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Appendix 7K

Ornithology Collision Risk Modelling Report, October 2023, RSK Ireland Ltd

Ballycar Green Energy Ltd

Appendix 7K – Ornithology Collision Risk Modelling Report

Ballycar Wind Farm Development

604162

DECEMBER 2023

RSK

RSK GENERAL NOTES

Project No.: 2485597

Title: Appendix 7K – Ornithology Collision Risk Modelling Report – Ballycar Wind Farm Development

Client: Ballycar Green Energy Ltd

Date: 08 December 2023

Office: Dublin

Status: Rev04

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1.0 INTRODUCTION

1.1 Purpose of this report

This report presents the methodology and findings of bird collision risk modelling for the proposed Ballycar Wind Farm Development (hereafter referred to as 'the project'). This report forms a technical appendix to Chapter 7 of the Environmental Impact Assessment Report (EIAR) for the project and has been produced using field survey data presented in Appendices 7C to 7J, which also support the EIAR. This study was undertaken by RSK on behalf of Ballycar Green Energy.

This collision risk modelling study has been undertaken in order to identify the potential impacts of the project on target bird species through collisions with new wind turbines, and to inform any requirement for mitigation measures.

The collision risk modelling study presented in this report has been prepared in reference to current best practice guidance, using field data from monthly Vantage Point (VP) surveys undertaken between 2019 and 2023 inclusive. Detailed methods for these surveys are described in Appendix 7B – Desktop Study and Survey Methodologies.

1.2 Site overview

The project site (hereafter referred to as 'the site') is located approximately 3 kilometres (km) north of Limerick City and suburbs in southeast County Clare. The site and surroundings predominantly comprise intensively managed farmland interspersed with less intensive areas of grazing pasture and conifer plantation. Elevations at the site range from approximately 62-260 metres (m) Above Ordnance Datum (AOD).

A desk-based search for relevant designated sites with features of ornithological interest (notably Special Protection Areas (SPAs) and Ramsar sites) was undertaken within a 15 km buffer around the site. This identified one designated site within 15 km of the project site, as summarised in Table 1 below (detailed information on the site is provided in Appendix 7B – Desktop Study and Survey Methodologies).

Relevant species included on the citation for this internationally designated site have been considered for inclusion within collision risk modelling (as described in Section 3.3).

Table 1. Relevant designated site

Designated site	Distance from the site	Description
River Shannon and River Fergus Estuaries SPA and Ramsar site	4.4 km SW	Estuaries forming the largest estuarine complex in Ireland. Qualifies on account of it regularly supporting over 20,000 waterbirds during the non-breeding season, and due to its important wintering populations of numerous waterbird species including whooper swan (*Cygnus cygnus*), light-bellied brent goose (*Branta bernicla hrota*), shelduck (*Tadorna tadorna*), golden plover (*Pluvialis apricaria*) and black-tailed godwit (*Limosa limosa*). The breeding population of cormorant (*Phalacrocorax carbo*) also forms a Special Conservation Interest feature for the SPA.

1.3 Key guidance

This collision risk modelling study has been undertaken in reference to current key industry standard guidance including that provided by SNH (now NatureScot). Relevant guidance to this report includes:

- *Recommended bird survey methods to inform impact assessment of onshore wind farms* (SNH, 2017);
- *Wind farms and birds: Calculating a theoretical collision risk assuming no avoiding action* (SNH, 2000);
- *Avoidance Rates for the onshore SNH Wind Farm Collision Risk Model* (SNH, 2018);
- *Developing field and analytical methods to assess avian collision risk at wind farms* (Band *et al.,* 2007); and
- *Calculation of collision risk for birds passing through rotor area* (Band, 2011).

Any departures from the standard approaches specified in the above best practice guidance, and any additional assumptions, are highlighted in the relevant sections of this report.

2.0 DEVELOPMENT DESIGN

2.1 Wind Farm Area

The project consists of a wind farm development comprising 12 new wind turbines. These will all be Vestas V136 turbines, with two different specifications selected for use within the development (as described in Section 2.2 below).

For the purposes of collision risk modelling, the Wind Farm Area (WFA) has been defined as the maximum area covered by the 12 turbine bases, allowing for 68 m for the span of the turbine blades (on a precautionary basis) and a 100 m buffer to allow for any inaccuracies in mapping bird flight lines during VP surveys. On a precautionary basis, the WFA also includes land between the turbine bases. The WFA for the purposes of collision risk modelling measures 202.48 hectares (ha).

2.2 Turbine parameters

Collision risk modelling within this report has been based on the specifications of the selected turbine for the project: the Vestas V136. Technical specifications for this turbine incorporated into collision risk modelling are provided in Table 2 below. Of the 12 turbines installed, 11 will have a turbine height of 158 m, whilst one (Turbine 10) will have a turbine height of 150 m. It is understood the turbines will have an operational lifespan of 35 years.

Table 2. Turbine technical specifications

Specification	Value (Turbines 1-9 and 11-12)	Value (Turbine 10)
Turbine	Vestas V136	Vestas V136
Number of turbines within the project	11	1
Number of blades per turbine	3	3
Tower height	90 m	82 m
Rotor radius	66.66 m	66.66 m
Rotor diameter (including hub)	136 m	136 m
Turbine height (ground to blade tip)	158 m	150 m
Rotor sweep zone (RSZ)	14,527 m^2	14,527 m^2
Maximum rotor chord	4.1 m	4.1 m
Rotor pitch	6^o	6^o
Rotor depth	4.265 m	4.265 m
Maximum rotation period (seconds)	4.286	4.286

3.0 METHODOLOGY

3.1 Overview

This section presents the methods used for collision risk modelling, including survey coverage, identification of Key Ornithological Receptors and collision risk model selection.

Collision risk modelling was undertaken using the standard approach described in the best practice guidance and calculation tools specified in Section 1.3.

Collision risk modelling is essentially a three-stage process:

1. Initial modelling uses field survey data on bird flight activity to assess the number of birds passing through the zone swept by the rotating turbine blades (i.e. the 'flight risk volume');
2. Modelling then estimates the probability of a bird being hit if it were to fly through an operational turbine, based on the estimated flight parameters of the specific bird species and the turbine parameters. This stage assumes birds take no action to avoid collisions with turbines (i.e. 'avoiding actions');
   - The outputs of Stages 1 and 2 are then multiplied together to provide an estimate of the number of collisions that would occur in the absence of avoiding actions. Assuming all collisions result in fatalities, this provides an estimate of the number of fatalities that would occur.
3. Finally modelling applies an avoidance rate to account for avoiding actions. This is based on the understanding that birds will often either avoid the wind farm entirely, fly above or below an operational turbine, or perform 'emergency' maneuvers to avoid a moving turbine blade.
   - This provides an estimate of the number of fatalities that would occur, taking into account avoiding actions (again assuming all collisions result in fatalities).

