Upper Ogmore Wind Farm

Technical Appendix 6.4: Collision Risk Analysis

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Collision Risk Analysis

1.1 Worked collision risk analysis for four species (red kite, kestrel, peregrine and golden plover) is contained in this Appendix.

1.2 For all species collision risk has been calculated using both the 'random' flight models as this is more appropriate of two models available[1].

1.3 There are numerous sources of information on flight speed in birds, but few of these present figures that correspond, and birds can vary their speed according to what they are doing (e.g. soaring, gliding or pursuing prey / trying to evade capture). Precautionary (low) flight speeds are presented for each species modelled[2]. Slower speed makes birds less likely to avoid turning blades by chance (i.e. through flying through the rotor swept area without taking avoiding action).

1.4 The size of birds (total length and length of the wing) is also precautionary in each case, and is based on the largest given measurement for the species concerned in Baker (2016)[3]. Larger size also makes avoiding rotating blades by chance less likely.

1.5 Only those flights that included time at collision risk height and that passed within 250 m (to account for the sweep of the blades (50 m) and observer error (200 m, as recommended in the relevant guidance (SNH, 2000; Band et al, 2007)) were entered into the model. The flight times, height and durations are provided for each species in the methods.

1.6 The length and width of the Site, including a perimeter 'buffer' of 250 m (as described above), has been taken as 2608 m (the distance between turbines 1 and 6) x 842 m (the distance between turbines 1 and 4) respectively. This was calculated using ArcGIS.

[1] The alternative model is applied to species that make predictable / non-random flights, and is best suited to species (including geese) that fly in flocks on relatively direct flight paths)
[2] Based on data presented in Bruderer, B. & Boldt, A. (2001) Flight characteristics of birds: I. radar measurements of speeds. Ibis.143. Pp. 178-204.
[3] J K Baker (2016) Identification of European Non-Passerines. British Trust for Ornithology

Site Name

Upper Ogmore

Bird Dimensions

Species	Red kite
length (m)	0.72
wing span (m)	1.65
speed (m/sec)	8

= data input required
= model calculates value

Sources of speed and dimension information: Whitfield & Madders (2006); Svensson *et al* ., (1999)

Turbine Dimensions

Height of tower (m)	97.4
Blade length (m)	51.15
Max blade height (m)	148.55
Min blade height (m)	46.25
Depth of rotor (m)	3.651781003

Wind Farm Dimensions

No of turbines	7
Site width (m)	842
Site length (m)	2608

Both width and length include a 440m 'extension' to allow for the sweep of the blades and margin for flight line plo

Turbine Specifications

K: [1D or [3D] (0 or 1)	1
NoBlades	3
MaxChord	4 *
Pitch (degrees)	20 *
Rotation period	3 *

Flight Characteristics

Flapping (0) or gliding (+1) 1

Night adjustment

What percentage of the night is the target species active? 5 **%**

Survey Data

Total survey time (hours) 288

Period when Red kite **likely to be on site.** **Type in the number of days in each month where the target species is present within the site:**

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
31	28	31	30	30	30	31	31	30	31	30	31

Total number of months when Red kite **likely to be present:** 12

Enter the date of each record, the time the bird(s) was recorded in the collision risk area and the number of birds on a separate.
Bird occupancy is automatically calculated.

Date	Time observed (seconds)	Number of birds	Bird Occupancy in flight risk volume	
25/04/14	120	1	120	(the time in seconds is aggregated time
25/04/14	90	1	90	for each species modelled)
26/06/14	15	1	15	
26/06/14	15	1	15	
22/08/14	30	2	60	
22/10/14	75	1	75	
22/10/14	15	1	15	
22/10/14	15	1	15	
22/10/14	15	1	15	
22/10/14	15	1	15	
28/10/14	120	1	120	
28/10/14	15	1	15	
28/10/14	45	1	45	
28/10/14	30	1	30	
28/10/14	30	1	30	
25/11/14	30	1	30	
25/11/14	30	1	30	
13/05/15	90	1	90	
13/05/15	60	2	120	
13/05/15	15	1	15	
13/05/15	75	4	300	
13/05/15	15	2	30	
04/06/15	45	1	45	
04/06/15	60	1	60	
04/06/15	60	1	60	
04/06/15	75	1	75	
04/06/15	15	1	15	
04/06/15	30	1	30	
31/07/15	165	2	330	
31/07/15	165	2	330	
31/07/15	75	2	150	
31/07/15	30	2	60	
31/07/15	45	2	90	
31/07/15	15	2	30	
31/07/15	30	2	60	
09/09/15	15	1	15	
09/09/15	15	1	15	
09/09/15	15	1	15	
09/09/15	15	1	15	

	Time observed (seconds)	Number of birds	Bird Occupancy in flight risk volume
19/10/15	30	1	30
19/10/15	30	1	30
19/10/15	15	1	15
19/10/15	15	1	15
19/10/15	15	1	15
19/10/15	30	1	30
20/11/15	30	1	30
20/11/15	15	1	15
20/11/15	30	1	30
10/12/15	30	1	30
10/12/15	45	2	90
10/12/15	105	2	210
10/12/15	15	2	30
10/12/15	90	1	90
16/01/16	45	1	45
16/01/16	30	1	30
28/01/16	15	1	15
28/01/16	30	1	30
28/01/16	30	1	30
28/01/16	60	1	60
28/01/16	60	1	60
28/01/16	15	1	15
24/02/16	60	2	120
21/03/16	45	1	45
Total	**2715**	**80**	**3795**

Method 1 - Birds using the windfarm airspace (to be used for birds that fly across the site using a variety of different flight paths)

= data input required
= model calculates value

Step 1 **Go to Data Input**

Input data about the species that is being assessed - body length, wing span and flight speed
Input data on turbine dimensions
Input data on wind farm area
Input data on turbine dimensions and specification
Input all vantage point data for the species that is being assessed - number of birds and flight time within the study area
Input the number of days for each month where the species is likely to be present within the site
Input days for those months where the species is likely to be present within the site
Input the appropriate night time correction factor for the species being assessed, e.g. a 25% nocturnal flight time correction was proposed by Band et al for geese. This correction cannot be applied to all species, for example raptors.

