Lynemore Wind Farm

Additional Information (AI)

AI Technical Appendix 7.1: Updated Collision Risk Model Calculations

avianecology

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1 INTRODUCTION

1.1.1 This technical appendix has been prepared to accompany the Additional Information (AI) Report for Lynemore Wind Farm (the 'Revised Proposed Development').

1.1.2 The AI Report provides information that updates the original Environmental Impact Assessment (EIA) Report following redesign between the EIA Proposed Development and the Revised Proposed Development.

1.1.3 This technical appendix presents details of updated Collision Risk Modelling (CRM) calculations applicable to the revised layout. The aim of the CRM is to determine potential collision mortality impacts upon relevant ornithological interests as a result of the Revised Proposed Development.

1.1.4 This technical appendix should be read in conjunction with **EIA Report Volume 3, Appendix 7.1** of the EIA Report, as this provides full details of the baseline surveys (methods and results) that have informed the CRM calculations.

2 BACKGROUND

2.1.1 The baseline ornithology surveys undertaken for the EIA Proposed Development (and the Revised Proposed Development) included Vantage Point (VP) flight activity surveys, which recorded flight activity of 'target species' in the vicinity of proposed turbine locations. The results of the VP flight activity surveys were used to carry out CRM analysis to inform the impact assessment for the EIA Proposed Development, as submitted in the EIA Report (14 turbine design). Full details can be found in **EIA Report Volume 3, Appendix 7.2**.

2.1.2 CRM calculations use a large number of parameters, including details of flight activity and turbine parameters, to produce outputs that give an estimate as to the collision mortality risk posed by the turbines of a wind farm development (generally presented as deaths per year (or season)), for those species included in the assessment.

2.1.3 The Revised Proposed Development (now 12 turbines) has two fewer turbines than the EIA Proposed Development. Such a change is sufficient to invalidate the results of the original CRM analyses. Thus, new CRM analyses have now been undertaken, as set out in this appendix.

2.1.4 The CRM for the EIA Proposed Development, as presented in the EIA Report, was undertaken using the standard model (original version) used for wind farm developments in Scotland, devised by Band *et al*. (2007)[1]. This method has since been superseded by version 2 (Band (2024))[2], which has now become the method advocated by NatureScot (2024)[3].

2.1.5 The writing of the impact assessment for the EIA Proposed Development coincided with a transitional period in adoption of the Band (2024) method, with the CRM analyses for the EIA Proposed Development having already been carried out using the 2007 methodology. However, as described in **EIA Report Volume 3, Appendix 7.2**, the CRM methods used at that time were still valid, as Band (2024) states that the two methods are 'equivalent'.

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[1] 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.F.E. & Ferrer, M. (Eds.) *Birds and Wind Farms: Risk Assessment and Mitigation*, pp. 259- 275. Quercus, Madrid.

[2] Band, W. (2024). *Using a collision risk model to assess bird collision risks for onshore wind farms*. NatureScot Research Report 909.

[3] NatureScot. (2024). *Guidance on using an updated collision risk model to assess collision risk at onshore wind* farms. NatureScot, Inverness.

2.1.6 The main aim of the updated guidance has been to standardise the approach to CRM used by practitioners. Therefore, the opportunity has been taken to carry out the updated CRM analyses using the 2024 version of the model. This will be of benefit when looking at the cumulative risk from new wind farm applications, assuming widespread adoption of the 2024 guidance. It has been highlighted by NatureScot that the cumulative collision risk to white-tailed eagle is now an important consideration in Scotland and, therefore, adoption of the updated model aids in creating collision risk outputs that should be comparable between projects when undertaking cumulative assessments.

2.1.7 However, it should be noted that the large number of parameters and assumptions involved in the CRM method, some of which are not absolute but are reliant on expert judgement, mean that the outputs from one practitioner may not exactly match those of another, even when using the same ornithological data.

2.1.8 Furthermore, the outputs of CRM cannot ever be considered to be the number of bird deaths that would definitely occur as a result of a project, but are better treated as a relative indicator of risk.

2.1.9 Given that the updated CRM analyses have been undertaken differently to those presented in **EIA Report Volume 3, Appendix 7.2**, this appendix fully sets out the updated methods used and does not simply provide revised mortality estimates.

3 METHODOLOGY

3.1 Overview

3.1.1 The CRM analysis estimates collision mortality risk in five stages:

- Stage A: bird survey data are examined to establish the density of flying birds in the vicinity of the proposed turbines and the proportion of birds flying at rotor swept height (between the minimum and maximum rotor heights proposed for the project);
- Stage B: an estimate of the potential number of bird transits through the rotors during a set time period is estimated based on bird density and the proportion determined to be at collision risk;
- Stage C: the probability of collision during a single rotor transit is calculated;
- Stage D: the time during which turbines are not operational is estimated and applied, whereby it is assumed that collisions only occur with operational (spinning) turbine rotors; and
- Stage E: appropriate avoidance factors are applied, whereby it is assumed most birds avoid turbines or take action to prevent collision.

3.1.2 A spreadsheet is available from NatureScot[4] to aid in the completion of the CRM calculations using the methods recommended in their guidance.

3.1.3 Details of how this process has been undertaken for the Revised Proposed Development, including the parameters used in the model, are presented below. Parameters are the same as were used in the previous assessment for the EIA Proposed Development, unless otherwise stated.

[4] Available from: https://www.nature.scot/sites/default/files/2024-12/collision-risk-model-for-onshore-wind-farm-spreadsheet-2024_0.xlsm (accessed November 2025).

3.2 Target Species for Assessment

3.2.1 Collision mortality estimates have only been calculated for ornithological features for which there is a potential for a significant effect. For species with few at-risk flights and recorded in very low numbers during baseline surveys it can reasonably be predicted that the risk of collision mortality would be very small (a negligible impact at any population level) and no significant effect can be concluded for these ornithological interests without the requirement for undertaking a detailed assessment.

3.2.2 For the purposes of this assessment, a target species qualified for inclusion in the CRM if there were three or more 'at-risk' flights (see below), or 10 or more individuals, within the two year baseline period (September 2022 to August 2024). This is the same approach as was used in the EIA Report.

3.2.3 The species assessed are accordingly dunlin, golden eagle, golden plover, red kite and white-tailed eagle.

3.2.4 The at-risk flight activity recorded for all target species during the baseline VP surveys, including those that did not qualify for CRM, is presented in **Annex 1** (flights within the turbine envelope[5] only).

3.3 Determining Bird Density

3.3.1 The data recorded during the VP flight activity surveys were examined to determine whether the flightlines of each target species identified for assessment were best considered as 'directional' or 'non-directional' flights; with these flight patterns analysed differently by the model. Directional flights describe flights used by birds passing over the Site in a regular pattern following the same orientation (e.g. migrating geese) and non-directional, or random, flights describe those that have no regular pattern (e.g. foraging flights or local movements). Following consideration of the flight activity data, all target species assessed were determined as having non-directional flights.