Once collision risk modelling has calculated the estimated number of fatalities for target species (taking into account avoiding actions) as a result of the new turbines, this information is applied to knowledge of the populations of the Key Ornithological Receptors to assess the potential impacts of the new turbines on the populations of those species. Where significant impacts are anticipated, mitigation measures may be required to minimise the potential for impacts and thus avoid adverse impacts on the Key Ornithological Receptors. This impact assessment is undertaken in Chapter 7 of the EIAR for the project.

3.2 Survey coverage and methods

Field data used for collision risk modelling were collected during VP surveys undertaken at the site in 2019-2023. Survey locations, methods and effort are described in Chapter 7 Ornithology of the EIAR and detailed in Appendices 7B, 7I and 7J.

These surveys were undertaken in accordance with best practice guidance (SNH, 2017) in order to record bird flight activity throughout the site during the breeding season (i.e. April to September inclusive; 'B') and the non-breeding season (i.e. October to March inclusive; 'NB'), with emphasis on recording activity by target species (see Section 3.3).

In summary, VP surveys were undertaken between October 2019 and September 2023 inclusive. A total of three VPs were surveyed. A summary of VP survey effort is provided in Table 3 below.

Table 3. Summary of Vantage Point survey effort

VP	Hours of observation								
	NB 2019/20	B 2020	NB 2020/21	B 2021	NB 2021/22	B 2022	NB 2022/23	B 2023	Total
VP1	36	36	36	36	36	36	36	36	288
VP2	36	36	36	36	36	48	36	36	300
VP3	36	36	36	36	36	24	36	36	276

Recording of flight data

Parameters for target species observed flying within or in close proximity to the site were recorded to enable collision risk modelling. Parameters recorded were as follows:

- Start time of flight observation;
- Duration of flight observation;
- Species and number of individuals;
- Approximate height of flight in metres, with the time spent in each flight height category (non-flight, 0-20 m, 20-50 m, 50-100 m, 100-180 m and >180 m) recorded; and
- The likely purpose of the flight (e.g. foraging, displaying, commuting, etc.).

Some flight observations from the VP surveys were entirely within the WFA. As such, the entirety of the flight time at collision risk height from these observations was included in collision risk modelling. However, some flight observations crossed the WFA boundary (i.e. indicating birds flying into or out of the WFA). When including these flight lines within collision risk modelling, only the proportion of flight time observed within the WFA was included. To ensure a suitably precautionary approach was adopted, for flight lines where only a small fraction of the flight line was outside of the WFA, the flight line was included in its entirety. Similarly, flight lines for birds circling near the WFA boundary and occasionally leaving the WFA were also included in their entirety.

Based on the turbine parameters described in Section 2.2, flight records included within collision risk modelling (i.e. flights at 'collision risk height' and therefore included within the 'flight risk volume') were those recorded in the 20-50 m, 50-100 m and 100-180 m height categories described above.

3.3 Key ornithological receptors

Selection of target species for VP surveys undertaken in 2019-2023 inclusive is described in detail in the Appendix 7B – Desktop Study and Survey Methodologies. In summary, the following species were identified as target species:

- All species of waterfowl;
- All species of raptor;
- All species of owl;
- All species of grouse;
- All species of wader; and
- All species of gull and skua.

Regarding determination of target species recorded during the VP surveys which require detailed collision risk modelling to assess potential impacts (referred to as 'Key Ornithological Receptors'), species were selected based on the following factors:

- Their level of legal protection (e.g. inclusion on Annex 1 of the Birds Directive) and conservation concern (e.g. inclusion on the Birds of Conservation Concern in Ireland (BoCCI) Red or Amber Lists (Gilbert *et al*., 2021));
- Their relevance to any nearby designated sites (notably the statutory designated site described in Table 1);
- The assessed importance of the site to these species at an international, national, regional or local level; and
- Their level of flight activity at risk height within the WFA.

As such, five species were identified as Key Ornithological Receptors requiring detailed collision risk modelling, as indicated in Table 4 below. Considering their legal protection and conservation status, and their level of activity within the WFA, no other species were identified as Key Ornithological Receptors requiring detailed collision risk modelling.

Table 4. Key Ornithological Receptors for collision risk modelling

Species	Justification for inclusion
Buzzard (*Buteo buteo*)	Whilst a common and widespread species in Ireland, reflected by its inclusion on the BoCCI Green List, high levels of flight activity were recorded within the WFA. Buzzard activity was recorded within the site throughout the breeding and non-breeding seasons.
Hen harrier (*Circus cyaneus*)	A species of conservation concern in Ireland due to its inclusion on the BoCCI Amber List, and afforded additional legal protection due to its inclusion on Annex 1 of the Birds Directive. Relevant designated sites of importance for this species have been identified within 20 km of the development site (notably Lough Derg (Shannon) SPA and Slieve Aughty Mountains SPA). Hen harrier activity was recorded within the site during the breeding and non-breeding seasons. Approximately 20% of the ornithological study area for the project overlaps with one of nine non-designated but regionally important breeding areas for hen harrier in Ireland, as established from the 2015 National Hen Harrier Survey (Ruddock *et al*., 2016). This area, the 'South Clare' non-designated Regional Zone for hen harrier, includes a total area of over 14,000 hectares.
Kestrel (*Falco tinnunculus*)	A species of high conservation importance in Ireland due to its inclusion on the BoCCI Red List. High levels of flight activity were recorded within the WFA. Kestrel activity was recorded within the site throughout the breeding and non-breeding seasons.
Peregrine (*Falco peregrinus*)	A locally common and increasing species in Ireland, reflected by its inclusion on the BoCCI Green List. Afforded additional legal protection due to its inclusion on Annex 1 of the Birds Directive. Peregrine activity was recorded within the site during the breeding and (to a lesser extent) non-breeding seasons.
Sparrowhawk (*Accipiter nisus*)	Whilst a common and widespread species in Ireland, reflected by its inclusion on the BoCCI Green List, high levels of flight activity were recorded during the VP surveys. Sparrowhawk activity was recorded within the site during the breeding and non-breeding seasons.

Whilst consideration was given to other target species (including cormorant, snipe (*Gallinago gallinago*), whimbrel (*Numenius phaeopus*) and woodcock (*Scolopax rusticola*)), on account of the level of activity recorded on site and/or the potential sensitivity of these species to collision impacts, collision risk modelling was not undertaken for these species.

To maximise the accuracy of collision risk modelling outputs, collision risk calculations were undertaken for a duration of time appropriate to the species in question. All five species potentially use the WFA during the breeding and non-breeding seasons. As such, collision risk modelling was undertaken based on the entire duration of the period surveyed (i.e. from October 2019 to September 2023 inclusive).

Collision risk modelling requires the typical measurements and flight parameters of modelled species (i.e. Key Ornithological Receptors) to be known. Relevant data for Key Ornithological Receptors based on existing literature are detailed in Table 5 below.

