Appendix 15.8

Collision Risk Model

Coolglass Wind Farm EIAR Volume 3

Coolglass Wind Farm Limited

SLR Project No.: 501.V00727.00006

27 June 2023

COOLGLASS WIND FARM

Avian Collision Risk Assessment

Coolglass Wind Farm Ltd

SLR Ref: 501.V00727.00006
Version No: 2
May 2023

Document Control	
Document Properties	
Organisation	SLR Consulting Ireland
Project Name	Coolglass Wind Farm
Report Title	Avian Collision Risk Assessment
Author(s)	Michael Austin
Draft version/final	Final
Document reference	23.02.23 Coolglass Collision Risk Assessment_v2_Issue01

DATE	**Revision No**	**Prepared by**	**Reviewed by**	**Approved by**	**Status**	**Comments**
28/02/23	1	Michael Austen	Dr Jonathon Dunn		Draft	
02/05/2023	2	Michael Austin	Dr Jonathon Dunn	Richard Arnold	Issue01	Updated with two candidate turbine model info

BASIS OF REPORT

CONTENTS

DOCUMENT REFERENCES

TABLES

APPENDICES

1.0 Introduction

This report presents the results of Collision Risk Modelling (CRM) undertaken for five bird species to inform an assessment of potential ornithological impacts relating to the proposed Coolglass Wind Farm, which has a layout comprising a North Cluster of seven turbines, and a South Cluster of six turbines.

As requested by Coolglass Wind Farm Ltd, modelling was based on the use of two turbine options:

- Siemens Gamesa 155 6.6 MW, each with a rotor diameter of 155m, tip height of 180 m and hub height of 102.5 m.
- Vestas V162-7.2 MW turbines, each with a rotor diameter of 162m, tip height of 180m and hub height of 99 m.

The CRM was undertaken in accordance with current NatureScot (NS) (formerly Scottish Natural Heritage (SNH)) guidance, which is recognised as standard best practice guidance through the UK and Ireland to inform impact assessment for onshore wind farms. Further details regarding the methodology used, including details of assumptions used and any corrections applied, are provided in Section 2. The monitoring results are presented in Section 3 and copies of the modelling calculations for each species modelled are included in Appendices 01-02.

1.1 Primary Target Species

Target species for the surveys were defined by legal and/ or conservation status and vulnerability to impacts caused by wind turbines, as defined in NS Guidance (SNH 2017[1]).

There are no nearby Special Protection Areas (SPAs) which are potentially within the core foraging range of any qualifying features which may occur on the Site (e.g., as defined by SNH 2016[2]). Therefore, bird species of high conservation importance in this case are those which are Annex I species and other species of high conservation importance which are considered to be vulnerable to impacts from wind farm developments. The following species are therefore considered relevant as primary target species:

- Annex I raptor and owl species;
- Qualifying interest species for nearby SPAs; and
- Other raptors, waders or wildfowl red-listed on the latest Birds of Conservation Concern in Ireland (BoCCI) scheme[3].

[1] Scottish Natural Heritage (SNH) (2017). *Recommended Bird Survey Methods to Inform Impact Assessment of Onshore Wind Farms. Version 2*.
[2] Scottish Natural Heritage (SNH) (2016). *Assessing Connectivity with Special Protection Areas (SPAs). Version 3 – June 2016*. Scottish Natural Heritage, Inverness.
[3] Gilbert, G., Stanbury, A. and Lewis, L. (2021). Birds of Conservation Concern in Ireland 2020–2026. Irish Birds 43: 1–22

2.0 Methods

The standard Band CRM (Band *et. al.* 2007[4]) was used to estimate collision risk based on recorded target species activity levels and flight behaviour, proposed turbine numbers and specifications, and the relevant species biometrics and flight characteristics. Modelling collision risk under the Band CRM is a two-stage process. Stage 1 estimates the number of birds that fly through the rotor swept area. Stage 2 predicts the proportion of these birds that have the potential to be hit by a rotor blade. Combining both stages produces an estimate of collision mortality in the absence of any avoidance action/behaviour by birds. Avoidance rates are then applied to generate predicted rates of collision mortality.

2.1 Prediction of Rotor Transits from Vantage Point Survey Data

2.1.1 Survey Data 2017 to 2018

The number of birds that fly through the rotor swept area was estimated using flight data gathered during baseline surveys carried out during September 2017 to March 2018. These data were collected by Fehily Timoney and Company and were provided to SLR in raw format only.

Table 2-1
VP Surveys undertaken at Coolglass, Sept 2017 – Mar 2018

VP Number	WF Cluster	ITM Coordinates (x,y)	Hours of Survey Completed (hrs:mins)
1	North	654394, 690098	51:00
2	North	656489, 687433	43:04
3	North	654863, 687925	40:00
4	South	657247, 685790	32:30
5	South	658446, 683332	30:00
7	South	655853, 683304	36:00

2.1.2 Survey Data 2020 to 2022

The number of birds that fly through the rotor swept area was estimated using flight data gathered during baseline surveys carried out during May 2020 to March 2022, which equates to two breeding seasons and two non-breeding seasons. These data were collected by SLR.

The surveys gathered data from two vantage points (VPs). The total number of hours are as shown in **Table 2-2**.

[4] Band, W., Madders, M. and Whitfield, D.P. (2007) Developing Field and Analytical Methods to Assess Avian Collision Risk at Wind Farms. In: De Lucas, M., Janss, G. and Ferrer, M., Eds., Birds and Wind Power, Quercus Editions, Madrid, 259-275.

Table 2-2
VP Surveys undertaken at Coolglass, Apr 2021 – Aug 2022

VP Number	WF Cluster	ITM Coordinates (x,y)	Hours of Survey Completed (hrs:mins)			
			Apr 2021-Aug 2021	Sep 2021-Mar 2022	Apr 2022-Aug 2022	Total
1	North	654394, 690098	30:00	36:00	42:00	108:00
2	North	656489, 687433	30:00	35:00	42:00	107:00
3	North	654863, 687925	30:00	36:00	42:00	108:00
4	South	657247, 685790	30:00	36:00	42:00	108:00
5	South	658446, 683332	30:00	42:00	00:00	72:00
7	South	655853, 683304	30:00	39:00	36:00	105:00

2.1.3 Viewshed Data

Viewshed data, i.e., the area visible from each VP within each wind farm polygon (WP)[5], are summarised in **Table 2-3** and **Table 2-5**. Separate analyses were undertaken for each turbine model as follows.

North Cluster

Siemens Gamesa 155 Turbine

Using a surface offset of 25.0m, the combined viewshed area (minus overlap) from VP1, VP2 & VP3 (3,948,319m²) represents 77.6% of the survey WP (i.e., turbines buffered by 577.5m) (5,087,989m²). Viewshed data are presented in **Table 2-3**.

Table 2-3
Coolglass VP Viewshed Data - North Cluster (SG155)

VP/ Viewshed Number	Area of visibility (m²)*
VP 1 viewshed	700,356
VP 2 viewshed	2,497,213
VP 3 viewshed	1,870,676
VP 1-3 viewshed combined (minus overlap)	3,948,319

[5] The survey wind farm polygon (WP) includes the area within 500m of the outermost turbine blades.

Vestas 162 Turbine

Using a surface offset of 17.0m, the combined viewshed area (minus overlap) from VP1, VP2 & VP3 (3,660,514m²) represents 71.5% of the survey WP (i.e., turbines buffered by 582m) (5,118,214m²). Viewshed data are presented in **Table 2-4**.

Table 2-4
Coolglass VP Viewshed Data - North Cluster (V162)

VP/ Viewshed Number	Area of visibility (m²)*
VP 1 viewshed	661,483
VP 2 viewshed	2,130,074
VP 3 viewshed	1,644,556
VP 1-3 viewshed combined (minus overlap)	3,660,514

South Cluster

The viewshed coverage of the survey WP from VP5 is very small (c.16ha) and lies completely within the survey WP coverage from VP7. For this reason, surveys from VP5 were discontinued in 2022 once the layout design was known.

Siemens Gamesa 155 Turbine

Using a surface offset of 25.0m, the combined viewshed area (minus overlap) from VP4, VP5 & VP7 (3,261,764m²) represents 89.3% of the survey WP (i.e., turbines buffered by 577.5m) (3,649,139m²). Viewshed data are presented in **Table 2-5**.

Table 2-5
Coolglass VP Viewshed Data - South Cluster (SG155)

VP/ Viewshed Number	Area of visibility (m²)*
VP 4 viewshed	2,141,875
VP 5 viewshed	161,473
VP 7 viewshed	2,551,864
VP 4,5,7 viewshed combined (minus overlap)	3,261,764

Vestas 162 Turbine

Using a surface offset of 17.0m, the combined viewshed area (minus overlap) from VP4, VP5 & VP7 (3,272,030m²) represents 89.1% of the survey WP (i.e., turbines buffered by 582m) (3,673,529m²). Viewshed data are presented in **Table 2-6**.

Table 2-6
Coolglass VP Viewshed Data - South Cluster (V162)

VP/ Viewshed Number	Area of visibility (m^2)*
VP 4 viewshed	2,093,582
VP 5 viewshed	165,069
VP 7 viewshed	2,453,118
VP 4,5,7 viewshed combined (minus overlap)	3,272,030

2.1.4 Flight Selection for CRM

In order to select flights liable to incur a potential risk of collision, i.e., within the areas occupied by proposed turbines, the CRM used only observations collected within the WP – defined by a 500 m buffer around the proposed outermost turbine locations. The size of buffer takes into account rotor blade length and potential spatial errors in flight recording accuracy. It is known that bird detection rates vary between species. To ensure the CRM used robust measures of flight activity, a 2 km distance truncation was used in the viewshed from each VP, i.e., only flights within 2 km of each VP were included (as per NS guidance).

Analysis in MS Excel and GIS identified those flights that were at Potential Collision Height (PCH) and within the WP. Flight times that were used in the CRM were derived from field data for each flight. Time spent at different flight heights was estimated in a database from interval data for flights that entered the WP. Flying time estimated to occur within the survey recording height bands (see following section) was used to determine the period that target species were at risk of collision with the rotors.

2.1.5 Correcting Survey PCH to Actual PCH

September 2017 to March 2018 Surveys

Baseline VP surveys were initiated before the current candidate turbine details were known. The baseline surveys during September 2017 to March 2018 utilised the following height bands:

- 1 = <30m
- 2 = 30-40m
- 3 = 40-50m
- 4 = 50-170m
- 5 = >170m

Siemens Gamesa 155 Turbine

The height bands used to record flight activity do not correspond precisely to PCH for the Siemens Gamesa 155 turbine (25-180m), i.e., height band 1 overlaps with the lower limit of the actual PCH (25-30m of the 0-30m band) and height band 5 overlaps with the upper limit of the actual PCH (170-180m of the >170m band). Assuming flight heights are equally distributed it is likely that a proportion of height band 1 will be below PCHs.

For height band 5 (>170m), it is not possible to make assumptions on the proportion of flights that were above risk height. Therefore, all flights in height band 5 were included in the CRM.

Overall, the proportion of flights included within the CRM for the SG 155 turbine in all height bands was 155/170 (91%).

Vestas 162 Turbine

Similarly, for the Vestas 162 turbine, the actual PCH is 17-180m. It is therefore assumed that a proportion of height band 1 will be below PCHs. All flights in height band 5 were included in the CRM. Overall, the proportion of flights included within the CRM in all height bands was 163/170 (96%).

April 2021 to August 2022 Surveys

On resumption of surveys in 2021, survey height bands were reviewed. Baseline surveys during this period utilised the following height bands:

- 1 = <15m
- 2 = 15-30m
- 3 = 30-150m
- 4 = 150-200m
- 5 = >200m

Siemens Gamesa 155 Turbine

It is assumed that a proportion of flights in height band 1 will be below PCH and a proportion of flights in height band 4 will be above PCH. Height band 5 was above the upper limit of PCH, so any flights in this height band were excluded from the CRM. Overall, the proportion of flights included within the CRM for the SG 155 turbine in all height bands was (180-25)/200 (77.5%).

Vestas 162 Turbine

It is assumed that a proportion of flights in height band 1 will be below PCH and a proportion of flights in height band 4 will be above PCH. Height band 5 was above the upper limit of PCH, so any flights in this height band were excluded from the CRM. Overall, the proportion of flights included within the CRM for the Vestas 162 turbine in all height bands was (180-17)/200 (81.5%).

2.1.6 Seasonal Definitions

CRMs were constructed using data from the relevant breeding and non-breeding season periods, assumed to be April – August (breeding season) and September – March (non-breeding season)[6].

The theoretical time that birds could be active with potential for turbine collisions was assumed to be the period between sunrise and sunset within each survey period using the latitude of the Site[7].

For waders and wildfowl, which could be active nocturnally, an additional 25% of nocturnal hours were added to the daylight hours to give a more accurate representation of the available hours for these species (as per Band *et al.*, 2007).

2.1.7 Undertaking CRM

Collision risk modelling employs an estimated three-dimensional risk volume[8], in keeping with the assumption that flight directions are random in space. For species with non-directional (e.g., random, circling and foraging)

[6] Note that in the 2021 breeding season and 2021/22 non-breeding baseline reports, the breeding season was defined as April – September and non-breeding season as October – March. This difference has no effect on the CRM.
[7] https://www.timeanddate.com [Accessed in September 2022].
[8] Calculated by multiplying the area of the wind farm by the diameter of the rotors.

flights, the occupancy data are derived by multiplying the numbers of a particular species flying through the survey risk area (i.e., the WP) by the total time spent.

The following parameters were entered into a bespoke modelling spreadsheet:-

- The total observation effort within the risk volume (V_w) visible from each VP;
- The occupancy total: the total time spent by a particular species flying within the risk volume (V_w) visible from each VP;
- The size of the risk volume Vw in m^3 visible from each VP (this is area covered by the outermost turbines with the 500m buffer);
- An estimation of average daylight hours within the season of analysis;
- Species-specific bird parameters (**Table 2-7**); and
- Wind farm and turbine parameters (**Table 2-8, Table 2-9, Table 2-10** and **Table 2-11**).

Maps showing VP locations and viewsheds along with the 500 m buffer around the outermost turbine blades are shown in associated baseline bird reports.

The NS CRM spreadsheet[9] calculates the probability of collision for each species. The model then combines this probability of collision with the observed flight activity per unit area (hours per hectare) weighted for observation effort from each VP to produce an estimate of the number of transits through the rotor blades. Mortality estimates are then derived by applying species-specific avoidance rates.

2.1.8 Bird Biometrics and Avoidance Rates

Measurements and flight speeds of the species for which CRM was undertaken were derived from British Trust for Ornithology (BTO)[10], Provan & Whitfield (2007[11]), Bruderer & Boldt (2001[12]) and Alerstram *et al.* (2007[13]). The avoidance rates for these species are taken from NS (2018[14]).

Table 2-7
Bird biometrics and avoidance rates used in CRM

Species name	Bird length (m)	Wingspan (m)	Flight speed (m/s)	Avoidance rate (%)
Common kestrel	0.34	0.8	12.7	95

[9] https://www.nature.scot/wind-farm-impacts-birds-calculating-probability-collision [Accessed in September 2022].
[10] https://www.bto.org/understanding-birds/birdfacts [Accessed in September 2022].
[11] Provan, S. and Whitfield, D.P. (2007) Avian flight speeds and biometrics for use in collision risk modelling. Report to Scottish Natural Heritage.
[12] Bruderer, B. and Bolt, A. (2001) Flight characteristics of birds: 1. Radar measurements of speeds, *Ibis*, **143**. 178 – 204.
[13] Alerstam T, Rosén M, Bäckman J, Ericson PG, Hellgren O. (2007). Flight speeds among bird species: allometric and phylogenetic effects. PLoS Biol.
[14] SNH (2018) Avoidance rates for the onshore SNH wind farm collision risk model. https://www.nature.scot/doc/wind-farm-impacts-birds-use-avoidance-rates-naturescot-wind-farm-collision-risk-model#:~:text=2.%20Recommended%20avoidance%20rates%20%20%20Species%20,%20SNH%20%282013%29%20%207%20more%20rows%20. [Accessed in September 2022].