3.3.2 For non-directional flights, areal bird density (D_A) is calculated. This is the number of birds in flight at any height at any given point in time, per unit of area. The results of the VP flight activity surveys allow calculation of D_A, based on the following formula:

$D_A = b / (t \times A)$ bird-seconds m^{-2}, where:

- b = the number of flight seconds from a VP;
- t = time (in seconds) that the VP is watched; and
- A = the area of the VP viewshed (visible area) (km^2).

3.3.3 NatureScot guidance (2024) states that D_A should be calculated for each VP and the figure averaged. The guidance also states that where there is a significant difference in the area and/or time covered by VPs, the average figure should be weighted appropriately.

3.3.4 The use of the Band (2024) model requires an appropriate survey area to be defined, to determine bird number per unit of area. In the case of the Revised Proposed Development, it was not considered appropriate to use all flight data recorded during the VP surveys given the extent of the VP viewsheds which, in places, cover ground that is more than 1.5km from proposed turbine locations. However, Band (2024) does recommend that data collection extends beyond the wind farm footprint to ensure it is representative of the area as a whole. NatureScot (2024) states that the key flight activity data for use in the CRM are those data within a 'turbine envelope'. For the CRM analysis of the Revised Proposed Development the turbine envelope that has been utilised is a single continuous area

[5] A single continuous area that encompasses the proposed turbine locations plus a 500m buffer.

encompassing all turbines plus a surrounding 500m buffer. Only flight activity within the turbine envelope has been used in the CRM calculations.

3.3.5 The area of the turbine envelope that was covered by each VP viewshed has been calculated using GIS, based on a 20m above ground level cut-off. These data have been updated for the Revised Proposed Development. Details of the VPs and their viewsheds are presented in **Table 3.1**.

Table 3.1: Vantage Point locations and area of visibility.

VP name	VP iterations	Grid reference	Visible area within wind farm turbine envelope with 500m buffer	Time period covered
VP1	VP1	NH 72601 32581	225.7 ha	Sept 2022 - Jan 2023
	VP1a	NH 72662 33009	181.1 ha	Feb – Mar 2023
	VP1b (looking southeast)	NH 72527 32582	185.9 ha	Apr 2023 - Feb 2024
	VP1b (looking northeast)	NH 72527 32582	172.9 ha	Mar - Aug 2024
VP2	VP2	NH 76208 32545	306.3 ha	Sept 2022 - Jan 2023
	VP2a	NH 75100 32837	259.3 ha	Feb – Mar 2023
	VP2b	NH 76206 32544	297.4 ha	Apr 2023 - Aug 2024
VP3	-	NH 73889 32337	241.8 ha	Feb – Mar 2023

3.3.6 The full viewshed area (clipped to the turbine envelope) of each VP has been used in the model to determine the watched area. During baseline surveys, VP1b and VP2b were sometimes undertaken at the same time (the VP locations themselves being well outside the viewshed of the other VP), whilst this was not the case for the other VP iterations. The actual overlap in these two viewsheds was, however, small in extent and at the far periphery of both viewsheds. Examination of the data has confirmed that, for the target species assessed, there was no duplication in flight activity recorded. Note that in the CRM analysis for the EIA Proposed Development this small overlap was allocated to only one of the overlapping viewsheds, but on re-examination of the data this was considered unnecessary.

3.3.7 **Table 3.1** shows that the VP locations changed during the course of baseline surveys, as the project layout evolved. Survey effort at each VP iteration has been incorporated into the model. Survey effort was calculated for the seven individual VP viewsheds used across the baseline survey period, as shown in **Table 3.2**.

Table 3.2: VP flight activity survey effort (hours).

Year 1 (2022-2023)													Total VP hours	
VP	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**		
1	6	6	6	0	2.5								**20.5**	
1a						6	6						**12.0**	**68.5**
1b (SE)[#]								6	6	6	12	6	**36.0**	
2	6	6	6	6	2.5								**26.5**	
2a						6	6						**12.0**	**74.5**
2b								6	6	6	12	6	**36.0**	

3						6	6						**12.0**	
Year 2 (2023-2024)													**Total VP hours**	
VP	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**		
1b (SE)[#]	6	6	6	6	6	6	6						**42.0**	**78.0**
1b (NE)[#]								9	6	6	9	6	**36.0**	
2b	6	6	6	6	6	6	6	9	6	6	9	6	**78.0**	

[#]*Orientation of viewshed: looking southeast or northeast*

3.3.8 The number of flight seconds recorded within the watched area was determined for each flight, with time multiplied by the number of individuals (flock size) where appropriate. NatureScot (2024) guidance states that where the number of flights is too few to produce reliable flight activity by month, that data should be aggregated by season (breeding and non-breeding season) and, based on flight activity recorded during baseline surveys, this is the approach that has been taken.

3.3.9 Species-specific seasons have been used (based on NatureScot guidance (SNH, 2014[6]) and professional judgement), with bird density estimates applied to all months within the relevant season. The breeding and non-breeding seasons used for each target species assessed are summarised in **Table 3.3**.

Table 3.3: Species-specific breeding and non-breeding seasons.

Species	Breeding Season	Non-breeding Season
Dunlin	April to July	August to March
Golden eagle	February to August	September to January
Golden plover	April to July	August to March
Red kite	March to July	August to February
White-tailed eagle	February to August	September to January

3.3.10 **Table 3.4** presents calculated bird density for inclusion in the CRM analyses, for each target species assessed. As well as estimates for each individual survey year, mean bird density is also provided. A value of '0.0000' is given for those species where there was no at-risk flight activity in that season or where flight activity was recorded in that season but was too low to register at four decimal places.

3.3.11 In accordance with NatureScot (2024) guidance, weighting should be applied where there are differences in VP flight activity survey effort or differences in the habitats present in the viewsheds. In the case of the Revised Proposed Development, there is a difference in the VPs in that VP2 (and its variations) had a viewshed that covered more proposed turbine locations than VP1 (and its variations). Therefore a 'turbine weighting' has been applied. For completeness, calculations using an 'effort weighting' factor have also been undertaken, which accounts for variation in survey effort between VP locations and which is most similar to the original (Band *et al*. (2007)) method, as used for the EIA Proposed Development. The three scenarios (unweighted, turbine weighted and effort weighted) are presented in **Table 3.4**.

[6] SNH (2014). *Breeding season dates for key breeding species in Scotland*. Scottish Natural Heritage (now NatureScot), Inverness.

Table 3.4: Estimated bird density (birds/km^2).

