

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 available¹.
- 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 modelled². 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 length (m) wing span (m) speed (m/sec)	Red kite 0.72 1.65 8	 = data input required = model calculates value Sources of speed and dimension information: Whitfield & Madders (2006); Svensson <i>et al.</i>, (1999)
Turbine Dimensions Height of tower (m) Blade length (m) Max blade height (m) Min blade height (m) Depth of rotor (m)	97.4 51.15 148.55 46.25 3.651781003	
Wind Farm Dimensions No of turbines Site width (m) Site length (m)	7 842 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) NoBlades MaxChord Pitch (degrees) Rotation period	1 3 4 * 20 * 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 <mark>Red kite</mark>	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 31 28 Total number of months when		r May Jun Jul Aug Sep Oct Nov Dec 30 30 30 31 31 30 31 30 31 to be present: 12

Date	Time observed (seconds)	Number of birds	Bird Occupancy in flight ris	sk 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 2 2	330	
31/07/15	75	2	150	
31/07/15	30	2	60	
31/07/15	45	2 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	

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.

	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 va

Bird Flight Data

Time spent in V_w (sec)

No of birds

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	

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 (m²)	2195936

Method '	1 - Birds using the windfarm airspace	(to be used	for birds that fly across the site u	sing a variety of different flight paths)
Step No 1	Description of Calculation Identify 'flight risk volume' V_w ' which is the area of the wind farm multiplied by the height of the turbines	V _w =	Calculation 326206292.8 m ³	Comments 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 $V_r = N \times R^2 \times (d + I)$ where N is the number of turbines, d is the depth of the	V _r =	251503.08 m ³	

80

58144.54

= model calculates value

rotor front to back, and I 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 + I) / 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 ann	um
Number c	of bird transits through the rotors per annun	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.

1 Calculation of alpha and p(collision) as a function of radius K: [1D or [3D] (0 or 1) 3 NoBlades Upwind: Downwind: MaxChord 4 m r/R c/C α collide contribution collide contribution p(collision) 20 radius length Pitch (degrees) chord alpha length from radius r p(collision) from radius r BirdLength 0.72 m 0.025 0.575 2.99 10.38 1.00 0.00125 8.81 1.00 0.00125 Wingspan 1.65 m 0.075 0.575 1.00 3.98 0.50 0.00374 2.41 0.30 0.00226 F: Flapping (0) or gliding (+1) 1 0.125 0.702 0.60 0.40 0.00494 1.24 0.16 0.00194 3.16 0.00717 0.175 0.860 0.43 3.28 0.41 0.92 0.12 0.00202 Bird speed 8 m/sec 0.225 0.994 0.33 3.32 0.42 0.00934 0.84 0.10 0.00236 RotorDiam 102.3 m 0.275 0.947 0.27 2.98 0.37 0.01025 1.05 0.13 0.00361 RotationPeriod 3.00 sec 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 0.01307 0.00776 0.475 0.756 0.16 2.20 0.28 1.31 0.16 Bird aspect ratioo: β 0.44 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 0.00935 0.16 0.01432 0.01002 0.625 0.613 0.12 1.83 0.23 1.28 0.16 0.675 0.565 0.22 0.01458 1.26 0.16 0.01061 0.11 1.73 0.01475 1.23 0.15 0.01112 0.725 0.517 0.10 1.63 0.20 0.470 0.01485 0.01155 0.775 0.10 1.53 0.19 1.19 0.15 0.825 0.422 0.01486 0.14 0.01190 0.09 1.44 0.18 1.15 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 0.01464 1.07 0.13 0.01234 0.16 0.279 0.08 0.01440 1.02 0.13 0.975 1.18 0.15 0.01245 Overall p(collision) = 23.0% Upwind Downwind 14.9%

Average 18.9%

W Band

15/10/2018

Bird survey data

	rved (seconds)			Number of g	geese	Bird Occupa		t risk vol	ume					
TOTAL 2715				80			3795							
TOTAL SURVEY TIME 288	hours	or		<mark>1036800</mark> s	econds									
Period when Red kite likely to be	on site (see below) =													
Jan Feb Mar	Apr	Ma	ay	Jun	Jul	Aug	Sep	Oct	Nov	Dec				
<u>31 28 31</u>		30	30	30	31	31	30	31	30	31				
	Total hours (corrected - see below	,				4412.55								
Period when Red kite likely to be	on site =	1588	5180	seconds (i	in each yea	ar)								
Assumptions (write in any assumptions	that have been included in the mo	dal)												
Assumption 1: The flying period extends		,												
Assumption 2:		o /o or mgm.												
Assumption 3:														
Assumption 4:														
Proportion of time during which a collision				15885180 (i	in each yea	ar)								
5	seconds	in		<mark>1036800</mark> s	econds	survey time								
Therefore in 12 months =	581	44.54 secor	nds				No				nt when calcul	•		
										•	ovides an adju		or nocturnal	
Number of hours geese are potentially	active during winter (from Band	d et al, in pr	'ess)						fli	ght behavio	our for these s	pecies.		
	Jan	Feb		Mar A	\pr	May Ju	ın Ju	ıl .	Aug Se	ep C	Oct No	x [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 2	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	44	12.55												