Species name	Bird length (m)	Wingspan (m)	Flight speed (m/s)	Avoidance rate (%)
Peregrine falcon	0.45	1.1	14.0	98
European golden plover	0.28	0.72	17.5	98
Northern lapwing	0.30	0.84	12.3	98
Common snipe	0.26	0.455	16.0	98

2.1.9 Wind Farm and Turbine Parameters

The wind turbine parameters used in the CRM are detailed in **Table 2-8 Table 2-9, Table 2-10** and **Table 2-11** based on the use of 1) Siemens Gamesa 155 Turbine, and 2) Vestas V162-7.2 MW turbines.

Table 2-8
Wind farm & turbine parameters – North Cluster (SG155)

Parameter	Value
Size of survey wind farm polygon (WP)	508.8 ha
Number of turbines	7
Rotor radius/ diameter	77.5m/ 157.0m
Hub height	102.5m
Max. chord	4.5m
Pitch	6°
Rotation period	5.4s (max 11.1rpm)
Turbine operation time	85%

Table 2-9
Wind farm & turbine parameters – North Cluster (V162)

Parameter	Value
Size of survey wind farm polygon (WP)	511.8 ha
Number of turbines	7
Rotor radius/ diameter	81.0m/ 162.0m
Hub height	99.0m
Max. chord	4.3m
Pitch	6°
Rotation period	4.96s (max 12.1rpm)
Turbine operation time	85%

Table 2-10
Wind farm & turbine parameters – South Cluster (SG155)

Parameter	Value
Size of survey wind farm polygon (WP)	364.9 ha
Number of turbines	6
Rotor radius/ diameter	77.5m/ 157.0m
Hub height	102.5m
Max. chord	4.5m
Pitch	6°
Rotation period	5.4s (max 11.1rpm)
Turbine operation time	85%

Table 2-11
Wind farm & turbine parameters – South Cluster (V162)

Parameter	Value
Size of survey wind farm polygon (WP)	367.4 ha
Number of turbines	6
Rotor radius/ diameter	81.0m/ 162.0m
Hub height	99.0m
Max. chord	4.3m
Pitch	6°
Rotation period	4.96s (max 12.1rpm)
Turbine operation time	85%

2.2 Coolglass Flightline Data

Table 2-12 and **Table 2-19** summarise the primary target species flightline[15] data from VP surveys conducted, presented for each cluster and season. **Table 2-13** to **Table 2-18** (inclusive) and **Table 2-20** to **Table 2-26** (inclusive) present the seasonal primary target species occupancy data within each height band, and the total at-risk occupancy data used in the CRM.

[15] A flight line refers to the line drawn to record avian movement during a VP survey. A single flight line may be used indicate the collective movement of a flock of birds. In Table 2-12 'Individuals' refers to the cumulative number of birds within these flight lines.

2.2.1 North Cluster

Table 2-12
Number of target species flights and individuals observed passing through the Coolglass North Cluster WP during VP surveys (2017/18 and 2021/ 2022)

Species name	Period of analysis	Cumulative number of birds recorded in flight	Flights through WP		Flights through WP at Potential Collision Height (PCH[16])	
			Flights	Individuals	Flights	Individuals
Hen harrier	Non-breeding season 2017/18 (01 Sep-31 Mar)	3	2	2	2	2
Common kestrel	Non-breeding season 2017/18 (01 Sep-31 Mar)	18	11	11	11	11
	Breeding season 2021 (01 Apr-31 Aug)	29	14	14	14	14
	Non-breeding season 2021/22 (01 Sep-31 Mar)	14	4	4	4	4
	Breeding season 2022 (01 Apr-31 Aug)	92	40	43	38	41
Peregrine falcon	Breeding season 2021 (01 Apr-31 Aug)	6	5	5	3	3
	Non-breeding season 2021/22 (01 Sep-31 Mar)	2	2	2	1	1
	Breeding season 2022 (01 Apr-31 Aug)	9	3	3	3	3
European golden plover	Non-breeding season 2017/18 (01 Sep-31 Mar)	2	1	2	1	2
	Non-breeding season 2021/22 (01 Sep-31 Mar)	2,039	1	9	0	0
Northern lapwing	Non-breeding season 2017/18 (01 Sep-31 Mar)	1	1	1	1	1

[16] In this table, PCH is assumed to be within the 0-170m survey height bands (2017/2018 data) or within the 15-200m survey height bands (2021/2022 data)

Species name	Period of analysis	Cumulative number of birds recorded in flight	Flights through WP		Flights through WP at Potential Collision Height (PCH[16])	
			Flights	Individuals	Flights	Individuals
	Breeding season 2022 (01 Apr-31 Aug)	3	0	0	0	0
Common snipe	Non-breeding season 2017/18 (01 Sep-31 Mar)	2	2	2	2	2
	Non-breeding season 2021/22 (01 Sep-31 Mar)	1	0	0	0	0
	Breeding season 2022 (01 Apr-31 Aug)	4	4	4	4	4
Eurasian woodcock	Breeding season 2022 (01 Apr-31 Aug)	1	1	1	1	1

Table 2-13
Details of Common Kestrel Flights Recorded within 500m Buffer of North Cluster Turbines

Period	VP No.	No. of flights	No. of birds	Total flying time (s)	Time in height category (s)					
					<30m	**30-40m**	**40-50m**	**50-170m**	**>170m**	**At risk**
Sep-17 to Mar-18	VP1	0	0	0	0	0	0	0	0	0
	VP2	2	2	152	40	0	18	94	0	112
	VP3	9	9	889	249	18	112	510	0	640
Total		11	11	1041	289	18	130	604	0	752
					<15m	**15-30m**	**30-150m**	**150-200m**	**>200m**	**At risk**
Apr-21 to Aug-21	VP1	1	1	270	15	90	165	0	0	165
	VP2	4	4	480	30	420	30	0	0	30
	VP3	7	7	435	180	180	75	0	0	75
Sep-21 to Mar-22	VP1	1	1	60	15	45	0	0	0	0
	VP2	0	0	0	0	0	0	0	0	0
	VP3	5	5	315	165	150	0	0	0	0
Apr-22 to Aug-22	VP1	12	14	1950	45	1710	195	0	0	195
	VP2	4	4	495	45	435	15	0	0	15
	VP3	24	25	2145	195	1650	300	0	0	300
Total		58	61	6150	690	4680	780	0	0	780

Table 2-14
Details of Peregrine Falcon Flights Recorded within 500m Buffer of North Cluster Turbines

Period	VP No.	No. of flights	No. of birds	Total flying time (s)	Time in height category (s)					
					<15m	**15-30m**	**30-150m**	**150-200m**	**>200m**	**At risk**
Apr-21 to Aug-21	VP1	3	3	630	30	30	45	30	495	75
	VP2	2	2	255	0	30	120	105	0	225
	VP3	0	0	0	0	0	0	0	0	0
Sep-21 to Mar-22	VP1	1	1	150	45	30	75	0	0	75
	VP2	1	1	45	45	0	0	0	0	0
	VP3	0	0	0	0	0	0	0	0	0
	VP1	0	0	0	0	0	0	0	0	0

Period	VP No.	No. of flights	No. of birds	Total flying time (s)	Time in height category (s)					
					<15m	**15-30m**	**30-150m**	**150-200m**	**>200m**	**At risk**
Apr-22 to Aug-22	VP2	1	1	315	0	180	135	0	0	135
	VP3	2	2	105	0	105	0	0	0	0
Total		10	10	1500	120	375	375	135	495	510

Table 2-15
Details of European Golden Plover Flights Recorded within 500m Buffer of North Cluster Turbines

Period	VP No.	No. of flights	No. of birds	Total flying time (s)	Time in height category (s)					
					<30m	**30-40m**	**40-50m**	**50-170m**	**>170m**	**At risk**
Sep-17 to Mar-18	VP1	0	0	0	0	0	0	0	0	0
	VP2	0	0	0	0	0	0	0	0	0
	VP3	1	2	84	44	20	20	0	0	40
Total		1	2	84	44	20	20	0	0	40
					<15m	**15-30m**	**30-150m**	**150-200m**	**>200m**	**At risk**
Sep-21 to Mar-22	VP1	0	0	0	0	0	0	0	0	0
	VP2	0	0	0	0	0	0	0	0	0
	VP3	1	9	405	405	0	0	0	0	0
Total		1	9	405	405	0	0	0	0	0

Table 2-16
Details of Northern Lapwing Flights Recorded within 500m Buffer of North Cluster Turbines

Period	VP No.	No. of flights	No. of birds	Total flying time (s)	Time in height category (s)					
					<30m	**30-40m**	**40-50m**	**50-170m**	**>170m**	**At risk**
Sep-17 to Mar-18	VP1	0	0	0	0	0	0	0	0	0
	VP2	0	0	0	0	0	0	0	0	0
	VP3	1	1	93	0	0	0	93	0	93
Total		1	1	93	0	0	0	93	0	93

Table 2-17
Details of Common Snipe Flights Recorded within 500m Buffer of North Cluster Turbines

Period	VP No.	No. of flights	No. of birds	Total flying time (s)	Time in height category (s)					
					<30m	**30-40m**	**40-50m**	**50-170m**	**>170m**	**At risk**
Sep-17 to Mar-18	VP1	0	0	0	0	0	0	0	0	0
	VP2	0	0	0	0	0	0	0	0	0
	VP3	3	3	31	7	1	23	0	0	0
Total		3	3	31	7	1	23	0	0	0
					<15m	**15-30m**	**30-150m**	**150-200m**	**>200m**	**At risk**
Sep-21 to Mar-22	VP1	0	0	0	0	0	0	0	0	0
	VP2	1	1	45	30	15	0	0	0	0
	VP3	0	0	0	0	0	0	0	0	0
Apr-22 to Aug-22	VP1	2	2	6240	630	5610	0	0	0	0
	VP2	1	1	1575	975	600	0	0	0	0
	VP3	0	0	0	0	0	0	0	0	0
Total		4	4	7860	1635	6225	0	0	0	0

Table 2-18
Details of Woodcock Flights Recorded within 500m Buffer of North Cluster Turbines

Period	VP No.	No. of flights	No. of birds	Total flying time (s)	Time in height category (s)					
					<15m	15-30m	30-150m	150-200m	>200m	At risk
Apr-22 to Aug-22	VP1	0	0	0	0	0	0	0	0	0
	VP2	0	0	0	0	0	0	0	0	0
	VP3	1	1	45	0	45	0	0	0	0
Total		1	1	45	0	45	0	0	0	0

2.2.2 South Cluster

Table 2-19
Number of target species flights and individuals observed passing through the Coolglass South Cluster WP during VP surveys (2017/18 and 2021/ 2022)

Species name	Period of analysis	Total number of birds recorded in flight	Flights through WP		Flights through WP at Potential Collision Height (PCH)	
			Flights	Individuals	Flights	Individuals
Common kestrel	Non-breeding season 2017/18 (01 Sep-31 Mar)	61	10	10	10	10
	Breeding season 2021 (01 Apr-31 Aug)	29	18	19	15	16
	Non-breeding season 2021/22 (01 Sep-31 Mar)	27	12	12	1	1
	Breeding season 2022 (01 Apr-31 Aug)	10	3	3	3	3
Peregrine falcon	Non-breeding season 2017/18 (01 Sep-31 Mar)	2	1	1	1	1
	Breeding season 2021 (01 Apr-31 Aug)	4	1	1	1	1
	Non-breeding season 2021/22 (01 Sep-31 Mar)	3	2	2	2	2
	Breeding season 2022 (01 Apr-31 Aug)	0	0	0	0	0

Species name	Period of analysis	Total number of birds recorded in flight	Flights through WP		Flights through WP at Potential Collision Height (PCH)	
			Flights	Individuals	Flights	Individuals
European golden plover	Non-breeding season 2017/18 (01 Sep-31 Mar)	39	2	7	2	7
	Non-breeding season 2021/22 (01 Sep-31 Mar)	330	2	39	2	39
Northern lapwing	Non-breeding season 2021/22 (01 Sep-31 Mar)	10	1	10	1	10
Common snipe	Breeding season 2021 (01 Apr-31 Aug)	2	1	2	1	2
	Non-breeding season 2021/22 (01 Sep-31 Mar)	13	5	7	3	4
Woodcock	Breeding season 2021 (01 Apr-31 Aug)	1	1	1	0	0

Table 2-20
Details of Common Kestrel Flights Recorded within 500m Buffer of South Cluster Turbines

Period	VP No.	No. of flights	No. of birds	Total flying time (s)	Time in height category (s)					
					<30m	**30-40m**	**40-50m**	**50-170m**	**>170m**	**At risk**
Sep-17 to Mar-18	VP4	0	0	0	0	0	0	0	0	0
	VP5	0	0	0	0	0	0	0	0	0
	VP7	10	10	1322	800	130	149	88	155	522
Total		10	10	1322	800	130	149	88	155	522
					<15m	**15-30m**	**30-150m**	**150-200m**	**>200m**	**At risk**
Apr-21 to Aug-21	VP4	4	5	255	0	255	0	0	0	0
	VP5	0	0	0	0	0	0	0	0	0
	VP7	14	14	1230	930	300	0	0	0	0
Sep-21 to Mar-22	VP4	1	1	60	60	0	0	0	0	0
	VP5	0	0	0	0	0	0	0	0	0
	VP7	11	11	1170	555	585	30	0	0	30
Apr-22 to Aug-22	VP4	3	3	240	0	45	195	0	0	195
	VP5	0	0	0	0	0	0	0	0	0
	VP7	0	0	0	0	0	0	0	0	0
Total		33	34	2955	1545	1185	225	0	0	225

Table 2-21
Details of Peregrine Falcon Flights Recorded within 500m Buffer of South Cluster Turbines

Period	VP No.	No. of flights	No. of birds	Total flying time (s)	Time in height category (s)					
					<30m	**30-40m**	**40-50m**	**50-170m**	**>170m**	**At risk**
Sep-17 to Mar-18	VP4	0	0	0	0	0	0	0	0	0
	VP5	0	0	0	0	0	0	0	0	0
	VP7	1	1	106	45	22	28	11	0	61
Total		1	1	106	45	22	28	11	0	61
					<15m	**15-30m**	**30-150m**	**150-200m**	**>200m**	**At risk**
Apr-21 to Aug-21	VP4	0	0	0	0	0	0	0	0	0
	VP5	0	0	0	0	0	0	0	0	0
	VP7	1	1	165	0	30	135	0	0	135
Sep-21 to Mar-22	VP4	1	1	30	0	30	0	0	0	0
	VP5	0	0	0	0	0	0	0	0	0
	VP7	1	1	90	0	0	90	0	0	90
Total		3	3	285	0	60	225	0	0	225

Table 2-22
Details of European Golden plover Flights Recorded within 500m Buffer of South Cluster Turbines

Period	VP No.	No. of flights	No. of birds	Total flying time (s)	Time in height category (s)					
					<30m	**30-40m**	**40-50m**	**50-170m**	**>170m**	**At risk**
Sep-17 to Mar-18	VP4	0	0	0	0	0	0	0	0	0
	VP5	0	0	0	0	0	0	0	0	0
	VP7	2	7	141	105	36	0	0	0	36
Total		2	7	141	105	36	0	0	0	36
					<15m	**15-30m**	**30-150m**	**150-200m**	**>200m**	**At risk**
Sep-21 to Mar-22	VP4	1	23	1035	0	1035	0	0	0	0
	VP5	1	16	2400	0	0	2400	0	0	2400
	VP7	0	0	0	0	0	0	0	0	0
Total		2	39	3435	0	1035	2400	0	0	2400

Table 2-23
Details of Northern Lapwing Flights Recorded within 500m Buffer of South Cluster Turbines

Period	VP No.	No. of flights	No. of birds	Total flying time (s)	Time in height category (s)					
					<15m	**15-30m**	**30-150m**	**150-200m**	**>200m**	**At risk**
Sep-21 to Mar-22	VP4	0	0	0	0	0	0	0	0	0
	VP5	0	0	0	0	0	0	0	0	0
	VP7	1	10	2250	0	300	1950	0	0	1950
Total		1	10	2250	0	300	1950	0	0	1950

Table 2-24
Details of Common Snipe Flights Recorded within 500m Buffer of South Cluster Turbines

Period	VP No.	No. of flights	No. of birds	Total flying time (s)	Time in height category (s)					
					<15m	**15-30m**	**30-150m**	**150-200m**	**>200m**	**At risk**
Apr-21 to Aug-21	VP4	0	0	0	0	0	0	0	0	0
	VP5	0	0	0	0	0	0	0	0	0
	VP7	1	2	30	30	0	0	0	0	0
Sep-21 to Mar-22	VP4	1	1	15	15	0	0	0	0	0
	VP5	0	0	0	0	0	0	0	0	0
	VP7	4	6	255	150	105	0	0	0	0
Total		6	9	300	195	105	0	0	0	0

Table 2-25
Details of Woodcock Flights Recorded within 500m Buffer of South Cluster Turbines

Period	VP No.	No. of flights	No. of birds	Total flying time (s)	Time in height category (s)					
					<15m	**15-30m**	**30-150m**	**150-200m**	**>200m**	**At risk**
Apr-21 to Aug-21	VP4	0	0	0	0	0	0	0	0	0
	VP5	0	0	0	0	0	0	0	0	0
	VP7	1	1	75	75	0	0	0	0	0
Total		1	1	75	75	0	0	0	0	0

3.0 Collision Risk Modelling Results

Table 3-1 (Siemens Gamesa 155 Turbine Model) and **Table 3-2** (Vestas V162-7.2 MW Turbine Model) summarise the predicted collision rates for the five species under consideration. Copies of the modelling calculations for each species are included in Appendices 01-02.