Year	Bird Density (Unweighted)		Turbine Weighted Bird Density		Effort Weighted Bird Density	
	Breeding	Non-breeding	Breeding	Non-breeding	Breeding	Non-breeding
Dunlin						
Year 1	0.0003	0.0000	0.0007	0.0000	0.0012	0.0000
Year 2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Mean	**0.0002**	**0.0000**	**0.0003**	**0.0000**	**0.0006**	**0.0000**
Golden eagle						
Year 1	0.0003	0.0000	0.0006	0.0000	0.0006	0.0000
Year 2	0.0005	0.0000	0.0010	0.0000	0.0007	0.0000
Mean	**0.0004**	**0.0000**	**0.0008**	**0.0000**	**0.0007**	**0.0000**
Golden plover						
Year 1	0.0001	0.0010	0.0003	0.0039	0.0004	0.0011
Year 2	0.0000	0.0000	0.0002	0.0001	0.0002	0.0001
Mean	**0.0001**	**0.0005**	**0.0002**	**0.0020**	**0.0003**	**0.0006**
Red kite						
Year 1	0.0011	0.0006	0.0036	0.0018	0.0027	0.0010
Year 2	0.0012	0.0009	0.0038	0.0031	0.0039	0.0024
Mean	**0.0012**	**0.0007**	**0.0037**	**0.0025**	**0.0034**	**0.0017**
White-tailed eagle						
Year 1	0.0002	0.0000	0.0006	0.0000	0.0004	0.0000
Year 2	0.0003	0.0001	0.0010	0.0004	0.0009	0.0004
Mean	**0.0002**	**0.0001**	**0.0008**	**0.0002**	**0.0006**	**0.0002**

3.3.12 Variation in the flight data is acknowledged, with large differences in density estimates between the survey years for some species (**Table 3.4**). For example, for dunlin the at-risk flight activity came from one date in year 1 and for golden plover small flocks of wandering birds resulted in differences between year 1 and year 2. For white-tailed eagle, the actual number of at-risk flights was relatively low in both years (five in year 1 and eight in year 2) but the location and length of these flights differed, resulting in the contrasting outputs between survey years. This variation is considered to be within that expected by natural variation, which is the reason behind undertaking two years of baseline surveys. For this reason, the mean density estimates are considered most appropriate, and it is these that have been used in the updated impact assessments, as presented in the AI Report.

3.4 Determining the Proportion of Flights at Risk of Collision

3.4.1 The potential risk of collision was informed by the details of the Revised Proposed Development, as set out below.

3.4.2 The Revised Proposed Development comprises 12 wind turbines. The proposed turbines would have a maximum tip height of 200m and a rotor diameter of 162m. Therefore, rotor swept height would be

between a minimum of 38m and a maximum of 200m (referred to hereafter as potential collision height (PCH)).

3.4.3 The proportion of flights at-risk has been assessed for each species, based on turbine parameters and recorded flight heights. For each individual flight, the proportion at-risk was calculated using the data recorded during survey, which recorded height bands at 15 second intervals. During the VP flight activity surveys, the height bands (HT) used to record target species are shown in **Table 3.5**.

Table 3.5: Height bands used for recording during baseline surveys.

Height Band	September 2022 to January 2023	February 2023 to August 2024
HT1	0-15m	0-20m
HT2	15-30m	20-40m
HT3	30-50m	40-160m
HT4	50-200m	160-200m
HT5	>200m	>200m

3.4.4 All flights recorded in height band 4 were considered as representing flights at risk of collision due to HT4 fully overlapping with PCH throughout the baseline period. A precautionary approach has been applied such that all flights at HT3 have also been considered as being at risk, as this was the case for the majority of the baseline period. Flights in HT1 and HT5 were considered as not being at risk, as throughout the baseline period these height bands did not overlap with PCH. For height bands that partly overlap with PCH, guidance (Band (2024)) recommends that proportioning is applied. Thus, apportioning has been applied to HT2, which slightly overlapped with PCH for the majority of the baseline period. An assumption has been made that flights are equally distributed within each height band and on this basis, 10% of HT2 flights (accounting for those above 38m in the 20-40m height range) have been considered as at-risk. This is also precautionary as for the first part of the baseline survey period all flights in HT2 were below PCH.

3.4.5 Combining all flight activity, an overall proportion of at-risk flight activity for each species has been calculated. The percentage of flights considered to be at potential collision height for each of the five assessed species, and as used in the CRM analyses, were as follows:

- Dunlin – 3.7%;
- Golden eagle – 12.1%
- Golden plover – 41.5%;
- Red kite – 47.3%; and
- White-tailed eagle – 72.6%.

3.5 Application of Nocturnal Activity Factor

3.5.1 The results of the baseline VP flight activity surveys, as used in the CRM analyses, provide details of daytime flight activity. The hours of daylight experienced at a location are factored into the calculations. Hours of daylight per month, and subsequently in each species-specific breeding/ non-breeding season, have been calculated using a latitude of 57.36679 decimal degrees for the Revised Proposed Development.

3.5.2 For golden eagle, red kite and white-tailed eagle flight activity is considered to only occur during daylight hours, with these species going to roost at night. Dunlin is also considered as only being active during the day when on their breeding grounds.

3.5.3 For golden plover a low level of flight activity outside daylight hours has been assumed, as this species has been shown to partly feed at night (e.g. Whittingham *et al*., 2000[7]), although it can be expected that time in flight would be less than during daylight hours. In accordance with guidance (NatureScot, 2024) a nocturnal activity factor of '2' has been applied, which adds an additional 25% to the calculated (day-time) flight activity for golden plover.

3.6 Species Parameters

3.6.1 The CRM analysis uses parameters for each species to inform potential collision risk. The parameters used are presented in **Table 3.6**.

Table 3.6: Target species parameters.

Species	Length (m)	Wingspan (m)	Flight Speed (m/s)	'Gliding' or 'Flapping' Flight	Collision Probability (%)	Avoidance Rate (%)
Dunlin	0.18	0.41	15.3	Flapping	3.58	98.0
Golden eagle	0.82	2.12	11.9	Flapping	5.79	99.0
Golden plover	0.28	0.72	17.9	Flapping	3.90	98.0
Red kite	0.63	1.85	12.0	Gliding	5.19	99.0
White-tailed eagle	0.80	2.20	13.6	Gliding	5.41	95.0

3.6.2 Parameters are primarily taken from Snow and Perrins (1998)[8] (biometrics) and Alerstam *et al*. (2007)[9] (flight speeds). Biometrics (bird length and wingspan) are average measurements.

3.6.3 Avoidance rates are taken from NatureScot guidance (2025)[10], with a default value of 98% applied where species-specific avoidance rates are not available.

3.6.4 Dunlin and golden plover were considered to have 'flapping' flights. Red kite and white-tailed eagle were considered to have 'gliding' flights as these two species had flight activity that consisted mostly of high soaring flights. The flight activity of golden eagle, which included low and hunting flights, is best represented as 'flapping'. Note that this is a change from the previous CRM in which golden eagle was classed as having gliding flights, but is considered a better reflection based on re-examination of the data.

3.6.5 'Collision probability' in **Table 3.6** relates to the probability of collision in a single bird rotor transit, as calculated by the NatureScot spreadsheet.