Step 2 **Go to Collision Risk**

Final collision risk estimates are highlighted
Only use the collision risk estimate for the method that has been used

Scottish Natural Heritage: Calculating a theoretical collision risk assuming no avoiding action

Site Name: Upper Ogmore

= data input required
= model calculates value

Stage 1: Number of birds flying through rotors

Input Parameters

Bird Dimensions

Species	Red kite
length (m)	0.72
wing span (m)	1.65
speed (m/sec)	8

Bird Flight Data

No of birds	80
Time spent in V_w (sec)	58144.54

Turbine Dimensions

Height of tower (m)	97.4
Blade length (m)	51.15
Max blade height (m)	148.55
Min blade height (m)	46.25
Depth of rotor (m)	3.651781

Wind Farm Dimensions

No of turbines	7
Site width (m)	842
Site length (m)	2608
Area (m^2)	2195936

Method 1 - Birds using the windfarm airspace

(to be used for birds that fly across the site using a variety of different flight paths)

Step No	Description of Calculation		Calculation	Comments
1	Identify 'flight risk volume' V_w' which is the area of the wind farm multiplied by the height of the turbines	V_w =	326206292.8 m^3	Area is equivalent to survey area and should include minimum of 500m buffer around turbines
2	Calculate the combined volume swept out by the rotors $V_r = N \times \pi R^2 \times (d + l)$ where N is the number of turbines, d is the depth of the	V_r =	251503.08 m^3	

	rotor front to back, and l is the bird length				
3	Estimate bird occupancy n within V_w This is the number of birds multiplied by the time spent within V_w (per season/year)	n =	58144.54	secs per yr	Bird occupancy is based on observations of birds flying through rotor-swept area
4	Bird occupancy of V_r n x (V_r / V_w) bird-seconds	occupancy =	44.83	bird-seconds	
5	Time taken for a bird to make transit through and completely clear the rotors t = (d + l) / v where v is bird speed (m/sec)	t =	0.55	seconds	Speed should be assessed in the field but published values are available
6	Calculate number of bird transits through the rotors = n x (V_r / V_w) / t	transits =	82.03	bird transits per annum	

Number of bird transits through the rotors per annum = 82.03

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA

Input parameters regarding the turbine specification will need to be obtained from the design engineers or manufacturers.

W Band 15/10/2018

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	4	m
Pitch (degrees)	20	
BirdLength	0.72	m
Wingspan	1.65	m
F: Flapping (0) or gliding (+1)	1	
Bird speed	8	m/sec
RotorDiam	102.3	m
RotationPeriod	3.00	sec
Bird aspect ratioo: β	0.44	

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

				Upwind:			Downwind:		
r/R	c/C	α	collide		contribution	collide		contribution
radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
0.025	0.575	2.99	10.38	1.00	0.00125	8.81	1.00	0.00125
0.075	0.575	1.00	3.98	0.50	0.00374	2.41	0.30	0.00226
0.125	0.702	0.60	3.16	0.40	0.00494	1.24	0.16	0.00194
0.175	0.860	0.43	3.28	0.41	0.00717	0.92	0.12	0.00202
0.225	0.994	0.33	3.32	0.42	0.00934	0.84	0.10	0.00236
0.275	0.947	0.27	2.98	0.37	0.01025	1.05	0.13	0.00361
0.325	0.899	0.23	2.73	0.34	0.01108	1.17	0.15	0.00477
0.375	0.851	0.20	2.52	0.32	0.01182	1.25	0.16	0.00585
0.425	0.804	0.18	2.35	0.29	0.01248	1.29	0.16	0.00685
0.475	0.756	0.16	2.20	0.28	0.01307	1.31	0.16	0.00776
0.525	0.708	0.14	2.07	0.26	0.01357	1.31	0.16	0.00860
0.575	0.660	0.13	1.95	0.24	0.01399	1.30	0.16	0.00935
0.625	0.613	0.12	1.83	0.23	0.01432	1.28	0.16	0.01002
0.675	0.565	0.11	1.73	0.22	0.01458	1.26	0.16	0.01061
0.725	0.517	0.10	1.63	0.20	0.01475	1.23	0.15	0.01112
0.775	0.470	0.10	1.53	0.19	0.01485	1.19	0.15	0.01155
0.825	0.422	0.09	1.44	0.18	0.01486	1.15	0.14	0.01190
0.875	0.374	0.09	1.35	0.17	0.01479	1.11	0.14	0.01216
0.925	0.327	0.08	1.27	0.16	0.01464	1.07	0.13	0.01234
0.975	0.279	0.08	1.18	0.15	0.01440	1.02	0.13	0.01245

Overall p(collision) = Upwind 23.0% Downwind 14.9%

Average 18.9%

Bird survey data

Date	Time observed (seconds)		Number of geese	Bird Occupancy in flight risk volume
TOTAL	2715		80	3795

TOTAL SURVEY TIME 288 hours or 1036800 seconds

Period when Red kite likely to be on site (see below) =

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
31	28	31	30	30	30	31	31	30	31	30	31

Total days = 364 Total hours (corrected - see below) = 4412.55

Period when Red kite likely to be on site = 15885180 seconds (in each year)

Assumptions (write in any assumptions that have been included in the model)
Assumption 1: The flying period extends from dawn to dusk and includes 25% of night.
Assumption 2:
Assumption 3:
Assumption 4:

Proportion of time during which a collision may occur = 15885180 (in each year)

Red kite flight time = 3795 seconds in 1036800 seconds survey time

Therefore in 12 months = 58144.54 seconds

Note: This table is only relevant when calculating collision risk for goose species. It provides an adjustment for nocturnal flight behaviour for these species.

Number of hours geese are potentially active during winter (from Band et al, in press)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nox	Dec	
Mean Daylight hours		8	10	12	13	14	15	14	13	12	11	9	7	
Mean Nocturnal hrs*	5	0.8	0.7	0.6	0.55	0.5	0.45	0.5	0.55	0.6	0.65	0.75	0.85	
Combined Daily Mean		8.8	10.7	12.6	13.55	14.5	15.45	14.5	13.55	12.6	11.65	9.75	7.85	
No of days birds present		31	28	31	30	30	30	31	31	30	31	30	31	
Total hours each month		**272.8**	**299.6**	**390.6**	**406.5**	**435**	**463.5**	**449.5**	**420.05**	**378**	**361.15**	**292.5**	**243.35**	**4412.55**
Total hours per year		**4412.55**												

Method 1 - Birds using the windfarm airspace (to be used for birds that fly across the site using a variety of different flight paths)

Number of bird transits through the rotors per annum =	82.03
Average collision risk for bird passing through rotor =	18.9%
Number of birds potentially killed by rotors per annum =	15.53