Table 3-1
Summary of CRM Output (SG155)

Species name	Wind farm cluster	Period of analysis	Modelled collisions per Season	Years per collision
Common kestrel	North	Breeding season 2021+2022	0.6094	1.64
		Non-breeding season 2017/18	0.2104	4.75
		Non-breeding season 2021/22	0.0406	24.65
		Annual	0.6791	1.47
	South	Breeding season 2021+2022	0.0879	11.38
		Non-breeding season 2017/18	0.3001	3.33
		Non-breeding season 2021/22	0.1076	9.29
		Annual	0.2755	3.63
	North + South	**Annual**	**0.9546**	**1.05**
Peregrine falcon	North	Breeding season 2021+2022	0.0423	23.63
		Non-breeding season 2017/18	0	-
		Non-breeding season 2021/22	0.0102	97.65
		Annual	0.0433	23.08
	South	Breeding season 2021+2022	0.0086	116.95
		Non-breeding season 2017/18	0.0113	88.66
		Non-breeding season 2021/22	0.0098	101.60

Species name	Wind farm cluster	Period of analysis	Modelled collisions per Season	Years per collision
		Annual	0.0185	54.10
	North + South	**Annual**	**0.0618**	**16.2**
European golden plover	North	Breeding season 2021+2022	0	-
		Non-breeding season 2017/18	0.0119	84.15
		Non-breeding season 2021/22	0	-
		Annual	0.0056	178.23
	South	Breeding season 2021+2022	0	-
		Non-breeding season 2017/18	0.0224	44.64
		Non-breeding season 2021/22	0.4207	2.38
		Annual	0.2306	4.34
	North + South	**Annual**	**0.2362**	**4.23**
Northern lapwing	North	Breeding season 2021+2022	0	-
		Non-breeding season 2017/18	0.0099	100.82
		Non-breeding season 2021/22	0	-
		Annual	0.0047	213.52
	South	Breeding season 2021+2022	0	-
		Non-breeding season 2017/18	0	-
		Non-breeding season 2021/22	0.2077	4.81
		Annual	0.1094	9.14
	North + South	**Annual**	**0.1141**	**8.76**
Common snipe	North	Breeding season 2021+2022	0.4324	2.31

Species name	Wind farm cluster	Period of analysis	Modelled collisions per Season	Years per collision
		Non-breeding season 2017/18	0.0046	215.16
		Non-breeding season 2021/22	0.0022	445.88
		Annual	0.4291	2.33
	South	Breeding season 2021+2022	0	-
		Non-breeding season 2017/18	0	-
		Non-breeding season 2021/22	0.0083	120.95
		Annual	0.0048	209.84
	North + South	**Annual**	**0.4339**	**2.30**

Table 3-2
Summary of CRM Output (V162)

Species name	Wind farm cluster	Period of analysis	Modelled collisions per Season	Years per collision
Common kestrel	North	Breeding season 2021+2022	0.7349	1.36
		Non-breeding season 2017/18	0.1829	5.47
		Non-breeding season 2021/22	0.489	20.45
		Annual	0.7820	1.28
	South	Breeding season 2021+2022	0.957	10.45
		Non-breeding season 2017/18	0.3266	3.06
		Non-breeding season 2021/22	0.1170	8.54
		Annual	0.2998	3.34
	North + South	**Annual**	**0.9244**	**0.92**

Species name	Wind farm cluster	Period of analysis	Modelled collisions per Season	Years per collision
Peregrine falcon	North	Breeding season 2021+2022	0.0513	19.47
		Non-breeding season 2017/18	0	-
		Non-breeding season 2021/22	0.0124	80.51
		Annual	0.0525	19.03
	South	Breeding season 2021+2022	0.0094	106.80
		Non-breeding season 2017/18	0.0124	80.96
		Non-breeding season 2021/22	0.0108	92.83
		Annual	0.0202	49.41
	North + South	**Annual**	**0.0727**	**13.76**
European golden plover	North	Breeding season 2021+2022	0	-
		Non-breeding season 2017/18	0.140	71.58
		Non-breeding season 2021/22	0	-
		Annual	0.066	151.41
	South	Breeding season 2021+2022	0	-
		Non-breeding season 2017/18	0.238	41.99
		Non-breeding season 2021/22	0.4469	2.24
		Annual	0.2451	4.08
	North + South	**Annual**	**0.3111**	**3.21**
Northern lapwing	North	Breeding season 2021+2022	0	-
		Non-breeding season 2017/18	0.118	84.45

Species name	Wind farm cluster	Period of analysis	Modelled collisions per Season	Years per collision
		Non-breeding season 2021/22	0	-
		Annual	0.0056	178.63
	South	Breeding season 2021+2022	0	-
		Non-breeding season 2017/18	0	-
		Non-breeding season 2021/22	0.2241	4.46
		Annual	0.1181	8.47
	North + South	**Annual**	**0.1237**	**8.08**
Common snipe	North	Breeding season 2021+2022	0.3327	3.01
		Non-breeding season 2017/18	0.0034	290.33
		Non-breeding season 2021/22	0.0017	578.42
		Annual	0.3297	3.03
	South	Breeding season 2021+2022	0	-
		Non-breeding season 2017/18	0	-
		Non-breeding season 2021/22	0.0088	113.33
		Annual	0.0051	196.56
	North + South	**Annual**	**0.3348**	**2.99**

3.1 Species Summary

The annual mortality rates for the north and south clusters combined for each species modelled are summarised in as follows:

Table 3-3
Summary of CRM Output (Annual Rates)

Species name	Wind farm cluster	Turbine Model	Annual collisions	Years per collision
Common kestrel	North	SG155	0.6791	1.47
	North	V162	0.7820	1.28
	South	SG155	0.2755	3.63
	South	V162	0.2998	3.34
	North + South	**SG155**	**0.9546**	**1.05**
	North + South	**V162**	**0.9244**	**0.92**
Peregrine falcon	North	SG155	0.0433	23.08
	North	V162	0.0525	19.03
	South	SG155	0.0185	54.10
	South	V162	0.0202	49.41
	North + South	**SG155**	**0.0618**	**16.2**
	North + South	**V162**	**0.0727**	**13.76**
European golden plover	North	SG155	0.0056	178.23
	North	V162	0.066	151.41
	South	SG155	0.2306	4.34
	South	V162	0.2451	4.08
	North + South	**SG155**	**0.2362**	**4.23**
	North + South	**V162**	**0.3111**	**3.21**
Northern lapwing	North	SG155	0.0047	213.52
	North	V162	0.0056	178.63
	South	SG155	0.1094	9.14
	South	V162	0.1181	8.47
	North + South	**SG155**	**0.1141**	**8.76**

Species name	Wind farm cluster	Turbine Model	Annual collisions	Years per collision
	North + South	**V162**	**0.1237**	**8.08**
Common snipe	North	SG155	0.4291	2.33
	North	V162	0.3297	3.03
	South	SG155	0.0048	209.84
	South	V162	0.0051	196.56
	North + South	**SG155**	**0.4339**	**2.30**
	North + South	**V162**	**0.3348**	**2.99**

APPENDIX 01

CRM Probability Calculations

Siemens Gamesa 155

Common Kestrel

K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3					Upwind:			Downwind:		
MaxChord	4.5	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.34	m	0.025	0.575	5.63	17.64	0.77	0.00096	17.10	0.75	0.00093
Wingspan	0.8	m	0.075	0.575	1.88	6.06	0.27	0.00199	5.52	0.24	0.00181
F: Flapping (0) or gliding (1	1		0.125	0.702	1.13	4.44	0.19	0.00243	3.78	0.17	0.00207
			0.175	0.860	0.80	3.91	0.17	0.00299	3.10	0.14	0.00238
Bird speed	12.7	m/sec	0.225	0.994	0.63	3.57	0.16	0.00352	2.64	0.12	0.00260
RotorDiam	155	m	0.275	0.947	0.51	2.88	0.13	0.00346	1.99	0.09	0.00239
RotationPeriod	5.40	sec	0.325	0.899	0.43	2.39	0.10	0.00339	1.54	0.07	0.00219
			0.375	0.851	0.38	2.17	0.09	0.00356	1.37	0.06	0.00225
			0.425	0.804	0.33	1.91	0.08	0.00355	1.15	0.05	0.00214
			0.475	0.756	0.30	1.70	0.07	0.00353	0.99	0.04	0.00205
Bird aspect ratioo: β	0.43		0.525	0.708	0.27	1.52	0.07	0.00350	0.86	0.04	0.00197
			0.575	0.660	0.24	1.37	0.06	0.00346	0.75	0.03	0.00189
			0.625	0.613	0.23	1.25	0.05	0.00341	0.67	0.03	0.00183
			0.675	0.565	0.21	1.13	0.05	0.00335	0.60	0.03	0.00178
			0.725	0.517	0.19	1.03	0.05	0.00328	0.55	0.02	0.00173
			0.775	0.470	0.18	0.94	0.04	0.00320	0.50	0.02	0.00170
			0.825	0.422	0.17	0.86	0.04	0.00311	0.46	0.02	0.00167
			0.875	0.374	0.16	0.79	0.03	0.00301	0.43	0.02	0.00166
			0.925	0.327	0.15	0.72	0.03	0.00290	0.41	0.02	0.00165
			0.975	0.279	0.14	0.65	0.03	0.00278	0.39	0.02	0.00166
				Overall p(collision) =			**Upwind**	**6.1%**		**Downwind**	**3.8%**
								Average	**5.0%**		

Peregrine Falcon

K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3					Upwind:			Downwind:		
MaxChord	4.5	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.45	m	0.025	0.575	6.21	20.60	0.82	0.00102	20.06	0.80	0.00099
Wingspan	1.1	m	0.075	0.575	2.07	7.05	0.28	0.00210	6.51	0.26	0.00194
F: Flapping (0) or gliding (1	1		0.125	0.702	1.24	5.10	0.20	0.00253	4.44	0.18	0.00220
			0.175	0.860	0.89	4.44	0.18	0.00308	3.63	0.14	0.00252
Bird speed	14	m/sec	0.225	0.994	0.69	4.02	0.16	0.00359	3.09	0.12	0.00276
RotorDiam	155	m	0.275	0.947	0.56	3.23	0.13	0.00353	2.34	0.09	0.00256
RotationPeriod	5.40	sec	0.325	0.899	0.48	2.68	0.11	0.00346	1.83	0.07	0.00236
			0.375	0.851	0.41	2.27	0.09	0.00337	1.47	0.06	0.00218
			0.425	0.804	0.37	2.14	0.08	0.00361	1.39	0.05	0.00234
			0.475	0.756	0.33	1.91	0.08	0.00360	1.20	0.05	0.00226
Bird aspect ratioo: β	0.41		0.525	0.708	0.30	1.72	0.07	0.00358	1.05	0.04	0.00220
			0.575	0.660	0.27	1.56	0.06	0.00356	0.94	0.04	0.00214
			0.625	0.613	0.25	1.42	0.06	0.00352	0.84	0.03	0.00209
			0.675	0.565	0.23	1.30	0.05	0.00348	0.77	0.03	0.00205
			0.725	0.517	0.21	1.19	0.05	0.00342	0.70	0.03	0.00202
			0.775	0.470	0.20	1.09	0.04	0.00336	0.65	0.03	0.00200
			0.825	0.422	0.19	1.00	0.04	0.00329	0.61	0.02	0.00199
			0.875	0.374	0.18	0.92	0.04	0.00321	0.57	0.02	0.00198
			0.925	0.327	0.17	0.85	0.03	0.00312	0.54	0.02	0.00199
			0.975	0.279	0.16	0.78	0.03	0.00302	0.52	0.02	0.00200
				Overall p(collision) =			**Upwind**	**6.3%**		**Downwind**	**4.3%**
								Average	**5.3%**		

European Golden Plover

K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3					Upwind:			Downwind:		
MaxChord	4.5	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.28	m	0.025	0.575	7.98	26.41	0.82	0.00102	25.87	0.80	0.00100
Wingspan	0.7	m	0.075	0.575	2.66	8.98	0.28	0.00208	8.44	0.26	0.00195
F: Flapping (0) or gliding (1	0		0.125	0.702	1.60	6.46	0.20	0.00249	5.80	0.18	0.00224
			0.175	0.860	1.14	5.59	0.17	0.00302	4.78	0.15	0.00258
Bird speed	18	m/sec	0.225	0.994	0.89	5.04	0.16	0.00350	4.10	0.13	0.00285
RotorDiam	155	m	0.275	0.947	0.73	4.03	0.12	0.00342	3.14	0.10	0.00266
RotationPeriod	5.40	sec	0.325	0.899	0.61	3.32	0.10	0.00333	2.48	0.08	0.00249
			0.375	0.851	0.53	2.80	0.09	0.00324	2.00	0.06	0.00231
			0.425	0.804	0.47	2.40	0.07	0.00314	1.64	0.05	0.00215
			0.475	0.756	0.42	2.07	0.06	0.00304	1.36	0.04	0.00199
Bird aspect ratioo: β	0.40		0.525	0.708	0.38	1.82	0.06	0.00295	1.15	0.04	0.00187
			0.575	0.660	0.35	1.62	0.05	0.00287	1.00	0.03	0.00177
			0.625	0.613	0.32	1.44	0.04	0.00279	0.87	0.03	0.00167
			0.675	0.565	0.30	1.29	0.04	0.00270	0.76	0.02	0.00159
			0.725	0.517	0.28	1.16	0.04	0.00260	0.67	0.02	0.00151
			0.775	0.470	0.26	1.04	0.03	0.00249	0.60	0.02	0.00144
			0.825	0.422	0.24	0.94	0.03	0.00238	0.54	0.02	0.00137
			0.875	0.374	0.23	0.84	0.03	0.00226	0.49	0.02	0.00131
			0.925	0.327	0.22	0.75	0.02	0.00214	0.44	0.01	0.00126
			0.975	0.279	0.20	0.67	0.02	0.00201	0.40	0.01	0.00122
				Overall p(collision) =			**Upwind**	**5.3%**		**Downwind**	**3.7%**
								Average	**4.5%**		