[7] Whittingham, M.J., Percival, S.M. and Brown, A.F. (2000). Time budgets and foraging of breeding golden plover *Pluvialis apricaria. Journal of Applied Ecology,* 37(4), 632-646.
[8] Snow, D. W. & Perrins, C. M. (1998). *The Birds of the Western Palearctic. Concise Edition*. Oxford University Press.
[9] Alerstam T., Rosén M., Bäckman J., Ericson P.G.P., and Hellgren O. (2007). Flight speeds among bird species: allometric and phylogenetic effects. *PLoS Biol*, 5, 1656-1662
[10] NatureScot (2025). *Wind farm impacts on birds – use of avoidance rates in the NatureScot Wind Farm Collision Risk Model*. NatureScot, Inverness.

3.6.6 It has been assumed that there would be an even spread of upwind and downwind flights for all species given their non-directional (random) nature. It is also assumed that none of the assessed species would be attracted towards the turbines.

3.7 Turbine Parameters

3.7.1 Turbine parameters used in the analysis are summarised in **Table 3.7**. Where certain details were not available, a representative value has been utilised, with these parameters marked with an asterisk in the table. With the exception of number of turbines, the parameters are the same as in the CRM analysis for the EIA Proposed Development.

Table 3.7: Turbine parameters used in the collision risk model.

Parameter	Value	Unit
No. of turbines	12	-
No. of blades (per turbine)	3	-
Rotor diameter	162	metres
Rotor radius	81	metres
Max chord*	4.1	metres
Pitch (average)*	15	degrees
Rotation speed (average)*	7.2	revolutions per minute
Downtime*	15	%

* Representative values

3.7.2 The CRM calculations include for turbine downtime, for example time when the wind is below cut-in speed, time when rotors are idling or stationary, time when rotors are stopped to protect against very high wind speeds and down-time for maintenance. Downtime will vary through the year and can only be estimated. In accordance with guidance (NatureScot (2024)) a default value of 15% has been used, which has been applied across all months.

3.7.3 The model allows for a 'large array correction' where the collision rate would be expected to decline significantly as birds pass through the turbine array. Given the relatively small scale of the Revised Proposed Development the large array correction has not been applied.

3.8 Additional White-tailed Eagle Modelling

3.8.1 For white-tailed eagle, the CRM analysis was undertaken for an additional scenario. It is the mortality of breeding adults that most affects a species' population. Therefore, two sets of estimates were calculated for this species: one including all at-risk flights and the other with the flight activity of juvenile and immature birds removed.

3.8.2 Examination of the data showed that of the 13 at-risk white-tailed eagle flights, 11 had been aged as adults. A further record was of an unaged bird, so a precautionary approach has been taken and this has also been treated as an adult. Therefore, only one flight was removed in the rerunning of the model.

4 COLLISION MORTALITY RISKS

4.1 Annual Estimates

4.1.1 Examples of the completed NatureScot (2024) CRM spreadsheet are provided in **Annex 2** for each of the five assessed species: dunlin, golden eagle, golden plover, red kite and white-tailed eagle.

4.1.2 The outputs are summarised in **Table 4.1**. The presented values are collisions per year (estimated mortality per annum). Mean estimates are provided, as well as the estimates for each survey year. The mean estimate is that calculated when mean density estimates are included in the model, rather than being the mean of the year 1 and year 2 outputs.

4.1.3 As described above, as well as calculating standard (unweighted) collision mortality estimates for the Revised Proposed Development, turbine-weighted and effort-weighted estimates have also been calculated.

4.1.4 For all target species assessed, the turbine weighted approach produced the largest collision estimates, except for dunlin which had the largest estimate under the effort weighted scenario. It is the most precautionary estimates (mean estimates) that have been used in the updated impact assessments, as presented in the AI Report.

Table 4.1: Annual collision mortality estimates.

Species	Unweighted			Turbine Weighted			Effort Weighted		
	Year 1	Year 2	Mean	Year 1	Year 2	Mean	Year 1	Year 2	Mean
Dunlin	0.001	0.000	0.001	0.003	0.000	0.001	**0.005**	**0.000**	**0.002**
Golden eagle	0.004	0.007	0.005	**0.008**	**0.013**	**0.010**	0.008	0.009	0.009
Golden plover	0.091	0.000	0.049	**0.349**	**0.022**	**0.182**	0.120	0.022	0.071
Red kite	0.052	0.066	0.058	**0.170**	**0.215**	**0.194**	0.118	0.198	0.158
White-tailed eagle	0.078	0.134	0.095	**0.233**	**0.458**	**0.346**	0.156	0.420	0.268

4.1.5 The turbine weighted estimates for white-tailed eagle with flight activity for immature birds removed are, Year 1: 0.233 (unchanged); Year 2: 0.367; **mean: 0.329**.

4.2 Risk With Different Avoidance Rates

4.2.1 CRM guidance (Band (2024)) states that there are many uncertainties in the model output and a list of the main sources of uncertainty (error) is provided in the guidance. It is recommended that this uncertainty be acknowledged when presenting CRM analysis results.

4.2.2 Band (2024) states that the greatest uncertainty comes from the avoidance rates used and that this uncertainty is likely to 'dwarf' the other uncertainties, such as using an inexact collision model or variability in the survey data. Given that avoidance rate is the most fundamental source of uncertainty, this requires consideration.

4.2.3 The CRM analyses have been undertaken for different avoidance rate scenarios, as recommended in guidance (Band (2024), NatureScot (2024)) and the associated outputs cover a considerable range. **Table 4.2** presents these collision risk estimates for each of the avoidance rates assessed for each

species, using the mean turbine weighted density estimates. The recommended avoidance rate for each species is highlighted, in accordance with NatureScot guidance (2025).

Table 4.2: Collision mortality estimates with different avoidance rates.

Species	Annual Mortality Estimate				
	95.0% avoidance	**98.0% avoidance**	**99.0% avoidance**	**99.5% avoidance**	**99.9% avoidance**
Dunlin	0.006	**0.002**	0.001	0.001	0.000
Golden eagle	0.052	0.021	**0.010**	0.005	0.001
Golden plover	0.455	**0.182**	0.091	0.046	0.009
Red kite	0.971	0.388	**0.194**	0.097	0.019
White-tailed eagle	**0.346**	0.138	0.069	0.035	0.007

4.2.4 The species that have a species-specific avoidance rate (golden eagle, red kite and white-tailed eagle) are considered to have the least uncertainty, as these species have been subject to research that has informed the applicable avoidance rate. The species for which the default avoidance rate of 98.0% has been used (dunlin and golden plover) are considered to have greater uncertainty as there is not sufficient data for these species to suggest an appropriate alternative avoidance rate. However, as it is the case that for most species for which there is a species-specific avoidance rate it has been found to be higher than the default, this uncertainty is considered most likely to result in an over-estimation of collision risk rather than an under-estimation.

4.2.5 Although a different avoidance rate results in a large difference in predicted collision risk, the collision estimates used in the updated impact assessment are based on the avoidance rates recommended in guidance (NatureScot (2025)), and so represent the best informed and most likely scenario.