Method 1 - Birds using the windfarm airspace (to be used for birds that fly across the site Number of bird transits through the rotors per annum = 82.03	using a variety of different flight paths)	
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 = 0.3106	21 Number of birds potentially killed by rotors per annum = 0.15531

Site Name	Upper Ogmore	
Bird Dimensions Species length (m) wing span (m) speed (m/sec)	Red kite (2020) 0.72 1.65 8	= data input required = model calculates value Sources of speed and dimension information: Whitfield & Madders (2006); Svensson <i>et al</i> ., (1999)
Turbine Dimensions Height of tower (m) Blade length (m) Max blade height (m) Min blade height (m) Depth of rotor (m)	97.4 51.15 148.55 46.25 3.651781003	
Wind Farm Dimensions No of turbines Site width (m) Site length (m)	S 7 842 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) NoBlades MaxChord Pitch (degrees) Rotation period	1 3 4 20 3	۲ ۲ ۲
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) Period when <mark>Red kite (2020)</mark>	72 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 30 30 31 31 30 31 30 31

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

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

12

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



Stage 1: Number of birds flying through rotors

Input Parameters

Max blade height (m) Min blade height (m)

Depth of rotor (m)

Bird Dimensions		Bird Flight Data	
Species	Red kite (2020)	No of birds	9
length (m)	0.72	Time spent in V_w (sec)	50560.47
wing span (m)	1.65		
speed (m/sec)	8		
Turbine Dimensions	5	Wind Farm Dimen	sions
Height of tower (m)	97.4	No of turbines	7
Blade length (m)	51.15	Site width (m)	842

51.15	Site width (m)	842
148.55	Site length (m)	2608
46.25	Area (m²)	2195936
3.651781		

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 1	Description of Calculation Identify 'flight risk volume' V_w ' which is the area of the wind farm multiplied by the height of the turbines	V _w =	Calculation 326206292.8 m ³	Comments 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 $V_r = N \times \pi R^2 \times (d + I)$ where N is the number of turbines, d is the depth of the	V _r =	251503.08 m ³			

rotor front to back, and I 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 + I) / 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 annu	Im
Number o	f 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.

1 Calculation of alpha and p(collision) as a function of radius K: [1D or [3D] (0 or 1) 3 NoBlades Upwind: Downwind: MaxChord **4** m r/R c/C collide contribution collide contribution α 20 radius length from radius r length p(collision) from radius r Pitch (degrees) chord alpha p(collision) BirdLength 0.72 m 0.025 0.575 2.99 10.38 1.00 0.00125 8.81 1.00 0.00125 1.65 m 0.50 0.30 0.00226 Wingspan 0.075 0.575 1.00 3.98 0.00374 2.41 F: Flapping (0) or gliding (+1) 1 0.125 0.702 0.60 3.16 0.40 0.00494 1.24 0.16 0.00194 0.175 0.00717 0.92 0.12 0.00202 0.860 0.43 3.28 0.41 Bird speed 8 m/sec 0.225 0.994 0.33 3.32 0.42 0.00934 0.84 0.10 0.00236 RotorDiam 102.3 m 0.27 0.01025 0.13 0.00361 0.275 0.947 2.98 0.37 1.05 RotationPeriod 3.00 sec 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 2.20 0.01307 1.31 0.16 0.00776 0.756 0.16 0.28 Bird aspect ratioo: β 0.44 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 0.12 0.23 0.01432 1.28 0.16 0.01002 0.613 1.83 0.675 0.565 0.11 1.73 0.22 0.01458 1.26 0.16 0.01061 0.725 0.20 0.01475 1.23 0.15 0.01112 0.517 0.10 1.63 0.775 0.470 0.10 1.53 0.19 0.01485 1.19 0.15 0.01155 0.825 0.422 1.44 0.01486 0.14 0.01190 0.09 0.18 1.15 0.875 0.374 0.09 1.35 0.17 0.01479 1.11 0.14 0.01216 0.01234 0.925 0.327 0.08 1.27 0.16 0.01464 1.07 0.13 0.975 1.02 0.13 0.279 0.08 1.18 0.15 0.01440 0.01245 Overall p(collision) = 23.0% Upwind Downwind 14.9%