NB: The above calculation assumes no avoidance

Correcting for 95% avoidance rate:		Correcting for 98% avoidance rate:		Correcting for 99% avoidance rate:	
Number of birds potentially killed by rotors per annum =	0.776554	Number of birds potentially killed by rotors per annum =	0.310621	Number of birds potentially killed by rotors per annum =	0.15531

Site Name

Upper Ogmore

Bird Dimensions

Species	Red kite (2020)
length (m)	0.72
wing span (m)	1.65
speed (m/sec)	8

= data input required
= model calculates value

Sources of speed and dimension information: Whitfield & Madders (2006); Svensson *et al* ., (1999)

Turbine Dimensions

Height of tower (m)	97.4
Blade length (m)	51.15
Max blade height (m)	148.55
Min blade height (m)	46.25
Depth of rotor (m)	3.651781003

Wind Farm Dimensions

No of turbines	7
Site width (m)	842
Site length (m)	2608

Both width and length include a 440m 'extension' to allow for the sweep of the blades and margin for fl

Turbine Specifications

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	4	*
Pitch (degrees)	20	*
Rotation period	3	*

Flight Characteristics

Flapping (0) or gliding (+1)	1

Night adjustment

What percentage of the night is the target species active? 5 **%**

Survey Data

Total survey time (hours)	72

Period when Red kite (2020) likely to be on site.

Type in the number of days in each month where the target species is present within the site:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
31	28	31	30	30	30	31	31	30	31	30	31

Total number of months when Red kite (2020) **likely to be present:** 12

Enter the date of each record, the time the bird(s) was recorded in the collision risk area and the number of birds on a separate.
Bird occupancy is automatically calculated.

Date	Time observed (seconds)	Number of birds	Bird Occupancy in flight risk volume	
22/04/20	60	1	60	(the time in seconds is aggregated
15/05/20	15	1	15	for each species modelled)
15/05/20	195	1	195	
15/05/20	210	1	210	
01/06/20	45	1	45	
01/06/20	90	1	90	
17/06/20	60	1	60	
25/06/20	135	1	135	
25/06/20	15	1	15	
Total	**825**	**9**	**825**	

Method 1 - Birds using the windfarm airspace (to be used for birds that fly across the site using a variety of different flight paths)

= data input required
= model calculates value

Step 1 **Go to Data Input**

Input data about the species that is being assessed - body length, wing span and flight speed
Input data on turbine dimensions
Input data on wind farm area
Input data on turbine dimensions and specification
Input all vantage point data for the species that is being assessed - number of birds and flight time within the study area
Input the number of days for each month where the species is likely to be present within the site
Input days for those months where the species is likely to be present within the site
Input the appropriate night time correction factor for the species being assessed, e.g. a 25% nocturnal flight time correction was proposed by Band et al for geese. This correction cannot be applied to all species, for example raptors.

Step 2 **Go to Collision Risk**

Final collision risk estimates are highlighted
Only use the collision risk estimate for the method that has been used

Scottish Natural Heritage: Calculating a theoretical collision risk assuming no avoiding action

Site Name: Upper Ogmore

= data input required
= model calculates value

Stage 1: Number of birds flying through rotors

Input Parameters

Bird Dimensions

Species	Red kite (2020)
length (m)	0.72
wing span (m)	1.65
speed (m/sec)	8

Bird Flight Data

No of birds	9
Time spent in V_w (sec)	50560.47

Turbine Dimensions

Height of tower (m)	97.4
Blade length (m)	51.15
Max blade height (m)	148.55
Min blade height (m)	46.25
Depth of rotor (m)	3.651781

Wind Farm Dimensions

No of turbines	7
Site width (m)	842
Site length (m)	2608
Area (m^2)	2195936

Method 1 - Birds using the windfarm airspace

(to be used for birds that fly across the site using a variety of different flight paths)

Step No	Description of Calculation		Calculation	Comments
1	Identify 'flight risk volume' V_w' which is the area of the wind farm multiplied by the height of the turbines	V_w =	326206292.8 m^3	Area is equivalent to survey area and should include minimum of 500m buffer around turbines
2	Calculate the combined volume swept out by the rotors $V_r = N \times \pi R^2 \times (d + l)$ where N is the number of turbines, d is the depth of the	V_r =	251503.08 m^3	

	rotor front to back, and l is the bird length				
3	Estimate bird occupancy n within V_w This is the number of birds multiplied by the time spent within V_w (per season/year)	n =	50560.47	secs per yr	Bird occupancy is based on observations of birds flying through rotor-swept area
4	Bird occupancy of V_r n x (V_r / V_w) bird-seconds	occupancy =	38.98	bird-seconds	
5	Time taken for a bird to make transit through and completely clear the rotors t = (d + l) / v where v is bird speed (m/sec)	t =	0.55	seconds	Speed should be assessed in the field but published values are available
6	Calculate number of bird transits through the rotors = n x (V_r / V_w) / t	transits =	71.33	bird transits per annum	

Number of bird transits through the rotors per annum = 71.33

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA

Input parameters regarding the turbine specification will need to be obtained from the design engineers or manufacturers.

W Band 04/09/2020

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	4	m
Pitch (degrees)	20	
BirdLength	0.72	m
Wingspan	1.65	m
F: Flapping (0) or gliding (+1)	1	
Bird speed	8	m/sec
RotorDiam	102.3	m
RotationPeriod	3.00	sec
Bird aspect ratioo: β	0.44	

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

				Upwind:			Downwind:		
r/R	c/C	α	collide		contribution	collide		contribution
radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
0.025	0.575	2.99	10.38	1.00	0.00125	8.81	1.00	0.00125
0.075	0.575	1.00	3.98	0.50	0.00374	2.41	0.30	0.00226
0.125	0.702	0.60	3.16	0.40	0.00494	1.24	0.16	0.00194
0.175	0.860	0.43	3.28	0.41	0.00717	0.92	0.12	0.00202
0.225	0.994	0.33	3.32	0.42	0.00934	0.84	0.10	0.00236
0.275	0.947	0.27	2.98	0.37	0.01025	1.05	0.13	0.00361
0.325	0.899	0.23	2.73	0.34	0.01108	1.17	0.15	0.00477
0.375	0.851	0.20	2.52	0.32	0.01182	1.25	0.16	0.00585
0.425	0.804	0.18	2.35	0.29	0.01248	1.29	0.16	0.00685
0.475	0.756	0.16	2.20	0.28	0.01307	1.31	0.16	0.00776
0.525	0.708	0.14	2.07	0.26	0.01357	1.31	0.16	0.00860
0.575	0.660	0.13	1.95	0.24	0.01399	1.30	0.16	0.00935
0.625	0.613	0.12	1.83	0.23	0.01432	1.28	0.16	0.01002
0.675	0.565	0.11	1.73	0.22	0.01458	1.26	0.16	0.01061
0.725	0.517	0.10	1.63	0.20	0.01475	1.23	0.15	0.01112
0.775	0.470	0.10	1.53	0.19	0.01485	1.19	0.15	0.01155
0.825	0.422	0.09	1.44	0.18	0.01486	1.15	0.14	0.01190
0.875	0.374	0.09	1.35	0.17	0.01479	1.11	0.14	0.01216
0.925	0.327	0.08	1.27	0.16	0.01464	1.07	0.13	0.01234
0.975	0.279	0.08	1.18	0.15	0.01440	1.02	0.13	0.01245