ANNEX 1: TARGET FLIGHT ACTIVITY DATA

Table A1.1 presents target species flight activity identified for the Revised Proposed Development and used in the CRM analyses. The listed records are those flights that passed within the turbine envelope (proposed turbine locations plus 500 m).

The data come from the VP flight activity surveys and were recorded over two years (September 2022 to August 2024).

The following British Trust for Ornithology (BTO) species codes are used to denote species: *CU – curlew, DN – dunlin, EA – golden eagle, GI – goshawk, GP – golden plover, HH – hen harrier, KT – red kite, ML – merlin, PG – pink-footed goose, WE – white-tailed eagle and YF – gyrfalcon.*

Table A1.1: Target species flight activity.

Date	VP	Target species	Number	Start time	Duration (s)	Height band					Flight length (m)
						H1	H2	H3	H4	H5	
24/10/22	1	KT	1	15:58	133	120	13	0	0	0	1095.11
16/09/22	1	KT	1	10:51	97	97	0	0	0	0	613.186
16/09/22	1	KT	1	11:47	277	15	60	60	142	0	1986.44
16/09/22	1	KT	2	10:54	136	136	0	0	0	0	642.294
16/09/22	1	KT	1	12:09	141	90	30	21	0	0	638.677
16/09/22	1	KT	3	10:59	100	60	40	0	0	0	869.727
25/10/22	2	KT	1	11:17	238	180	58	0	0	0	555.526
16/09/22	2	KT	2	13:44	200	0	0	15	105	80	1499.96
25/10/22	2	KT	1	13:46	193	193	0	0	0	0	329.249
24/02/23	1a	GP	11	15:19	180	15	60	105	0	0	935.217
24/02/23	1a	GP	11	15:35	225	0	45	180	0	0	160.323
17/03/23	3	GP	13	10:21	142	0	0	0	0	142	1484.93
27/02/23	3	GP	12	14:09	163	0	0	0	163	0	2003.55
17/03/23	3	GP	13	10:48	111	111	0	0	0	0	1985
17/03/23	3	GP	13	14:03	128	128	0	0	0	0	3526.77
26/04/23	1b - SE	PG	64	13:02	125	0	0	50	75	0	929.916
26/04/23	1b - SE	KT	1	11:18	98	0	38	60	0	0	934.604
11/08/23	1b - SE	KT	1	13:04	399	0	0	399	0	0	90.0843
26/04/23	1b - SE	KT	1	12:42	259	0	34	225	0	0	2260.9
13/09/23	1b - SE	WE	1	13:41	50	50	0	0	0	0	234.88
16/06/23	1b - SE	GP	1	06:24	110	50	60	0	0	0	2268.09
15/05/23	1b - SE	EA	1	14:32	835	465	270	100	0	0	2317.82
16/06/23	1b - SE	DN	1	06:21	95	95	0	0	0	0	1007.47
09/11/23	1b - SE	KT	1	11:45	203	30	38	135	0	0	1169.27
15/05/23	1b - SE	KT	1	15:18	236	180	56	0	0	0	3353.9
24/10/23	1b - SE	GP	1	13:58	10	10	0	0	0	0	368.797
14/07/23	1b - SE	KT	1	11:22	30	0	30	0	0	0	519.144
16/06/23	1b - SE	DN	1	06:33	90	90	0	0	0	0	147.277
16/06/23	1b - SE	KT	1	10:21	190	0	30	160	0	0	1927.5
16/06/23	1b - SE	EA	1	09:23	100	0	55	45	0	0	238.197
09/11/23	1b - SE	KT	1	12:17	18	0	18	0	0	0	17.8593

Date	VP	Target species	Number	Start time	Duration (s)	Height band					Flight length (m)
						H1	H2	H3	H4	H5	
16/06/23	1b - SE	DN	1	07:18	90	90	0	0	0	0	1772.63
24/07/23	1b - SE	EA	1	16:45	51	51	0	0	0	0	298.737
16/06/23	1b - SE	EA	2	10:04	260	0	0	0	0	260	2219.03
13/02/24	1b - SE	EA	1	13:24	162	45	117	0	0	0	190.015
16/06/23	1b - SE	DN	1	07:53	200	80	120	0	0	0	3774.53
16/06/23	1b - SE	ML	1	10:04	260	0	0	0	0	260	2219.03
13/09/23	1b - SE	PG	70	15:32	65	0	0	0	0	65	705.471
16/06/23	1b - SE	DN	2	07:56	90	90	0	0	0	0	2550.39
13/09/23	1b - SE	PG	65	10:01	119	0	0	0	0	119	1051.18
16/06/23	1b - SE	DN	1	08:02	40	40	0	0	0	0	205.392
16/06/23	1b - SE	WE	1	10:25	970	0	0	735	225	10	2906.65
16/06/23	1b - SE	GP	1	09:21	230	15	45	170	0	0	3891.88
16/06/23	1b - SE	DN	1	09:28	160	70	90	0	0	0	3541.43
16/06/23	1b - SE	DN	2	09:33	150	60	90	0	0	0	2395.19
16/06/23	1b - SE	DN	1	11:18	140	50	90	0	0	0	3672.87
16/06/23	1b - SE	KT	1	11:35	200	0	0	0	110	90	2005.52
16/06/23	1b - SE	KT	1	09:51	320	0	15	180	125	0	681.257
13/09/23	1b - SE	KT	1	11:30	31	31	0	0	0	0	98.976
11/08/23	1b - SE	HH	1	09:47	137	137	0	0	0	0	1484.12
14/07/23	1b - SE	KT	1	12:28	120	0	75	45	0	0	1598.82
24/07/23	1b - SE	WE	1	18:01	94	94	0	0	0	0	412.863
24/07/23	1b - SE	EA	1	16:51	85	0	0	85	0	0	1417.87
16/06/23	1b - SE	KT	1	08:31	560	0	50	225	195	90	2659.83
11/08/23	1b - SE	KT	1	12:50	321	30	261	30	0	0	560.037
13/09/23	1b - SE	PG	108	15:28	103	0	0	60	30	13	839.109
16/06/23	1b - SE	KT	1	10:17	280	0	0	165	115	0	3498.11
13/09/23	1b - SE	PG	50	09:37	162	0	0	162	0	0	862.916
13/09/23	1b - SE	WE	1	13:35	108	33	45	30	0	0	767.249
24/10/23	1b - SE	GP	9	11:02	35	0	30	5	0	0	603.236
09/11/23	1b - SE	YF	1	10:22	63	63	0	0	0	0	645.987
05/12/23	1b - SE	GI	1	13:57	133	133	0	0	0	0	1390.99
13/02/24	1b - SE	EA	1	13:08	514	514	0	0	0	0	3085.29
22/07/24	1b - NE	KT	1	15:51	38	0	0	0	0	38	843.793
04/03/24	1b - NE	KT	1	12:43	156	15	75	66	0	0	327.182
04/03/24	1b - NE	GP	28	13:28	47	32	15	0	0	0	166.955
16/05/24	1b - NE	KT	1	15:51	96	66	30	0	0	0	309.1
22/07/24	1b - NE	KT	1	15:49	40	0	10	30	0	0	711.193
04/03/24	1b - NE	WE	1	12:52	371	60	90	150	45	26	1676.67
22/04/24	1b - NE	KT	1	12:02	205	0	180	25	0	0	3178.34
11/08/24	1b - NE	KT	1	13:54	235	0	75	160	0	0	360.029
22/04/24	1b - NE	KT	2	12:21	230	30	105	95	0	0	3232.4
11/08/24	1b - NE	KT	1	13:58	230	0	0	230	0	0	1273