Average 18.9%

W Band

04/09/2020

Bird survey data

-0741		Fime observed (seco	nds)			Number of	geese	Bird Occup	ancy in flig	ght risk vo	olume					
FOTAL		825				9			825							
FOTAL SURVE	EY TIME	72 hours		or		259200	seconds									
eriod when	Red kite (202 li	ikely to be on site (see	e below) =													
Jan	Feb	Mar	Apr		Иay	Jun	Jul	Aug	Sep	Oct	Nov	Dec				
31	28	31		30	30	30	31	31	30	31	30	31				
otal days =	364		(corrected - see below	,				4412.55								
eriod when	Red kite (202 li	ikely to be on site =		158	885180	seconds	(in each ye	ar)								
ssumptions	(write in any as	sumptions that have	been included in the mo	del)												
•		•	to dusk and includes 2	,	nt											
ssumption 2:				, , , , , , , , , , , , , , , , , , ,												
ssumption 3:																
ssumption 4:																
Southpuon 4.																
•																
roportion of tir	0	h a collision may occu	r =			15885180	· ·	,								
roportion of tir ed kite (2020)	flight time =	825 seconds		in			· ·	ar) survey time								
Proportion of tir Red kite (2020)	flight time =	,		in <mark>60.47</mark> seco	onds		· ·	,		Note:	This table is					
Proportion of tir ted kite (2020 herefore in	flight time = 12 n	825 seconds months =	5056	0.47 seco		259200	· ·	,		Note:	for goose sp	ecies. It pr	rovides an ac	djustment fo		I
Proportion of tir Red kite (2020 herefore in	flight time = 12 n	825 seconds months =		0.47 seco		259200	· ·	,		Note:	for goose sp	ecies. It pr		djustment fo		I
roportion of tir ed kite (2020) herefore in	flight time = 12 n	825 seconds months =	5056	0.47 seco	press)	259200	seconds	survey time		Note: Jul	for goose sp fi	ecies. It pr ight behav	rovides an ac iour for these	djustment fo species.		I
roportion of tir ed kite (2020) herefore in umber of hou	flight time = 12 n 12 n urs geese are j	825 seconds nonths = potentially active du	5056	6 <mark>0.47</mark> seco I et al, in	press)	259200 Mar	seconds	survey time			for goose sp fl Aug	ecies. It pr ight behav	rovides an ac iour for these	djustment fo species.	or nocturnal	I
roportion of tir ed kite (2020) herefore in umber of hou lean Daylight	flight time = 12 n 12 n urs geese are p hours	825 seconds nonths = potentially active du	5056	6 <mark>0.47</mark> seco I et al, in Feb	press)	259200 Mar	seconds	survey time May	Jun	Jul	for goose sp fi Aug S 13	ecies. It pr ight behav	rovides an ac iour for these Oct N	djustment fo e species. lox [or nocturnal	I
roportion of tir ed kite (2020) herefore in umber of hou lean Daylight lean Nocturna	flight time = 12 n 12 n urs geese are p hours al hrs*	825 seconds nonths = potentially active du	5056	6 <mark>0.47</mark> seco I et al, in Feb 8	press) 10	259200 Mar 12	seconds Apr 13	survey time May	Jun 15	Jul 14	for goose sp fl Aug S 13 0.55	ecies. It pr ight behav Sep 12	rovides an ac iour for these Oct N 11	djustment fo e species. lox [9	or nocturnal Dec 7	I
Proportion of tir Red kite (2020) herefore in Iumber of hou Iean Daylight Iean Nocturna Combined Daily Io of days bird	flight time = 12 n 12 n urs geese are p hours al hrs* y Mean Is present	825 seconds nonths = potentially active du	5056 ring winter (from Banc	60.47 seco l et al, in Feb 8 0.8 8.8 31	press) 10 0.7 10.7 28	259200 Mar 12 0.6 12.6 31	Apr 13 0.55 13.55 30	Survey time May	Jun 15 0.45 15.45 30	Jul 14 0.5 14.5 31	for goose sp ff Aug 5 13 0.55 13.55 31	ecies. It pr ight behav sep 12 0.6 12.6 30	rovides an ac iour for these Oct N 11 0.65 11.65 31	djustment fo e species. lox [0.75 9.75 30	Dec 7 0.85 7.85 31	
Proportion of tir Red kite (2020) Therefore in	flight time = 12 n 12 n urs geese are p hours al hrs* y Mean Is present	825 seconds nonths = potentially active du	5056 ring winter (from Banc	60.47 seco l et al, in Feb 8 0.8 8.8	press) 10 0.7 10.7	259200 Mar 12 0.6 12.6 31	Seconds Apr 13 0.55 13.55	May 14 0.5 14.5	Jun 15 0.45 15.45	Jul 14 0.5 14.5	for goose sp ff Aug 5 13 0.55 13.55 31	ecies. It pr ight behav Sep 12 0.6 12.6	rovides an ac iour for these Oct N 11 0.65 11.65	djustment fo e species. lox [0.75 9.75	Dec 7 0.85 7.85	4412