Overall p(collision) = Upwind 23.0% Downwind 14.9%

Average 18.9%

Bird survey data

Date	Time observed (seconds)			Number of geese	Bird Occupancy in flight risk volume
TOTAL	825			9	825
TOTAL SURVEY TIME	72	hours	or	259200	seconds

Period when Red kite (202 likely to be on site (see below) =

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
31	28	31	30	30	30	31	31	30	31	30	31

Total days = 364 Total hours (corrected - see below) = 4412.55

Period when Red kite (202 likely to be on site = 15885180 seconds (in each year)

Assumptions (write in any assumptions that have been included in the model)
Assumption 1: The flying period extends from dawn to dusk and includes 25% of night.
Assumption 2:
Assumption 3:
Assumption 4:

Proportion of time during which a collision may occur = 15885180 (in each year)
Red kite (2020 flight time = 825 seconds in 259200 seconds survey time
Therefore in 12 months = 50560.47 seconds

Note: This table is only relevant when calculating collision risk for goose species. It provides an adjustment for nocturnal flight behaviour for these species.

Number of hours geese are potentially active during winter (from Band et al, in press)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nox	Dec	
Mean Daylight hours		8	10	12	13	14	15	14	13	12	11	9	7	
Mean Nocturnal hrs*	5	0.8	0.7	0.6	0.55	0.5	0.45	0.5	0.55	0.6	0.65	0.75	0.85	
Combined Daily Mean		8.8	10.7	12.6	13.55	14.5	15.45	14.5	13.55	12.6	11.65	9.75	7.85	
No of days birds present		31	28	31	30	30	30	31	31	30	31	30	31	
Total hours each month		**272.8**	**299.6**	**390.6**	**406.5**	**435**	**463.5**	**449.5**	**420.05**	**378**	**361.15**	**292.5**	**243.35**	**4412.55**
Total hours per year		**4412.55**												

Method 1 - Birds using the windfarm airspace (to be used for birds that fly across the site using a variety of different flight paths)

Number of bird transits through the rotors per annum =	71.33
Average collision risk for bird passing through rotor =	18.9%
Number of birds potentially killed by rotors per annum =	13.51

NB: The above calculation assumes no avoidance

Correcting for 95% avoidance rate:		Correcting for 98% avoidance rate:		Correcting for 99% avoidance rate:	
Number of birds potentially killed by rotors per annum =	0.675264	Number of birds potentially killed by rotors per annum =	0.270106	Number of birds potentially killed by rotors per annum =	0.13505

Site Name

Upper Ogmore

Bird Dimensions

Species	Kestrel
length (m)	0.34
wing span (m)	0.76
speed (m/sec)	9.9

= data input required
= model calculates value

Sources of speed and dimension information: Whitfield & Madders (2006); Svensson *et al* ., (1999)

Turbine Dimensions

Height of tower (m)	97.4
Blade length (m)	51.15
Max blade height (m)	148.55
Min blade height (m)	46.25
Depth of rotor (m)	3.651781003

Wind Farm Dimensions

No of turbines	7
Site width (m)	842
Site length (m)	2608

Both width and length include a 440m 'extension' to allow for the sweep of the blades and margin for fl

Turbine Specifications

K: [1D or [3D] (0 or 1)	1
NoBlades	3
MaxChord	4 *
Pitch (degrees)	20 *
Rotation period	3 *

Flight Characteristics

Flapping (0) or gliding (+1) 0

Night adjustment

What percentage of the night is the target species active? 5 **%**

Survey Data

Total survey time (hours) 288

Period when Kestrel likely to be on site.

Type in the number of days in each month where the target species is present within the site:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
31	28	31	30	30	30	31	31	30	31	30	31

Total number of months when Kestrel **likely to be present:** 12

Enter the date of each record, the time the bird(s) was recorded in the collision risk area and the number of birds on a separate.
Bird occupancy is automatically calculated.

Date	Time observed (seconds)	Number of birds	Bird Occupancy in flight risk volume	
23/05/14	75	1	75	(the time in seconds is aggregated
24/09/14	60	1	60	time for each species modelled)
24/09/14	15	1	15	
12/02/15	45	1	45	
25/06/15	15	2	30	
31/07/15	30	1	30	
31/07/15	30	1	30	
31/07/15	30	1	30	
24/08/15	30	1	30	
29/09/15	15	1	15	
29/09/15	60	1	60	
29/09/15	15	1	15	
29/09/15	120	1	120	
29/09/15	240	1	240	
29/09/15	15	1	15	
29/09/15	180	1	180	
29/09/15	145	1	145	
29/09/15	180	1	180	
10/12/15	45	1	45	
28/05/15	15	1	15	
23/07/15	150	2	300	
24/08/15	45	1	45	
24/08/15	45	1	45	
Total	**1600**	**25**	**1765**	

Method 1 - Birds using the windfarm airspace (to be used for birds that fly across the site using a variety of different flight paths)

= data input required
= model calculates value

Step 1 **Go to Data Input**

Input data about the species that is being assessed - body length, wing span and flight speed
Input data on turbine dimensions
Input data on wind farm area
Input data on turbine dimensions and specification
Input all vantage point data for the species that is being assessed - number of birds and flight time within the study area
Input the number of days for each month where the species is likely to be present within the site
Input days for those months where the species is likely to be present within the site
Input the appropriate night time correction factor for the species being assessed, e.g. a 25% nocturnal flight time correction was proposed by Band et al for geese. This correction cannot be applied to all species, for example raptors.