Date	VP	Target species	Number	Start time	Duration (s)	Height band					Flight length (m)
						H1	H2	H3	H4	H5	
22/04/24	1b - NE	KT	1	12:24	70	15	55	0	0	0	988.113
22/04/24	1b - NE	KT	1	13:18	90	15	45	30	0	0	733.545
11/08/24	1b - NE	KT	1	12:49	85	0	60	25	0	0	213.352
22/04/24	1b - NE	KT	1	14:09	82	7	60	15	0	0	1024.1
22/04/24	1b - NE	GP	3	14:17	50	0	0	50	0	0	1004.23
10/06/24	1b - NE	KT	1	11:40	288	15	108	165	0	0	2250.28
10/06/24	1b - NE	KT	1	13:13	324	30	60	234	0	0	1710.2
10/06/24	1b - NE	KT	1	14:31	247	202	45	0	0	0	1499.2
11/08/24	1b - NE	KT	1	14:02	100	0	60	40	0	0	62.671
22/07/24	1b - NE	WE	1	15:50	238	0	0	0	163	75	4015.26
10/06/24	2b	KT	1	14:26	55	0	55	0	0	0	760.788
15/05/23	2b	KT	1	14:32	36	0	36	0	0	0	597.724
11/08/23	2b	KT	1	12:56	62	17	45	0	0	0	1684.59
26/04/23	2b	CU	1	09:23	221	0	0	45	30	146	113.394
13/09/23	2b	PG	48	09:24	48	0	0	48	0	0	418.035
15/04/24	2b	KT	1	13:05	246	0	0	246	0	0	1770.75
09/11/23	2b	YF	1	10:37	75	60	15	0	0	0	774.942
14/07/23	2b	WE	1	09:22	45	0	0	45	0	0	476.014
14/07/23	2b	KT	1	13:14	60	0	60	0	0	0	1281.83
26/04/23	2b	KT	1	11:16	290	20	105	75	90	0	1317.63
26/04/23	2b	KT	1	12:15	193	0	88	105	0	0	1615.02
16/06/23	2b	WE	1	10:38	257	2	90	135	30	0	1453.95
13/09/23	2b	KT	1	13:04	177	0	0	75	60	42	718.698
15/05/23	2b	KT	1	12:52	44	0	14	30	0	0	935.384
13/09/23	2b	PG	75	12:37	214	0	0	0	214	0	380.011
09/11/23	2b	YF	1	10:30	19	19	0	0	0	0	184.55
15/05/23	2b	KT	1	13:20	93	45	48	0	0	0	2161.92
13/09/23	2b	WE	1	13:29	248	83	60	105	0	0	1067.9
14/07/23	2b	KT	1	12:44	90	0	60	30	0	0	1187.89
09/11/23	2b	KT	1	08:39	89	89	0	0	0	0	1364.6
16/06/23	2b	KT	1	10:44	184	0	64	120	0	0	2119.77
13/09/23	2b	PG	47	10:21	126	0	0	0	0	126	1001.87
16/06/23	2b	WE	1	10:50	343	0	15	45	45	238	1224.29
13/09/23	2b	PG	21	14:07	140	0	0	0	0	140	926.146
14/07/23	2b	KT	1	11:11	420	30	285	105	0	0	3459.62
09/11/23	2b	KT	1	14:01	327	327	0	0	0	0	769.517
13/09/23	2b	PG	50	09:35	141	0	0	30	105	6	527.589
13/09/23	2b	KT	1	15:31	132	0	0	132	0	0	850.515
13/09/23	2b	PG	65	10:03	199	0	0	0	0	199	2075.59
09/11/23	2b	KT	1	13:03	153	108	45	0	0	0	1124.03
13/09/23	2b	KT	1	11:54	363	0	138	225	0	0	2664.77
22/04/24	2b	GP	2	16:02	50	0	50	0	0	0	1080.6

Date	VP	Target species	Number	Start time	Duration (s)	Height band					Flight length (m)
						H1	H2	H3	H4	H5	
05/12/23	2b	KT	1	09:54	245	140	105	0	0	0	2538.1
15/04/24	2b	KT	2	16:20	156	0	120	36	0	0	1311.99
22/04/24	2b	GP	2	16:08	40	0	40	0	0	0	704.603
05/12/23	2b	KT	1	14:24	356	135	150	71	0	0	3630.98
05/12/23	2b	HH	1	15:01	388	388	0	0	0	0	4049.64
15/04/24	2b	KT	1	14:15	235	70	135	30	0	0	2136.24
25/07/24	2b	KT	1	16:21	128	0	30	98	0	0	1799.41
22/04/24	2b	KT	1	17:21	620	30	360	230	0	0	2545.54
10/06/24	2b	KT	1	12:02	238	178	60	0	0	0	2611.65
22/07/24	2b	KT	1	15:12	105	0	45	60	0	0	1689.57
22/07/24	2b	WE	1	15:47	138	0	0	0	123	15	1630.96
22/07/24	2b	WE	1	15:47	686	0	0	0	671	15	3171.26
10/08/24	2b	KT	1	11:42	565	0	130	435	0	0	1007.18

ANNEX 2: COLLISION RISK MODEL ANALYSIS - SPECIES OUTPUTS

- Dunlin
- Golden eagle
- Golden plover
- Red kite
- White-tailed eagle

Bird data		Value	Units		Windfarm data		Value	Units		Turbine data		Value	Units
Species name		Dunlin			Site name	Lynemore				Model	2 MW Type		
Bird Length	L	0.18	m		Latitude	57.3668	degrees			Hub height	119		m
Wingspan	W	0.41	m		No of turbines	12				Rotor radius	81	R	m
Bird flight speed	v	15.3	m s^{-1}		Width of windfarm	3.92	km			No of blades	3	b	
Flight type, flapping or gliding		flapping								Rotation speed	7.2	Ω	rpm
% of flights upwind/downwind		50.0%	50.0%							Max blade width	4.1	C	m
Nocturnal activity ranking 1-5		1								Blade pitch	15	λ	degrees
Nocturnal activity factor	f_{night}	0%								Risk height range	38 - 200		m

normal approach

Stage A				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Daytime bird density	D_A		birds/km^2	0	0	0	0.0006	0.0006	0.0006	0.0006	0	0	0	0	0	
Proportion at rotor risk height	Q_{2R}	3.71%														
At latitude 57.36679		Daylight hours per month		229.3	262.9	365.1	428.0	512.7	535.8	535.9	473.5	386.0	322.4	243.3	209.7	4504.6
		Nightime hours per month		514.7	409.1	378.9	292.0	231.3	184.2	208.1	270.5	334.0	421.6	476.7	534.3	4255.4