Northern Lapwing

K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3					Upwind:			Downwind:		
MaxChord	4.5	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.3	m	0.025	0.575	5.46	18.89	0.85	0.00107	18.35	0.83	0.00104
Wingspan	0.84	m	0.075	0.575	1.82	6.48	0.29	0.00219	5.94	0.27	0.00201
F: Flapping (0) or gliding (1	0		0.125	0.702	1.09	4.67	0.21	0.00264	4.01	0.18	0.00227
			0.175	0.860	0.78	4.06	0.18	0.00321	3.25	0.15	0.00257
Bird speed	12.3	m/sec	0.225	0.994	0.61	3.67	0.17	0.00373	2.74	0.12	0.00278
RotorDiam	155	m	0.275	0.947	0.50	2.96	0.13	0.00368	2.07	0.09	0.00257
RotationPeriod	5.40	sec	0.325	0.899	0.42	2.46	0.11	0.00362	1.62	0.07	0.00238
			0.375	0.851	0.36	2.09	0.09	0.00354	1.29	0.06	0.00219
			0.425	0.804	0.32	1.83	0.08	0.00352	1.08	0.05	0.00207
			0.475	0.756	0.29	1.63	0.07	0.00349	0.92	0.04	0.00196
Bird aspect ratioo: β	0.36		0.525	0.708	0.26	1.46	0.07	0.00345	0.79	0.04	0.00187
			0.575	0.660	0.24	1.31	0.06	0.00341	0.69	0.03	0.00179
			0.625	0.613	0.22	1.19	0.05	0.00335	0.61	0.03	0.00172
			0.675	0.565	0.20	1.08	0.05	0.00328	0.55	0.02	0.00166
			0.725	0.517	0.19	0.98	0.04	0.00321	0.49	0.02	0.00161
			0.775	0.470	0.18	0.89	0.04	0.00312	0.45	0.02	0.00157
			0.825	0.422	0.17	0.81	0.04	0.00302	0.41	0.02	0.00154
			0.875	0.374	0.16	0.74	0.03	0.00291	0.39	0.02	0.00152
			0.925	0.327	0.15	0.67	0.03	0.00280	0.36	0.02	0.00151
			0.975	0.279	0.14	0.61	0.03	0.00267	0.34	0.02	0.00151
				Overall p(collision) =			**Upwind**	**6.2%**		**Downwind**	**3.8%**
								Average	**5.0%**		

Common Snipe

K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3					Upwind:			Downwind:		
MaxChord	4.5	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.26	m	0.025	0.575	7.10	21.76	0.76	0.00094	21.22	0.74	0.00092
Wingspan	0.455	m	0.075	0.575	2.37	7.43	0.26	0.00194	6.89	0.24	0.00180
F: Flapping (0) or gliding (1	0		0.125	0.702	1.42	5.43	0.19	0.00236	4.77	0.17	0.00207
			0.175	0.860	1.01	4.77	0.17	0.00290	3.96	0.14	0.00241
Bird speed	16	m/sec	0.225	0.994	0.79	4.34	0.15	0.00339	3.40	0.12	0.00266
RotorDiam	155	m	0.275	0.947	0.65	3.47	0.12	0.00332	2.58	0.09	0.00247
RotationPeriod	5.40	sec	0.325	0.899	0.55	2.88	0.10	0.00325	2.03	0.07	0.00229
			0.375	0.851	0.47	2.46	0.09	0.00321	1.66	0.06	0.00216
			0.425	0.804	0.42	2.14	0.07	0.00316	1.38	0.05	0.00204
			0.475	0.756	0.37	1.88	0.07	0.00310	1.17	0.04	0.00193
Bird aspect ratioo: β	0.57		0.525	0.708	0.34	1.66	0.06	0.00303	1.00	0.03	0.00182
			0.575	0.660	0.31	1.48	0.05	0.00296	0.86	0.03	0.00172
			0.625	0.613	0.28	1.33	0.05	0.00288	0.75	0.03	0.00163
			0.675	0.565	0.26	1.19	0.04	0.00279	0.66	0.02	0.00154
			0.725	0.517	0.24	1.07	0.04	0.00269	0.58	0.02	0.00147
			0.775	0.470	0.23	0.96	0.03	0.00259	0.52	0.02	0.00140
			0.825	0.422	0.22	0.86	0.03	0.00248	0.47	0.02	0.00134
			0.875	0.374	0.20	0.78	0.03	0.00236	0.42	0.01	0.00129
			0.925	0.327	0.19	0.69	0.02	0.00223	0.39	0.01	0.00124
			0.975	0.279	0.18	0.62	0.02	0.00209	0.36	0.01	0.00121
				Overall p(collision) =			**Upwind**	**5.4%**		**Downwind**	**3.5%**
								Average	**4.5%**		

APPENDIX 02

CRM Probability Calculations

Vestas 162

Common Kestrel

K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3					Upwind:			Downwind:		
MaxChord	4.3	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.34	m	0.025	0.575	4.95	14.95	0.71	0.00089	14.44	0.69	0.00086
Wingspan	0.8	m	0.075	0.575	1.65	5.16	0.25	0.00184	4.64	0.22	0.00166
F: Flapping (0) or gliding (-	1		0.125	0.702	0.99	3.79	0.18	0.00226	3.16	0.15	0.00188
			0.175	0.860	0.71	3.35	0.16	0.00279	2.58	0.12	0.00215
Bird speed	12.7	m/sec	0.225	0.994	0.55	3.07	0.15	0.00329	2.17	0.10	0.00233
RotorDiam	162	m	0.275	0.947	0.45	2.48	0.12	0.00324	1.63	0.08	0.00213
RotationPeriod	4.96	sec	0.325	0.899	0.38	2.21	0.11	0.00342	1.40	0.07	0.00217
			0.375	0.851	0.33	1.92	0.09	0.00344	1.16	0.06	0.00207
			0.425	0.804	0.29	1.70	0.08	0.00344	0.98	0.05	0.00198
			0.475	0.756	0.26	1.52	0.07	0.00344	0.84	0.04	0.00191
Bird aspect ratioo: β	0.43		0.525	0.708	0.24	1.37	0.07	0.00343	0.74	0.04	0.00184
			0.575	0.660	0.22	1.24	0.06	0.00341	0.65	0.03	0.00178
			0.625	0.613	0.20	1.13	0.05	0.00338	0.58	0.03	0.00174
			0.675	0.565	0.18	1.04	0.05	0.00333	0.53	0.03	0.00170
			0.725	0.517	0.17	0.95	0.05	0.00328	0.49	0.02	0.00168
			0.775	0.470	0.16	0.87	0.04	0.00322	0.45	0.02	0.00166
			0.825	0.422	0.15	0.80	0.04	0.00314	0.42	0.02	0.00165
			0.875	0.374	0.14	0.73	0.03	0.00306	0.40	0.02	0.00166
			0.925	0.327	0.13	0.67	0.03	0.00297	0.38	0.02	0.00167
			0.975	0.279	0.13	0.62	0.03	0.00286	0.37	0.02	0.00170
				Overall p(collision) =			**Upwind**	**6.0%**		**Downwind**	**3.6%**
								Average	**4.8%**		

Peregrine Falcon

K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3					Upwind:			Downwind:		
MaxChord	4.3	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.45	m	0.025	0.575	5.46	17.50	0.76	0.00095	16.98	0.73	0.00092
Wingspan	1.1	m	0.075	0.575	1.82	6.01	0.26	0.00195	5.49	0.24	0.00178
F: Flapping (0) or gliding (1	1		0.125	0.702	1.09	4.35	0.19	0.00235	3.72	0.16	0.00201
			0.175	0.860	0.78	3.80	0.16	0.00287	3.03	0.13	0.00229
Bird speed	14	m/sec	0.225	0.994	0.61	3.45	0.15	0.00335	2.56	0.11	0.00248
RotorDiam	162	m	0.275	0.947	0.50	2.78	0.12	0.00330	1.93	0.08	0.00229
RotationPeriod	4.96	sec	0.325	0.899	0.42	2.31	0.10	0.00325	1.50	0.06	0.00211
			0.375	0.851	0.36	2.16	0.09	0.00349	1.39	0.06	0.00226
			0.425	0.804	0.32	1.91	0.08	0.00352	1.19	0.05	0.00219
			0.475	0.756	0.29	1.72	0.07	0.00353	1.04	0.04	0.00213
Bird aspect ratioo: β	0.41		0.525	0.708	0.26	1.56	0.07	0.00353	0.92	0.04	0.00208
			0.575	0.660	0.24	1.42	0.06	0.00352	0.82	0.04	0.00205
			0.625	0.613	0.22	1.30	0.06	0.00350	0.75	0.03	0.00202
			0.675	0.565	0.20	1.19	0.05	0.00348	0.68	0.03	0.00200
			0.725	0.517	0.19	1.10	0.05	0.00344	0.63	0.03	0.00199
			0.775	0.470	0.18	1.01	0.04	0.00340	0.59	0.03	0.00198
			0.825	0.422	0.17	0.94	0.04	0.00334	0.56	0.02	0.00199
			0.875	0.374	0.16	0.87	0.04	0.00328	0.53	0.02	0.00201
			0.925	0.327	0.15	0.80	0.03	0.00321	0.51	0.02	0.00203
			0.975	0.279	0.14	0.74	0.03	0.00313	0.49	0.02	0.00207
				Overall p(collision) =			**Upwind**	**6.2%**		**Downwind**	**4.1%**
								Average	**5.2%**		

European Golden Plover

K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3					Upwind:			Downwind:		
MaxChord	4.3	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.28	m	0.025	0.575	7.02	22.42	0.75	0.00094	21.91	0.74	0.00092
Wingspan	0.7	m	0.075	0.575	2.34	7.65	0.26	0.00193	7.13	0.24	0.00180
F: Flapping (0) or gliding (1	0		0.125	0.702	1.40	5.51	0.19	0.00231	4.88	0.16	0.00205
			0.175	0.860	1.00	4.78	0.16	0.00281	4.00	0.13	0.00235
Bird speed	18	m/sec	0.225	0.994	0.78	4.31	0.14	0.00326	3.41	0.11	0.00258
RotorDiam	162	m	0.275	0.947	0.64	3.45	0.12	0.00319	2.60	0.09	0.00241
RotationPeriod	4.96	sec	0.325	0.899	0.54	2.86	0.10	0.00312	2.05	0.07	0.00224
			0.375	0.851	0.47	2.41	0.08	0.00304	1.65	0.06	0.00208
			0.425	0.804	0.41	2.07	0.07	0.00295	1.35	0.05	0.00192
			0.475	0.756	0.37	1.81	0.06	0.00289	1.13	0.04	0.00181
Bird aspect ratioo: β	0.40		0.525	0.708	0.33	1.61	0.05	0.00284	0.97	0.03	0.00172
			0.575	0.660	0.31	1.44	0.05	0.00278	0.84	0.03	0.00163
			0.625	0.613	0.28	1.29	0.04	0.00271	0.74	0.02	0.00155
			0.675	0.565	0.26	1.16	0.04	0.00264	0.65	0.02	0.00148
			0.725	0.517	0.24	1.05	0.04	0.00255	0.58	0.02	0.00142
			0.775	0.470	0.23	0.95	0.03	0.00246	0.52	0.02	0.00136
			0.825	0.422	0.21	0.85	0.03	0.00237	0.47	0.02	0.00131
			0.875	0.374	0.20	0.77	0.03	0.00226	0.43	0.01	0.00127
			0.925	0.327	0.19	0.69	0.02	0.00215	0.40	0.01	0.00124
			0.975	0.279	0.18	0.62	0.02	0.00203	0.37	0.01	0.00121
				Overall p(collision) =			**Upwind**	**5.1%**		**Downwind**	**3.4%**
								Average	**4.3%**		

K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3					Upwind:			Downwind:		
MaxChord	4.3	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.3	m	0.025	0.575	4.79	16.08	0.79	0.00099	15.56	0.77	0.00096
Wingspan	0.84	m	0.075	0.575	1.60	5.53	0.27	0.00204	5.01	0.25	0.00185
F: Flapping (0) or gliding (1	0		0.125	0.702	0.96	4.00	0.20	0.00246	3.37	0.17	0.00207
			0.175	0.860	0.68	3.48	0.17	0.00300	2.71	0.13	0.00233
Bird speed	12.3	m/sec	0.225	0.994	0.53	3.16	0.16	0.00350	2.27	0.11	0.00251
RotorDiam	162	m	0.275	0.947	0.44	2.56	0.13	0.00346	1.71	0.08	0.00231
RotationPeriod	4.96	sec	0.325	0.899	0.37	2.13	0.10	0.00341	1.32	0.07	0.00212
			0.375	0.851	0.32	1.85	0.09	0.00340	1.08	0.05	0.00199
			0.425	0.804	0.28	1.63	0.08	0.00341	0.91	0.04	0.00190
			0.475	0.756	0.25	1.46	0.07	0.00340	0.78	0.04	0.00181
Bird aspect ratioo: β	0.36		0.525	0.708	0.23	1.31	0.06	0.00338	0.67	0.03	0.00174
			0.575	0.660	0.21	1.19	0.06	0.00335	0.59	0.03	0.00167
			0.625	0.613	0.19	1.08	0.05	0.00331	0.53	0.03	0.00162
			0.675	0.565	0.18	0.98	0.05	0.00326	0.48	0.02	0.00158
			0.725	0.517	0.17	0.90	0.04	0.00320	0.43	0.02	0.00154
			0.775	0.470	0.15	0.82	0.04	0.00313	0.40	0.02	0.00152
			0.825	0.422	0.15	0.75	0.04	0.00305	0.37	0.02	0.00151
			0.875	0.374	0.14	0.69	0.03	0.00296	0.35	0.02	0.00151
			0.925	0.327	0.13	0.63	0.03	0.00286	0.33	0.02	0.00152
			0.975	0.279	0.12	0.57	0.03	0.00274	0.32	0.02	0.00154
				Overall p(collision) =			**Upwind**	**6.0%**		**Downwind**	**3.6%**
								Average	**4.8%**		

Common Snipe

K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3					Upwind:			Downwind:		
MaxChord	4.3	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.26	m	0.025	0.575	6.24	18.43	0.70	0.00087	17.92	0.68	0.00085
Wingspan	0.455	m	0.075	0.575	2.08	6.32	0.24	0.00179	5.80	0.22	0.00164
F: Flapping (0) or gliding (1	0		0.125	0.702	1.25	4.63	0.17	0.00219	3.99	0.15	0.00189
			0.175	0.860	0.89	4.07	0.15	0.00269	3.30	0.12	0.00218
Bird speed	16	m/sec	0.225	0.994	0.69	3.71	0.14	0.00315	2.82	0.11	0.00239
RotorDiam	162	m	0.275	0.947	0.57	2.98	0.11	0.00310	2.13	0.08	0.00221
RotationPeriod	4.96	sec	0.325	0.899	0.48	2.51	0.09	0.00308	1.70	0.06	0.00209
			0.375	0.851	0.42	2.16	0.08	0.00306	1.39	0.05	0.00197
			0.425	0.804	0.37	1.88	0.07	0.00302	1.16	0.04	0.00186
			0.475	0.756	0.33	1.66	0.06	0.00298	0.98	0.04	0.00176
Bird aspect ratioo: β	0.57		0.525	0.708	0.30	1.48	0.06	0.00293	0.84	0.03	0.00167
			0.575	0.660	0.27	1.32	0.05	0.00288	0.73	0.03	0.00158
			0.625	0.613	0.25	1.19	0.04	0.00281	0.64	0.02	0.00151
			0.675	0.565	0.23	1.07	0.04	0.00274	0.56	0.02	0.00144
			0.725	0.517	0.22	0.97	0.04	0.00265	0.50	0.02	0.00138
			0.775	0.470	0.20	0.88	0.03	0.00256	0.45	0.02	0.00133
			0.825	0.422	0.19	0.79	0.03	0.00247	0.41	0.02	0.00128
			0.875	0.374	0.18	0.71	0.03	0.00236	0.38	0.01	0.00125
			0.925	0.327	0.17	0.64	0.02	0.00225	0.35	0.01	0.00122
			0.975	0.279	0.16	0.58	0.02	0.00212	0.33	0.01	0.00120
				Overall p(collision) =			**Upwind**	**5.2%**		**Downwind**	**3.3%**
								Average	**4.2%**		