Table 5. Measurements and flight parameters for Key Ornithological Receptors

Species	Average body length (m)	Average wingspan (m)	Average flight speed (m/s)	Data sources
Buzzard	0.54	1.20	9.45	BTO BirdFacts (2022); Hawk & Owl Trust (2022); Robinson (2005); Snow & Perrins (1998); Bruderer & Boldt (2001)
Hen Harrier	0.48	1.10	9.10	BTO BirdFacts (2022); Hawk & Owl Trust (2022); Bruderer & Boldt (2001)
Kestrel	0.34	0.76	9.95	BTO BirdFacts (2022); Hawk & Owl Trust (2022); Robinson (2005); Snow & Perrins (1998); Bruderer & Boldt (2001); Taylor *et al*. (2003)
Peregrine	0.42	1.02	12.10	BTO BirdFacts (2022); Alerstam *et al.* (2007)
Sparrowhawk	0.35	0.70	11.3	BTO BirdFacts (2022); Hawk & Owl Trust (2022); Alerstam *et al.* (2007)

3.4 Model selection

SNH has published two models for calculation of collision risk. These models are appropriate for different scenarios, depending on how Key Ornithological Receptors are using the WFA:

- The 'Airspace' Model applies where birds are typically recorded within the airspace of the WFA; for example, birds with breeding territories or observed foraging within the WFA; and
- The 'Fly Through' Model applies where birds are typically recorded using regular commuting routes across the WFA.

Observations of the five Key Ornithological Receptors from the VP surveys undertaken in 2019-2023 inclusive were typically of birds hunting, circling, soaring and perching within the WFA, and habitats within the site were suitable for use by these species (rather than only being suitable for commuting over). As such, the Airspace Model was selected as being most appropriate for collision risk modelling of buzzard, hen harrier, kestrel, peregrine and sparrowhawk.

3.5 Avoidance rates

The third stage of collision risk modelling takes account of the understanding that birds will often take action to avoid collision with wind turbines, either by avoiding the wind farm entirely (i.e. displacement), by flying above or below operational turbines, or by performing 'emergency' maneuvers to avoid moving turbine blades.

Avoidance rates are generally derived by comparing data on actual observed collisions with the predicted no-avoidance collision estimate. SNH *Avoidance Rates for the onshore SNH Wind Farm Collision Risk Model* (SNH, 2018) collates species-specific estimates of avoidance rates from a range of information sources to determine estimates of avoidance that should be used for Key Ornithological Receptors.

Avoidance rates used are indicated in Table 6 below. As per SNH guidance, a default avoidance rate of 98% has been applied for species for which a specific avoidance rate is not specified (due to a lack of empirical evidence to the contrary).

Table 6. Avoidance rates for Key Ornithological Receptors (SNH, 2018)

Species	Avoidance rate
Buzzard	98% (default value)
Hen harrier	99%
Kestrel	95%
Peregrine	98% (default value)
Sparrowhawk	98% (default value)

3.6 Limitations and assumptions

This report is based on field data collected during VP surveys undertaken at the site between 2019-2023. Survey limitations where identified are discussed in the Desktop Study and Survey Methodology Report (see Appendix 7B and Chapter 7 Ornithology).

Collision risk modelling assumes all turbines are turning constantly throughout the modelled period. In reality this will not be the case, as turbines will not be turning at certain times (e.g. at wind speeds below the minimum cut-in speed/above the maximum cut-out speed, or during maintenance periods). In addition, as stated in Section 3.1, collision risk modelling assumes all bird collisions with turbines will be fatal, which may not necessarily be the case. On a precautionary basis, all birds flying between 20 and 180 m within the WFA were included within collision risk modelling, despite the proposed turbines having a maximum height of 158 m. As such, based on these assumptions and methods, collision risk modelling is considered to represent a precautionary scenario of collision fatalities.

As stated in Section 2.1, to account for potential errors when recording the precise locations of birds in flight, an additional 100 m buffer was included around turbine bases when mapping the WFA. This is based on the typical proximity of surveyors to the birds recorded and the site topography, which included boundary features aiding precise mapping of flight lines. As such, this buffer is considered appropriate to ensure all relevant flight lines were included in collision risk modelling.

Collision risk modelling assumes bird activity observed during the baseline VP surveys is representative of the site, in the absence of the proposed development. It does not account for any displacement of birds which may result from the physical presence of the turbines and other associated infrastructure, which may reduce the levels of bird activity within the WFA during the operational period. This represents an additional contributory factor to the precautionary nature of the collision risk modelling calculations.

4.0 RESULTS

Flight times for Key Ornithological Receptors within the flight risk volume (vW) were calculated as the number of birds observed within the WFA at collision risk height (see Section 3.2) during each observation, multiplied by the number of seconds spent within vW. For example, two birds flying at a height of 80 m for 15 seconds would constitute 30 flight seconds within the flight risk volume.

The following flight seconds for each Key Ornithological Receptor at collision risk height were recorded within the WFA (as provided in full in Annex A):

- Buzzard: 7,606 seconds during the breeding season / 1,556 seconds during the non-breeding season;
- Hen harrier: 9 seconds during the non-breeding season / 25 seconds during the breeding season;
- Kestrel: 1,853 seconds during the breeding season / 1,317 seconds during the non-breeding season;
- Peregrine: 998 seconds during the breeding season / 0 seconds during the non-breeding season; and
- Sparrowhawk: 45 seconds during the breeding season / 130 seconds during the non-breeding season.

Species-specific collision risk models for each Key Ornithological Receptor are summarised below. Collision risk probability calculations are provided in Annex B. Collision risk modelling analysis is provided in Annex C.

4.1 Buzzard

Buzzard was frequently recorded during the VP surveys undertaken between 2019 and 2023, with observations at collision risk height within the WFA totaling 9,162 flight seconds.

Based on the measurements and flight parameters for buzzard described in Table 5, and the turbine specifications described in Table 2, the probability of a bird flying through an operational turbine resulting in a collision, in the absence of any avoiding actions, is 7.6%.

Therefore, in the absence of any avoiding actions, the estimated number of buzzard fatalities (based on the 2019-2023 data) is 85.48 birds. This would equate to 21.37 buzzard fatalities per year.

Taking into consideration an avoidance rate of 98% (in line with SNH guidance), the estimated number of buzzard collision fatalities over the modelled period is 1.71, equating to 0.43 birds per year. This would equate to an estimated 14.96 buzzard collision fatalities over the anticipated lifespan of the wind farm (35 years). Collision risk modelling for buzzard is summarised in Table 7 below.

Table 7. Buzzard airspace collision risk model summary

Survey period	Avoidance rate	Estimated collision fatalities		
		Modelled period	Per year	35 years
October 2019-September 2023	98% (default value)	1.710	0.427	14.958

4.2 Hen harrier

Hen harrier was recorded infrequently during the VP surveys undertaken between 2019 and 2023, with two records observed at collision risk height within the WFA totaling 34 flight seconds.

Based on the measurements and flight parameters for hen harrier described in Table 5, and the turbine specifications described in Table 2, the probability of a bird flying through an operational turbine resulting in a collision, in the absence of any avoiding actions, is 7.3%.

Therefore, in the absence of any avoiding actions, the estimated number of hen harrier fatalities (based on the 2019-2023 data) is 0.29 birds. This would equate to 0.07 hen harrier fatalities per year.