Stage B																
No of Turbines	T	12														
Rotor radius	R	81	m													
		Total rotor frontal area m^2		247,344												
Nocturnal activity factor	f_{night}	0%														
Bird flight speed	v	15	m s^{-1}	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year total
		Projected number of rotor transits		-	-	-	0.8	1.0	1.0	1.0	-	-	-	-	-	**4**

Stage C									
No of blades	b	3			Bird Length	L	0.18	m	
Rotation speed	Ω	7.2	rpm		Wingspan	W	0.41	m	
Rotor radius	R	81	m		Bird flight speed	v	15.3	m s^{-1}	
Max blade width	C	4.1	m		Flight type		0		
Pitch	λ	15	degrees	% of flights upwind/downwind			50.0%	50.0%	
Blade profile		See Blade profile sheet							
		Single transit risk	upwind	4.9%					
			downwind	2.2%					
			weighted mean	3.6%					

Stage D		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year average
Proportion of time operational	Qop	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	**85.0%**
		Collision rates before avoidance												Year total
		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.115**

Stage E																
Allow for Large array correction?		No														
Width of windfarm	w	3.92	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		95.0%	100.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.006**
		98.0%	100.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.002**
		99.0%	100.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.001**
		99.5%	100.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.001**
		99.9%	100.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.000**

Bird data		Value	Units
Species name		Golden eagle	
Bird Length	L	0.82	m
Wingspan	W	2.12	m
Bird flight speed	v	11.9	m s^{-1}
Flight type, flapping or gliding		0	
% of flights upwind/downwind		50.0%	50.0%
Nocturnal activity ranking 1-5		1	
Nocturnal activity factor	f_{night}	0%	

Windfarm data		Value	Units
Site name		Lynemore	
Latitude		57.3668	degrees
No of turbines		12	
Width of windfarm		3.92	km

Turbine data		Value	Units
Model		2 MW Type	
Hub height		119	m
Rotor radius	R	81	m
No of blades	b	3	
Rotation speed	Ω	7.2	rpm
Max blade width	C	4.1	m
Blade pitch	λ	15	degrees
Risk height range		38 - 200	m

normal approach

Stage A				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Daytime bird density	D_A		birds/km^2	0	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0	0	0	0	
Proportion at rotor risk height	Q_{2R}	12.10%														
At latitude 57.36679		Daylight hours per month		229.3	262.9	365.1	428.0	512.7	535.8	535.9	473.5	386.0	322.4	243.3	209.7	4504.6
		Nightime hours per month		514.7	409.1	378.9	292.0	231.3	184.2	208.1	270.5	334.0	421.6	476.7	534.3	4255.4

Stage B																
No of Turbines	T	12														
Rotor radius	R	81	m													
		Total rotor frontal area m^2		247,344												
Nocturnal activity factor	f_{night}	0%														
Bird flight speed	v	12	m s^{-1}	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year total
		Projected number of rotor transits		-	1.7	2.3	2.7	3.2	3.4	3.4	3.0	-	-	-	-	**20**

Stage C								
No of blades	b	3		Bird Length	L	0.82	m	
Rotation speed	Ω	7.2	rpm	Wingspan	W	2.12	m	
Rotor radius	R	81	m	Bird flight speed	v	11.9	m s^{-1}	
Max blade width	C	4.1	m	Flight type		0		
Pitch	λ	15	degrees	% of flights upwind/downwind		50.0%	50.0%	
Blade profile		See Blade profile sheet						
		Single transit risk	upwind	7.9%				
			downwind	4.6%				
			weighted mean	6.2%				

Stage D		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year average
Proportion of time operational	Qop	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	**85.0%**
		Collision rates before avoidance												Year total
		0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	**1.046**

Stage E																
Allow for Large array correction?		No														
Width of windfarm	w	3.92	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		95.0%	100.0%	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	**0.052**
		98.0%	100.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.021**
		99.0%	100.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.010**
		99.5%	100.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.005**
		99.9%	100.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.001**

Bird data		Value	Units
Species name		Golden plover	
Bird Length	L	0.28	m
Wingspan	W	0.72	m
Bird flight speed	v	17.9	m s^{-1}
Flight type, flapping or gliding		0	
% of flights upwind/downwind		50.0%	50.0%
Nocturnal activity ranking 1-5		2	
Nocturnal activity factor	f_{night}	25%	

Windfarm data		Value	Units
Site name		Lynemore	
Latitude		57.3668	degrees
No of turbines		12	
Width of windfarm		3.92	km

Turbine data		Value	Units
Model		2 MW Type	
Hub height		119	m
Rotor radius	R	81	m
No of blades	b	3	
Rotation speed	Ω	7.2	rpm
Max blade width	C	4.1	m
Blade pitch	λ	15	degrees
Risk height range		38 - 200	m

normal approach

Stage A				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Daytime bird density	D_A		birds/km^2	0.002	0.002	0.002	0.0002	0.0002	0.0002	0.0002	0.002	0.002	0.002	0.002	0.002	
Proportion at rotor risk height	Q_{2R}	41.46%														
At latitude 57.36679		Daylight hours per month		229.3	262.9	365.1	428.0	512.7	535.8	535.9	473.5	386.0	322.4	243.3	209.7	4504.6
		Nightime hours per month		514.7	409.1	378.9	292.0	231.3	184.2	208.1	270.5	334.0	421.6	476.7	534.3	4255.4

Stage B																
No of Turbines	T	12														
Rotor radius	R	81	m													
		Total rotor frontal area m^2		247,344												
Nocturnal activity factor	f_{night}	25%														
Bird flight speed	v	18	m s^{-1}	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year total
		Projected number of rotor transits		23.4	26.8	37.2	4.4	5.2	5.5	5.5	48.3	39.4	32.9	24.8	21.4	**275**

Stage C							
No of blades	b	3		Bird Length	L	0.28	m
Rotation speed	Ω	7.2	rpm	Wingspan	W	0.72	m
Rotor radius	R	81	m	Bird flight speed	v	17.9	m s^{-1}
Max blade width	C	4.1	m	Flight type		0	
Pitch	λ	15	degrees	% of flights upwind/downwind		50.0%	50.0%
Blade profile		See Blade profile sheet					
		Single transit risk	upwind	5.0%			
			downwind	2.8%			
			weighted mean	3.9%			

