2021

Tom na Clach Wind Farm Extension

Appendix 12.C: Collision Risk Modelling

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Introduction

1.1. Birds that are not displaced by the Proposed Development would be potentially vulnerable to collision with the turbines. The level of collision with wind turbines is presumed to be dependent on the level of flight activity over the Proposed Development and the ability of birds to detect and manoeuvre around rotating turbine blades. Birds that collide with a turbine are likely to be killed or fatally injured. This may in turn affect the maintenance of bird populations.

1.2. Further studies in the field of bird-windfarm research are required to establish with certainty the extent to which birds can avoid collision with wind turbines, although an increasing body of evidence suggests that avoidance capacity is very high (Whitfield & Madders, 2006[1]; Urquhart & Whitfield, 2016[2]; SNH, 2018[3]). The indications from studies are that collisions are rare events (Fielding *et al*., 2021)[4] and occur mainly at sites where there are unusual concentrations of birds and turbines, or where the behaviour of the birds concerned leads to high-risk situations (e.g., Gill *et al*., 1996[5]; Percival, 1998[6]; de Lucas *et al.,* 2007[7]). Examples include migration flyways, and where the food resource, and therefore level of bird activity, is exceptional.

Collision Risk Modelling

1.3. The Band collision risk model (CRM) (Band *et al*., 2007)[8] was used to estimate the potential number of bird collisions likely to occur at the proposed Tom na Clach Wind Farm Extension. The model requires input data based on species biometrics and flight characteristics, turbine specification and data on flights observed at the site.

1.4. NatureScot guidance on collision risk modelling was used. This is a three-stage process, which involves:

1) An assessment of the probability of a collision, based on a bird flying through an operational turbine; and
2) An estimation of the number of birds passing through the swept zone of the turbine blades.

Multiplying stages 1 and 2 provides an estimate of collision risk with the turbines, assuming no avoidance action. After, the third stage is applied:

[1] Madders, M. & Whitfield, D.P. (2006). Upland raptors and the assessment of wind farm impacts. Ibis, 148, pp 43-56.
[2] Urquhart, B. & Whitfield, D.P. (2016). Derivation of an avoidance rate for red kite *Milvus milvus* suitable for onshore wind farm collision risk modelling Natural Research Information Note 7. Available at https://www.natural-research.org/ecological-research-charity/our-publications
[3] SNH. (2018). Avoidance Rates for the onshore SNH Wind Farm Collision Risk Model. SNH Information and Guidance Note. Scottish Natural Heritage, Battleby.
[4] Fielding, A.H., Anderson, D., Benn, S., Dennis, R., Geary, M., Weston, E. & Whitfield, D.P. (2021). Non-territorial GPS-tagged golden eagles *Aquila chrysaetos* a two Scottish wind farms: Avoidance influenced by preferred habitat distribution, wind speed and blade motion status. PLoS ONE 16(8): e0254159. https://doi.org/10.1371/journal.pone.0254159
[5] Gill, J.P., Townsley, M. & Mudge, G.P. (1996). Review of the impacts of wind farms and other aerial structures upon birds. SNH Review 21: 68pp.
[6] Percival, S.M. (1998). Birds and Turbines: managing potential planning issues. Proc. of the 20th BWEA Conference 1998: pp 345-350.
[7] de Lucas, M., Janss, G.F.E. & Ferrer, M. (eds). (2007). Birds and Wind Power: Risk Assessment and Mitigation. Quercus, Madrid.
[8] Band, W., Madders, M., & Whitfield, D.P. (2007). Developing field and analytical methods to assess avian collision risk at wind farms. In: de Lucas, M., Janss, G.F.E. & Ferrer, M. (Eds.) Birds and Wind Farms: Risk Assessment and Mitigation, pp. 259- 275. Quercus, Madrid.

3) An avoidance rate is applied (where known) to account for the fact that many species will take avoidance action.

1.5. The result of the model provides an estimate of the number of collisions that can be expected over a year or for the lifetime of the wind farm.

1.6. For the turbines proposed, the probability of a bird being struck by a turbine blade when passing through the rotor swept volume has been estimated, **assuming no avoidance** (see Appendix 1). However, it is widely accepted that birds are able to avoid turbine blades in a number of ways. Birds may exercise avoidance by detecting the wind farm or turbine and modifying their flight lines to avoid the structures (Macro avoidance). At close proximity, birds may see an oncoming blade and emergency avoidance action can be taken (Micro avoidance) (SNH, 2000)[9]. As such, an avoidance rate (SNH, 2018)[10] was applied to each model to estimate the collision risk for each species respectively.