Step 2 **Go to Collision Risk**

Final collision risk estimates are highlighted
Only use the collision risk estimate for the method that has been used

Scottish Natural Heritage: Calculating a theoretical collision risk assuming no avoiding action

Site Name: Upper Ogmore

= data input required
= model calculates value

Stage 1: Number of birds flying through rotors

Input Parameters

Bird Dimensions

Species	Kestrel
length (m)	0.34
wing span (m)	0.76
speed (m/sec)	9.9

Bird Flight Data

No of birds	25
Time spent in V_w (sec)	27042.19

Turbine Dimensions

Height of tower (m)	97.4
Blade length (m)	51.15
Max blade height (m)	148.55
Min blade height (m)	46.25
Depth of rotor (m)	3.651781

Wind Farm Dimensions

No of turbines	7
Site width (m)	842
Site length (m)	2608
Area (m^2)	2195936

Method 1 - Birds using the windfarm airspace

(to be used for birds that fly across the site using a variety of different flight paths)

Step No	Description of Calculation		Calculation	Comments
1	Identify 'flight risk volume' V_w' which is the area of the wind farm multiplied by the height of the turbines	V_w =	326206292.8 m^3	Area is equivalent to survey area and should include minimum of 500m buffer around turbines
2	Calculate the combined volume swept out by the rotors $V_r = N \times \pi R^2 \times (d + l)$ where N is the number of turbines, d is the depth of the	V_r =	229642.15 m^3	

	rotor front to back, and l is the bird length				
3	Estimate bird occupancy n within V_w This is the number of birds multiplied by the time spent within V_w (per season/year)	n =	27042.19	secs per yr	Bird occupancy is based on observations of birds flying through rotor-swept area
4	Bird occupancy of V_r n x (V_r / V_w) bird-seconds	occupancy =	19.04	bird-seconds	
5	Time taken for a bird to make transit through and completely clear the rotors t = (d + l) / v where v is bird speed (m/sec)	t =	0.40	seconds	Speed should be assessed in the field but published values are available
6	Calculate number of bird transits through the rotors = n x (V_r / V_w) / t	transits =	47.21	bird transits per annum	

Number of bird transits through the rotors per annum = 47.21

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA

Input parameters regarding the turbine specification will need to be obtained from the design engineers or manufacturers.

W Band 15/10/2018

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	4	m
Pitch (degrees)	20	
BirdLength	0.34	m
Wingspan	0.76	m
F: Flapping (0) or gliding (+1)	0	
Bird speed	9.9	m/sec
RotorDiam	102.3	m
RotationPeriod	3.00	sec
Bird aspect ratioo: β	0.45	

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

				Upwind:			Downwind:		
r/R	c/C	α	collide		contribution	collide		contribution
radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
0.025	0.575	3.70	11.59	1.00	0.00125	10.01	1.00	0.00125
0.075	0.575	1.23	4.39	0.44	0.00332	2.81	0.28	0.00213
0.125	0.702	0.74	3.47	0.35	0.00438	1.55	0.16	0.00196
0.175	0.860	0.53	3.29	0.33	0.00581	0.93	0.09	0.00165
0.225	0.994	0.41	3.24	0.33	0.00735	0.51	0.05	0.00117
0.275	0.947	0.34	2.83	0.29	0.00786	0.44	0.04	0.00122
0.325	0.899	0.28	2.53	0.26	0.00831	0.61	0.06	0.00200
0.375	0.851	0.25	2.29	0.23	0.00869	0.72	0.07	0.00271
0.425	0.804	0.22	2.10	0.21	0.00900	0.78	0.08	0.00336
0.475	0.756	0.19	1.93	0.19	0.00924	0.82	0.08	0.00394
0.525	0.708	0.18	1.78	0.18	0.00943	0.84	0.08	0.00446
0.575	0.660	0.16	1.64	0.17	0.00954	0.84	0.09	0.00491
0.625	0.613	0.15	1.52	0.15	0.00959	0.84	0.08	0.00529
0.675	0.565	0.14	1.40	0.14	0.00957	0.82	0.08	0.00561
0.725	0.517	0.13	1.30	0.13	0.00949	0.80	0.08	0.00586
0.775	0.470	0.12	1.19	0.12	0.00934	0.77	0.08	0.00604
0.825	0.422	0.11	1.09	0.11	0.00912	0.74	0.07	0.00616
0.875	0.374	0.11	1.00	0.10	0.00884	0.70	0.07	0.00622
0.925	0.327	0.10	0.91	0.09	0.00850	0.66	0.07	0.00621
0.975	0.279	0.09	0.82	0.08	0.00808	0.62	0.06	0.00613

Overall p(collision) = Upwind 15.7% Downwind 7.8%

Average 11.7%

Bird survey data

Date	Time observed (seconds)			Number of geese	Bird Occupancy in flight risk volume
TOTAL	1600			25	1765

TOTAL SURVEY TIME 288 hours or 1036800 seconds

Period when Kestrel likely to be on site (see below) =

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
31	28	31	30	30	30	31	31	30	31	30	31

Total days = 364 Total hours (corrected - see below) = 4412.55

Period when Kestrel likely to be on site = 15885180 seconds (in each year)

Assumptions (write in any assumptions that have been included in the model)
Assumption 1: The flying period extends from dawn to dusk and includes 25% of night.
Assumption 2:
Assumption 3:
Assumption 4:

Proportion of time during which a collision may occur = 15885180 (in each year)

Kestrel flight time = 1765 seconds in 1036800 seconds survey time

Therefore in 12 months = 27042.19 seconds

Note: This table is only relevant when calculating collision risk for goose species. It provides an adjustment for nocturnal flight behaviour for these species.

Number of hours geese are potentially active during winter (from Band et al, in press)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nox	Dec	
Mean Daylight hours	8	10	12	13	14	15	14	13	12	11	9	7	
Mean Nocturnal hrs* 5	0.8	0.7	0.6	0.55	0.5	0.45	0.5	0.55	0.6	0.65	0.75	0.85	
Combined Daily Mean	8.8	10.7	12.6	13.55	14.5	15.45	14.5	13.55	12.6	11.65	9.75	7.85	
No of days birds present	31	28	31	30	30	30	31	31	30	31	30	31	
Total hours each month	**272.8**	**299.6**	**390.6**	**406.5**	**435**	**463.5**	**449.5**	**420.05**	**378**	**361.15**	**292.5**	**243.35**	**4412.55**
Total hours per year	**4412.55**												

Method 1 - Birds using the windfarm airspace (to be used for birds that fly across the site using a variety of different flight paths)

Number of bird transits through the rotors per annum =	47.21
Average collision risk for bird passing through rotor =	11.7%
Number of birds potentially killed by rotors per annum =	5.55