Method 1 - Birds using the windfarm airspace (to be used for birds Number of bird transits through the rotors per annum =	that fly across the site us 71.33	sing a variety of different flight paths)			
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 length (m) wing span (m) speed (m/sec)	Kestrel 0.34 0.76 9.9	 = data input required = model calculates value Sources of speed and dimension information: Whitfield & Madders (2006); Svensson <i>et al.</i>, (1999)
Turbine Dimensions Height of tower (m) Blade length (m) Max blade height (m) Min blade height (m) Depth of rotor (m)	97.4 51.15 148.55 46.25 3.651781003	
Wind Farm Dimensions No of turbines Site width (m) Site length (m)	5 7 842 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) NoBlades MaxChord Pitch (degrees) Rotation period	1 3 4 * 20 * 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 31 24	Mar 8 31	AprMayJunJulAugSepOctNovDec3030313130313031

Total number of months when Kestrel likely to be present:

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

12

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
 = model calculates value

Bird Flight Data

Time spent in V_w (sec)

No of birds

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	

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 (m²)	2195936			

Method 1 - Birds using the windfarm airspace		(to be use	(to be used for birds that fly across the site using a variety of different flight paths)				
Step No 1	Description of Calculation Identify 'flight risk volume' V_w ' which is the area of the wind farm multiplied by the height of the turbines	V _w =	Calculation 326206292.8 m ³	Comments 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 $V_r = N \times R^2 \times (d + I)$ where N is the number of turbines, d is the depth of the	V _r =	229642.15 m³				

25

27042.19

rotor front to back, and I 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 + I) / 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 annu	m	
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.

1 Calculation of alpha and p(collision) as a function of radius K: [1D or [3D] (0 or 1) 3 NoBlades Upwind: Downwind: MaxChord 4 m r/R c/C α collide contribution collide contribution p(collision) 20 radius Pitch (degrees) chord alpha length from radius r length p(collision) from radius r BirdLength 0.34 m 0.025 0.575 3.70 11.59 1.00 0.00125 10.01 1.00 0.00125 Wingspan 0.76 m 0.075 0.575 1.23 4.39 0.44 0.00332 2.81 0.28 0.00213 F: Flapping (0) or gliding (+1) 0 0.125 0.702 0.74 3.47 0.35 0.00438 0.16 0.00196 1.55 0.53 0.175 0.860 3.29 0.33 0.00581 0.93 0.09 0.00165 Bird speed 9.9 m/sec 0.225 0.994 0.41 3.24 0.00735 0.51 0.05 0.00117 0.33 RotorDiam 102.3 m 0.275 0.947 0.34 2.83 0.29 0.00786 0.44 0.04 0.00122 RotationPeriod 3.00 sec 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 0.00924 0.08 0.00394 0.475 0.756 0.19 1.93 0.19 0.82 Bird aspect ratioo: β 0.45 0.525 0.708 0.18 1.78 0.18 0.00943 0.84 0.08 0.00446 0.575 0.660 0.16 0.17 0.00954 0.84 0.09 0.00491 1.64 0.00959 0.08 0.00529 0.625 0.613 0.15 1.52 0.15 0.84 0.675 0.565 0.00957 0.82 0.08 0.00561 0.14 1.40 0.14 0.00949 0.80 0.08 0.00586 0.725 0.517 0.13 1.30 0.13 0.470 0.00934 0.00604 0.775 0.12 1.19 0.12 0.77 0.08 0.825 0.422 1.09 0.00912 0.74 0.07 0.00616 0.11 0.11 0.875 0.374 0.11 1.00 0.10 0.00884 0.70 0.07 0.00622 0.925 0.327 0.00850 0.66 0.07 0.00621 0.10 0.91 0.09 0.279 0.00808 0.62 0.00613 0.975 0.09 0.82 0.08 0.06 Overall p(collision) = 15.7% 7.8% Upwind Downwind