Taking into consideration an avoidance rate of 99% (in line with SNH guidance), the estimated number of hen harrier collision fatalities over the modelled period is 0.003, equating to 0.0007 birds per year. This would equate to an estimated 0.026 hen harrier collision fatalities over the anticipated lifespan of the wind farm (35 years). Collision risk modelling for hen harrier is summarised in Table 8 below.

Table 8. Hen harrier airspace collision risk model summary

Survey period	Avoidance rate	Estimated collision fatalities		
		Modelled period	Per year	35 years
October 2019-September 2023	99%	0.003	0.0007	0.026

4.3 Kestrel

Kestrel was frequently recorded during the VP surveys undertaken between 2019 and 2023, with observations at collision risk height within the WFA totaling 3,170 flight seconds.

Based on the measurements and flight parameters for kestrel described in Table 5, and the turbine specifications described in Table 2, the probability of a bird flying through an operational turbine resulting in a collision, in the absence of any avoiding actions, is 6.1%.

Therefore, in the absence of any avoiding actions, the estimated number of kestrel fatalities (based on the 2019-2023 data) is 24.99 birds. This would equate to 6.25 kestrel fatalities per year.

Taking into consideration an avoidance rate of 95% (in line with SNH guidance), the estimated number of kestrel collision fatalities over the modelled period is 1.25, equating to 0.31 birds per year. This would equate to an estimated 10.94 kestrel collision fatalities over the anticipated lifespan of the wind farm (35 years). Collision risk modelling for kestrel is summarised in Table 9 below.

Table 9. Kestrel airspace collision risk model summary

Survey period	Avoidance rate	Estimated collision fatalities		
		Modelled period	Per year	35 years
October 2019-September 2023	95%	1.250	0.312	10.935

4.4 Peregrine

Peregrine was recorded during the VP surveys undertaken between 2019 and 2023, with records observed at collision risk height within the WFA totaling flight 998 seconds.

Based on the measurements and flight parameters for peregrine described in Table 5, and the turbine specifications described in Table 2, the probability of a bird flying through an operational turbine resulting in a collision, in the absence of any avoiding actions, is 6.2%.

Therefore, in the absence of any avoiding actions, the estimated number of peregrine fatalities (based on the 2019-2023 data) is 9.73 birds. This would equate to 2.43 peregrine fatalities per year.

Taking into consideration an avoidance rate of 98% (in line with SNH guidance), the estimated number of peregrine collision fatalities over the modelled period is 0.19, equating to 0.05 birds per year. This would equate to an estimated 1.70 peregrine collision fatalities over the anticipated lifespan of the wind farm (35 years). Collision risk modelling for peregrine is summarised in Table 10 below.

Table 10. Peregrine airspace collision risk model summary

Survey period	Avoidance rate	Estimated collision fatalities		
		Modelled period	Per year	35 years
October 2019-September 2023	98% (default value)	0.195	0.049	1.702

4.5 Sparrowhawk

Sparrowhawk was frequently recorded during the VP surveys undertaken between 2019 and 2023, with observations at collision risk height within the WFA totaling 130 flight seconds.

Based on the measurements and flight parameters for sparrowhawk described in Table 5, and the turbine specifications described in Table 2, the probability of a bird flying through an operational turbine resulting in a collision, in the absence of any avoiding actions, is 5.9%.

Therefore, in the absence of any avoiding actions, the estimated number of sparrowhawk fatalities (based on the 2019-2023 data) is 1.52 birds. This would equate to 0.38 sparrowhawk fatalities per year.

Taking into consideration an avoidance rate of 98% (in line with SNH guidance), the estimated number of sparrowhawk collision fatalities over the modelled period is 0.03, equating to 0.01 birds per year. This would equate to an estimated 0.27 sparrowhawk collision fatalities over the anticipated lifespan of the wind farm (35 years). Collision risk modelling for sparrowhawk is summarised in Table 11 below.

Table 11. Sparrowhawk airspace collision risk model summary

Survey period	Avoidance rate	Estimated collision fatalities		
		Modelled period	Per year	35 years
October 2019-September 2023	98% (default value)	0.030	0.008	0.265

5.0 DISCUSSION

Based on the VP survey data recorded at the project site between 2019 and 2023 inclusive, five Key Ornithological Receptors were identified as being potentially susceptible to collision impacts with new wind turbines: specifically buzzard, hen harrier, kestrel, peregrine and sparrowhawk. These species are potentially susceptible to collision impacts year-round.

Estimated collision risk fatalities for these species as a result of the new turbines, both annually and during the anticipated operational lifespan of the development (35 years), are presented in Section 4.

It should be noted that, for the reasons specified in Section 3.6, these calculations represent a precautionary scenario of collision fatalities from the project.

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ANNEX A – FLIGHT ACTIVITY DATA

Flight activity by Key Ornithological Receptors within the flight risk volume (vW)									
Species	Season	VP	Date	No. birds	Total flight time	Flight height	Flight time at risk height	Flight time in vW	Bird flight seconds in vW
Buzzard	B20	1	06/04/2020	3	476	0-180	448	350	1050
Buzzard	B20	1	14/04/2020	2	105	20-180	105	105	210
Buzzard	B20	1	14/04/2020	1	135	20-100	135	135	135
Buzzard	B20	2	06/04/2020	1	149	0-100	138	138	138
Buzzard	B20	3	14/04/2020	2	544	0-180	436	350	700
Buzzard	B20	3	14/04/2020	1	103	0-100	91	85	85
Buzzard	B20	2	11/05/2020	1	42	100-180	42	5	5
Buzzard	B20	2	16/06/2020	2	1	50-100	1	1	2
Buzzard	**B20**				**Total**				**2325**
Buzzard	B21	2	10/08/2021	1	420	50-100	420	280	280
Buzzard	B21	2	08/09/2021	1	54	50-100	54	40	40
Buzzard	**B21**				**Total**				**320**
Buzzard	NB21/22	3	09/02/2022	1	8	20-50	8	2	2
Buzzard	NB21/22	2	16/02/2022	1	7	50-100	7	3	3
Buzzard	NB21/22	3	17/02/2022	2	10	50-100	10	10	20
Buzzard	NB21/22	3	17/02/2022	1	9	20-50	9	5	5
Buzzard	NB21/22	3	17/02/2022	1	6	20-50	6	4	4
Buzzard	**NB21/22**				**Total**				**34**
Buzzard	B22	1	20/04/2022	1	265	20-100	265	200	200
Buzzard	B22	1	20/04/2022	1	1020	20-100	1020	1020	1020
Buzzard	B22	1	20/04/2022	1	480	20-50	480	160	160
Buzzard	B22	1	20/04/2022	1	360	20-100	360	360	360
Buzzard	B22	1	20/04/2022	1	570	50-100	570	350	350
Buzzard	B22	2	20/04/2022	1	770	0-180	740	150	150
Buzzard	B22	2	20/04/2022	1	320	50-100	320	150	150
Buzzard	B22	2	22/04/2022	1	90	0-50	60	60	60
Buzzard	B22	1	22/04/2022	1	45	20-50	45	45	45
Buzzard	B22	2	25/05/2022	1	20	50-100	20	20	20
Buzzard	B22	2	25/05/2022	1	25	20-50	25	25	25
Buzzard	B22	2	15/06/2022	1	90	50-100	90	5	5
Buzzard	B22	2	11/07/2022	1	180	20-50	180	100	100
Buzzard	B22	2	11/07/2022	1	120	0-50	60	60	60
Buzzard	B22	3	11/07/2022	1	70	0-50	30	25	25
Buzzard	B22	3	11/07/2022	1	180	20-50	180	180	180
Buzzard	B22	3	11/07/2022	1	150	20-100	150	150	150
Buzzard	B22	3	13/07/2022	1	530	20-100	530	500	500
Buzzard	B22	3	13/07/2022	1	140	20-50	140	140	140
Buzzard	B22	3	19/08/2022	1	360	20-100	360	30	30