NB: The above calculation assumes no avoidance

Correcting for 95% avoidance rate:		Correcting for 98% avoidance rate:		Correcting for 99% avoidance rate:	
Number of birds potentially killed by rotors per annum =	0.277355	Number of birds potentially killed by rotors per annum =	0.110942	Number of birds potentially killed by rotors per annum =	0.05547

Site Name

Upper Ogmore

Bird Dimensions

Species	Peregrine
length (m)	0.42
wing span (m)	1.02
speed (m/sec)	12.1

= data input required

= model calculates value

Sources of speed and dimension information: https://app.bto.org/birdfacts/; Cochran & Applegate (198

Turbine Dimensions

Height of tower (m)	97.4
Blade length (m)	51.15
Max blade height (m)	148.55
Min blade height (m)	46.25
Depth of rotor (m)	3.651781003

Wind Farm Dimensions

No of turbines	7
Site width (m)	842
Site length (m)	2608

Both width and length include a 440m 'extension' to allow for the sweep of the blades and margin for fl

Turbine Specifications

K: [1D or [3D] (0 or 1)	1
NoBlades	3
MaxChord	4 *
Pitch (degrees)	20 *
Rotation period	3 *

Flight Characteristics

Flapping (0) or gliding (+1) 0

Night adjustment

What percentage of the night is the target species active? 5 **%**

Survey Data

Total survey time (hours) 288

Period when Peregrine likely to be on site.

Type in the number of days in each month where the target species is present within the site:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
31	28	31	30	30	30	31	31	30	31	30	31

Total number of months when Peregrine **likely to be present:** 12

Enter the date of each record, the time the bird(s) was recorded in the collision risk area and the number of birds on a separate.
Bird occupancy is automatically calculated.

Date	Time observed (seconds)	Number of birds	Bird Occupancy in flight risk volume	
31/07/15	120	1	120	(the time in seconds is aggregated
09/09/15	30	1	30	time for each species modelled)
09/09/15	15	1	15	
09/09/15	30	1	30	
09/09/15	45	1	45	
Total	**240**	**5**	**240**	

Method 1 - Birds using the windfarm airspace (to be used for birds that fly across the site using a variety of different flight paths)

= data input required
= model calculates value

Step 1 **Go to Data Input**

Input data about the species that is being assessed - body length, wing span and flight speed
Input data on turbine dimensions
Input data on wind farm area
Input data on turbine dimensions and specification
Input all vantage point data for the species that is being assessed - number of birds and flight time within the study area
Input the number of days for each month where the species is likely to be present within the site
Input days for those months where the species is likely to be present within the site
Input the appropriate night time correction factor for the species being assessed, e.g. a 25% nocturnal flight time correction was proposed by Band et al for geese. This correction cannot be applied to all species, for example raptors.

Step 2 **Go to Collision Risk**

Final collision risk estimates are highlighted
Only use the collision risk estimate for the method that has been used

Scottish Natural Heritage: Calculating a theoretical collision risk assuming no avoiding action

Site Name: Upper Ogmore

= data input required
= model calculates value

Stage 1: Number of birds flying through rotors

Input Parameters

Bird Dimensions

Species	Peregrine
length (m)	0.42
wing span (m)	1.02
speed (m/sec)	12.1

Bird Flight Data

No of birds	5
Time spent in V_w (sec)	3677.13

Turbine Dimensions

Height of tower (m)	97.4
Blade length (m)	51.15
Max blade height (m)	148.55
Min blade height (m)	46.25
Depth of rotor (m)	3.651781

Wind Farm Dimensions

No of turbines	7
Site width (m)	842
Site length (m)	2608
Area (m^2)	2195936

Method 1 - Birds using the windfarm airspace

(to be used for birds that fly across the site using a variety of different flight paths)

Step No	Description of Calculation		Calculation	Comments
1	Identify 'flight risk volume' V_w' which is the area of the wind farm multiplied by the height of the turbines	V_w =	326206292.8 m^3	Area is equivalent to survey area and should include minimum of 500m buffer around turbines
2	Calculate the combined volume swept out by the rotors $V_r = N \times \pi R^2 \times (d + l)$ where N is the number of turbines, d is the depth of the	V_r =	234244.45 m^3	

	rotor front to back, and l is the bird length				
3	Estimate bird occupancy n within V_w This is the number of birds multiplied by the time spent within V_w (per season/year)	n =	3677.13	secs per yr	Bird occupancy is based on observations of birds flying through rotor-swept area
4	Bird occupancy of V_r n x (V_r / V_w) bird-seconds	occupancy =	2.64	bird-seconds	
5	Time taken for a bird to make transit through and completely clear the rotors t = (d + l) / v where v is bird speed (m/sec)	t =	0.34	seconds	Speed should be assessed in the field but published values are available
6	Calculate number of bird transits through the rotors = n x (V_r / V_w) / t	transits =	7.85	bird transits per annum	

Number of bird transits through the rotors per annum = 7.85

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA

Input parameters regarding the turbine specification will need to be obtained from the design engineers or manufacturers.

W Band 15/10/2018

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	4	m
Pitch (degrees)	20	
BirdLength	0.42	m
Wingspan	1.02	m
F: Flapping (0) or gliding (+1)	0	
Bird speed	12.1	m/sec
RotorDiam	102.3	m
RotationPeriod	3.00	sec
Bird aspect ratioo: β	0.41	

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

				Upwind:			Downwind:		
r/R	c/C	α	collide		contribution	collide		contribution
radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
0.025	0.575	4.52	15.16	1.00	0.00125	13.59	1.00	0.00125
0.075	0.575	1.51	5.58	0.46	0.00346	4.00	0.33	0.00248
0.125	0.702	0.90	4.26	0.35	0.00440	2.34	0.19	0.00242
0.175	0.860	0.65	3.92	0.32	0.00567	1.57	0.13	0.00227
0.225	0.994	0.50	3.75	0.31	0.00697	1.03	0.08	0.00191
0.275	0.947	0.41	3.18	0.26	0.00722	0.59	0.05	0.00133
0.325	0.899	0.35	2.82	0.23	0.00759	0.48	0.04	0.00128
0.375	0.851	0.30	2.55	0.21	0.00790	0.62	0.05	0.00192
0.425	0.804	0.27	2.32	0.19	0.00816	0.72	0.06	0.00252
0.475	0.756	0.24	2.13	0.18	0.00836	0.78	0.06	0.00306
0.525	0.708	0.22	1.96	0.16	0.00851	0.82	0.07	0.00354
0.575	0.660	0.20	1.81	0.15	0.00861	0.84	0.07	0.00397
0.625	0.613	0.18	1.67	0.14	0.00865	0.84	0.07	0.00435
0.675	0.565	0.17	1.55	0.13	0.00864	0.84	0.07	0.00467
0.725	0.517	0.16	1.43	0.12	0.00857	0.82	0.07	0.00494
0.775	0.470	0.15	1.32	0.11	0.00845	0.81	0.07	0.00516
0.825	0.422	0.14	1.21	0.10	0.00828	0.78	0.06	0.00532
0.875	0.374	0.13	1.11	0.09	0.00805	0.75	0.06	0.00543
0.925	0.327	0.12	1.02	0.08	0.00777	0.72	0.06	0.00548
0.975	0.279	0.12	0.92	0.08	0.00744	0.68	0.06	0.00548