Average 11.7%

W Band

15/10/2018

Bird survey data

	rved (seconds)		Number of ge	ese Bird	Occupand	y in flight ris	sk volume				
TOTAL 1600			25			1765					
TOTAL SURVEY TIME 288	hours	or	1036800 sec	onds							
Period when Kestrel likely to be	on site (see below) =										
Jan Feb Mar	Apr	May	Jun	Jul A	Aug S	Sep O	ct Nov	Dec			
31 28 31	30	0 30	30	31	31	30	31 3	0 31			
	Total hours (corrected - see below) =			44	<mark>12.55</mark>						
Period when Kestrel likely to be	on site =	15885180	seconds (in	each year)							
Accumptions (write in any accumption	that have been included in the model)										
Assumptions (write in any assumptions Assumption 1: The flying period extends											
Assumption 2:	nom dawn to dusk and inciddes 23% (or night.									
Assumption 3:											
Assumption 4:											
Proportion of time during which a collisio	n may occur =		15885180 (in	each year)							
Kestrel flight time = 1765	seconds	in	1036800 sec	onds surv	ey time						
Therefore in 12 months =	27042.19	9 seconds				Note:			ant when calcula	0	
							for goose	• •	rovides an adjus		urnal
Number of hours geese are potentially	/ active during winter (from Band et a	al, in press)						flight behav	iour for these sp	ecies.	
								•	0 / N		
	.lan	Feb	Mar Apr	· Mav	.lun	.lul	Aug	Sen	Oct Nox	Dec	
	Jan	Feb 8 10	Mar Apr 12			Jul 15	Aug 14 1		Oct Nox	Dec 9	7
Mean Daylight hours Mean Nocturnal hrs* 5		8 10	12	13	14	Jul 15 0.45	14 1	3 12	11	9	7).85
Mean Daylight hours Mean Nocturnal hrs* 5	0.0	8 10 8 0.7	12 0.6	13 0.55	14 0.5	15 0.45	14 1 0.5 0.5	3 12 5 0.6	11 0.65	9 0.75 (7).85 7.85
Mean Daylight hours Mean Nocturnal hrs* 5 Combined Daily Mean		8 10 8 0.7 8 10.7	12 0.6 12.6	13	14	15	14 1	3 12 5 0.6 5 12.6	11	9 0.75 (7).85 7.85 31
Mean Daylight hours Mean Nocturnal hrs* 5	0.1 8.1	8 10 8 0.7 8 10.7 1 28	12 0.6 12.6 31	13 0.55 13.55	14 0.5 14.5	15 0.45 15.45 30	14 1 0.5 0.5 14.5 13.5	3 12 5 0.6 5 12.6 1 30	11 0.65 11.65 31	9 0.75 (9.75 ; 30	.85

ds that fly across the site using a variety of different flight paths)		
47.21		
11.7%		
5.55		
Correcting for 98% avoidance r	rate:	Correcting for 99% avoidance rate:
Number of hirds potentially kills	ed by rotors per annum = 0.110942	Number of birds potentially killed by rotors per annum =
	47.21 11.7% 5.55 Correcting for 98% avoidance i	47.21 11.7% 5.55 Correcting for 98% avoidance rate:

Bird Dimensions Peregrine 0.42 length (m) 0.42 speed (m/sec) 1.02 speed (m/sec) 1.21 Sources of speed and dimension information: https://app.bto.org/birdfacts/; Cochran & Applegate (198 Turbine Dimensions Height of tower (m) Max blade height (m) Max blade height (m) 3.651781003 Wind Farm Dimensions No of turbines Turbine Specifications K: (1D or (3D) (0 or 1) No diade set (m) MaxChade Nergerine Bide length (m) Addiades Mind Farm Dimensions K: (1D or (3D) (0 or 1) No of turbines Site length (m) Addiades MaxChade Nergerine K: (1D or (3D) (0 or 1) Not durbines Site length (m) Addiades MaxChade Nergerine K: (1D or (3D) (0 or 1) Not durbines Site length (m) Addiades MaxChared Site length (m) Site length (m) Site	Site Name	Upper Ogmore	
Height of tower (m) 97.4 Blade length (m) 148.55 Max blade height (m) 148.55 Depth of rotor (m) 3.651781003 Wind Farm Dimensions 7 No of turbines 7 Site width (m) 842 Site width (m) 842 Site length (m) 2608 Turbine Specifications 8 K: [1D or [3D] (0 or 1) 1 NoBlades 3 MaxChord 4 Pitch (degrees) 20 Rotation period 3 Flight Characteristics Night adjustment Flapping (0) or gliding (+1) 0 Survey Data 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	Species length (m) wing span (m)	0.42 1.02	= model calculates value
No of turbines7 Ste width (m)842 842 2608Both width and length include a 440m 'extension' to allow for the sweep of the blades and margin for flSite length (m)842 2608Both width and length include a 440m 'extension' to allow for the sweep of the blades and margin for flTurbine Specifications K: [1D or [3D] (0 or 1) NoBlades1 1 3 3 	Height of tower (m) Blade length (m) Max blade height (m) Min blade height (m)	51.15 148.55 46.25	
K: [1D or [3D] (0 or 1) 1 NoBlades 3 MaxChord 4 * Pitch (degrees) 20 * Rotation period 3 * Flight Characteristics Night adjustment Flapping (0) or gliding (+1) 0 What percentage of the night is the target species active? 5 % Survey Data 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	No of turbines Site width (m)	7 842	Both width and length include a 440m 'extension' to allow for the sweep of the blades and margin for fl
Flapping (0) or gliding (+1) 0 What percentage of the night is the target species active? 5 % Survey Data Total survey time (hours) 288 288 5 % 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	K: [1D or [3D] (0 or 1) NoBlades MaxChord Pitch (degrees)	3 4 20	*
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		0	
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec	Total survey time (hours)		
	Jan Feb	Mar	Apr May Jun Jul Aug Sep Oct Nov Dec