Windfarm characteristics

1.7. The scheme has seven turbines and the flight risk volume (Vw), in these analyses, is based on a buffer constructed with a radius of 500 m (area = 390 ha), centred on the turbine locations with a height that was equal to the diameter of the turbine blades (136 m). The turbines used for the collision risk modelling were based on a hub height of 82 m, giving an overall tip height of 150 m. The turbine used in these analyses is the Vestas V136-4.2 and turbine specifications were obtained from the manufacturer[11] and are shown where relevant.

Viewsheds

1.8. Flight data were obtained from a total of four Vantage Points (VPs) that overlooked the seven-turbine layout. Viewsheds were estimated using a Digital Elevation Model (DEM) and a 20 m vertical offset above the ground surface (lowest point of rotor sweep at 14 m). Other details of the viewshed calculation are given in **Table 1**.

Table 1. Vantage point survey effort and visible areas within the 500 m buffer drawn around the turbines.

GVP No.	Visible area with 500m turbine buffer (ha)	Hours of observation (hrs)
1	147.2	190.5
2	239.6	116.0
3	69.4	114.5
4	218.2	72.0

Flight activity within 500 m of turbines

1.9. An 'at–risk' flight is one which passes into the 500 m turbine buffer with at least part of its flight at an altitude between 10 m and 150 m. Details of 'at-risk' flights for consideration under a CRM are shown in **Tables 2** and **3**.

1.10. The total flight duration recorded during the vantage point watches was adjusted to give an estimate for the total expected over the period of occupancy by each species. The total potential flying time for each species was estimated from the sum of the day lengths of each day. Day length was estimated, for each day, using the method of Forsythe *et al*. (1995)[12] at latitude 57.34° N.

Table 2. Flight durations recorded within GVP viewsheds and clipped to 500 m survey buffer during April 2014 to August 2015. Part, or all, of these flights at a height of 10 – 150 m agl places them at risk of a collision with the turbine blades (shaded columns).

Species	Season	GVP No.	No. of Flights	No. of Birds	Total fly time (sec)	Time in height category (sec)					
						<10m	10-30m	30-50m	50-100m	100-150m	>150m
Golden eagle	Apr-Aug	GVP1	3	3	222	46	107	69			
		GVP2	4	4	138	97	41				
		GVP3	3	3	148	8	45	39	56		
Golden eagle Total			**10**	**10**	**508**	**151**	**193**	**108**	**56**		
Hen harrier	Apr-Aug	GVP1	2	2	228	87	77	32	32		
	Sep-Mar	GVP1	1	1	62		17	45			
		GVP2	1	1	105	105					
		GVP3	2	2	61	32	29				
Hen harrier Total			**6**	**6**	**456**	**224**	**123**	**77**	**32**		
Red kite	Apr-Aug	GVP1	1	1	192				54	138	
		GVP2	10	10	1868	109	530	519	261	346	103
		GVP3	14	16	1603	431	454	569	149		
	Sep-Mar	GVP1	1	1	85					85	
Red kite Total			**26**	**28**	**3748**	**540**	**984**	**1088**	**464**	**569**	**103**

[9] SNH. (2000). WINDFARMS AND BIRDS: Calculating a theoretical collision risk assuming no avoiding action. Scottish Natural Heritage, Inverness

[10] SNH. (2010, updated 2018). Use of Avoidance Rates in the SNH Wind Farm Collision Risk Model. Scottish Natural Heritage, Inverness.

[11] https://www.vestas.com/en/products/turbines

[12] Forsythe, W.C., Rykiel, E.J., Stahl, R.S., Wu, H. and Schoolfield, R.M. (1995). A model comparison for day length as a function of latitude and day of year. Ecological Modelling. 80: 87 –95

Table 3. Flight durations recorded within GVP viewsheds and clipped to 500 m survey buffer during April 2018 to March 2019. Part, or all, of these flights at a height of 10 – 150 m agl places them at risk of a collision with the turbine blades (shaded columns).