APPENDIX 03

CRM Calculations

Siemens Gamesa 155

Common Kestrel North Cluster Breeding Season SG 155

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	2160	900	2,205						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	72	72	72						
Windfarm area (ha) visible within viewshed (*v*)[1]	70.04	249.72	187.0676						
Observation effort (*e*v*)	5042.56	17979.93	13468.87						
T_wV rate=$T_wV/e*v$	1.19E-04	1.39E-05	4.55E-05						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)*[1]									
Weight: proportion of total survey effort made at the VP	0.138	0.493	0.369	0.000	0.000	0.000	0.000		
Weighted T_wV rate (T_wV rate * weight)	1.64E-05	6.85E-06	1.68E-05						
Total weighted occupancy rate	0.000040 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	2.039%								
Mean % activity hr^-1 in wind farm at rotor height (z)	1.580%								

Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,377	hours
Tw=z*a	37.56	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	788,638,295	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.34	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	639,288.19	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	109.6067	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.7	m/sec
$t=(d+L)/s$	0.38	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	288	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.050	
STAGE 3: Predicted mortality (birds per year)		
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	12.188	collisions

Step 3.2: Adjusted using a range of avoidance rates:				
95.00%	**0.6094**	**approx one collision every**	**1.64**	**years**

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.34m, wingspan 0.8m, flight speed= 12.7m/sec

Common Kestrel North Cluster Non-Breeding Season 2017/18 SG 155

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	152	889						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	51	43	40						
Windfarm area (ha) visible within viewshed (*v*)[1]	70.04	249.72	187.0676						
Observation effort (*e*v*)	3571.81	10738.01	7482.70						
T_wV rate=$T_wV/e*v$	0.00E+00	3.93E-06	3.30E-05						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)*[1]									
Weight: proportion of total survey effort made at the VP	0.164	0.493	0.343						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	1.94E-06	1.13E-05						
Total weighted occupancy rate	0.000013					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.675%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.616%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,107	hours
Tw=z*a	12.97	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	788,638,295	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.34	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	639,288.19	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	37.84	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.7	m/sec
$t=(d+L)/s$	0.38	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	99	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.050	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	4.208	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
95.00%	**0.2104**	**approx one collision every**	**4.75**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.34m, wingspan 0.8m, flight speed= 12.7m/sec

Common Kestrel Non-Breeding Season 2021/22 SG 155

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	45	0	150						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	36	35	36						
Windfarm area (ha) visible within viewshed (*v*)[1]	70.04	249.72	187.0676						
Observation effort (*e*v*)	2521.28	8740.24	6734.43						
T_wV rate=$T_wV/e*v$	4.96E-06	0.00E+00	6.19E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.140	0.486	0.374						
Weighted T_wV rate (T_wV rate * weight)	6.95E-07	0.00E+00	2.32E-06						
Total weighted occupancy rate	0.000003					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.153%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.119%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,107	hours
Tw=z*a	2.50	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	788,638,295	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.34	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	639,288.19	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	7.30	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.7	m/sec
$t=(d+L)/s$	0.38	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	19	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.050	
STAGE 3: Predicted mortality (birds per year)		

Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	0.811	collisions		
Step 3.2: Adjusted using a range of avoidance rates:				
95.00%	**0.0406**	**approx one collision every**	**24.65**	**years**

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.34m, wingspan 0.8m, flight speed= 12.7m/sec

Common Kestrel North Cluster Annual SG 155

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	2205	1,052	3,244						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	159	150	148						
Windfarm area (ha) visible within viewshed (*v*)[1]	70.04	249.72	187.07						
Observation effort (*e*v*)	11135.65	37458.19	27686.01						
T_wV rate=$T_wV/e*v$	5.50E-05	7.80E-06	3.25E-05						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.146	0.491	0.363						
Weighted T_wV rate (T_wV rate * weight)	8.03E-06	3.83E-06	1.18E-05						
Total weighted occupancy rate	0.000024 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	1.205%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.934%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	4,483	hours
Tw=z*a	41.85	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	788,638,295	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.34	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	639,288.19	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	122.1340	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.7	m/sec
$t=(d+L)/s$	0.38	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	320	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.050	
STAGE 3: Predicted mortality (birds per year)		

Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	13.582	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
95.00%	**0.6791**	**approx one collision every**	**1.47**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.34m, wingspan 0.8m, flight speed= 12.7m/sec

Common Kestrel South Cluster Breeding Season SG 155

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	495	0	300						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	72	30	66						
Windfarm area (ha) visible within viewshed (*v*)[1]	214.19	16.15	255.1864						
Observation effort (*e*v*)	15421.50	484.42	16842.31						
T_wV rate=$T_wV/e*v$	8.92E-06	0.00E+00	4.95E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)*[1]									
Weight: proportion of total survey effort made at the VP	0.471	0.015	0.514	0.000	0.000	0.000	0.000		
Weighted T_wV rate (T_wV rate * weight)	4.20E-06	0.00E+00	2.54E-06						
Total weighted occupancy rate	0.000007 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	0.246%								
Mean % activity hr^-1 in wind farm at rotor height (z)	0.191%								

Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,377	hours
Tw=z*a	4.53	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	565,616,700	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.34	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	547,961.30	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	15.8074	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.7	m/sec
$t=(d+L)/s$	0.38	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	41	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.050	
STAGE 3: Predicted mortality (birds per year)		

Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	1.758	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
95.00%	**0.0879**	**approx one collision every**	**11.38**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.34m, wingspan 0.8m, flight speed= 12.7m/sec

Common Kestrel South Cluster Non-Breeding Season 2017/18 SG 155

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	1,322						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	33	30	36						
Windfarm area (ha) visible within viewshed (*v*)[1]	214.19	16.15	255.18644						
Observation effort (*e*v*)	6961.09	484.42	9186.71						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	4.00E-05						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.419	0.029	0.552						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	2.21E-05						
Total weighted occupancy rate	0.000022 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	0.806%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.735%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,107	hours
Tw=z*a	15.48	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	565,616,700	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.34	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	547,961.30	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	53.97	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.7	m/sec
$t=(d+L)/s$	0.38	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	142	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.050	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	6.002	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
95.00%	**0.3001**	**approx one collision every**	**3.33**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.34m, wingspan 0.8m, flight speed= 12.7m/sec

Common Kestrel South Cluster Non-Breeding Season 2021/22 SG 155

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	615						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	36	42	39						
Windfarm area (ha) visible within viewshed (*v*)[1]	214.19	16.15	255.18644						
Observation effort (*e*v*)	7710.75	678.19	9952.27						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	1.72E-05						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.420	0.037	0.543						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	9.31E-06						
Total weighted occupancy rate	0.000009 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	0.340%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.263%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,107	hours
Tw=z*a	5.55	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	565,616,700	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.34	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	547,961.30	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	19.35	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.7	m/sec
$t=(d+L)/s$	0.38	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	51	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.050	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	2.152	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
95.00%	**0.1076**	**approx one collision every**	**9.29**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.34m, wingspan 0.8m, flight speed= 12.7m/sec

Common Kestrel South Cluster Annual SG 155

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	495	0	2,237						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	141	102	141						
Windfarm area (ha) visible within viewshed (*v*)[1]	214.19	16.15	255.19						
Observation effort (*e*v*)	30093.34	1647.03	35981.29						
T_wV rate=$T_wV/e*v$	4.57E-06	0.00E+00	1.73E-05						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.444	0.024	0.531						
Weighted T_wV rate (T_wV rate * weight)	2.03E-06	0.00E+00	9.18E-06						
Total weighted occupancy rate	0.000011					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.409%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.317%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	4,483	hours
Tw=z*a	14.21	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	565,616,700	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.34	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	547,961.30	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	49.5533	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.7	m/sec
$t=(d+L)/s$	0.38	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	130	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.050	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	5.510	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
95.00%	**0.2755**	**approx one collision every**	**3.63**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.34m, wingspan 0.8m, flight speed= 12.7m/sec

Peregrine Falcon North Cluster Breeding Season SG 155

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	105	570	105						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	72	72	72						
Windfarm area (ha) visible within viewshed (*v*)[1]	70.04	249.72	187.0676						
Observation effort (*e*v*)	5042.56	17979.93	13468.87						
T_wV rate=$T_wV/e*v$	5.78E-06	8.81E-06	2.17E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)*[1]									
Weight: proportion of total survey effort made at the VP	0.138	0.493	0.369	0.000	0.000	0.000	0.000		
Weighted T_wV rate (T_wV rate * weight)	7.99E-07	4.34E-06	7.99E-07						
Total weighted occupancy rate	0.000006					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.302%								
Mean % activity hr^-1 in wind farm at rotor height (z)	0.234%								

Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,377	hours
Tw=z*a	5.56	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	788,638,295	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.45	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	653,817.46	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	16.6071	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	14	m/sec
$t=(d+L)/s$	0.35	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	47	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.053	
STAGE 3: Predicted mortality (birds per year)		
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	2.116	collisions

Step 3.2: Adjusted using a range of avoidance rates:				
98.00%	**0.0423**	**approx one collision every**	**23.63**	**years**

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.45m, wingspan 1.1m, flight speed= 14.0m/sec

Peregrine Falcon North Cluster Non-Breeding Season 2021/22 SG 155

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	105	0	0						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	36	35	36						
Windfarm area (ha) visible within viewshed (*v*)[1]	70.04	249.72	187.0676						
Observation effort (*e*v*)	2521.28	8740.24	6734.43						
T_wV rate=$T_wV/e*v$	1.16E-05	0.00E+00	0.00E+00						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.140	0.486	0.374						
Weighted T_wV rate (T_wV rate * weight)	1.62E-06	0.00E+00	0.00E+00						
Total weighted occupancy rate	0.000002					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.082%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.064%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,107	hours
Tw=z*a	1.35	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	788,638,295	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.45	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	653,817.46	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	4.02	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	14	m/sec
$t=(d+L)/s$	0.35	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	11	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.053	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	0.512	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0102**	**approx one collision every**	**97.65**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.45m, wingspan 1.1m, flight speed= 14.0m/sec

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	210	570	105						
Step 1.2: Unweighted occupancy rate each viewshed (T_wVrate)									
Hours of survey effort (*e*)	159	150	148						
Windfarm area (ha) visible within viewshed (*v*)[1]	70.04	249.72	187.07						
Observation effort (*e*v*)	11135.65	37458.19	27686.01						
T_wV rate=$T_wV/e*v$	5.24E-06	4.23E-06	1.05E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.146	0.491	0.363						
Weighted T_wV rate (T_wV rate * weight)	7.65E-07	2.08E-06	3.82E-07						
Total weighted occupancy rate	0.000003					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.164%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.127%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	4,483	hours
Tw=z*a	5.70	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	788,638,295	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.45	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	653,817.46	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	17.0043	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	14	m/sec
$t=(d+L)/s$	0.35	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	48	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.053	
STAGE 3: Predicted mortality (birds per year)		

Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	2.167	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0433**	**approx one collision every**	**23.08**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.45m, wingspan 1.1m, flight speed= 14.0m/sec

Peregrine Falcon South Cluster Breeding Season SG 155

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	165						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	72	30	66						
Windfarm area (ha) visible within viewshed (*v*)[1]	214.19	16.15	255.1864						
Observation effort (*e*v*)	15421.50	484.42	16842.31						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	2.72E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)*[1]									
Weight: proportion of total survey effort made at the VP	0.471	0.015	0.514	0.000	0.000	0.000	0.000		
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	1.40E-06						
Total weighted occupancy rate	0.000001 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	0.051%								
Mean % activity hr^-1 in wind farm at rotor height (z)	0.040%								

Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,377	hours
Tw=z*a	0.94	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	565,616,700	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.45	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	560,414.97	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	3.3554	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	14	m/sec
$t=(d+L)/s$	0.35	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	9	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.053	
STAGE 3: Predicted mortality (birds per year)		
Step 3.1: With no avoidance, turbines operational 97% of the time N*p(collision)*0.97	0.428	collisions

Step 3.2: Adjusted using a range of avoidance rates:				
98.00%	**0.0086**	**approx one collision every**	**116.95**	**years**

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.45m, wingspan 1.1m, flight speed= 14.0m/sec

Peregrine Falcon South Cluster Non-Breeding Season 2017/18 SG 155

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	106						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	33	30	36						
Windfarm area (ha) visible within viewshed (*v*)[1]	214.19	16.15	255.18644						
Observation effort (*e*v*)	6961.09	484.42	9186.71						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	3.21E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.419	0.029	0.552						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	1.77E-06						
Total weighted occupancy rate	0.000002					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.065%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.059%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,107	hours
Tw=z*a	1.24	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	565,616,700	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.45	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	560,414.97	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	4.43	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	14	m/sec
$t=(d+L)/s$	0.35	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	13	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.053	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 97% of the time N*p(collision)*0.97	0.564	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0113**	**approx one collision every**	**88.66**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.45m, wingspan 1.1m, flight speed= 14.0m/sec

Peregrine Falcon South Cluster Non-Breeding Season 2021/22 SG 155

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	30	0	90						
Step 1.2: Unweighted occupancy rate each viewshed (T_wVrate)									
Hours of survey effort (*e*)	36	42	39						
Windfarm area (ha) visible within viewshed (*v*)[1]	214.19	16.15	255.18644						
Observation effort (*e*v*)	7710.75	678.19	9952.27						
T_wV rate=$T_wV/e*v$	1.08E-06	0.00E+00	2.51E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.420	0.037	0.543						
Weighted T_wV rate (T_wV rate * weight)	4.54E-07	0.00E+00	1.36E-06						
Total weighted occupancy rate	0.000002 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	0.066%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.051%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,107	hours
Tw=z*a	1.08	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	565,616,700	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.45	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	560,414.97	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	3.86	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	14	m/sec
$t=(d+L)/s$	0.35	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	11	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.053	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 97% of the time N*p(collision)*0.97	0.492	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0098**	**approx one collision every**	**101.60**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.45m, wingspan 1.1m, flight speed= 14.0m/sec

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	30	0	361						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	141	102	141						
Windfarm area (ha) visible within viewshed (*v*)[1]	214.19	16.15	255.19						
Observation effort (*e*v*)	30093.34	1647.03	35981.29						
T_wV rate=$T_wV/e*v$	2.77E-07	0.00E+00	2.79E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.444	0.024	0.531						
Weighted T_wV rate (T_wV rate * weight)	1.23E-07	0.00E+00	1.48E-06						
Total weighted occupancy rate	0.000002					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.059%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.045%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	4,483	hours
Tw=z*a	2.03	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	565,616,700	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.45	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	560,414.97	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	7.2532	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	14	m/sec
$t=(d+L)/s$	0.35	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	21	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.053	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 97% of the time N*p(collision)*0.97	0.924	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0185**	**approx one collision every**	**54.10**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.45m, wingspan 1.1m, flight speed= 14.0m/sec