Overall p(collision) = Upwind 14.4% Downwind 6.9%

Average 10.6%

Bird survey data

Date	Time observed (seconds)	Number of geese	Bird Occupancy in flight risk volume
TOTAL	240	5	240

TOTAL SURVEY TIME 288 hours or 1036800 seconds

Period when Peregrine likely to be on site (see below) =

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
31	28	31	30	30	30	31	31	30	31	30	31

Total days = 364 Total hours (corrected - see below) = 4412.55

Period when Peregrine likely to be on site = 15885180 seconds (in each year)

Assumptions (write in any assumptions that have been included in the model)
Assumption 1: The flying period extends from dawn to dusk and includes 25% of night.
Assumption 2:
Assumption 3:
Assumption 4:

Proportion of time during which a collision may occur = 15885180 (in each year)

Peregrine flight time = 240 seconds in 1036800 seconds survey time

Therefore in 12 months = 3677.13 seconds

Note: This table is only relevant when calculating collision risk for goose species. It provides an adjustment for nocturnal flight behaviour for these species.

Number of hours geese are potentially active during winter (from Band et al, in press)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nox	Dec	
Mean Daylight hours		8	10	12	13	14	15	14	13	12	11	9	7	
Mean Nocturnal hrs*	5	0.8	0.7	0.6	0.55	0.5	0.45	0.5	0.55	0.6	0.65	0.75	0.85	
Combined Daily Mean		8.8	10.7	12.6	13.55	14.5	15.45	14.5	13.55	12.6	11.65	9.75	7.85	
No of days birds present		31	28	31	30	30	30	31	31	30	31	30	31	
Total hours each month		**272.8**	**299.6**	**390.6**	**406.5**	**435**	**463.5**	**449.5**	**420.05**	**378**	**361.15**	**292.5**	**243.35**	**4412.55**
Total hours per year		**4412.55**												

Method 1 - Birds using the windfarm airspace (to be used for birds that fly across the site using a variety of different flight paths)

Number of bird transits through the rotors per annum =	7.85
Average collision risk for bird passing through rotor =	10.6%
Number of birds potentially killed by rotors per annum =	0.83

NB: The above calculation assumes no avoidance

Correcting for 95% avoidance rate:		Correcting for 98% avoidance rate:		Correcting for 99% avoidance rate:	
Number of birds potentially killed by rotors per annum =	**0.041730**	Number of birds potentially killed by rotors per annum =	**0.016692**	Number of birds potentially killed by rotors per annum =	**0.00835**

Site Name

Upper Ogmore

Bird Dimensions

Species	Golden Plover
length (m)	0.28
wing span (m)	0.72
speed (m/sec)	22

= data input required
= model calculates value

Sources of speed and dimension information: Whitfield & Madders (2006); Svensson *et al* ., (1999)

Turbine Dimensions

Height of tower (m)	97.4
Blade length (m)	51.15
Max blade height (m)	148.55
Min blade height (m)	46.25
Depth of rotor (m)	3.651781003

Wind Farm Dimensions

No of turbines	7
Site width (m)	842
Site length (m)	2608

Both width and length include a 440m 'extension' to allow for the sweep of the blades and margin for fl

Turbine Specifications

K: [1D or [3D] (0 or 1)	1
NoBlades	3
MaxChord	4 *
Pitch (degrees)	20 *
Rotation period	3 *

Flight Characteristics

Flapping (0) or gliding (+1) 0

Night adjustment

What percentage of the night is the target species active? 5 **%**

Survey Data

Total survey time (hours) 288

Period when Golden Plover likely to be on site.

Type in the number of days in each month where the target species is present within the site:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
31	28	31	30	30	30	31	31	30	31	30	31

Total number of months when Golden Plover **likely to be present:** 12

Enter the date of each record, the time the bird(s) was recorded in the collision risk area and the number of birds on a separate.
Bird occupancy is automatically calculated.

Date	Time observed (seconds)	Number of birds	Bird Occupancy in flight risk volume	
26/01/15	195	1	195	(the time in seconds is aggregated
26/01/15	15	1	15	time for each species modelled)
26/01/15	15	5	75	
26/01/15	15	7	105	
12/02/15	15	43	645	
12/02/15	15	43	645	
12/02/15	15	43	645	
12/02/15	15	43	645	
10/12/15	60	1	60	
10/12/15	15	1	15	
24/02/16	15	1	15	
Total	**390**	**189**	**3060**	

Method 1 - Birds using the windfarm airspace (to be used for birds that fly across the site using a variety of different flight paths)

= data input required
= model calculates value

Step 1 **Go to Data Input**

Input data about the species that is being assessed - body length, wing span and flight speed
Input data on turbine dimensions
Input data on wind farm area
Input data on turbine dimensions and specification
Input all vantage point data for the species that is being assessed - number of birds and flight time within the study area
Input the number of days for each month where the species is likely to be present within the site
Input days for those months where the species is likely to be present within the site
Input the appropriate night time correction factor for the species being assessed, e.g. a 25% nocturnal flight time correction was proposed by Band et al for geese. This correction cannot be applied to all species, for example raptors.