Species	Season	GVP No.	No. of Flights	No. of Birds	Total fly time (sec)	Time in height category (sec)					
						<10m	10-30m	30-50m	50-100m	100-150m	>150m
Hen harrier	Sep-Mar	GVP1	1	1	35	35					
		GVP4	2	2	109	89	20				
Hen harrier Total			**3**	**3**	**144**	**124**	**20**				
Red kite	Apr-Aug	GVP1	2	2	199					82	117
		GVP4	4	4	639	168	232	182	57		
	Sep-Mar	GVP4	7	7	506		272	234			
Red kite Total			**13**	**13**	**1344**	**168**	**504**	**416**	**57**	**82**	**117**

Species-specific information

1.11. **Table 4** summarises the species-specific information used in the collision risk calculations. Collision probability was obtained using the SNH (2000)[9] model and details, for each species, are available in Appendix 1. Species length and wingspan have been derived using a mean of the figures presented within Snow & Perrins (1998)[13] and flight speeds were derived using Alerstam *et al.* (2007)[14] or Provan & Whitfield (2006)[15] as suggested by NatureScot (SNH, 2014)[16].

Table 4. Species-specific information used in the collision risk calculations.

Species	Bird length			Wingspan			Flight speed (ms^{-1})	Collision probability (%)	Total potential flying time (hrs)
	Min (cm)	Max (cm)	Average (m)	Min (cm)	Max (cm)	Average (m)			
Hen harrier	44	52	**0.48**	100	120	**1.10**	11.4	6.0%	4,504
Red kite	60	66	**0.63**	175	195	**1.90**	12.1	6.5%	4,504
Golden eagle	75	88	**0.815**	204	220	**2.12**	14.1	6.7%	4,504

Results

1.12. **Table 5** summarises the results of collision risk modelling for each of the four species.

Table 5. Collision risk modelling results.

Species	Occupancy	Avoidance Rate (%)	Birds colliding per year	Years per collision
Hen harrier	All year	99.0	0.006	165.7
Red kite	All year	99.0	0.115	8.7
Golden eagle	All year	99.0	0.012	85.0

1.13. The annual collision risk for hen harrier is predicted to be 0.006 birds or one bird every 166 years.

1.14. The annual collision risk for red kite is predicted to be 0.115 birds or one bird every 9 years.

1.15. The annual collision risk for golden eagle is predicted to be 0.012 birds or one bird every 85 years.

[13] Snow, D. W. & Perrins, C. M. (1998). The Birds of the Western Palearctic. Concise Edition. Oxford University Press.
[14] Alerstam T., Rosén M., Bäckman J., Ericson P.G.P., Hellgren O. (2007). Flight speeds among bird species: allometric and phylogenetic effects. PLoS Biol, **5**, 1656-1662
[15] Provan, S. & Whitfield, D.P. (2006). Avian flight speeds and biometrics for use in collision risk modelling. Report to Scottish Natural Heritage from Natural Research (Projects) Ltd
[16] SNH. (2014). Bird Speeds and Biometrics for Collision Risk Modelling. Scottish Natural Heritage, Inverness.

Detailed calculations

Hen harrier

WIND FARM PARAMETERS		
Size of windfarm envelope	393.3	ha
Number of turbines	7	
Rotor diameter	136	m
Hub height	82.0	m
Max. rotor depth in metres	3.5	m
Max. chord	4.10	m
Pitch	15.0	degrees
Rotation period	5.9	s
Turbine operation time	85	%

BIRD PARAMETERS		
Length	0.48	m
Wingspan	1.10	m
Flapping (0) or gliding (+1)	1	
Assumed flight speed	11.4	ms^-1
Number of hours birds potentially present	4504	hrs
Assumed avoidance rate	99	%

BAND USED TO DEFINE 'RISK HEIGHT'		
Max height	150	m
Min height	10	m

VP	Watch Data		Bird Flight Data	
	Area (ha)	Time (hrs)	Total (s)	'Risk height' (s)
1	147.2	190.5	325	203
2	239.6	116.0	105	0
3	69.4	114.5	61	29
4	218.2	72.0	109	20
Totals	674.4	493.0	600	252

Flight Activity Per Unit Time & Area			Weighted By Observation Effort	
VP	Observation effort (HaHr)	Flying time at 'risk height' (Hahr^-1)	Weighting	Adjusted time at 'risk height' (Hahr^-1)
1	28046.95	0.0000020	0.353	0.0000007
2	27790.39	0.0000000	0.350	0.0000000
3	7946.34	0.0000010	0.100	0.0000001
4	15707.20	0.0000004	0.198	0.0000001
Totals	79490.89	0.0000008	1.000	0.0000009