European Golden Plover North Cluster Non-Breeding Season 2017/18 SG 155

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	84						
Step 1.2: Unweighted occupancy rate each viewshed (T_wVrate)									
Hours of survey effort (*e*)	51	43	40						
Windfarm area (ha) visible within viewshed (*v*)[1]	70.04	249.72	187.0676						
Observation effort (*e*v*)	3571.81	10738.01	7482.70						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	3.12E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)*[1]									
Weight: proportion of total survey effort made at the VP	0.164	0.493	0.343						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	1.07E-06						
Total weighted occupancy rate	0.000001					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.054%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.050%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,860	hours
Tw=z*a	1.42	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	788,638,295	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.28	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	631,363.13	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	4.09	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	18	m/sec
$t=(d+L)/s$	0.27	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	15	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.045	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	0.594	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0119**	**approx one collision every**	**84.15**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.28m, wingspan 0.7m, flight speed= 18m/sec

European Golden Plover North Cluster Annual SG 155

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	84						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	159	150	148						
Windfarm area (ha) visible within viewshed (*v*)[1]	70.04	249.72	187.07						
Observation effort (*e*v*)	11135.65	37458.19	27686.01						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	8.43E-07						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.146	0.491	0.363						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	3.06E-07						
Total weighted occupancy rate	0.000000 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	0.016%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.012%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	5,560	hours
Tw=z*a	0.67	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	788,638,295	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.28	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	631,363.13	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	1.9328	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	18	m/sec
$t=(d+L)/s$	0.27	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	7	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.045	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	0.281	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0056**	**approx one collision every**	**178.23**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.28m, wingspan 0.7m, flight speed= 18m/sec

European Golden Plover South Cluster Non-Breeding Season 2017/18 SG 155

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	141						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	33	30	36						
Windfarm area (ha) visible within viewshed (*v*)[1]	214.19	16.15	255.18644						
Observation effort (*e*v*)	6961.09	484.42	9186.71						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	4.26E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.419	0.029	0.552						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	2.35E-06						
Total weighted occupancy rate	0.000002					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.086%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.078%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,860	hours
Tw=z*a	2.24	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	565,616,700	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.28	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	541,168.39	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	7.72	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	18	m/sec
$t=(d+L)/s$	0.27	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	29	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.045	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	1.120	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0224**	**approx one collision every**	**44.64**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.28m, wingspan 0.72m, flight speed= 17.5m/sec

European Golden Plover South Cluster Non-Breeding Season 2021/22 SG 155

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	1035	2,400	0						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	36	42	39						
Windfarm area (ha) visible within viewshed (*v*)[1]	214.19	16.15	255.18644						
Observation effort (*e*v*)	7710.75	678.19	9952.27						
T_wV rate=$T_wV/e*v$	3.73E-05	9.83E-04	0.00E+00						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.420	0.037	0.543						
Weighted T_wV rate (T_wV rate * weight)	1.57E-05	3.63E-05	0.00E+00						
Total weighted occupancy rate	0.000052 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	1.898%								

Mean % activity hr^-1 in wind farm at rotor height (z)	1.471%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,860	hours
Tw=z*a	42.07	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	565,616,700	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.28	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	541,168.39	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	144.91	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	18	m/sec
$t=(d+L)/s$	0.27	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	546	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.045	
STAGE 3: Predicted mortality (birds per year)		

Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	21.033	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.4207**	**approx one collision every**	**2.38**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.28m, wingspan 0.72m, flight speed= 17.5m/sec

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	1035	2,400	141						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	141	102	141						
Windfarm area (ha) visible within viewshed (*v*)[1]	214.19	16.15	255.19						
Observation effort (*e*v*)	30093.34	1647.03	35981.29						
T_wV rate=$T_wV/e*v$	9.55E-06	4.05E-04	1.09E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.444	0.024	0.531						
Weighted T_wV rate (T_wV rate * weight)	4.25E-06	9.84E-06	5.78E-07						
Total weighted occupancy rate	0.000015					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.535%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.415%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	5,560	hours
Tw=z*a	23.06	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	565,616,700	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.28	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	541,168.39	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	79.4413	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	18	m/sec
$t=(d+L)/s$	0.27	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	299	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.045	
STAGE 3: Predicted mortality (birds per year)		

Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	11.530	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.2306**	**approx one collision every**	**4.34**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.28m, wingspan 0.72m, flight speed= 17.5m/sec

Northern Lapwing North Cluster Non-Breeding 2017/18 SG 155

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	93						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	51	43	40						
Windfarm area (ha) visible within viewshed (*v*)[1]	70.04	249.72	187.0676						
Observation effort (*e*v*)	3571.81	10738.01	7482.70						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	3.45E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.164	0.493	0.343						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	1.19E-06						
Total weighted occupancy rate	0.000001 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	0.060%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.055%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,860	hours
Tw=z*a	1.57	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	788,638,295	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.3	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	634,004.81	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	4.55	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.3	m/sec
$t=(d+L)/s$	0.39	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	12	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.050	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	0.496	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0099**	**approx one collision every**	**100.82**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.34m, wingspan 0.8m, flight speed= 12.7m/sec

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	93						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	159	150	148						
Windfarm area (ha) visible within viewshed (*v*)[1]	70.04	249.72	187.07						
Observation effort (*e*v*)	11135.65	37458.19	27686.01						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	9.33E-07						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.146	0.491	0.363						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	3.39E-07						
Total weighted occupancy rate	0.000000 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	0.017%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.013%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	5,560	hours
Tw=z*a	0.74	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	788,638,295	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.3	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	634,004.81	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	2.1489	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.3	m/sec
$t=(d+L)/s$	0.39	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	6	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.050	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	0.234	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0047**	**approx one collision every**	**213.52**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.34m, wingspan 0.8m, flight speed= 12.7m/sec

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	2,250						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	36	42	39						
Windfarm area (ha) visible within viewshed (*v*)[1]	214.19	16.15	255.18644						
Observation effort (*e*v*)	7710.75	678.19	9952.27						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	6.28E-05						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.420	0.037	0.543						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	3.41E-05						
Total weighted occupancy rate	0.000034 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	1.243%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.964%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,860	hours
Tw=z*a	27.56	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	565,616,700	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.3	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	543,432.70	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	95.32	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.3	m/sec
$t=(d+L)/s$	0.39	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	244	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.050	

STAGE 3: Predicted mortality (birds per year)				
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	10.387	collisions		
Step 3.2: Adjusted using a range of avoidance rates:				
98.00%	**0.2077**	**approx one collision every**	**4.81**	**years**

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.30m, wingspan 0.84m, flight speed= 12.3m/sec

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	2,250						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	141	102	141						
Windfarm area (ha) visible within viewshed (*v*)[1]	214.19	16.15	255.19						
Observation effort (*e*v*)	30093.34	1647.03	35981.29						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	1.74E-05						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)*[1]									
Weight: proportion of total survey effort made at the VP	0.444	0.024	0.531						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	9.23E-06						
Total weighted occupancy rate	0.000009 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	0.337%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.261%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	5,560	hours
Tw=z*a	14.51	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	565,616,700	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.3	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	543,432.70	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	50.1932	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.3	m/sec
$t=(d+L)/s$	0.39	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	129	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.050	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	5.470	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.1094**	**approx one collision every**	**9.14**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.30m, wingspan 0.84m, flight speed= 12.3m/sec

Common Snipe North Cluster Breeding Season SG 155

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	5610	600	0						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	72	72	72						
Windfarm area (ha) visible within viewshed (*v*)[1]	70.04	249.72	187.0676						
Observation effort (*e*v*)	5042.56	17979.93	13468.87						
T_wV rate=$T_wV/e*v$	3.09E-04	9.27E-06	0.00E+00						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)*[1]									
Weight: proportion of total survey effort made at the VP	0.138	0.493	0.369	0.000	0.000	0.000	0.000		
Weighted T_wV rate (T_wV rate * weight)	4.27E-05	4.57E-06	0.00E+00						
Total weighted occupancy rate	0.000047					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	2.405%								
Mean % activity hr^-1 in wind farm at rotor height (z)	2.193%								

Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,700	hours
Tw=z*a	59.22	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	788,638,295	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.26	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	628,721.44	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	169.9617	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	16	m/sec
$t=(d+L)/s$	0.30	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	571	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.045	
STAGE 3: Predicted mortality (birds per year)		
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	21.621	collisions

Step 3.2: Adjusted using a range of avoidance rates:				
98.00%	**0.4324**	**approx one collision every**	**2.31**	**years**

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.26m, wingspan 0.455m, flight speed= 16.0m/sec

Common Snipe North Cluster Non-Breeding Season 2017/18 SG 155

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	31						
Step 1.2: Unweighted occupancy rate each viewshed (T_wVrate)									
Hours of survey effort (*e*)	51	43	40						
Windfarm area (ha) visible within viewshed (*v*)[1]	70.04	249.72	187.0676						
Observation effort (*e*v*)	3571.81	10738.01	7482.70						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	1.15E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.164	0.493	0.343						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	3.95E-07						
Total weighted occupancy rate	0.000000 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	0.020%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.022%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,860	hours
Tw=z*a	0.64	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	788,638,295	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.26	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	628,721.44	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	1.83	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	16	m/sec
$t=(d+L)/s$	0.30	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	6	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.045	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	0.232	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0046**	**approx one collision every**	**215.16**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.26m, wingspan 0.455m, flight speed= 16.0m/sec

Common Snipe North Cluster Non-Breeding Season 2020/21 SG 155

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	15	0						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	36	35	36						
Windfarm area (ha) visible within viewshed (*v*)[1]	70.04	249.72	187.0676						
Observation effort (*e*v*)	2521.28	8740.24	6734.43						
T_wV rate=$T_wV/e*v$	0.00E+00	4.77E-07	0.00E+00						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.140	0.486	0.374						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	2.32E-07	0.00E+00						
Total weighted occupancy rate	0.000000					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.012%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.011%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,860	hours
Tw=z*a	0.31	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	788,638,295	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.26	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	628,721.44	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	0.88	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	16	m/sec
$t=(d+L)/s$	0.30	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	3	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.045	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	0.112	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0022**	**approx one collision every**	**445.88**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.26m, wingspan 0.455m, flight speed= 16.0m/sec

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	5610	615	31						
Step 1.2: Unweighted occupancy rate each viewshed (T_wVrate)									
Hours of survey effort (*e*)	159	150	148						
Windfarm area (ha) visible within viewshed (*v*)[1]	70.04	249.72	187.07						
Observation effort (*e*v*)	11135.65	37458.19	27686.01						
T_wV rate=$T_wV/e*v$	1.40E-04	4.56E-06	3.11E-07						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.146	0.491	0.363						
Weighted T_wV rate (T_wV rate * weight)	2.04E-05	2.24E-06	1.13E-07						
Total weighted occupancy rate	0.000023 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	1.159%								

Mean % activity hr^-1 in wind farm at rotor height (z)	1.057%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	5,560	hours
Tw=z*a	58.76	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	788,638,295	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.26	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	628,721.44	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	168.6437	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	16	m/sec
$t=(d+L)/s$	0.30	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	567	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.045	
STAGE 3: Predicted mortality (birds per year)		

Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	21.454	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.4291**	**approx one collision every**	**2.33**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.26m, wingspan 0.455m, flight speed= 16.0m/sec

APPENDIX 04

CRM Calculations

Vestas 162

Common Kestrel North Cluster Breeding Season Vestas 162

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	2160	900	2,205						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	72	72	72						
Windfarm area (ha) visible within viewshed (*v*)[1]	66.15	213.01	164.456						
Observation effort (*e*v*)	4762.80	15336.50	11840.83						
T_wV rate=$T_wV/e*v$	1.26E-04	1.63E-05	5.17E-05						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)*[1]									
Weight: proportion of total survey effort made at the VP	0.149	0.480	0.371	0.000	0.000	0.000	0.000		
Weighted T_wV rate (T_wV rate * weight)	1.88E-05	7.83E-06	1.92E-05						
Total weighted occupancy rate	0.000046 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	2.344%								
Mean % activity hr^-1 in wind farm at rotor height (z)	1.898%								

Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,377	hours
Tw=z*a	45.12	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	829,150,668	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.34	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	669,477.42	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	131.1384	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.7	m/sec
$t=(d+L)/s$	0.37	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	359	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.048	
STAGE 3: Predicted mortality (birds per year)		
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	14.697	collisions

Step 3.2: Adjusted using a range of avoidance rates:				
95.00%	**0.7349**	**approx one collision every**	**1.36**	**years**

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.34m, wingspan 0.8m, flight speed= 12.7m/sec

Common Kestrel North Cluster Non-Breeding Season 2017/18 Vestas 162

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	112	640						
Step 1.2: Unweighted occupancy rate each viewshed (T_wVrate)									
Hours of survey effort (*e*)	51	43	40						
Windfarm area (ha) visible within viewshed (*v*)[1]	66.15	213.01	164.456						
Observation effort (*e*v*)	3373.65	9159.30	6578.24						
T_wV rate=$T_wV/e*v$	0.00E+00	3.40E-06	2.70E-05						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.177	0.479	0.344						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	1.63E-06	9.30E-06						
Total weighted occupancy rate	0.000011					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.559%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.533%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,107	hours
Tw=z*a	11.23	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	829,150,668	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.34	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	669,477.42	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	32.64	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.7	m/sec
$t=(d+L)/s$	0.37	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	89	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.048	
STAGE 3: Predicted mortality (birds per year)		

Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	3.659	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
95.00%	**0.1829**	**approx one collision every**	**5.47**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.34m, wingspan 0.8m, flight speed= 12.7m/sec

Common Kestrel Non-Breeding Season 2021/22 Vestas 162

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	45	0	150						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	36	35	36						
Windfarm area (ha) visible within viewshed (*v*)[1]	66.15	213.01	164.456						
Observation effort (*e*v*)	2381.40	7455.25	5920.42						
T_wV rate=$T_wV/e*v$	5.25E-06	0.00E+00	7.04E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.151	0.473	0.376						
Weighted T_wV rate (T_wV rate * weight)	7.93E-07	0.00E+00	2.64E-06						
Total weighted occupancy rate	0.000003					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.176%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.143%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,107	hours
Tw=z*a	3.00	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	829,150,668	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.34	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	669,477.42	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	8.73	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.7	m/sec
$t=(d+L)/s$	0.37	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	24	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.048	
STAGE 3: Predicted mortality (birds per year)		

Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	0.978	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
95.00%	**0.0489**	**approx one collision every**	**20.45**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.34m, wingspan 0.8m, flight speed= 12.7m/sec

Common Kestrel North Cluster Annual Vestas 162

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	2205	1,012	2,995						
Step 1.2: Unweighted occupancy rate each viewshed (T_wVrate)									
Hours of survey effort (*e*)	159	150	148						
Windfarm area (ha) visible within viewshed (*v*)[1]	66.15	213.01	164.46						
Observation effort (*e*v*)	10517.85	31951.05	24339.49						
T_wV rate=$T_wV/e*v$	5.82E-05	8.80E-06	3.42E-05						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.157	0.478	0.364						
Weighted T_wV rate (T_wV rate * weight)	9.17E-06	4.21E-06	1.25E-05						
Total weighted occupancy rate	0.000026					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	1.322%								

Mean % activity hr^-1 in wind farm at rotor height (z)	1.071%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	4,483	hours
Tw=z*a	48.01	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	829,150,668	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.34	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	669,477.42	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	139.5423	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.7	m/sec
$t=(d+L)/s$	0.37	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	382	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.048	
STAGE 3: Predicted mortality (birds per year)		

Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	15.639	collisions		
Step 3.2: Adjusted using a range of avoidance rates:				
95.00%	**0.7820**	**approx one collision every**	**1.28**	**years**

