



# Appendix 1

## Updated Collision Risk Model

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### Detailed Calculations

WIND FARM PARAMETERS			Watch Data		Bird Flight Data		MORTALITY ESTIMATE	
Size of windfarm envelope	511	ha	Area (ha)	Time (hrs)	Total (s)	'Risk height' (s)	Flight risk volume (Vw)	766500000 m <sup>3</sup>
Number of turbines	9							
Rotor diameter	150	m	1	36.0	0	0	Rotor radius <sup>2</sup>	5625 m <sup>2</sup>
Hub height	105.0	m	3	36.0	0	0	Combined rotor swept area (Va)	159043 m <sup>2</sup>
Max. rotor depth in metres	2.0	m	5	36.0	949	96	$Vr = Va * (d + 1)$	394427 m <sup>3</sup>
Max. chord	4.20	m	Totals	108.0	949	96	Bird occupancy (n)	0.92 hrs / yr
Pitch	6.0	degrees					Bird occupancy of rotor swept vol (b)	1.70 bird-secs
Rotation period	4.60	s					Bird transit time (t)	0.21 secs
Turbine operation time	87	%					No. of transits through rotors	8.24 per year
							Estimated no. of collisions	0.43 per year
							After allowing for avoidance	0.004 per year
							<b>i.e. equivalent to one bird every</b>	<b>233.2 years</b>
BIRD PARAMETERS			Flight Activity Per Unit Time & Area		Weighted By Observation Effort		© Copyright <b>natural</b> RESEARCH	
Length	0.48	m	VP	Observation effort (HaHr)	Flying time at 'risk height' (Hahr <sup>-1</sup> )	VP	Weighting	Adjusted time at 'risk height' (Hahr <sup>-1</sup> )
Wingspan	1.10	m	1	1666.80	0.0000000	1	0.062	0.0000000
Flapping (0) or gliding (1)	1		3	10760.40	0.0000000	3	0.397	0.0000000
Assumed flight speed	12	ms <sup>-1</sup>	5	14662.80	0.0000018	5	0.541	0.0000010
Number of hours birds potentially present	2070	hrs	Totals	27090.00	0.0000006	Totals	1.000	0.0000009844
Assumed avoidance rate	99	%						
BAND USED TO DEFINE 'RISK HEIGHT'			Mean activity hr <sup>-1</sup> in wind farm					
Max height	200	m						Risk height 0.05030%
Min height	30	m						Rotor height 0.04438%

Calculation of alpha and p(collision) as a function of radius										
K: [1D or [3D] (0 or 1)	1				Upwind:			Downwind:		
NoBlades	3	r/R	c/C	$\alpha$	collide	p(collision)	y(x)	collide	p(collision)	y(x)
MaxChord	4.20 m	radius	chord	alpha	length			length		
Pitch (degrees)	6.0	0				1.00	0.000		1.00	0.000
BirdLength	0.48 m	0.05	0.575	2.34	7.52	0.41	0.041	7.01	0.38	0.038
Wingspan	1.1 m	0.1	0.622	1.17	4.14	0.22	0.045	3.59	0.20	0.039
F: Flapping (0) or gliding (+1)	1	0.15	0.781	0.78	3.44	0.19	0.056	2.75	0.15	0.045
		0.2	0.939	0.59	3.12	0.17	0.068	2.30	0.12	0.050
Bird speed	12 m/sec	0.25	0.971	0.47	2.65	0.14	0.072	1.80	0.10	0.049
RotorDiam	150 m	0.3	0.923	0.39	2.39	0.13	0.078	1.58	0.09	0.052
RotationPeriod	4.60 sec	0.35	0.875	0.33	2.09	0.11	0.079	1.32	0.07	0.050
		0.4	0.827	0.29	1.86	0.10	0.081	1.13	0.06	0.049
integration interval	0.05	0.45	0.780	0.26	1.67	0.09	0.082	0.99	0.05	0.048
		0.5	0.732	0.23	1.52	0.08	0.082	0.87	0.05	0.048
Bird aspect ratio: $\beta$	0.44	0.55	0.684	0.21	1.39	0.08	0.083	0.79	0.04	0.047
		0.6	0.637	0.20	1.28	0.07	0.083	0.72	0.04	0.047
		0.65	0.589	0.18	1.18	0.06	0.083	0.66	0.04	0.047
		0.7	0.541	0.17	1.10	0.06	0.083	0.62	0.03	0.047
		0.75	0.494	0.16	1.02	0.06	0.083	0.59	0.03	0.048
		0.8	0.446	0.15	0.95	0.05	0.082	0.56	0.03	0.048
		0.85	0.398	0.14	0.88	0.05	0.082	0.53	0.03	0.049
		0.9	0.350	0.13	0.82	0.04	0.081	0.52	0.03	0.051
		0.95	0.303	0.12	0.77	0.04	0.079	0.50	0.03	0.052
		1	0.255	0.12	0.72	0.04	0.078	0.49	0.03	0.054
<b>Overall p(collision) =</b>					<b>Upwind</b>	<b>7.3%</b>	<b>Downwind</b>	<b>4.7%</b>		
					<b>Average</b>	<b>6.0%</b>				