Mean activity hr^-1 in wind farm	
Risk height	0.03463%
Rotor height	0.03364%

MORTALITY ESTIMATE		
Flight risk volume (Vw)	534891620.3	m^3
Rotor radius^2	4624	m
Combined rotor swept area (Va)	101687	m^2
Vr = Va * (d + l)	404715	m^3
Bird occupancy (n)	1.52	hrs / yr
Bird occupancy of rotor swept vol (b)	4.13	bird-secs
Bird transit time (t)	0.35	secs
No. of transits through rotors	11.82	per year
Estimated no. of collisions	0.60	per year
After allowing for avoidance	0.006	per year
i.e. equivalent to one bird every	**165.7**	**years**

Red kite

WIND FARM PARAMETERS		
Size of windfarm envelope	393.3	ha
Number of turbines	7	
Rotor diameter	136	m
Hub height	82.0	m
Max. rotor depth in metres	3.5	m
Max. chord	4.10	m
Pitch	15.0	degrees
Rotation period	5.9	s
Turbine operation time	85	%

BIRD PARAMETERS		
Length	0.63	m
Wingspan	1.85	m
Flapping (0) or gliding (+1)	1	
Assumed flight speed	12.1	ms^-1
Number of hours birds potentially present	4504	hrs
Assumed avoidance rate	99	%

BAND USED TO DEFINE 'RISK HEIGHT'		
Max height	150	m
Min height	10	m

VP	Watch Data		Bird Flight Data	
	Area (ha)	Time (hrs)	Total (s)	'Risk height' (s)
1	147.2	190.5	476	359
2	239.6	116.0	1868	1656
3	69.4	114.5	1603	1172
4	218.2	72.0	1145	977
Totals	674.4	493.0	5092	4164

Flight Activity Per Unit Time & Area			Weighted By Observation Effort	
VP	Observation effort (HaHr)	Flying time at 'risk height' (Hahr^-1)	Weighting	Adjusted time at 'risk height' (Hahr^-1)
1	28046.95	0.0000036	0.353	0.0000013
2	27790.39	0.0000166	0.350	0.0000058
3	7946.34	0.0000410	0.100	0.0000041
4	15707.20	0.0000173	0.198	0.0000034
Totals	79490.89	0.0000196	1.000	0.0000146

Mean activity hr^-1 in wind farm	
Risk height	0.57229%
Rotor height	0.55594%

MORTALITY ESTIMATE		
Flight risk volume (Vw)	534891620.3	m^3
Rotor radius^2	4624	m
Combined rotor swept area (Va)	101687	m^2
Vr = Va * (d + l)	419968	m^3
Bird occupancy (n)	25.04	hrs / yr
Bird occupancy of rotor swept vol (b)	70.78	bird-secs
Bird transit time (t)	0.34	secs
No. of transits through rotors	207.38	per year
Estimated no. of collisions	11.53	per year
After allowing for avoidance	0.115	per year
i.e. equivalent to one bird every	**8.7**	**years**

Golden eagle

WIND FARM PARAMETERS		
Size of windfarm envelope	393.3	ha
Number of turbines	7	
Rotor diameter	136	m
Hub height	82.0	m
Max. rotor depth in metres	3.5	m
Max. chord	4.10	m
Pitch	15.0	degrees
Rotation period	5.9	s
Turbine operation time	85	%

BIRD PARAMETERS		
Length	0.82	m
Wingspan	2.12	m
Flapping (0) or gliding (+1)	1	
Assumed flight speed	14.1	ms^-1
Number of hours birds potentially present	4504	hrs
Assumed avoidance rate	99	%

BAND USED TO DEFINE 'RISK HEIGHT'		
Max height	150	m
Min height	10	m

VP	Watch Data		Bird Flight Data	
	Area (ha)	Time (hrs)	Total (s)	'Risk height' (s)
1	147.2	190.5	222	176
2	239.6	116.0	138	41
3	69.4	114.5	148	140
4	218.2	72.0	0	0
Totals	674.4	493.0	508	357

Flight Activity Per Unit Time & Area			Weighted By Observation Effort	
VP	Observation effort (HaHr)	Flying time at 'risk height' (Hahr^-1)	Weighting	Adjusted time at 'risk height' (Hahr^-1)
1	28046.95	0.0000017	0.353	0.0000006
2	27790.39	0.0000004	0.350	0.0000001
3	7946.34	0.0000049	0.100	0.0000005
4	15707.20	0.0000000	0.198	0.0000000
Totals	79490.89	0.0000018	1.000	0.0000012

