77	0	0	0	
		Da = b / (t x A) m-2	0	0	0	0	0	0	0	0	0.000294	0	0	0	
VP11	5.56	hours	6	12	12	12	12	12	12	24	12	12	12	6	144
		t - seconds	21600	43200	43200	43200	43200	43200	43200	86400	43200	43200	43200	21600	
		b flight seconds	0	0	0	60	0	39	0	0	0	0	0	0	
		Da = b / (t x A) m-2	0	0	0	0.00025	0	0.000162	0	0	0	0	0	0	
VP12	5.99	hours	6	6	0	6	6	6	6	12	6	6	6	6	72
		t - seconds	21600	21600	0	21600	21600	21600	21600	43200	21600	21600	21600	21600	
		b flight seconds	0	0	0	0	0	0	0	0	0	0	0	0	
		Da = b / (t x A) m-2	0	0	0	0	0	0	0	0	0	0	0	0	
		Da Average	0	0	0	6.25E-05	0	4.06E-05	0	0	7.35E-05	0.000108	0	0	



Species name		Goshawk		Site name		HEC WE		Model		nordic 163									
Bird length	L	0.55	m	Latitude		55.6 degrees		Hub height		148.5 m									
Wingspan	W	1.5	m	No of turbines		18		Rotor radius		81.5 m									
Bird flight speed	v	13	m s ⁻¹	Width of windfarm		3 km		No of blades		3									
Flight type, flapping or gliding	flapping												Rotation speed		8.1 rpm				
% of flights upwind/downwind	50%		50%												Max blade width		4.15 m		
Nocturnal activity ranking 1-5	1												Blade pitch		6 degrees				
Nocturnal activity factor	f _{night}	0%												Risk height range		67-230 m			
normal approach		Set to 'normal approach' to use survey data on bird density																	
		Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A																	
Stage A																			
Daytime bird density	D _A	birds/km ²		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge			
Proportion at rotor risk height	Q _{2R}	3.67%		0	0	0	6.2E-05	0	4.1E-05	0	0	7.4E-05	0.00011	0	0	0.0000			
At latitude 55.6			Daylight hours per month		239.9	268.0	365.7	423.6	502.5	522.0	523.6	466.6	384.4	325.9	251.7	4496.0			
			Nighttime hours per month		504.1	404.0	378.3	296.4	241.5	198.0	220.4	277.4	335.6	418.1	468.3	4264.0			
Stage B																			
No of turbines	T	18																	
Rotor radius	R	81.5 m																	
		Total rotor frontal area		375610															
Nocturnal activity factor	f _{night}	0%																	
Bird flight speed	v	13 m s ⁻¹		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total			
			Projected number of rotor transits		0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0			
Stage C																			
No of blades	b	3		Bird length		l		0.55 m											
Rotation speed	Ω	8.1 rpm		Wingspan		w		1.5 m											
Rotor radius	R	81.5 m		Bird flight speed		v		13 m s ⁻¹											
Max blade width	C	4.15 m		Flight type				flapping											
Pitch	λ	6 degrees		% of flights upwind/downwind				50%		50%									
Blade profile	see Blade profile sheet																		
		Single transit risk		upwind		5.97%													
				downwind		4.51%													
		weighted mean				5.24%													
Stage D																			
Proportion of time operational	Q _{op}			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge			
				87.4%	89.3%	87.4%	84.6%	68.0%	68.9%	68.9%	77.3%	85.6%	91.2%	87.4%	86.5%	81.9%			
		Collision rates before avoidance														year total			
				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0			
Stage E																			
Allow for large array correction?		No																	
Width of windfarm	w	3 km																	
		large array correction		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year			
		Collision rates allowing for avoidance																	
Avoidance rates modelled		95.00%	100.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0			
		98.00%	100.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0			
		99.00%	100.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0			
		99.50%	100.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0			