Flight activity by Key Ornithological Receptors within the flight risk volume (vW)									
Species	Season	VP	Date	No. birds	Total flight time	Flight height	Flight time at risk height	Flight time in vW	Bird flight seconds in vW
Buzzard	B22	3	19/08/2022	1	80	20-100	80	30	30
Buzzard	B22	2	24/08/2022	1	30	50-100	30	25	25
Buzzard	**B22**				**Total**				**3785**
Buzzard	NB22/23	2	02/11/2022	1	120	100-180	120	120	120
Buzzard	NB22/23	2	03/01/2023	1	92	20-50	92	92	92
Buzzard	NB22/23	2	03/01/2023	1	600	20-50	600	300	300
Buzzard	NB22/23	2	03/01/2023	1	300	20-50	300	100	100
Buzzard	NB22/23	2	03/01/2023	1	120	20-50	120	50	50
Buzzard	NB22/23	2	03/01/2023	1	452	0-50	377	377	377
Buzzard	NB22/23	2	03/01/2023	1	261	0-50	44	44	44
Buzzard	NB22/23	2	02/02/2023	1	360	100-180	360	270	270
Buzzard	NB22/23	2	02/02/2023	1	5	100-180	5	5	5
Buzzard	NB22/23	1	07/03/2023	2	82	20-50	82	82	164
Buzzard	**NB22/23**				**Total**				**1522**
Buzzard	B23	1	04/04/2023	1	300	100-200	300	300	300
Buzzard	B23	3	04/04/2023	2	162	20-50	162	81	162
Buzzard	B23	1	03/05/2023	1	180	0-50	120	120	120
Buzzard	B23	1	03/05/2023	1	450	0-50	300	135	135
Buzzard	B23	3	01/06/2023	1	9	50-100	9	1	1
Buzzard	B23	3	01/06/2023	1	10	100-200	10	6	6
Buzzard	B23	2	03/07/2023	1	170	0-100	170	128	128
Buzzard	B23	3	03/07/2023	1	300	100-200	300	240	240
Buzzard	B23	3	03/07/2023	1	4	20-50	4	4	4
Buzzard	B23	1	08/09/2023	1	17	20-50	17	8	8
Buzzard	B23	1	08/09/2023	1	7	100-200	7	7	7
Buzzard	B23	2	08/09/2023	2	108	100-200	108	32	65
Buzzard	**B23**								**1176**
Buzzard	**2019-23**				**Total**				**9162**
Hen harrier	B20	1	06/04/2020	1	140	0-50	25	25	25
Hen harrier	**B20**				**Total**				**25**
Hen harrier	NB21/22	1	18/01/2022	1	9	20-50	9	9	9
Hen harrier	**NB21/22**				**Total**				**9**
Hen harrier	**2019-23**				**Total**				**34**
Kestrel	B20	3	08/04/2020	1	86	0-50	43	43	43
Kestrel	B20	3	14/04/2020	1	243	0-100	230	100	100
Kestrel	B20	1	11/05/2020	1	213	0-50	201	150	150
Kestrel	**B20**				**Total**				**293**
Kestrel	NB21/22	1	21/01/2022	1	5	20-50	5	5	5
Kestrel	NB21/22	2	09/02/2022	1	4	20-50	4	1	1
Kestrel	**NB21/22**				**Total**				**6**

Flight activity by Key Ornithological Receptors within the flight risk volume (vW)									
Species	Season	VP	Date	No. birds	Total flight time	Flight height	Flight time at risk height	Flight time in vW	Bird flight seconds in vW
Kestrel	B22	1	20/04/2022	1	180	0-50	120	60	60
Kestrel	B22	1	20/04/2022	1	60	0-50	30	20	20
Kestrel	B22	1	20/04/2022	1	170	20-50	170	120	120
Kestrel	B22	2	20/04/2022	1	85	0-50	40	40	40
Kestrel	B22	1	22/04/2022	1	190	20-50	190	190	190
Kestrel	B22	2	25/05/2022	1	90	0-50	20	20	20
Kestrel	B22	2	25/05/2022	1	45	0-50	30	30	30
Kestrel	B22	2	25/05/2022	1	210	0-50	180	180	180
Kestrel	B22	2	25/05/2022	1	140	0-50	40	40	40
Kestrel	B22	2	11/07/2022	1	120	0-50	20	20	20
Kestrel	B22	2	11/07/2022	2	130	0-50	40	40	80
Kestrel	B22	3	13/07/2022	2	330	20-100	330	100	200
Kestrel	B22	2	13/07/2022	1	90	50-100	90	90	90
Kestrel	B22	2	13/07/2022	1	60	0-50	30	30	30
Kestrel	B22	2	13/07/2022	1	150	0-50	90	90	90
Kestrel	B22	2	19/08/2022	1	220	0-50	180	170	170
Kestrel	B22	2	19/08/2022	1	330	0-50	180	180	180
Kestrel	**B22**				**Total**				**1560**
Kestrel	NB22/23	1	02/11/2022	1	8	50-100	8	2	2
Kestrel	NB22/23	1	05/12/2022	1	38	20-50	38	5	5
Kestrel	NB22/23	3	05/12/2022	1	7	20-50	7	7	7
Kestrel	NB22/23	2	05/12/2022	1	156	20-50	156	156	156
Kestrel	NB22/23	2	05/12/2022	1	239	20-50	239	239	239
Kestrel	NB22/23	3	03/01/2023	1	259	20-50	259	259	259
Kestrel	NB22/23	2	03/01/2023	1	67	20-50	67	67	67
Kestrel	NB22/23	1	03/01/2023	1	246	0-50	216	216	216
Kestrel	NB22/23	1	02/02/2023	1	420	0-50	360	360	360
Kestrel	**NB22/23**				**Total**				**1311**
Kestrel	**2019-23**				**Total**				**3170**
Peregrine	B22	1	20/04/2022	1	40	0-50	10	10	10
Peregrine	B22	2	25/05/2022	2	540	0-100	490	490	980
Peregrine	B22	2	13/07/2022	1	25	20-180	25	8	8
Peregrine	**B22**								**998**
Peregrine	**2019-23**				**Total**				**998**
Sparrowhawk	B20	1	06/04/2020	1	53	0-50	17	5	5
Sparrowhawk	B20				**Total**				**5**
Sparrowhawk	NB20/21	1	02/12/2020	1	20	50-100	20	20	20
Sparrowhawk	NB20/21				**Total**				**20**
Sparrowhawk	NB21/22	1	18/01/2022	1	20	20-50	20	20	20
Sparrowhawk	NB21/22	1	18/01/2022	1	10	20-50	10	10	10