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 o	f birds Bird Occupancy in fli	ight risk volume	
31/07/15	5 12	0 1	120	(the time in	n seconds is aggregated
09/09/15	3	0 1	30	time for ea	ach species modelled)
09/09/15	5 1	5 1	15		
09/09/15	3	0 1	30		
09/09/15	5 4	5 1	45		
Total	24	0 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

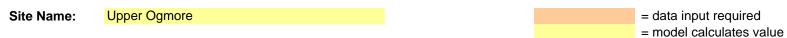
Step 1 Go to Data Input

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



Bird Flight Data

Time spent in V_w (sec)

No of birds

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	
speed (m/sec)	12.1	

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 Form Dimonsions

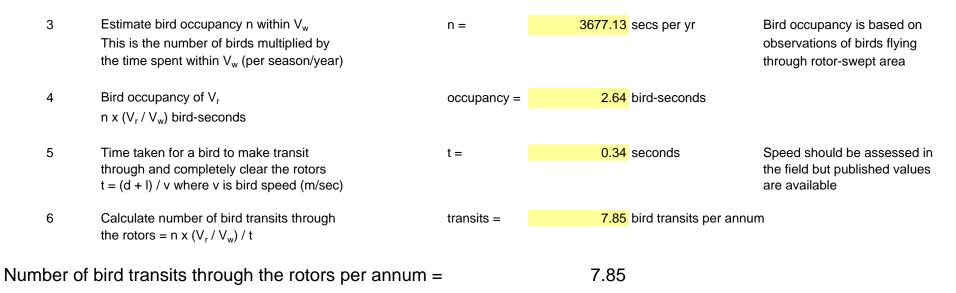
No of turbines	7			
Site width (m)	842			
Site length (m)	2608			
Area (m ²)	2195936			

Method 1	 Birds using the windfarm airspace 	(to be used	d for birds that fly across the site u	sing a variety of different flight paths)
Step No 1	Description of Calculation Identify 'flight risk volume' V_w ' which is the area of the wind farm multiplied by the height of the turbines	V _w =	Calculation 326206292.8 m ³	Comments 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 $V_r = N \times R^2 \times (d + I)$ where N is the number of turbines, d is the depth of the	V _r =	234244.45 m ³	

5

3677.13

rotor front to back, and I is the bird length



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.

1 Calculation of alpha and p(collision) as a function of radius K: [1D or [3D] (0 or 1) 3 NoBlades Upwind: Downwind: MaxChord 4 m r/R c/C α collide contribution collide contribution 20 radius p(collision) Pitch (degrees) chord alpha length from radius r length p(collision) from radius r BirdLength 0.42 m 0.025 0.575 4.52 15.16 1.00 0.00125 13.59 1.00 0.00125 Wingspan 1.02 m 0.075 0.575 1.51 5.58 0.46 0.00346 4.00 0.33 0.00248 0 F: Flapping (0) or gliding (+1) 0.125 0.702 0.90 0.35 0.00440 2.34 0.19 0.00242 4.26 0.00227 0.175 0.860 0.65 3.92 0.32 0.00567 1.57 0.13 Bird speed 12.1 m/sec 0.225 0.994 0.50 3.75 0.00697 1.03 0.08 0.00191 0.31 RotorDiam 102.3 m 0.275 0.947 0.41 3.18 0.26 0.00722 0.59 0.05 0.00133 RotationPeriod 3.00 sec 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 0.00836 0.06 0.00306 0.475 0.756 0.24 2.13 0.18 0.78 Bird aspect ratioo: β 0.41 0.525 0.708 0.22 1.96 0.16 0.00851 0.82 0.07 0.00354 0.575 0.660 0.20 0.00861 0.84 0.07 0.00397 1.81 0.15 0.00865 0.00435 0.625 0.613 0.18 1.67 0.14 0.84 0.07 0.675 0.565 0.00864 0.84 0.07 0.00467 0.17 1.55 0.13 0.00857 0.82 0.07 0.00494 0.725 0.517 0.16 1.43 0.12 0.470 0.00845 0.07 0.00516 0.775 0.15 1.32 0.11 0.81 0.825 0.422 1.21 0.00828 0.78 0.06 0.00532 0.14 0.10 0.875 0.374 0.13 1.11 0.09 0.00805 0.75 0.06 0.00543 0.925 0.327 0.00777 0.72 0.06 0.00548 0.12 1.02 0.08 0.279 0.12 0.92 0.00744 0.68 0.00548 0.975 0.08 0.06 Overall p(collision) = 14.4% Upwind Downwind 6.9%