Results Sheet 3 - CRM Results goshawk



Osprey

CRM – Input values

OSPREY			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Transfer to XL Sheet		Flight Time	0	0	0	176	0	0	0	0	0	0	0	0	176
		CRH flight time	0	0	0	176	0	0	0	0	0	0	0	0	176
		% time CRH													100
	A = VP Area km2	hours													
VP9	5.75	hours	6	12	12	12	12	12	12	24	12	12	12	6	144
		t - seconds	21600	43200	43200	43200	43200	43200	43200	86400	43200	43200	43200	21600	
		b flight seconds	0	0	0	0	0	0	0	0	0	0	0	0	
		Da = b / (t x A) m-2	0	0	0	0	0	0	0	0	0	0	0	0	
VP10	6.06	hours	6	12	12	12	12	12	12	24	12	12	12	6	144
		t - seconds	21600	43200	43200	43200	43200	43200	43200	86400	43200	43200	43200	21600	
		b flight seconds	0	0	0	176	0	0	0	0	0	0	0	0	
		Da = b / (t x A) m-2	0	0	0	0.000672	0	0	0	0	0	0	0	0	
VP11	5.56	hours	6	12	12	12	12	12	12	24	12	12	12	6	144
		t - seconds	21600	43200	43200	43200	43200	43200	43200	86400	43200	43200	43200	21600	
		b flight seconds	0	0	0	0	0	0	0	0	0	0	0	0	
		Da = b / (t x A) m-2	0	0	0	0	0	0	0	0	0	0	0	0	
VP12	5.99	hours	6	6	0	6	6	6	6	12	6	6	6	6	72
		t - seconds	21600	21600	0	21600	21600	21600	21600	43200	21600	21600	21600	21600	
		b flight seconds	0	0	0	0	0	0	0	0	0	0	0	0	
		Da = b / (t x A) m-2	0	0	0	0	0	0	0	0	0	0	0	0	
		Da Average	0	0	0	0.000168	0	0	0	0	0	0	0	0	



Species name	Osprey		Site name	HEC WE		Model	nordic 163								
Bird length	L	0.56 m	Latitude	55.6 degrees		Hub height	148.5 m								
Wingspan	W	1.58 m	No of turbines	18		Rotor radius	R 81.5 m								
Bird flight speed	v	13 m s ⁻¹	Width of windfarm	w 3 km		No of blades	b 3								
Flight type, flapping or gliding	flapping					Rotation speed	Ω 8.1 rpm								
% of flights upwind/downwind	50% 50%					Max blade width	C 4.15 m								
Nocturnal activity ranking 1-5	1					Blade pitch	λ 6 degrees								
Nocturnal activity factor	f _{night}	0%				Risk height range	67-230 m								
normal approach		Set to 'normal approach' to use survey data on bird density Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A													
Stage A			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year ave
Daytime bird density	D _A	birds/km ²	0	0	0	0.00017	0	0	0	0	0	0	0	0	0.0000
Proportion at rotor risk height	Q _{2R}	100.00%													
At latitude 55.6	Daylight hours per month		239.9	268.0	365.7	423.6	502.5	522.0	523.6	466.6	384.4	325.9	251.7	222.1	4496.0
	Nighttime hours per month		504.1	404.0	378.3	296.4	241.5	198.0	220.4	277.4	335.6	418.1	468.3	521.9	4264.0
Stage B															
No of turbines	T	18													
Rotor radius	R	81.5 m													
	Total rotor frontal area		375610												
Nocturnal activity factor	f _{night}	0%													
Bird flight speed	v	13 m s ⁻¹	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
	Projected number of rotor transits		0.0	0.0	0.0	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8
Stage C															
No of blades	b	3													
Rotation speed	Ω	8.1 rpm													
Rotor radius	R	81.5 m													
Max blade width	C	4.15 m													
Pitch	λ	6 degrees													
Blade profile	see Blade profile sheet														
	Single transit risk		upwind	6.03%											
			downwind	4.58%											
	weighted mean			5.31%											
Stage D			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year ave
Proportion of time operational	Q _{op}		87.4%	89.3%	87.4%	84.6%	68.0%	68.9%	68.9%	77.3%	85.6%	91.2%	87.4%	86.5%	81.9%
	Collision rates before avoidance														year total
			0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Stage E															
Allow for large array correction?		No													
Width of windfarm	w	3 km													
	large array correction		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
	Collision rates allowing for avoidance														
Avoidance rates modelled		95.00%	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		98.00%	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		99.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		99.50%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0