Step 2 **Go to Collision Risk**

Final collision risk estimates are highlighted
Only use the collision risk estimate for the method that has been used

Scottish Natural Heritage: Calculating a theoretical collision risk assuming no avoiding action

Site Name: Upper Ogmore

= data input required
= model calculates value

Stage 1: Number of birds flying through rotors

Input Parameters

Bird Dimensions

Species	Golden Plover
length (m)	0.28
wing span (m)	0.72
speed (m/sec)	22

Bird Flight Data

No of birds	189
Time spent in V_w (sec)	46883.34

Turbine Dimensions

Height of tower (m)	97.4
Blade length (m)	51.15
Max blade height (m)	148.55
Min blade height (m)	46.25
Depth of rotor (m)	3.651781

Wind Farm Dimensions

No of turbines	7
Site width (m)	842
Site length (m)	2608
Area (m^2)	2195936

Method 1 - Birds using the windfarm airspace

(to be used for birds that fly across the site using a variety of different flight paths)

Step No	Description of Calculation		Calculation	Comments
1	Identify 'flight risk volume' V_w' which is the area of the wind farm multiplied by the height of the turbines	V_w =	326206292.8 m^3	Area is equivalent to survey area and should include minimum of 500m buffer around turbines
2	Calculate the combined volume swept out by the rotors $V_r = N \times \pi R^2 \times (d + l)$ where N is the number of turbines, d is the depth of the	V_r =	226190.43 m^3	

	rotor front to back, and l is the bird length				
3	Estimate bird occupancy n within V_w This is the number of birds multiplied by the time spent within V_w (per season/year)	n =	46883.34	secs per yr	Bird occupancy is based on observations of birds flying through rotor-swept area
4	Bird occupancy of V_r n x (V_r / V_w) bird-seconds	occupancy =	32.51	bird-seconds	
5	Time taken for a bird to make transit through and completely clear the rotors t = (d + l) / v where v is bird speed (m/sec)	t =	0.18	seconds	Speed should be assessed in the field but published values are available
6	Calculate number of bird transits through the rotors = n x (V_r / V_w) / t	transits =	181.90	bird transits per annum	

Number of bird transits through the rotors per annum = 181.90

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA

Input parameters regarding the turbine specification will need to be obtained from the design engineers or manufacturers.

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K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	4	m
Pitch (degrees)	20	
BirdLength	0.28	m
Wingspan	0.72	m
F: Flapping (0) or gliding (+1)	0	
Bird speed	22	m/sec
RotorDiam	102.3	m
RotationPeriod	3.00	sec
Bird aspect ratioo: β	0.39	

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

				Upwind:			Downwind:		
r/R	c/C	α	collide		contribution	collide		contribution
radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
0.025	0.575	8.21	24.45	1.00	0.00125	22.88	1.00	0.00125
0.075	0.575	2.74	8.68	0.39	0.00296	7.10	0.32	0.00242
0.125	0.702	1.64	6.47	0.29	0.00368	4.56	0.21	0.00259
0.175	0.860	1.17	5.82	0.26	0.00463	3.46	0.16	0.00275
0.225	0.994	0.91	5.43	0.25	0.00555	2.71	0.12	0.00277
0.275	0.947	0.75	4.49	0.20	0.00561	1.90	0.09	0.00237
0.325	0.899	0.63	3.82	0.17	0.00564	1.36	0.06	0.00201
0.375	0.851	0.55	3.31	0.15	0.00564	0.98	0.04	0.00167
0.425	0.804	0.48	2.91	0.13	0.00562	0.71	0.03	0.00137
0.475	0.756	0.43	2.57	0.12	0.00556	0.51	0.02	0.00109
0.525	0.708	0.39	2.29	0.10	0.00547	0.35	0.02	0.00084
0.575	0.660	0.36	2.07	0.09	0.00541	0.30	0.01	0.00078
0.625	0.613	0.33	1.88	0.09	0.00533	0.36	0.02	0.00103
0.675	0.565	0.30	1.70	0.08	0.00521	0.41	0.02	0.00125
0.725	0.517	0.28	1.54	0.07	0.00507	0.44	0.02	0.00144
0.775	0.470	0.26	1.39	0.06	0.00490	0.45	0.02	0.00160
0.825	0.422	0.25	1.25	0.06	0.00470	0.46	0.02	0.00173
0.875	0.374	0.23	1.12	0.05	0.00446	0.46	0.02	0.00184
0.925	0.327	0.22	1.00	0.05	0.00420	0.45	0.02	0.00191
0.975	0.279	0.21	0.88	0.04	0.00391	0.44	0.02	0.00195

Overall p(collision) = Upwind 9.5% Downwind 3.5%

Average 6.5%

Bird survey data

Date	Time observed (seconds)	Number of geese	Bird Occupancy in flight risk volume
TOTAL	390	189	3060

TOTAL SURVEY TIME 288 hours or 1036800 seconds

Period when Golden Plove likely to be on site (see below) =

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
31	28	31	30	30	30	31	31	30	31	30	31

Total days = 364 Total hours (corrected - see below) = 4412.55

Period when Golden Plove likely to be on site = 15885180 seconds (in each year)

Assumptions (write in any assumptions that have been included in the model)
Assumption 1: The flying period extends from dawn to dusk and includes 25% of night.
Assumption 2:
Assumption 3:
Assumption 4:

Proportion of time during which a collision may occur = 15885180 (in each year)

Golden Plover flight time = 3060 seconds in 1036800 seconds survey time

Therefore in 12 months = 46883.34 seconds

Note: This table is only relevant when calculating collision risk for goose species. It provides an adjustment for nocturnal flight behaviour for these species.

Number of hours geese are potentially active during winter (from Band et al, in press)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nox	Dec	
Mean Daylight hours		8	10	12	13	14	15	14	13	12	11	9	7	
Mean Nocturnal hrs*	5	0.8	0.7	0.6	0.55	0.5	0.45	0.5	0.55	0.6	0.65	0.75	0.85	
Combined Daily Mean		8.8	10.7	12.6	13.55	14.5	15.45	14.5	13.55	12.6	11.65	9.75	7.85	
No of days birds present		31	28	31	30	30	30	31	31	30	31	30	31	
Total hours each month		**272.8**	**299.6**	**390.6**	**406.5**	**435**	**463.5**	**449.5**	**420.05**	**378**	**361.15**	**292.5**	**243.35**	**4412.55**
Total hours per year		**4412.55**												

Method 1 - Birds using the windfarm airspace (to be used for birds that fly across the site using a variety of different flight paths)

Number of bird transits through the rotors per annum =	181.90
Average collision risk for bird passing through rotor =	6.5%
Number of birds potentially killed by rotors per annum =	11.77

NB: The above calculation assumes no avoidance

Correcting for 95% avoidance rate:		Correcting for 98% avoidance rate:		Correcting for 99% avoidance rate:	
Number of birds potentially killed by rotors per annum =	0.588748	Number of birds potentially killed by rotors per annum =	0.235499	Number of birds potentially killed by rotors per annum =	0.11775