Mean activity hr^-1 in wind farm	
Risk height	0.04907%
Rotor height	0.04766%

MORTALITY ESTIMATE		
Flight risk volume (Vw)	534891620.3	m^3
Rotor radius^2	4624	m
Combined rotor swept area (Va)	101687	m^2
Vr = Va * (d + l)	438780	m^3
Bird occupancy (n)	2.15	hrs / yr
Bird occupancy of rotor swept vol (b)	6.34	bird-secs
Bird transit time (t)	0.31	secs
No. of transits through rotors	20.72	per year
Estimated no. of collisions	1.18	per year
After allowing for avoidance	0.012	per year
i.e. equivalent to one bird every	**85.0**	**years**

Appendix 1

Probability of collision – hen harrier

			Calculation of alpha and p(collision) as a function of radius								
K: [1D or [3D] (0 or 1)	1					Upwind:			Downwind:		
NoBlades	3										
MaxChord	4.10	m	r/R	c/C	α	collide			collide		
Pitch (degrees)	15.0		radius	chord	alpha	length	p(collision)	y(x)	length	p(collision)	y(x)
			0				1.00	0.000		1.00	0.000
BirdLength	0.48	m	0.05	0.575	3.15	9.97	0.45	0.045	8.75	0.39	0.039
Wingspan	1.1	m	0.1	0.622	1.57	5.64	0.25	0.050	4.32	0.19	0.039
F: Flapping (0) or gliding (+1)	1		0.15	0.781	1.05	4.80	0.21	0.064	3.15	0.14	0.042
			0.2	0.939	0.79	4.47	0.20	0.080	2.48	0.11	0.044
Bird speed	11	m/sec	0.25	0.971	0.63	3.89	0.17	0.087	1.83	0.08	0.041
RotorDiam	136	m	0.3	0.923	0.52	3.26	0.15	0.087	1.30	0.06	0.035
RotationPeriod	5.89	sec	0.35	0.875	0.45	2.80	0.13	0.088	0.94	0.04	0.029
			0.4	0.827	0.39	2.65	0.12	0.095	0.89	0.04	0.032
integration interval	0.05		0.45	0.780	0.35	2.39	0.11	0.096	0.73	0.03	0.029
			0.5	0.732	0.31	2.17	0.10	0.097	0.61	0.03	0.027
Bird aspect ratioo: β	0.44		0.55	0.684	0.29	1.98	0.09	0.097	0.53	0.02	0.026
			0.6	0.637	0.26	1.82	0.08	0.097	0.49	0.02	0.027
			0.65	0.589	0.24	1.67	0.07	0.097	0.54	0.02	0.031
			0.7	0.541	0.22	1.54	0.07	0.096	0.57	0.03	0.036
			0.75	0.494	0.21	1.41	0.06	0.095	0.59	0.03	0.040
			0.8	0.446	0.20	1.30	0.06	0.093	0.61	0.03	0.043
			0.85	0.398	0.19	1.19	0.05	0.091	0.61	0.03	0.046
			0.9	0.350	0.17	1.09	0.05	0.088	0.61	0.03	0.049
			0.95	0.303	0.17	1.00	0.04	0.085	0.60	0.03	0.051
			1	0.255	0.16	0.91	0.04	0.081	0.59	0.03	0.053