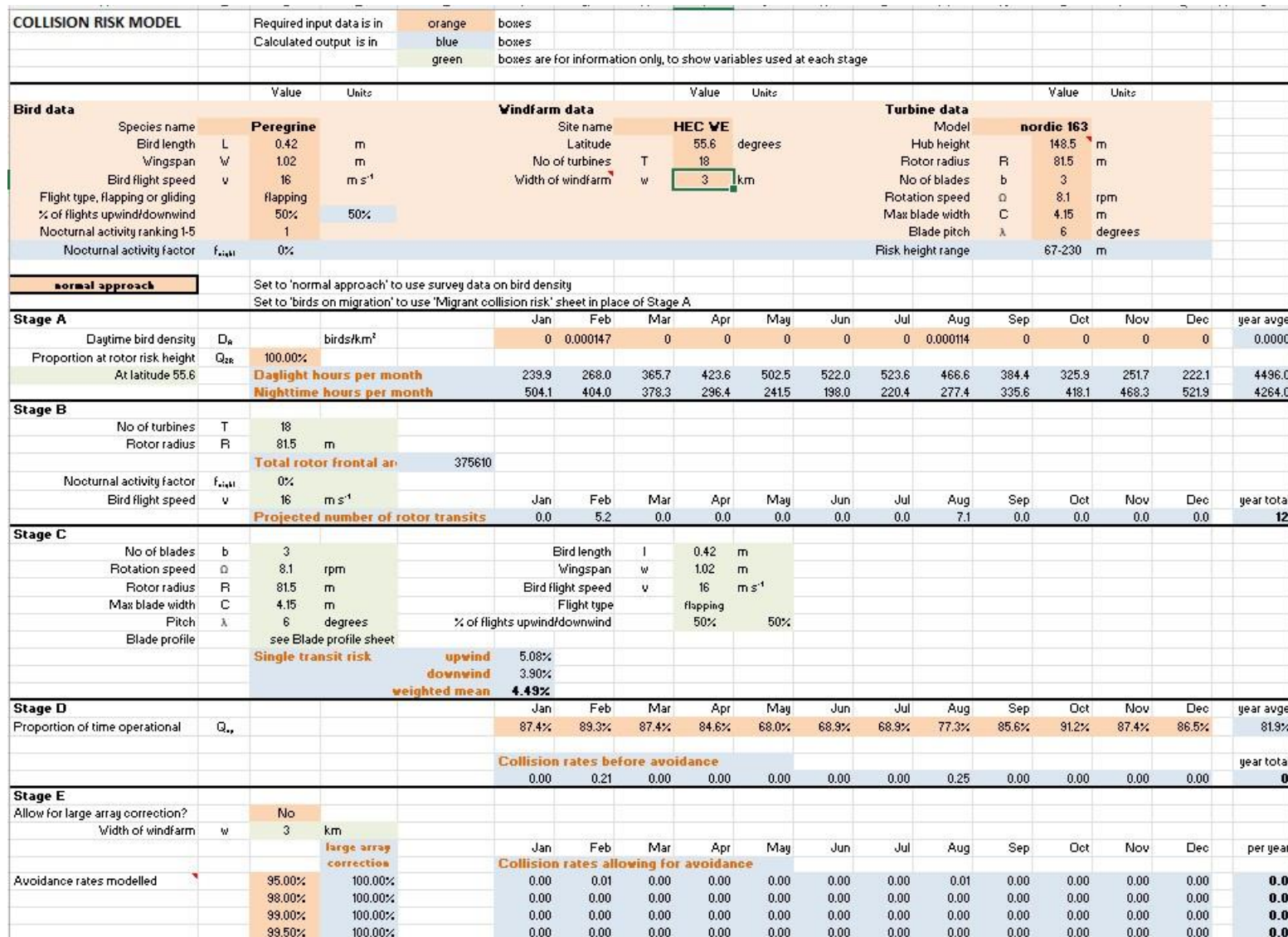
Results Sheet 4 - CRM results - Osprey



Peregrine

CRM – Input values

PEREGRINE			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Transfer to XL Sheet		Flight Time	0	146	0	0	0	0	0	227	0	0	0	0	373
		CRH flight time	0	146	0	0	0	0	0	227	0	0	0	0	373
		% time CRH													100
	A = VP Area km2	hours													
VP9	5.75	hours	6	12	12	12	12	12	12	24	12	12	12	6	144
		t - seconds	21600	43200	43200	43200	43200	43200	43200	86400	43200	43200	43200	21600	
		b flight seconds	0	146	0	0	0	0	0	227	0	0	0	0	
		Da = b / (t x A) m-2	0	0.000588	0	0	0	0	0	0.000457	0	0	0	0	
VP10	6.06	hours	6	12	12	12	12	12	12	24	12	12	12	6	144
		t - seconds	21600	43200	43200	43200	43200	43200	43200	86400	43200	43200	43200	21600	
		b flight seconds	0	0	0	0	0	0	0	0	0	0	0	0	
		Da = b / (t x A) m-2	0	0	0	0	0	0	0	0	0	0	0	0	
VP11	5.56	hours	6	12	12	12	12	12	12	24	12	12	12	6	144
		t - seconds	21600	43200	43200	43200	43200	43200	43200	86400	43200	43200	43200	21600	
		b flight seconds	0	0	0	0	0	0	0	0	0	0	0	0	
		Da = b / (t x A) m-2	0	0	0	0	0	0	0	0	0	0	0	0	
VP12	5.99	hours	6	6	0	6	6	6	6	12	6	6	6	6	72
		t - seconds	21600	21600	0	21600	21600	21600	21600	43200	21600	21600	21600	21600	
		b flight seconds	0	0	0	0	0	0	0	0	0	0	0	0	
		Da = b / (t x A) m-2	0	0	0	0	0	0	0	0	0	0	0	0	