Flight activity by Key Ornithological Receptors within the flight risk volume (vW)									
Species	Season	VP	Date	No. birds	Total flight time	Flight height	Flight time at risk height	Flight time in vW	Bird flight seconds in vW
Sparrowhawk	NB21/22	2	14/03/2022	1	120	50-100	120	40	40
Sparrowhawk	NB21/22				**Total**				**70**
Sparrowhawk	NB22/23	1	05/12/2022	1	58	20-50	58	40	40
Sparrowhawk	NB22/23				**Total**				**40**
Sparrowhawk	B23	1	01/08/2023	1	148	0-50	100	40	40
Sparrowhawk	**B23**								**40**
Sparrowhawk	**2019-23**				**Total**				**175**

ANNEX B – COLLISION PROBABILITY CALCULATIONS

Buzzard

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA

Only enter input parameters in blue | W Band | 18/06/2023

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	4.1	m
Pitch (degrees)	6	
BirdLength	0.54	m
Wingspan	1.2	m
F: Flapping (0) or gliding (+1)	1	
Bird speed	9.45	m/sec
RotorDiam	136	m
RotationPeriod	4.29	sec
Bird aspect ratioo: β	0.45	

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind: collide length	Upwind: p(collision)	Upwind: contribution from radius r	Downwind: collide length	Downwind: p(collision)	Downwind: contribution from radius r
0.025	0.575	3.79	12.03	0.89	0.00111	11.54	0.85	0.00107
0.075	0.575	1.26	4.18	0.31	0.00232	3.68	0.27	0.00205
0.125	0.702	0.76	3.05	0.23	0.00282	2.45	0.18	0.00227
0.175	0.860	0.54	2.68	0.20	0.00348	1.95	0.14	0.00252
0.225	0.994	0.42	2.67	0.20	0.00446	1.82	0.13	0.00304
0.275	0.947	0.34	2.28	0.17	0.00464	1.46	0.11	0.00298
0.325	0.899	0.29	1.99	0.15	0.00480	1.22	0.09	0.00295
0.375	0.851	0.25	1.78	0.13	0.00495	1.05	0.08	0.00292
0.425	0.804	0.22	1.62	0.12	0.00508	0.93	0.07	0.00292
0.475	0.756	0.20	1.48	0.11	0.00520	0.83	0.06	0.00292
0.525	0.708	0.18	1.36	0.10	0.00531	0.76	0.06	0.00295
0.575	0.660	0.16	1.27	0.09	0.00540	0.70	0.05	0.00299
0.625	0.613	0.15	1.18	0.09	0.00547	0.66	0.05	0.00304
0.675	0.565	0.14	1.11	0.08	0.00553	0.62	0.05	0.00311
0.725	0.517	0.13	1.04	0.08	0.00557	0.59	0.04	0.00319
0.775	0.470	0.12	0.98	0.07	0.00560	0.57	0.04	0.00329
0.825	0.422	0.11	0.92	0.07	0.00561	0.56	0.04	0.00340
0.875	0.374	0.11	0.87	0.06	0.00561	0.54	0.04	0.00353
0.925	0.327	0.10	0.82	0.06	0.00559	0.54	0.04	0.00372
0.975	0.279	0.10	0.77	0.06	0.00556	0.55	0.04	0.00396
		Overall p(collision) =		**Upwind**	**9.4%**		**Downwind**	**5.9%**
					Average	**7.6%**		

Hen harrier

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA

Only enter input parameters in blue

W Band 18/06/2023

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	4.1	m
Pitch (degrees)	6	
BirdLength	0.48	m
Wingspan	1.1	m
F: Flapping (0) or gliding (+1)	1	
Bird speed	9.1	m/sec
RotorDiam	136	m
RotationPeriod	4.29	sec
Bird aspect ratioo: β	0.44	

Calculation of alpha and p(collision) as a function of radius

			Upwind:			Downwind:		
r/R radius	c/C chord	α alpha	collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	3.65	11.37	0.87	0.00109	10.88	0.84	0.00105
0.075	0.575	1.22	3.96	0.30	0.00228	3.46	0.27	0.00200
0.125	0.702	0.73	2.90	0.22	0.00279	2.30	0.18	0.00221
0.175	0.860	0.52	2.57	0.20	0.00345	1.83	0.14	0.00246
0.225	0.994	0.41	2.55	0.20	0.00441	1.70	0.13	0.00294
0.275	0.947	0.33	2.17	0.17	0.00458	1.36	0.10	0.00287
0.325	0.899	0.28	1.90	0.15	0.00473	1.13	0.09	0.00281
0.375	0.851	0.24	1.69	0.13	0.00487	0.96	0.07	0.00277
0.425	0.804	0.21	1.53	0.12	0.00499	0.84	0.06	0.00274
0.475	0.756	0.19	1.40	0.11	0.00510	0.75	0.06	0.00273
0.525	0.708	0.17	1.29	0.10	0.00519	0.68	0.05	0.00274
0.575	0.660	0.16	1.19	0.09	0.00526	0.62	0.05	0.00276
0.625	0.613	0.15	1.11	0.09	0.00532	0.58	0.04	0.00280
0.675	0.565	0.14	1.03	0.08	0.00536	0.55	0.04	0.00285
0.725	0.517	0.13	0.97	0.07	0.00539	0.52	0.04	0.00292
0.775	0.470	0.12	0.91	0.07	0.00540	0.50	0.04	0.00300
0.825	0.422	0.11	0.85	0.07	0.00540	0.49	0.04	0.00310
0.875	0.374	0.10	0.80	0.06	0.00538	0.48	0.04	0.00323
0.925	0.327	0.10	0.75	0.06	0.00534	0.49	0.04	0.00347
0.975	0.279	0.09	0.71	0.05	0.00529	0.49	0.04	0.00369
Overall p(collision) =			**Upwind**		**9.2%**	**Downwind**		**5.5%**
				Average		**7.3%**		

Kestrel

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA

Only enter input parameters in blue — W Band 18/06/2023

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	4.1	m
Pitch (degrees)	6	
BirdLength	0.34	m
Wingspan	0.76	m
F: Flapping (0) or gliding (+1)	0	
Bird speed	9.95	m/sec
RotorDiam	136	m
RotationPeriod	4.29	sec
Bird aspect ratioo: β	0.45	