Average 10.6%

W Band

15/10/2018

Bird survey data

	rved (seconds)		Number of g	eese	Bird Occupan	cy in flight ri	sk volume				
TOTAL 240			5			240					
TOTAL SURVEY TIME 288	hours	or	<mark>1036800</mark> se	econds							
Period when Peregrine likely to be	on site (see below) =										
Jan Feb Mar	Apr	May	Jun	Jul	Aug	Sep O	ct Nov	Dec			
31 28 31		30 30	30	31	31	30	31 30	31			
Total days = <u>364</u>	Total hours (corrected - see below) =				4412.55						
Period when Peregrine likely to be	on site =	15885180	seconds (ir	n each yea	ar)						
	n may occur = seconds	in	<mark>15885180</mark> (ir 1036800 se		ar) survey time						
Therefore in 12 months =	3677.1	I3 seconds				Note			when calculatin	•	
Number of hours geese are potentially	- .	al, in press)					• •	•	vides an adjustm ur for these spec	nent for nocturnal cies.	I
	Jan	Feb	Mar A	.pr l	May Jur	n Jul	Aug S	Sep Od	ct Nox	Dec	
Mean Daylight hours		8 10		13	14	15	14 13	12	11	9 7	
Mean Nocturnal hrs* 5	0.			0.55	0.5	0.45	0.5 0.55	0.6		0.75 0.85	
Combined Daily Mean No of days birds present	8.			13.55 30	14.5 30	15.45 30	14.5 13.55 31 31	12.6 30	11.65 9 31	9.75 7.85 30 31	
Total hours each month	272.	-		406.5	435		449.5 420.05	30 378		92.5 243.35	4412.55
Total hours per year	4412.5		550.0	-00.5	400	-00.0	420.03	570	501.15 23	52.5 245.55	44 12.33

Method 1 - Birds using the windfarm airspace (to be used for bird Number of bird transits through the rotors per annum =	ds that fly across the site using a variety of different flight paths)		
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	e rate: Correcting for 99% avoid	dance rate:
Number of birds potentially killed by rotors per annum =	0.041730 Number of birds potentially kil	lled by rotors per annum = 0.016692 Number of birds potentia	ally killed by rotors per annum = 0.00835

Site Name	Upper Ogmore	
Bird Dimensions Species length (m) wing span (m) speed (m/sec)	Golden Plover 0.28 0.72 22	 = data input required = model calculates value Sources of speed and dimension information: Whitfield & Madders (2006); Svensson <i>et al.</i>, (1999)
Turbine Dimensions Height of tower (m) Blade length (m) Max blade height (m) Min blade height (m) Depth of rotor (m)	97.4 51.15 148.55 46.25 3.651781003	
Wind Farm Dimensions No of turbines Site width (m) Site length (m)	S 7 842 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) NoBlades MaxChord Pitch (degrees) Rotation period	1 3 4 * 20 * 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) Period when Golden Plover	288 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	AprMayJunJulAugSepOctNovDec3030313130313031

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

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	t 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	

12

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

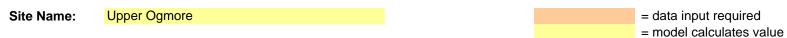
Step 1 Go to Data Input

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



Stage 1: Number of birds flying through rotors

Input Parameters

Bird Dimensions			Bird Flight Data
Species	Golden Plo	ver	No of birds
length (m)	0.28		Time spent in V_w (sec)
wing span (m)	0.72		
speed (m/sec)	22		

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

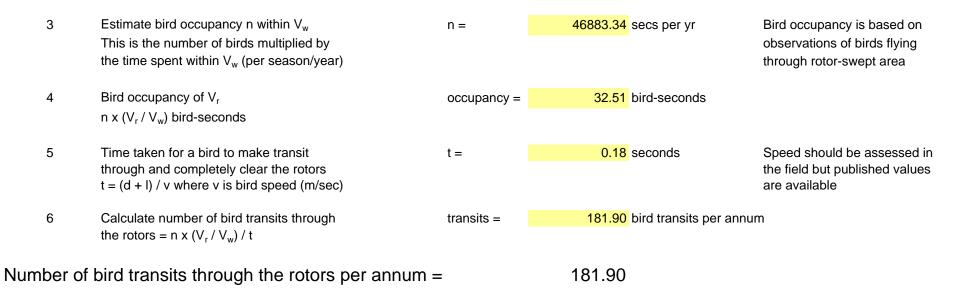
No of turbines	7
Site width (m)	842
Site length (m)	2608
Area (m²)	2195936

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 1	Step NoDescription of Calculation1Identify 'flight risk volume' Vw' which is the area of the wind farm multiplied by the height of the turbines		Calculation 326206292.8 m ³	Comments 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 $V_r = N \times R^2 \times (d + I)$ where N is the number of turbines, d is the depth of the	V _r =	<mark>226190.43</mark> m³						

189

46883.34

rotor front to back, and I is the bird length



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.