		Da Average	0	0.000147	0	0	0	0	0	0.000114	0	0	0	0	





RED KITE

CRM – Input values

RED KITE		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Transfer to XL Sheet	Flight Time	0	109	151	0	0	0	0	0	286	236	0	0	782
	CRH flight time	0	0	110.5	0	0	0	0	0	92.95	76.7	0	0	280.15
	% time CRH													35.82481
	A = Area km2													
VP9	5.75 hours 144	6	12	12	12	12	12	12	24	12	12	12	6	
	t - seconds	21600	43200	43200	43200	43200	43200	43200	86400	43200	43200	43200	21600	
	b flight seconds	0	0	0	0	0	0	0	0	0	0	0	0	
	Da = b / (t x A) m-	0	0	0	0	0	0	0	0	0	0	0	0	
VP10	6.06 144	12	12	12	12	12	12	12	24	12	12	12	6	
	t - seconds	43200	43200	43200	43200	43200	43200	43200	86400	43200	43200	43200	21600	
	b flight seconds	0	286	151	0	0	0	0	0	286	0	0	0	
	Da = b / (t x A) m-	0	0.00109247	0.00057679	0	0	0	0	0	0.001092	0	0	0	
VP11	5.56 144	6	12	12	12	12	12	12	24	12	12	12	6	
	t - seconds	21600	43200	43200	43200	43200	43200	43200	86400	43200	43200	43200	21600	
	b flight seconds	0	0	0	0	0	0	0	0	0	0	0	0	
	Da = b / (t x A) m-	0	0	0	0	0	0	0	0	0	0	0	0	
VP12	5.99 72	6	6	0	6	6	6	6	12	6	6	6	6	
	t - seconds	21600	21600	0	21600	21600	21600	21600	43200	21600	21600	21600	21600	
	b flight seconds	0	0	0	0	0	0	0	0	0	0	0	0	
	Da = b / (t x A) m-	0	0	0	0	0	0	0	0	0	0	0	0	
	Da Average	0	0.000273118	0.0001442	0	0	0	0	0	0.000273	0	0	0	