Stage D		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year average
Proportion of time operational	Qop	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	**85.0%**
		Collision rates before avoidance												Year total
		0.8	0.9	1.2	0.1	0.2	0.2	0.2	1.6	1.3	1.1	0.8	0.7	**9.104**

Stage E																
Allow for Large array correction?		No														
Width of windfarm	w	3.92	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		95.0%	100.0%	0.04	0.04	0.06	0.01	0.01	0.01	0.01	0.08	0.07	0.05	0.04	0.04	**0.455**
		98.0%	100.0%	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.03	0.03	0.02	0.02	0.01	**0.182**
		99.0%	100.0%	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.01	0.01	**0.091**
		99.5%	100.0%	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	**0.046**
		99.9%	100.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.009**

Bird data		Value	Units		Windfarm data		Value	Units		Turbine data		Value	Units
Species name		Red kite			Site name	Lynemore				Model	2 MW Type		
Bird Length	L	0.63	m		Latitude	57.3668	degrees			Hub height	119		m
Wingspan	W	1.85	m		No of turbines	12				Rotor radius	81	R	m
Bird flight speed	v	12	$m\,s^{-1}$		Width of windfarm	3.92	km			No of blades	3	b	
Flight type, flapping or gliding		1								Rotation speed	7.2	Ω	rpm
% of flights upwind/downwind		50.0%	50.0%							Max blade width	4.1	C	m
Nocturnal activity ranking 1-5		1								Blade pitch	15	λ	degrees
Nocturnal activity factor	f_{night}	0%								Risk height range	38 - 200		m

normal approach

Stage A				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Daytime bird density	D_A		birds/km^2	0.0025	0.0025	0.0037	0.0037	0.0037	0.0037	0.0037	0.0025	0.0025	0.0025	0.0025	0.0025	
Proportion at rotor risk height	Q_{2R}	47.27%														
At latitude 57.36679		Daylight hours per month		229.3	262.9	365.1	428.0	512.7	535.8	535.9	473.5	386.0	322.4	243.3	209.7	4504.6
		Nightime hours per month		514.7	409.1	378.9	292.0	231.3	184.2	208.1	270.5	334.0	421.6	476.7	534.3	4255.4

Stage B					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year total
No of Turbines	T	12															
Rotor radius	R	81	m														
		Total rotor frontal area m^2		247,344													
Nocturnal activity factor	f_{night}	0%															
Bird flight speed	v	12	$m\,s^{-1}$														
		Projected number of rotor transits			17.9	20.5	42.1	49.4	59.1	61.8	61.8	36.9	30.1	25.1	19.0	16.3	**440**

Stage C								
No of blades	b	3			Bird Length	L	0.63	m
Rotation speed	Ω	7.2	rpm		Wingspan	W	1.85	m
Rotor radius	R	81	m		Bird flight speed	v	12	$m\,s^{-1}$
Max blade width	C	4.1	m		Flight type		1	
Pitch	λ	15	degrees	% of flights upwind/downwind			50.0%	50.0%
Blade profile		See Blade profile sheet						
		Single transit risk		upwind	6.8%			
				downwind	3.5%			
				weighted mean	5.2%			

Stage D		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year average
Proportion of time operational	Qop	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	**85.0%**
		Collision rates before avoidance												Year total
		0.8	0.9	1.9	2.2	2.6	2.7	2.7	1.6	1.3	1.1	0.8	0.7	**19.417**

Stage E																
Allow for Large array correction?		No														
Width of windfarm	w	3.92	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		95.0%	100.0%		0.04	0.05	0.09	0.11	0.13	0.14	0.14	0.08	0.07	0.06	0.04	0.04	**0.971**
		98.0%	100.0%		0.02	0.02	0.04	0.04	0.05	0.05	0.05	0.03	0.03	0.02	0.02	0.01	**0.388**
		99.0%	100.0%		0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.02	0.01	0.01	0.01	0.01	**0.194**
		99.5%	100.0%		0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	**0.097**
		99.9%	100.0%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.019**

Bird data		Value	Units
Species name		White-tailed eagle	
Bird Length	L	0.8	m
Wingspan	W	2.2	m
Bird flight speed	v	13.6	m s^{-1}
Flight type, flapping or gliding		1	
% of flights upwind/downwind		50.0%	50.0%
Nocturnal activity ranking 1-5		1	
Nocturnal activity factor	f_{night}	0%	

Windfarm data		Value	Units
Site name		Lynemore	
Latitude		57.3668	degrees
No of turbines		12	
Width of windfarm		3.92	km

Turbine data			
Model		2 MW Type	
Hub height		119	m
Rotor radius	R	81	m
No of blades	b	3	
Rotation speed	Ω	7.2	rpm
Max blade width	C	4.1	m
Blade pitch	λ	15	degrees
Risk height range		38 - 200	m

normal approach

Stage A				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Daytime bird density	D_A		birds/km^2	0.0002	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0002	0.0002	0.0002	0.0002	
Proportion at rotor risk height	Q_{2R}	72.63%														
At latitude 57.36679		Daylight hours per month		229.3	262.9	365.1	428.0	512.7	535.8	535.9	473.5	386.0	322.4	243.3	209.7	4504.6
		Nightime hours per month		514.7	409.1	378.9	292.0	231.3	184.2	208.1	270.5	334.0	421.6	476.7	534.3	4255.4

Stage B																
No of Turbines	T	12														
Rotor radius	R	81	m													
		Total rotor frontal area m^2		247,344												
Nocturnal activity factor	f_{night}	0%														
Bird flight speed	v	14	m s^{-1}	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year total
		Projected number of rotor transits		2.5	11.4	15.9	18.6	22.3	23.3	23.3	20.6	4.2	3.5	2.6	2.3	**150**

Stage C								
No of blades	b	3		Bird Length	L	0.8	m	
Rotation speed	Ω	7.2	rpm	Wingspan	W	2.2	m	
Rotor radius	R	81	m	Bird flight speed	v	13.6	m s^{-1}	
Max blade width	C	4.1	m	Flight type		1		
Pitch	λ	15	degrees	% of flights upwind/downwind		50.0%	50.0%	
Blade profile		See Blade profile sheet						
		Single transit risk	upwind	6.9%				
			downwind	3.9%				
			weighted mean	5.4%				

Stage D		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year average
Proportion of time operational	Qop	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	85.0%	**85.0%**
		Collision rates before avoidance												Year total
		0.1	0.5	0.7	0.9	1.0	1.1	1.1	0.9	0.2	0.2	0.1	0.1	**6.918**

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	3.92	km														
			large array correction		Collision rates allowing for avoidance												
Avoidance rates modelled		95.0%	100.0%		0.01	0.03	0.04	0.04	0.05	0.05	0.05	0.05	0.01	0.01	0.01	0.01	**0.346**
		98.0%	100.0%		0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.00	0.00	0.00	0.00	**0.138**
		99.0%	100.0%		0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	**0.069**
		99.5%	100.0%		0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	**0.035**
		99.9%	100.0%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.007**