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.34m, wingspan 0.8m, flight speed= 12.7m/sec

Common Kestrel South Cluster Breeding Season Vestas 162

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	495	0	300						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	72	30	66						
Windfarm area (ha) visible within viewshed (*v*)[1]	209.36	16.51	245.3118						
Observation effort (*e*v*)	15073.79	495.21	16190.58						
T_wV rate=$T_wV/e*v$	9.12E-06	0.00E+00	5.15E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)*[1]									
Weight: proportion of total survey effort made at the VP	0.475	0.016	0.510	0.000	0.000	0.000	0.000		
Weighted T_wV rate (T_wV rate * weight)	4.33E-06	0.00E+00	2.62E-06						
Total weighted occupancy rate	0.000007 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	0.255%								
Mean % activity hr^-1 in wind farm at rotor height (z)	0.207%								

Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,377	hours
Tw=z*a	4.92	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	595,111,814	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.34	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	573,837.78	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	17.0692	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.7	m/sec
$t=(d+L)/s$	0.37	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	47	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.048	
STAGE 3: Predicted mortality (birds per year)		
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	1.913	collisions

Step 3.2: Adjusted using a range of avoidance rates:				
95.00%	**0.0957**	**approx one collision every**	**10.45**	**years**

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.34m, wingspan 0.8m, flight speed= 12.7m/sec

Common Kestrel South Cluster Non-Breeding Season 2017/18 Vestas

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	1,322						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	33	30	36						
Windfarm area (ha) visible within viewshed (*v*)[1]	209.36	16.51	245.31184						
Observation effort (*e*v*)	6804.14	495.21	8831.23						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	4.16E-05						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.422	0.031	0.547						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	2.28E-05						
Total weighted occupancy rate	0.000023 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	0.836%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.797%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,107	hours
Tw=z*a	16.79	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	595,111,814	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.34	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	573,837.78	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	58.28	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.7	m/sec
$t=(d+L)/s$	0.37	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	160	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.048	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	6.532	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
95.00%	**0.3266**	**approx one collision every**	**3.06**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.34m, wingspan 0.8m, flight speed= 12.7m/sec

Common Kestrel South Cluster Non-Breeding Season 2021/22 Vestas 162

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	615						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	36	42	39						
Windfarm area (ha) visible within viewshed (*v*)[1]	209.36	16.51	245.31184						
Observation effort (*e*v*)	7536.90	693.29	9567.16						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	1.79E-05						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)*[1]									
Weight: proportion of total survey effort made at the VP	0.423	0.039	0.538						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	9.60E-06						
Total weighted occupancy rate	0.000010 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	0.353%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.286%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,107	hours
Tw=z*a	6.02	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	595,111,814	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.34	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	573,837.78	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	20.89	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.7	m/sec
$t=(d+L)/s$	0.37	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	57	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.048	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	2.341	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
95.00%	**0.1170**	**approx one collision every**	**8.54**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.34m, wingspan 0.8m, flight speed= 12.7m/sec

Common Kestrel South Cluster Annual Vestas 162

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	495	0	2,237						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	141	102	141						
Windfarm area (ha) visible within viewshed (*v*)[1]	209.36	16.51	245.31						
Observation effort (*e*v*)	29414.83	1683.71	34588.97						
T_wV rate=$T_wV/e*v$	4.67E-06	0.00E+00	1.80E-05						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.448	0.026	0.527						
Weighted T_wV rate (T_wV rate * weight)	2.09E-06	0.00E+00	9.46E-06						
Total weighted occupancy rate	0.000012					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.424%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.344%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	4,483	hours
Tw=z*a	15.41	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	595,111,814	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.34	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	573,837.78	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	53.5003	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.7	m/sec
$t=(d+L)/s$	0.37	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	146	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.048	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	5.996	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
95.00%	**0.2998**	**approx one collision every**	**3.34**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.34m, wingspan 0.8m, flight speed= 12.7m/sec

Peregrine Falcon North Cluster Breeding Season Vestas 162

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	105	570	105						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	72	72	72						
Windfarm area (ha) visible within viewshed (*v*)[1]	66.15	213.01	164.456						
Observation effort (*e*v*)	4762.80	15336.50	11840.83						
T_wV rate=$T_wV/e*v$	6.12E-06	1.03E-05	2.46E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)*[1]									
Weight: proportion of total survey effort made at the VP	0.149	0.480	0.371						
Weighted T_wV rate (T_wV rate * weight)	9.13E-07	4.96E-06	9.13E-07						
Total weighted occupancy rate	0.000007					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.347%								
Mean % activity hr^-1 in wind farm at rotor height (z)	0.281%								

Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,377	hours
Tw=z*a	6.68	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	829,150,668	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.45	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	685,348.65	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	19.8885	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	14	m/sec
$t=(d+L)/s$	0.34	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	59	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.052	
STAGE 3: Predicted mortality (birds per year)		
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	2.567	collisions

Step 3.2: Adjusted using a range of avoidance rates:				
98.00%	**0.0513**	**approx one collision every**	**19.47**	**years**

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.45m, wingspan 1.1m, flight speed= 14.0m/sec

Peregrine Falcon North Cluster Non-Breeding Season 2021/22 Vestas 162

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	105	0	0						
Step 1.2: Unweighted occupancy rate each viewshed (T_wVrate)									
Hours of survey effort (*e*)	36	35	36						
Windfarm area (ha) visible within viewshed (*v*)[1]	66.15	213.01	164.456						
Observation effort (*e*v*)	2381.40	7455.25	5920.42						
T_wV rate=$T_wV/e*v$	1.22E-05	0.00E+00	0.00E+00						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.151	0.473	0.376						
Weighted T_wV rate (T_wV rate * weight)	1.85E-06	0.00E+00	0.00E+00						
Total weighted occupancy rate	0.000002					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.095%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.077%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,107	hours
Tw=z*a	1.62	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	829,150,668	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.45	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	685,348.65	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	4.81	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	14	m/sec
$t=(d+L)/s$	0.34	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	14	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.052	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	0.621	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0124**	**approx one collision every**	**80.51**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.45m, wingspan 1.1m, flight speed= 14.0m/sec

Peregrine Falcon North Cluster Annual Vestas 162

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	210	570	105						
Step 1.2: Unweighted occupancy rate each viewshed (T_wVrate)									
Hours of survey effort (*e*)	159	150	148						
Windfarm area (ha) visible within viewshed (*v*)[1]	66.15	213.01	164.46						
Observation effort (*e*v*)	10517.85	31951.05	24339.49						
T_wV rate=$T_wV/e*v$	5.55E-06	4.96E-06	1.20E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.157	0.478	0.364						
Weighted T_wV rate (T_wV rate * weight)	8.73E-07	2.37E-06	4.37E-07						
Total weighted occupancy rate	0.000004					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.188%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.153%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	4,483	hours
Tw=z*a	6.84	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	829,150,668	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.45	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	685,348.65	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	20.3514	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	14	m/sec
$t=(d+L)/s$	0.34	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	60	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.052	
STAGE 3: Predicted mortality (birds per year)		

Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	2.627	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0525**	**approx one collision every**	**19.03**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.45m, wingspan 1.1m, flight speed= 14.0m/sec

Peregrine Falcon South Cluster Breeding Season Vestas 162

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	165						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	72	30	66						
Windfarm area (ha) visible within viewshed (*v*)[1]	209.36	16.51	245.3118						
Observation effort (*e*v*)	15073.79	495.21	16190.58						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	2.83E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)*[1]									
Weight: proportion of total survey effort made at the VP	0.475	0.016	0.510						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	1.44E-06						
Total weighted occupancy rate	0.000001					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.053%								
Mean % activity hr^-1 in wind farm at rotor height (z)	0.043%								

Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,377	hours
Tw=z*a	1.02	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	595,111,814	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.45	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	587,441.70	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	3.6267	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	14	m/sec
$t=(d+L)/s$	0.34	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	11	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.052	
STAGE 3: Predicted mortality (birds per year)		
Step 3.1: With no avoidance, turbines operational 97% of the time N*p(collision)*0.97	0.468	collisions

Step 3.2: Adjusted using a range of avoidance rates:				
98.00%	**0.0094**	**approx one collision every**	**106.80**	**years**

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.45m, wingspan 1.1m, flight speed= 14.0m/sec

Peregrine Falcon South Cluster Non-Breeding Season 2017/18 Vestas 162

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	106						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	33	30	36						
Windfarm area (ha) visible within viewshed (*v*)[1]	209.36	16.51	245.31184						
Observation effort (*e*v*)	6804.14	495.21	8831.23						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	3.33E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.422	0.031	0.547						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	1.83E-06						
Total weighted occupancy rate	0.000002					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.067%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.064%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,107	hours
Tw=z*a	1.35	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	595,111,814	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.45	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	587,441.70	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	4.78	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	14	m/sec
$t=(d+L)/s$	0.34	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	14	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.052	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 97% of the time N*p(collision)*0.97	0.618	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0124**	**approx one collision every**	**80.96**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.45m, wingspan 1.1m, flight speed= 14.0m/sec

Peregrine Falcon South Cluster Non-Breeding Season 2021/22 Vestas 162

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	30	0	90						
Step 1.2: Unweighted occupancy rate each viewshed (T_wVrate)									
Hours of survey effort (*e*)	36	42	39						
Windfarm area (ha) visible within viewshed (*v*)[1]	209.36	16.51	245.31184						
Observation effort (*e*v*)	7536.90	693.29	9567.16						
T_wV rate=$T_wV/e*v$	1.11E-06	0.00E+00	2.61E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.423	0.039	0.538						
Weighted T_wV rate (T_wV rate * weight)	4.68E-07	0.00E+00	1.40E-06						
Total weighted occupancy rate	0.000002					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.069%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.056%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,107	hours
Tw=z*a	1.17	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	595,111,814	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.45	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	587,441.70	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	4.17	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	14	m/sec
$t=(d+L)/s$	0.34	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	12	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.052	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 97% of the time N*p(collision)*0.97	0.539	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0108**	**approx one collision every**	**92.83**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.45m, wingspan 1.1m, flight speed= 14.0m/sec

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	30	0	361						
Step 1.2: Unweighted occupancy rate each viewshed (T_wVrate)									
Hours of survey effort (*e*)	141	102	141						
Windfarm area (ha) visible within viewshed (*v*)[1]	209.36	16.51	245.31						
Observation effort (*e*v*)	29414.83	1683.71	34588.97						
T_wV rate=$T_wV/e*v$	2.83E-07	0.00E+00	2.90E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.448	0.026	0.527						
Weighted T_wV rate (T_wV rate * weight)	1.27E-07	0.00E+00	1.53E-06						
Total weighted occupancy rate	0.000002					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.061%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.049%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	4,483	hours
Tw=z*a	2.21	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	595,111,814	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.45	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	587,441.70	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	7.8384	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	14	m/sec
$t=(d+L)/s$	0.34	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	23	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.052	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 97% of the time N*p(collision)*0.97	1.012	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0202**	**approx one collision every**	**49.41**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.45m, wingspan 1.1m, flight speed= 14.0m/sec

European Golden Plover North Cluster Non-Breeding Season 2017/18 Vestas 162

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	84						
Step 1.2: Unweighted occupancy rate each viewshed (T_wVrate)									
Hours of survey effort (*e*)	51	43	40						
Windfarm area (ha) visible within viewshed (*v*)[1]	66.15	213.01	164.456						
Observation effort (*e*v*)	3373.65	9159.30	6578.24						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	3.55E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.177	0.479	0.344						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	1.22E-06						
Total weighted occupancy rate	0.000001					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.062%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.060%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,860	hours
Tw=z*a	1.70	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	829,150,668	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.28	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	660,820.38	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	4.89	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	18	m/sec
$t=(d+L)/s$	0.25	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	19	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.043	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	0.698	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0140**	**approx one collision every**	**71.58**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.28m, wingspan 0.7m, flight speed= 18m/sec

European Golden Plover North Cluster Annual Vestas 162

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	84						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	159	150	148						
Windfarm area (ha) visible within viewshed (*v*)[1]	66.15	213.01	164.46						
Observation effort (*e*v*)	10517.85	31951.05	24339.49						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	9.59E-07						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.157	0.478	0.364						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	3.49E-07						
Total weighted occupancy rate	0.000000 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	0.018%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.014%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	5,560	hours
Tw=z*a	0.81	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	829,150,668	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.28	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	660,820.38	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	2.3098	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	18	m/sec
$t=(d+L)/s$	0.25	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	9	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.043	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	0.330	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0066**	**approx one collision every**	**151.41**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.28m, wingspan 0.7m, flight speed= 18m/sec

European Golden Plover South Cluster Non-Breeding Season 2017/18 Vestas 162

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	141						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	33	30	36						
Windfarm area (ha) visible within viewshed (*v*)[1]	209.36	16.51	245.31184						
Observation effort (*e*v*)	6804.14	495.21	8831.23						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	4.44E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.422	0.031	0.547						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	2.43E-06						
Total weighted occupancy rate	0.000002					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.089%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.085%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,860	hours
Tw=z*a	2.43	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	595,111,814	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.28	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	566,417.47	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	8.33	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	18	m/sec
$t=(d+L)/s$	0.25	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	33	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.043	

STAGE 3: Predicted mortality (birds per year)				
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	1.191	collisions		
Step 3.2: Adjusted using a range of avoidance rates:				
98.00%	**0.0238**	**approx one collision every**	**41.99**	**years**

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.28m, wingspan 0.72m, flight speed= 17.5m/sec

European Golden Plover South Cluster Non-Breeding Season 2021/22 Vestas 162

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	1035	2,400	0						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	36	42	39						
Windfarm area (ha) visible within viewshed (*v*)[1]	209.36	16.51	245.31184						
Observation effort (*e*v*)	7536.90	693.29	9567.16						
T_wV rate=$T_wV/e*v$	3.81E-05	9.62E-04	0.00E+00						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.423	0.039	0.538						
Weighted T_wV rate (T_wV rate * weight)	1.62E-05	3.75E-05	0.00E+00						
Total weighted occupancy rate	0.000054					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	1.969%								

Mean % activity hr^-1 in wind farm at rotor height (z)	1.595%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,860	hours
Tw=z*a	45.62	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	595,111,814	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.28	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	566,417.47	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	156.30	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	18	m/sec
$t=(d+L)/s$	0.25	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	614	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.043	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	22.347	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.4469**	**approx one collision every**	**2.24**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.28m, wingspan 0.72m, flight speed= 17.5m/sec

European Golden Plover South Cluster Annual Vestas 162

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	1035	2,400	141						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	141	102	141						
Windfarm area (ha) visible within viewshed (*v*)[1]	209.36	16.51	245.31						
Observation effort (*e*v*)	29414.83	1683.71	34588.97						
T_wV rate=$T_wV/e*v$	9.77E-06	3.96E-04	1.13E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.448	0.026	0.527						
Weighted T_wV rate (T_wV rate * weight)	4.38E-06	1.01E-05	5.96E-07						
Total weighted occupancy rate	0.000015 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	0.556%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.450%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	5,560	hours
Tw=z*a	25.02	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	595,111,814	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.28	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	566,417.47	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	85.7226	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	18	m/sec
$t=(d+L)/s$	0.25	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	337	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.043	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	12.256	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.2451**	**approx one collision every**	**4.08**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.28m, wingspan 0.72m, flight speed= 17.5m/sec