COLLISION RISK MODEL			Required input data is in		orange	boxes									
			Calculated output is in		blue	boxes									
					green	boxes are for information only, to show variables used at each stage									
			Value	Units	Value	Units									
Bird data			Windfarm data			Turbine data									
Species name		Red kite	Site name		HEC WE	Model		nordic 163							
Bird length	L	0.63 m	Latitude		55.6 degrees	Hub height		148.5 m							
Wingspan	w	1.85 m	No of turbines	T	18	Rotor radius	R	81.5 m							
Bird flight speed	v	13 m s ⁻¹	Width of windfarm	w	2 km	No of blades	b	3							
Flight type, flapping or gliding		flapping				Rotation speed	Ω	8.1 rpm							
% of flights upwind/downwind		50% 50%				Max blade width	C	4.15 m							
Nocturnal activity ranking 1-5		1				Blade pitch	λ	6 degrees							
Nocturnal activity factor	f _{NAI}	0%				Risk height range		67-230 m							
normal approach			Set to 'normal approach' to use survey data on bird density												
			Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A												
Stage A			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Daytime bird density	D _a	birds/km ²	0	0.000273	0.000144	0	0	0	0	0	0.000273	0	0	0	0.000144
Proportion at rotor risk height	Q _{RR}	35.80%													
At latitude 55.6															
Daylight hours per month			239.9	268.0	365.7	423.6	502.5	522.0	523.6	466.6	384.4	325.9	251.7	222.1	4496.0
Nighttime hours per month			504.1	404.0	378.3	296.4	241.5	198.0	220.4	277.4	335.6	418.1	468.3	521.9	4264.0
Stage B			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
No of turbines	T	18													
Rotor radius	R	81.5 m													
Total rotor frontal area			375610												
Nocturnal activity factor	f _{NAI}	0%													
Bird flight speed	v	13 m s ⁻¹													
Projected number of rotor transits			0.0	2.8	2.0	0.0	0.0	0.0	0.0	0.0	4.1	0.0	0.0	0.0	9.9
Stage C			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
No of blades	b	3													
Rotation speed	Ω	8.1 rpm													
Rotor radius	R	81.5 m													
Max blade width	C	4.15 m													
Pitch	λ	6 degrees													
Blade profile		see Blade profile sheet													
Single transit risk															
upwind															
downwind															
weighted mean															
Stage D			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Proportion of time operational	Q _o		87.4%	89.3%	87.4%	84.6%	68.0%	68.9%	68.9%	77.3%	85.6%	91.2%	87.4%	86.5%	81.9%
Collision rates before avoidance															
			0.00	0.14	0.10	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00
Stage E			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
Allow for large array correction?		No													
Width of windfarm	w	2 km													
large array correction															
Collision rates allowing for avoidance															
Avoidance rates modelled		95.00%	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
		98.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		99.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		99.50%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Results Sheet 6 CRM Results – red kite