1 Calculation of alpha and p(collision) as a function of radius K: [1D or [3D] (0 or 1) 3 NoBlades Upwind: Downwind: MaxChord 4 m r/R c/C α collide contribution collide contribution p(collision) 20 radius Pitch (degrees) chord alpha length from radius r length p(collision) from radius r BirdLength 0.28 m 0.025 0.575 8.21 24.45 1.00 0.00125 22.88 1.00 0.00125 Wingspan 0.72 m 0.075 0.575 2.74 8.68 0.39 0.00296 7.10 0.32 0.00242 0 F: Flapping (0) or gliding (+1) 0.125 0.702 1.64 6.47 0.29 0.00368 0.21 0.00259 4.56 0.00275 0.175 0.860 1.17 5.82 0.26 0.00463 3.46 0.16 Bird speed 22 m/sec 0.225 0.994 0.91 5.43 0.00555 2.71 0.12 0.00277 0.25 RotorDiam 102.3 m 0.275 0.947 0.75 4.49 0.20 0.00561 1.90 0.09 0.00237 RotationPeriod 3.00 sec 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 0.00556 0.02 0.00109 0.475 0.756 0.43 2.57 0.12 0.51 Bird aspect ratioo: β 0.39 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 0.33 0.00533 0.02 0.00103 0.625 0.613 1.88 0.09 0.36 0.675 0.565 0.30 0.00521 0.41 0.02 0.00125 1.70 0.08 0.00507 0.44 0.02 0.00144 0.725 0.517 0.28 1.54 0.07 0.470 0.00490 0.45 0.02 0.00160 0.775 0.26 1.39 0.06 0.825 0.422 0.25 1.25 0.06 0.00470 0.02 0.00173 0.46 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 0.00420 0.45 0.02 0.00191 0.05 0.279 0.21 0.00391 0.44 0.02 0.00195 0.975 0.88 0.04 Overall p(collision) = 9.5% 3.5% Upwind Downwind

Average 6.5%

W Band

15/10/2018

Bird survey data

Date TOTAL	Т	ime observed (se 390	econds)			Number of g	geese	Bird Occupa	ancy in fligh 3060	nt risk vol	ume					
TOTAL		390				109			3000							
TOTAL SURV	EY TIME	288 hours		or		1036800 s	seconds									
Period when	Golden Plove li	kely to be on site (see below) =													
Jan	Feb	Mar	Apr	Ν	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec				
31		31		30	30	30	31	31	30	31	30	31				
Total days =	364		ours (corrected - see below)					4412.55								
Period when	Golden Plove li	kely to be on site =	=	158	885180	seconds (in each ye	ar)								
Assumptions	(write in any as	sumptions that has	ve been included in the mo	del)												
•	· ·	•	wn to dusk and includes 25	,	nt											
Assumption 2:	,			, o or mgr												
Assumption 3:																
Assumption 4:																
	U U	a collision may o				15885180 (,								
Golden Plover	0	3060 seconds		in		1036800 s	seconds	survey time			T his 4-hls is				tata a statu	
Therefore in	12 m	nonths =	4688	3.34 seco	onas				INC				nt when calcu ovides an adju	•		
Number of bo	ure deese are r	otentially active	during winter (from Band	otal in i	nraee)					I		•	our for these s		nocluma	
	and geese are p		during whiter (noni band	et ui, iii j	pi 000)							ight behavit		peoleo.		
		Jan		Feb		Mar A	Apr	May J	un Ju	l .	Aug S	ep C	Oct No	x D	Dec	
Mean Daylight	hours			8	10	12	13	14	15	14	13	12	11	9	7	
Mean Nocturn		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 Dai				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 bird	•			31	28	31	30	30	30	31	31	30	31	30	31	
Total hours e				72.8	299.6	390.6	406.5	435	463.5	449.5	420.05	378	361.15	292.5	243.35	4412.55
Total hours p	er year		441	2.55												

Method 1 - Birds using the windfarm airspace (to be used for birds Number of bird transits through the rotors per annum =	ds that fly across the site using a variety of different flight paths) 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 kil	ed by rotors per annum = 0.235499	Number of birds potentially killed by rotors per annum = 0.11775