Northern Lapwing North Cluster Non-Breeding 2017/18 Vestas 162

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	93						
Step 1.2: Unweighted occupancy rate each viewshed (T_wVrate)									
Hours of survey effort (*e*)	51	43	40						
Windfarm area (ha) visible within viewshed (*v*)[1]	66.15	213.01	164.456						
Observation effort (*e*v*)	3373.65	9159.30	6578.24						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	3.93E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.177	0.479	0.344						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	1.35E-06						
Total weighted occupancy rate	0.000001 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	0.069%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.066%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,860	hours
Tw=z*a	1.89	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	829,150,668	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.3	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	663,706.06	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	5.43	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.3	m/sec
$t=(d+L)/s$	0.37	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	15	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.048	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	0.592	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0118**	**approx one collision every**	**84.45**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.34m, wingspan 0.8m, flight speed= 12.7m/sec

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	93						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	159	150	148						
Windfarm area (ha) visible within viewshed (*v*)[1]	66.15	213.01	164.46						
Observation effort (*e*v*)	10517.85	31951.05	24339.49						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	1.06E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.157	0.478	0.364						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	3.87E-07						
Total weighted occupancy rate	0.000000 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	0.020%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.016%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	5,560	hours
Tw=z*a	0.89	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	829,150,668	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.3	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	663,706.06	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	2.5685	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.3	m/sec
$t=(d+L)/s$	0.37	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	7	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.048	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	0.280	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0056**	**approx one collision every**	**178.63**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.34m, wingspan 0.8m, flight speed= 12.7m/sec

Northern Lapwing South Cluster Non-Breeding 2021/22 Vestas 162

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	2,250						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	36	42	39						
Windfarm area (ha) visible within viewshed (*v*)[1]	209.36	16.51	245.31184						
Observation effort (*e*v*)	7536.90	693.29	9567.16						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	6.53E-05						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.423	0.039	0.538						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	3.51E-05						
Total weighted occupancy rate	0.000035 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	1.290%								

Mean % activity hr^-1 in wind farm at rotor height (z)	1.045%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,860	hours
Tw=z*a	29.88	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	595,111,814	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.3	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	568,890.91	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	102.83	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.3	m/sec
$t=(d+L)/s$	0.37	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	275	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.048	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	11.207	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.2241**	**approx one collision every**	**4.46**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.30m, wingspan 0.84m, flight speed= 12.3m/sec

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	2,250						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	141	102	141						
Windfarm area (ha) visible within viewshed (*v*)[1]	209.36	16.51	245.31						
Observation effort (*e*v*)	29414.83	1683.71	34588.97						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	1.81E-05						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.448	0.026	0.527						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	9.51E-06						
Total weighted occupancy rate	0.000010 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	0.350%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.283%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	5,560	hours
Tw=z*a	15.74	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	595,111,814	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.3	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	568,890.91	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	54.1717	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	12.3	m/sec
$t=(d+L)/s$	0.37	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	145	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.048	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	5.904	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.1181**	**approx one collision every**	**8.47**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.30m, wingspan 0.84m, flight speed= 12.3m/sec

Common Snipe North Cluster Breeding Season Vestas 162

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	5610	600	0						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	72	72	72						
Windfarm area (ha) visible within viewshed (*v*)[1]	82.35	325.82	171.6626						
Observation effort (*e*v*)	5929.45	23459.30	12359.71						
T_wV rate=$T_wV/e*v$	2.63E-04	7.10E-06	0.00E+00						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)*[1]									
Weight: proportion of total survey effort made at the VP	0.142	0.562	0.296						
Weighted T_wV rate (T_wV rate * weight)	3.73E-05	3.99E-06	0.00E+00						
Total weighted occupancy rate	0.000041 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	2.115%								
Mean % activity hr^-1 in wind farm at rotor height (z)	1.713%								

Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,700	hours
Tw=z*a	46.26	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	829,150,668	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.26	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	657,934.70	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	132.1430	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	16	m/sec
$t=(d+L)/s$	0.29	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	464	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.042	
STAGE 3: Predicted mortality (birds per year)		
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	16.635	collisions

Step 3.2: Adjusted using a range of avoidance rates:				
98.00%	**0.3327**	**approx one collision every**	**3.01**	**years**

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.26m, wingspan 0.455m, flight speed= 16.0m/sec

Common Snipe North Cluster Non-Breeding Season 2017/18 Vestas 162

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	31						
Step 1.2: Unweighted occupancy rate each viewshed (T_wVrate)									
Hours of survey effort (*e*)	51	43	40						
Windfarm area (ha) visible within viewshed (*v*)[1]	82.35	325.82	171.66259						
Observation effort (*e*v*)	4200.03	14010.41	6866.50						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	1.25E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.167	0.559	0.274						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	3.43E-07						
Total weighted occupancy rate	0.000000					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.018%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.017%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,860	hours
Tw=z*a	0.48	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	829,150,668	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.26	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	657,934.70	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	1.37	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	16	m/sec
$t=(d+L)/s$	0.29	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	5	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.042	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	0.172	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0034**	**approx one collision every**	**290.33**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.26m, wingspan 0.455m, flight speed= 16.0m/sec

Common Snipe North Cluster Non-Breeding Season 2020/21 Vestas 162

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	15	0						
Step 1.2: Unweighted occupancy rate each viewshed (T_wVrate)									
Hours of survey effort (*e*)	36	35	36						
Windfarm area (ha) visible within viewshed (*v*)[1]	82.35	325.82	171.66259						
Observation effort (*e*v*)	2964.73	11403.82	6179.85						
T_wV rate=$T_wV/e*v$	0.00E+00	3.65E-07	0.00E+00						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.144	0.555	0.301						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	2.03E-07	0.00E+00						
Total weighted occupancy rate	0.000000					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.010%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.008%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,860	hours
Tw=z*a	0.24	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	829,150,668	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.26	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	657,934.70	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	0.69	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	16	m/sec
$t=(d+L)/s$	0.29	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	2	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.042	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	0.086	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0017**	**approx one collision every**	**578.42**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.26m, wingspan 0.455m, flight speed= 16.0m/sec

	Viewsheds								
	1	**2**	**3**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	5610	615	31						
Step 1.2: Unweighted occupancy rate each viewshed (T_wVrate)									
Hours of survey effort (*e*)	159	150	148						
Windfarm area (ha) visible within viewshed (*v*)[1]	82.35	325.82	171.66						
Observation effort (*e*v*)	13094.21	48873.53	25406.06						
T_wV rate=$T_wV/e*v$	1.19E-04	3.50E-06	3.39E-07						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.150	0.559	0.291						
Weighted T_wV rate (T_wV rate * weight)	1.78E-05	1.96E-06	9.86E-08						
Total weighted occupancy rate	0.000020 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	1.018%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.825%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	5,560	hours
Tw=z*a	45.84	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	829,150,668	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.26	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	657,934.70	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	130.9610	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	16	m/sec
$t=(d+L)/s$	0.29	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	460	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.042	
STAGE 3: Predicted mortality (birds per year)		

Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	16.486	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.3297**	**approx one collision every**	**3.03**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.26m, wingspan 0.455m, flight speed= 16.0m/sec

Common Snipe South Cluster Non-Breeding Season 2020/21 Vestas 162

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	105						
Step 1.2: Unweighted occupancy rate each viewshed (T_wVrate)									
Hours of survey effort (*e*)	36	42	39						
Windfarm area (ha) visible within viewshed (*v*)[1]	209.36	16.51	245.31184						
Observation effort (*e*v*)	7536.90	693.29	9567.16						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	3.05E-06						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)* [1]									
Weight: proportion of total survey effort made at the VP	0.423	0.039	0.538						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	1.64E-06						
Total weighted occupancy rate	0.000002					birds seconds per ha/hour			
Mean % activity hr^-1 in wind farm at risk height	0.060%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.049%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	2,107	hours
Tw=z*a	1.03	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	595,111,814	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.26	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	563,944.03	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	3.50	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	16	m/sec
$t=(d+L)/s$	0.29	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	12	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.042	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	0.441	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0088**	**approx one collision every**	**113.33**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.26m, wingspan 0.455m, flight speed= 16.0m/sec

Common Snipe South Cluster Annual Vestas 162

	Viewsheds								
	4	**5**	**7**						
STAGE 1: Estimation of rotor transits									
Step 1.1: Seconds occupancy of the survey risk volume (T_w)[1] recorded within each viewshed (T_wV)	0	0	105						
Step 1.2: Unweighted occupancy rate each viewshed ($T_wV$rate)									
Hours of survey effort (*e*)	141	102	141						
Windfarm area (ha) visible within viewshed (*v*)[1]	209.36	16.51	245.31						
Observation effort (*e*v*)	29414.83	1683.71	34588.97						
T_wV rate=$T_wV/e*v$	0.00E+00	0.00E+00	8.43E-07						
Step 1.3: Weighted occupancy rate *(weighted T_wV rate)*[1]									
Weight: proportion of total survey effort made at the VP	0.448	0.026	0.527						
Weighted T_wV rate (T_wV rate * weight)	0.00E+00	0.00E+00	4.44E-07						
Total weighted occupancy rate	0.000000 birds seconds per ha/hour								
Mean % activity hr^-1 in wind farm at risk height	0.016%								

Mean % activity hr^-1 in wind farm at rotor height (z)	0.013%	
Step 1.4: Total occupancy of risk volume during surveys (T_w)		
Hours potentially active: breeding season (a) (footnote 2)	4,483	hours
Tw=z*a	0.59	hours
Step 1.6: Flight risk volume (V_w)		
Risk volume: $V_w=A*h$ (footnote 3)	595,111,814	m^3
Step 1.7: Volume swept by windfarm rotors (V_r)		
Bird length (L)	0.26	m
Rotor-swept volume: $V_r=N*\pi*r^2*(d+L)$ footnote 4	563,944.03	m^3
Step 1.8: Bird occupancy of rotor-swept volume (Tr)		
$T_r=T_w*(V_r/Vw)$	2.0207	seconds
Step 1.9: Time taken to transit rotor *(t)*		
Flight speed *(s)*	16	m/sec
$t=(d+L)/s$	0.29	seconds
Step 1.10: Number of rotor transits (N)		
$N=T_r/t$	7	rotor transits
STAGE 2: Probability of Collision for a bird flying through rotors (*p*(collision)) from SNH spreadsheet[5]	0.042	

STAGE 3: Predicted mortality (birds per year)					
Step 3.1: With no avoidance, turbines operational 85% of the time N*p(collision)*0.85	0.254	collisions			
Step 3.2: Adjusted using a range of avoidance rates:					
98.00%	**0.0051**	**approx one collision every**	**196.56**	**years**	

[1] The survey risk volume was derived from the windfarm polygon including a precautionary 500m buffer around the turbine rotors.

[2] The total number of daylight hours during the period

[3] A= size of windfarm polygon(ha) h= rotor diameter (m)

[4] N= number of turbines, r= rotor radius (m), d= max depth of rotors (m)

[5]Assumes bird length=0.26m, wingspan 0.455m, flight speed= 16.0m/sec

EUROPEAN OFFICES

United Kingdom

AYLESBURY
T: +44 (0)1844 337380

BELFAST
belfast@slrconsulting.com

BRADFORD-ON-AVON
T: +44 (0)1225 309400

BRISTOL
T: +44 (0)117 906 4280

CARDIFF
T: +44 (0)29 2049 1010

CHELMSFORD
T: +44 (0)1245 392170

EDINBURGH
T: +44 (0)131 335 6830

EXETER
T: + 44 (0)1392 490152

GLASGOW
glasgow@slrconsulting.com

GUILDFORD
guildford@slrconsulting.com

LONDON
T: +44 (0)203 805 6418

MAIDSTONE
T: +44 (0)1622 609242

MANCHESTER (Denton)
T: +44 (0)161 549 8410

MANCHESTER (Media City)
T: +44 (0)161 872 7564

NEWCASTLE UPON TYNE
T: +44 (0)191 261 1966

NOTTINGHAM
T: +44 (0)115 964 7280

SHEFFIELD
T: +44 (0)114 245 5153

SHREWSBURY
T: +44 (0)1743 23 9250

STIRLING
T: +44 (0)1786 239900

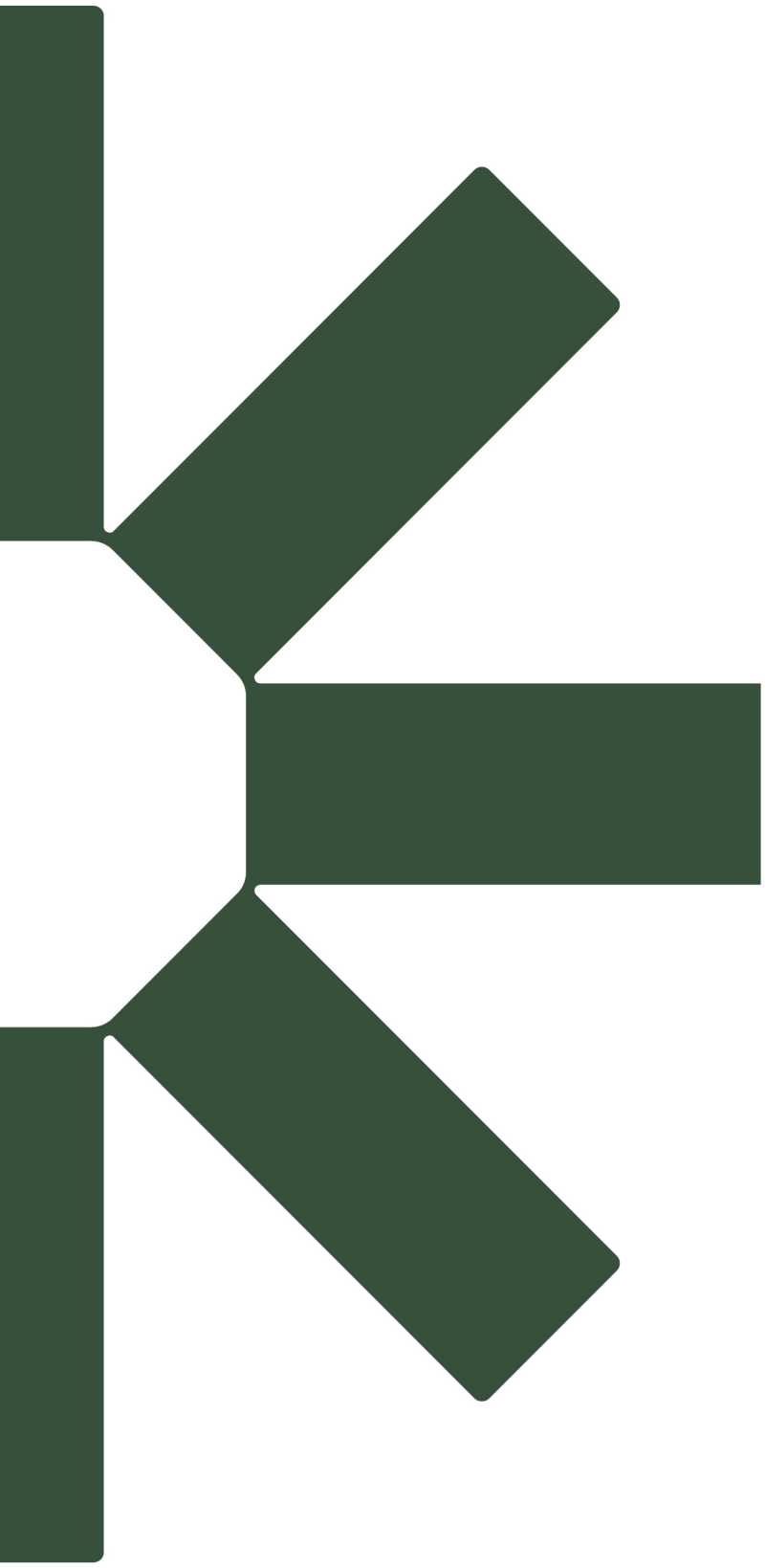
WORCESTER
T: +44 (0)1905 751310

Ireland

DUBLIN
T: + 353 (0)1 296 4667

France

GRENOBLE
T: +33 (0)6 23 37 14 14



Making Sustainability Happen