1.6 References

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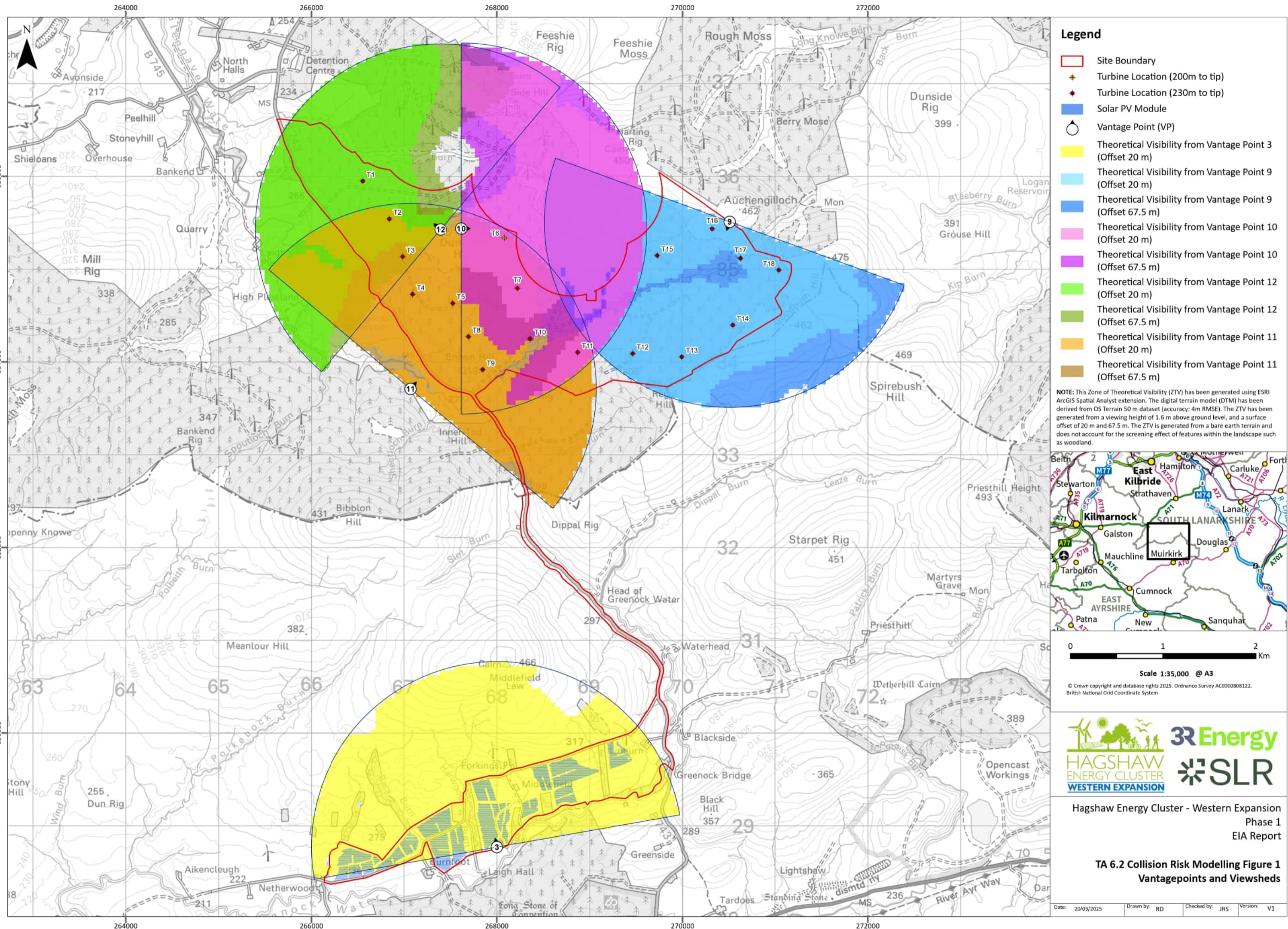
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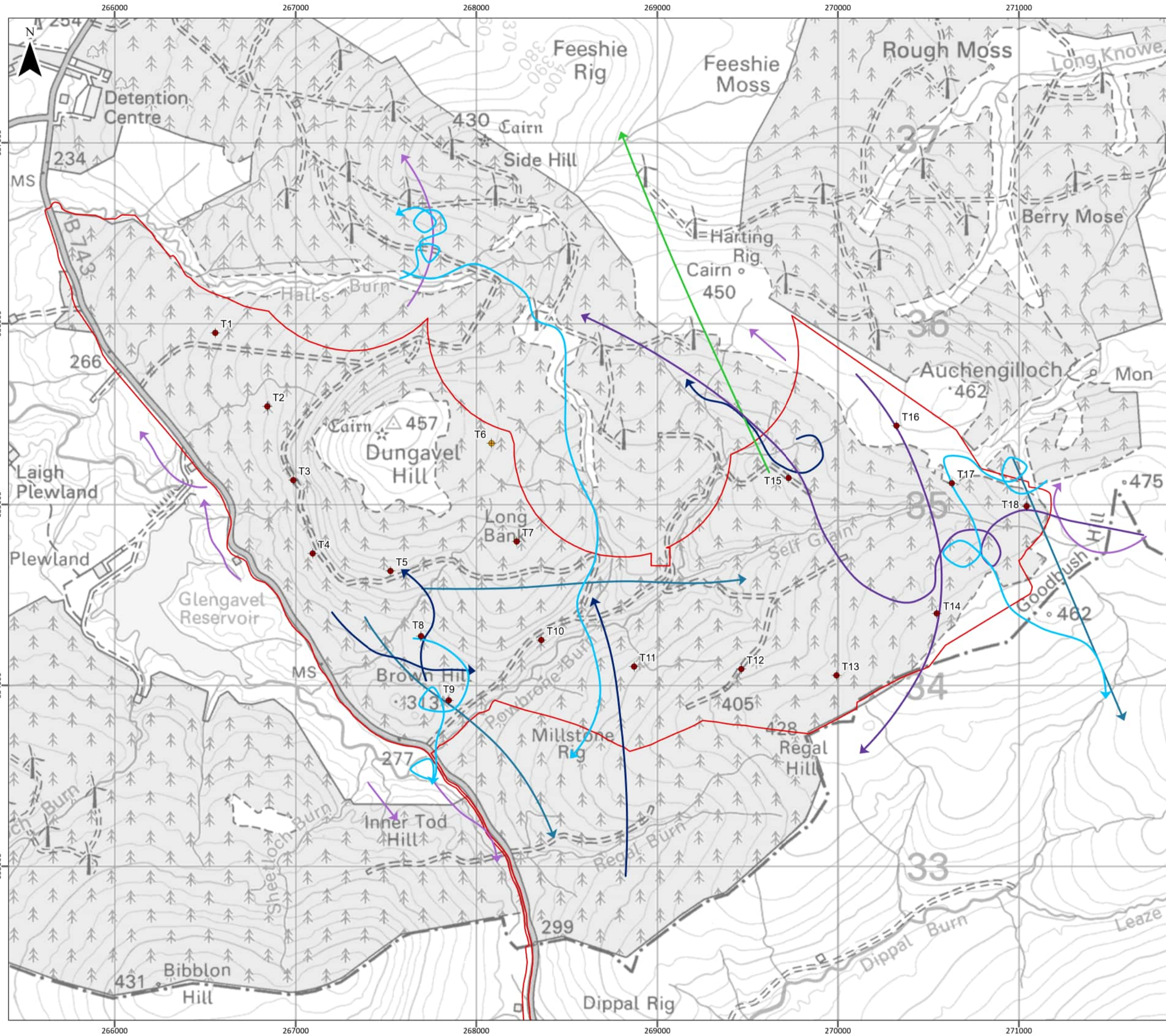
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Legend

Site Boundary

Turbine Location (200m to tip)

Turbine Location (230m to tip)

Flightline Record

Curlew

Golden Plover

Goshawk

Osprey

Peregrine

Red Kite

00.51

Km

Scale 1:20,000 @ A3

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British National Grid Coordinate System

Hagshaw Energy Cluster - Western Expansion
Phase 1
EIA Report

TA 6.2 Collision Risk Modelling Figure 2
Flightlines

Date: 20/03/2025

Drawn by: RD

Checked by: JRS

Version: V1

TA 6.2 Collision Risk Modelling Figure 2
Flightlines