Calculation of alpha and p(collision) as a function of radius

			Upwind:			Downwind:		
r/R radius	c/C chord	α alpha	collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	4.00	12.65	0.89	0.00111	12.16	0.85	0.00107
0.075	0.575	1.33	4.38	0.31	0.00231	3.89	0.27	0.00205
0.125	0.702	0.80	3.19	0.22	0.00281	2.59	0.18	0.00228
0.175	0.860	0.57	2.80	0.20	0.00345	2.07	0.15	0.00254
0.225	0.994	0.44	2.57	0.18	0.00406	1.71	0.12	0.00271
0.275	0.947	0.36	2.15	0.15	0.00415	1.34	0.09	0.00258
0.325	0.899	0.31	1.85	0.13	0.00423	1.08	0.08	0.00247
0.375	0.851	0.27	1.63	0.11	0.00429	0.90	0.06	0.00237
0.425	0.804	0.24	1.45	0.10	0.00434	0.77	0.05	0.00229
0.475	0.756	0.21	1.31	0.09	0.00438	0.66	0.05	0.00222
0.525	0.708	0.19	1.19	0.08	0.00440	0.59	0.04	0.00216
0.575	0.660	0.17	1.09	0.08	0.00441	0.52	0.04	0.00212
0.625	0.613	0.16	1.00	0.07	0.00440	0.48	0.03	0.00209
0.675	0.565	0.15	0.92	0.06	0.00438	0.44	0.03	0.00208
0.725	0.517	0.14	0.85	0.06	0.00434	0.41	0.03	0.00208
0.775	0.470	0.13	0.79	0.06	0.00429	0.39	0.03	0.00210
0.825	0.422	0.12	0.73	0.05	0.00423	0.37	0.03	0.00213
0.875	0.374	0.11	0.67	0.05	0.00415	0.35	0.02	0.00218
0.925	0.327	0.11	0.62	0.04	0.00406	0.34	0.02	0.00224
0.975	0.279	0.10	0.58	0.04	0.00395	0.34	0.02	0.00235
	Overall p(collision) =		**Upwind**		**7.8%**	**Downwind**		**4.4%**
				Average		**6.1%**		

Peregrine

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA

Only enter input parameters in blue — W Band — 18/06/2023

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	4.1	m
Pitch (degrees)	6	
BirdLength	0.42	m
Wingspan	1.02	m
F: Flapping (0) or gliding (+1)	0	
Bird speed	12.1	m/sec
RotorDiam	136	m
RotationPeriod	4.29	sec
Bird aspect ratioo: β	0.41	

Calculation of alpha and p(collision) as a function of radius

			Upwind:			Downwind:		
r/R radius	c/C chord	α alpha	collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	4.86	16.60	0.96	0.00120	16.10	0.93	0.00116
0.075	0.575	1.62	5.70	0.33	0.00247	5.20	0.30	0.00226
0.125	0.702	0.97	4.07	0.24	0.00294	3.47	0.20	0.00251
0.175	0.860	0.69	3.51	0.20	0.00355	2.77	0.16	0.00281
0.225	0.994	0.54	3.17	0.18	0.00412	2.31	0.13	0.00301
0.275	0.947	0.44	2.56	0.15	0.00407	1.75	0.10	0.00278
0.325	0.899	0.37	2.18	0.13	0.00409	1.41	0.08	0.00264
0.375	0.851	0.32	1.91	0.11	0.00414	1.18	0.07	0.00256
0.425	0.804	0.29	1.70	0.10	0.00418	1.01	0.06	0.00249
0.475	0.756	0.26	1.53	0.09	0.00421	0.88	0.05	0.00243
0.525	0.708	0.23	1.39	0.08	0.00422	0.78	0.05	0.00238
0.575	0.660	0.21	1.27	0.07	0.00423	0.71	0.04	0.00235
0.625	0.613	0.19	1.17	0.07	0.00422	0.64	0.04	0.00232
0.675	0.565	0.18	1.08	0.06	0.00420	0.59	0.03	0.00231
0.725	0.517	0.17	1.00	0.06	0.00417	0.55	0.03	0.00231
0.775	0.470	0.16	0.92	0.05	0.00413	0.52	0.03	0.00232
0.825	0.422	0.15	0.85	0.05	0.00407	0.49	0.03	0.00235
0.875	0.374	0.14	0.79	0.05	0.00401	0.47	0.03	0.00238
0.925	0.327	0.13	0.73	0.04	0.00393	0.45	0.03	0.00243
0.975	0.279	0.12	0.68	0.04	0.00384	0.44	0.03	0.00249
Overall p(collision) =			**Upwind**		**7.6%**	**Downwind**		**4.8%**

Average **6.2%**

Sparrowhawk

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA

Only enter input parameters in blue

W Band 20/06/2023

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	4.1	m
Pitch (degrees)	6	
BirdLength	0.35	m
Wingspan	0.7	m
F: Flapping (0) or gliding (+1)	0	
Bird speed	11.3	m/sec
RotorDiam	136	m
RotationPeriod	4.29	sec
Bird aspect ratioo: β	0.50	

Calculation of alpha and p(collision) as a function of radius

			Upwind:			Downwind:		
r/R radius	c/C chord	α alpha	collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	4.54	14.06	0.87	0.00109	13.57	0.84	0.00105
0.075	0.575	1.51	4.85	0.30	0.00225	4.36	0.27	0.00202
0.125	0.702	0.91	3.53	0.22	0.00273	2.93	0.18	0.00227
0.175	0.860	0.65	3.10	0.19	0.00335	2.36	0.15	0.00255
0.225	0.994	0.50	2.82	0.17	0.00393	1.97	0.12	0.00275
0.275	0.947	0.41	2.35	0.15	0.00400	1.54	0.10	0.00262
0.325	0.899	0.35	2.01	0.12	0.00405	1.24	0.08	0.00250
0.375	0.851	0.30	1.77	0.11	0.00410	1.04	0.06	0.00240
0.425	0.804	0.27	1.57	0.10	0.00413	0.88	0.05	0.00232
0.475	0.756	0.24	1.41	0.09	0.00415	0.76	0.05	0.00224
0.525	0.708	0.22	1.28	0.08	0.00415	0.67	0.04	0.00218
0.575	0.660	0.20	1.16	0.07	0.00414	0.60	0.04	0.00213
0.625	0.613	0.18	1.07	0.07	0.00412	0.54	0.03	0.00209
0.675	0.565	0.17	0.98	0.06	0.00409	0.50	0.03	0.00207
0.725	0.517	0.16	0.90	0.06	0.00405	0.46	0.03	0.00206
0.775	0.470	0.15	0.83	0.05	0.00399	0.43	0.03	0.00206
0.825	0.422	0.14	0.77	0.05	0.00392	0.41	0.03	0.00207
0.875	0.374	0.13	0.71	0.04	0.00384	0.39	0.02	0.00210
0.925	0.327	0.12	0.65	0.04	0.00374	0.37	0.02	0.00214
0.975	0.279	0.12	0.60	0.04	0.00363	0.36	0.02	0.00219

Overall p(collision) = **Upwind** **7.3%** **Downwind** **4.4%**

Average **5.9%**

ANNEX C – COLLISION RISK MODELLING ANALYSIS

Buzzard

STAGE 1 (Probability of birds being hit by a turbine blade)

Detail	2019-2023
Number of turbines	12
WFA (m^2)	2024750.342
Rotor diameter, inc. hub (m)	136
Rotor swept area (RSA) (m^2)	14,527.00
Rotor depth (m)	4.27
Bird length (m)	0.54
(Vw) Flight risk volume (m^3)	275,366,046.51
(Vr) Combined vol swept by blades (m^3)	837,626.82
(Vr) as % of (Vw) (%)	0.304187%