Overall p(collision) = Upwind 8.3% Downwind 3.7%

Average 6.0%

Probability of collision - red kite

			Calculation of alpha and p(collision) as a function of radius								
K: [1D or [3D] (0 or 1)	1					Upwind:			Downwind:		
NoBlades	3										
MaxChord	4.10	m	r/R	c/C	α	collide			collide		
Pitch (degrees)	15.0		radius	chord	alpha	length	p(collision)	y(x)	length	p(collision)	y(x)
			0				1.00	0.000		1.00	0.000
BirdLength	0.63	m	0.05	0.575	3.34	12.14	0.51	0.051	10.92	0.46	0.046
Wingspan	1.85	m	0.1	0.622	1.67	6.74	0.28	0.057	5.42	0.23	0.046
F: Flapping (0) or gliding (+1)	1		0.15	0.781	1.11	5.58	0.23	0.070	3.92	0.17	0.050
			0.2	0.939	0.83	5.08	0.21	0.086	3.09	0.13	0.052
Bird speed	12	m/sec	0.25	0.971	0.67	4.38	0.18	0.092	2.32	0.10	0.049
RotorDiam	136	m	0.3	0.923	0.56	3.67	0.15	0.093	1.71	0.07	0.043
RotationPeriod	5.89	sec	0.35	0.875	0.48	3.14	0.13	0.093	1.29	0.05	0.038
			0.4	0.827	0.42	2.74	0.12	0.092	0.98	0.04	0.033
integration interval	0.05		0.45	0.780	0.37	2.41	0.10	0.091	0.75	0.03	0.029
			0.5	0.732	0.33	2.37	0.10	0.100	0.82	0.03	0.035
Bird aspect ratioo: β	0.34		0.55	0.684	0.30	2.18	0.09	0.101	0.73	0.03	0.034
			0.6	0.637	0.28	2.01	0.08	0.101	0.66	0.03	0.033
			0.65	0.589	0.26	1.85	0.08	0.101	0.66	0.03	0.036
			0.7	0.541	0.24	1.72	0.07	0.101	0.69	0.03	0.041
			0.75	0.494	0.22	1.59	0.07	0.100	0.72	0.03	0.045
			0.8	0.446	0.21	1.47	0.06	0.099	0.73	0.03	0.049
			0.85	0.398	0.20	1.36	0.06	0.097	0.74	0.03	0.053
			0.9	0.350	0.19	1.26	0.05	0.095	0.74	0.03	0.056
			0.95	0.303	0.18	1.16	0.05	0.093	0.74	0.03	0.059
			1	0.255	0.17	1.07	0.04	0.090	0.73	0.03	0.062

Overall p(collision) = Upwind 8.8% Downwind 4.3%

Average 6.5%

Probability of collision – golden eagle

			Calculation of alpha and p(collision) as a function of radius								
K: [1D or [3D] (0 or 1)	1					Upwind:			Downwind:		
NoBlades	3										
MaxChord	4.10	m	r/R	c/C	α	collide			collide		
Pitch (degrees)	15.0		radius	chord	alpha	length	p(collision)	y(x)	length	p(collision)	y(x)
			0				1.00	0.000		1.00	0.000
BirdLength	0.82	m	0.05	0.575	3.89	14.72	0.53	0.053	13.50	0.49	0.049
Wingspan	2.12	m	0.1	0.622	1.95	8.08	0.29	0.058	6.76	0.24	0.049
F: Flapping (0) or gliding (+1)	1		0.15	0.781	1.30	6.59	0.24	0.071	4.93	0.18	0.053
			0.2	0.939	0.97	5.93	0.21	0.086	3.93	0.14	0.057
Bird speed	14	m/sec	0.25	0.971	0.78	5.07	0.18	0.092	3.01	0.11	0.054
RotorDiam	136	m	0.3	0.923	0.65	4.22	0.15	0.091	2.27	0.08	0.049
RotationPeriod	5.89	sec	0.35	0.875	0.56	3.60	0.13	0.091	1.75	0.06	0.044
			0.4	0.827	0.49	3.13	0.11	0.090	1.37	0.05	0.040
integration interval	0.05		0.45	0.780	0.43	2.75	0.10	0.089	1.09	0.04	0.035
			0.5	0.732	0.39	2.43	0.09	0.088	0.88	0.03	0.032
Bird aspect ratioo: β	0.38		0.55	0.684	0.35	2.50	0.09	0.099	1.05	0.04	0.042
			0.6	0.637	0.32	2.31	0.08	0.100	0.96	0.03	0.041
			0.65	0.589	0.30	2.14	0.08	0.100	0.89	0.03	0.042
			0.7	0.541	0.28	1.98	0.07	0.100	0.84	0.03	0.042
			0.75	0.494	0.26	1.85	0.07	0.100	0.83	0.03	0.045
			0.8	0.446	0.24	1.72	0.06	0.099	0.86	0.03	0.050
			0.85	0.398	0.23	1.60	0.06	0.098	0.88	0.03	0.054
			0.9	0.350	0.22	1.49	0.05	0.097	0.89	0.03	0.058
			0.95	0.303	0.20	1.38	0.05	0.095	0.89	0.03	0.061
			1	0.255	0.19	1.28	0.05	0.093	0.89	0.03	0.064

Overall p(collision) = Upwind 8.7% Downwind 4.6%

Average 6.7%