STAGE 2 (Birds flying through turbine area)

Detail	2019-2023
VP survey hours	846.00
Bird flight seconds within (Vw)	9162
Average Day length (over period)	11.89
Season days	1,460
Bird speed (m/sec)	9.45
Probability of collision (p) [model]	7.6%
Flight Seconds/survey hour (bird secs)	10.82979
Flight Seconds/season day (bird secs)	128.76617
Flight Seconds/season (bird secs)	187998.60851
n x (Vr/Vw)	571.86672
Bird transit time through turbine (t)	0.50847
No. of transits through rotor swept vol	1124.69104
No. of birds hit by blades/survey period	85.47652
No. of birds hit by blades/year	21.36913

STAGE 3 (Avoidance)

Detail	2019-2023
Avoidance rate (SNH 2018)	98.0%
No. of birds hit by blades/survey period	1.709530386
No. of birds hit by blades/survey year	0.427382596
No of birds hit by blades/35 yrs	14.958

Hen harrier

STAGE 1 (Probability of birds being hit by a turbine blade)

Detail	2019-2023
Number of turbines	12
WFA (m^2)	2024750.342
Rotor diameter, inc. hub (m)	136
Rotor swept area (RSA) (m^2)	14,527.00
Rotor depth (m)	4.27
Bird length (m)	0.48
(Vw) Flight risk volume (m^3)	275,366,046.51
(Vr) Combined vol swept by blades (m^3)	827,167.38
(Vr) as % of (Vw) (%)	0.300388%

STAGE 2 (Birds flying through turbine area)

Detail	2019-2023
VP survey hours	846.00
Bird flight seconds within (Vw)	34
Average Day length (over period)	11.89
Season days	1,460
Bird speed (m/sec)	9.1
Probability of collision (p) [model]	7.3%
Flight Seconds/survey hour (bird secs)	0.04019
Flight Seconds/season day (bird secs)	0.47785
Flight Seconds/season (bird secs)	697.65910
n x (Vr/Vw)	2.09569
Bird transit time through turbine (t)	0.52143
No. of transits through rotor swept vol	4.01912
No. of birds hit by blades/survey period	0.29340
No. of birds hit by blades/year	0.07335

STAGE 3 (Avoidance)

Detail	2019-2023
Avoidance rate (SNH 2018)	99.0%
No. of birds hit by blades/survey period	0.002933961
No. of birds hit by blades/survey year	0.00073349
No of birds hit by blades/35 yrs	0.026

Kestrel

STAGE 1 (Probability of birds being hit by a turbine blade)

Detail	2019-2023
Number of turbines	12
WFA (m^2)	2024750.342
Rotor diameter, inc. hub (m)	136
Rotor swept area (RSA) (m^2)	14,527.00
Rotor depth (m)	4.27
Bird length (m)	0.34
(Vw) Flight risk volume (m^3)	275,366,046.51
(Vr) Combined vol swept by blades (m^3)	802,762.02
(Vr) as % of (Vw) (%)	0.291525%

STAGE 2 (Birds flying through turbine area)

Detail	2019-2023
VP survey hours	846.00
Bird flight seconds within (Vw)	3170
Average Day length (over period)	11.89
Season days	1,460
Bird speed (m/sec)	9.95
Probability of collision (p) [model]	6.1%
Flight Seconds/survey hour (bird secs)	3.74704
Flight Seconds/season day (bird secs)	44.55236
Flight Seconds/season (bird secs)	65046.45154
n x (Vr/Vw)	189.62694
Bird transit time through turbine (t)	0.46281
No. of transits through rotor swept vol	409.72596
No. of birds hit by blades/survey period	24.99328
No. of birds hit by blades/year	6.24832

STAGE 3 (Avoidance)

Detail	2019-2023
Avoidance rate (SNH 2018)	95.0%
No. of birds hit by blades/survey period	1.249664184
No. of birds hit by blades/survey year	0.312416046
No of birds hit by blades/35 yrs	10.935

Peregrine

STAGE 1 (Probability of birds being hit by a turbine blade)

Detail	2019-2023
Number of turbines	12
WFA (m^2)	2024750.342
Rotor diameter, inc. hub (m)	136
Rotor swept area (RSA) (m^2)	14,527.00
Rotor depth (m)	4.27
Bird length (m)	0.35
(Vw) Flight risk volume (m^3)	275,366,046.51
(Vr) Combined vol swept by blades (m^3)	804,505.26
(Vr) as % of (Vw) (%)	0.292158%

STAGE 2 (Birds flying through turbine area)

Detail	2019-2023
VP survey hours	846.00
Bird flight seconds within (Vw)	998
Average Day length (over period)	11.89
Season days	1,460
Bird speed (m/sec)	12.1
Probability of collision (p) [model]	6.2%
Flight Seconds/survey hour (bird secs)	1.17967
Flight Seconds/season day (bird secs)	14.02626
Flight Seconds/season (bird secs)	20478.34657
n x (Vr/Vw)	60.73671
Bird transit time through turbine (t)	0.38719
No. of transits through rotor swept vol	156.86536
No. of birds hit by blades/survey period	9.72565
No. of birds hit by blades/year	2.43141

STAGE 3 (Avoidance)

Detail	2019-2023
Avoidance rate (SNH 2018)	98.0%
No. of birds hit by blades/survey period	0.194513047
No. of birds hit by blades/survey year	0.048628262
No of birds hit by blades/35 yrs	1.702

Sparrowhawk

STAGE 1 (Probability of birds being hit by a turbine blade)

Detail	2019-2023
Number of turbines	12
WFA (m^2)	2024750.342
Rotor diameter, inc. hub (m)	136
Rotor swept area (RSA) (m^2)	14,527.00
Rotor depth (m)	4.27
Bird length (m)	0.35
(Vw) Flight risk volume (m^3)	275,366,046.51
(Vr) Combined vol swept by blades (m^3)	804,505.26
(Vr) as % of (Vw) (%)	0.292158%

STAGE 2 (Birds flying through turbine area)

Detail	2019-2023
VP survey hours	846.00
Bird flight seconds within (Vw)	175
Average Day length (over period)	11.89
Season days	1,460
Bird speed (m/sec)	11.3
Probability of collision (p) [model]	5.9%
Flight Seconds/survey hour (bird secs)	0.20686
Flight Seconds/season day (bird secs)	2.45952
Flight Seconds/season (bird secs)	3590.89243
n x (Vr/Vw)	10.49110
Bird transit time through turbine (t)	0.40841
No. of transits through rotor swept vol	25.68784
No. of birds hit by blades/survey period	1.51558
No. of birds hit by blades/year	0.37890

STAGE 3 (Avoidance)

Detail	2019-2023
Avoidance rate (SNH 2018)	98.0%
No. of birds hit by blades/survey period	0.030311654
No. of birds hit by blades/survey year	0.007577914
No of birds hit by blades/35 yrs	0.265