

ANNEX E. COLLISION RISK ASSESSMENTS

The Collision Risk Analysis Area (CRAA) was created using a 500 metre (m) buffer (see EIA Figure 7.3). Using the larger 500 m area around the turbines accounts for possible inaccuracies in the recording of flightlines and ensures the assessment is precautionary.

As recommended in NatureScot guidance (SNH 2017^h), the aim of baseline flight activity surveys should be to achieve maximum visual coverage of proposed turbines and associated CRAA from Vantage Point (VP) viewsheds using the minimum number of VPs. However, in practice complete (100%) coverage is often unachievable as a result of the topography of the site, presence of mature forestry and access permissions outwith site boundaries.

For the Proposed Development, some areas of the CRAA remain ‘invisible’ at 20 m above ground level (see EIA Figure 7.3). The habitats within these areas are however of sufficient similarity to that ‘seen’ within the VP viewsheds in the CRAA, such that the survey data collected over the course of flight activity surveys and subsequently assessed for potential collision mortality risks, is considered to be representative of the whole CRAA and therefore appropriate for the purposes of estimating collision mortality risks using the NatureScot Collision Risk Model (CRM) (Band 2024^h) .

In the use of the NatureScot CRM, flying time at risk height (secsHahr⁻¹) for each species is calculated as a single mean activity rate within the entirety of the CRAA.

Table E-1,

Table E-2 and Table E-3 present the parameters which apply to each Collision Risk Model (CRM).

Table E-1 Wind farm parameters

Size of wind farm envelope (CRAA)	854.8	hectares (ha)
Number of turbines	20	turbines
Rotor diameter	136	metres (m)
Hub height	81.9	m
Max. rotor depth	0.43	m (at 6° pitch angle)
Max. chord	4.1	m
Pitch	6	degrees (°)
Rotation period	4.29	seconds (secs)
Turbine operation time	87.5	percent (%)
Risk height: highest	149.9	m
Risk height: lowest	13.9	m
Flight risk volume	1162571164	m ³

Table E-2 CRM parameters per species

Species	Length (m)	Wingspan (m)	Assumed flight speed, v (ms ⁻¹)	Avoidance rate ⁱⁱⁱ	Probability of collision	Bird transit time (secs)
Curlew	0.6	1	13	0.98	0.0697	0.0791
Golden plover	0.28	0.72	17.9	0.98	0.0493	0.0396
Goshawk	0.62	1.65	9.7	0.98	0.0832	0.1081
Hen harrier	0.48	1.1	12	0.99	0.0659	0.0757
Herring gull	0.64	1.5	12.8	0.98	0.0736	0.0835
Hobby	0.36	0.92	11.3	0.98	0.0601	0.0698
Merlin	0.28	0.56	13	0.98	0.0522	0.0545
Osprey	0.58	1.7	11.4	0.98	0.0749	0.0885
Peregrine falcon	0.48	1.1	12.1	0.98	0.0657	0.0751

Table E-3 Visible area within the CRAA per vantage point

VP	Area (ha)
1	221.15
2	355.06
3	276.04

Birds are assumed to be active during all the daylight hours and this is estimated by calculating the number of hours per day between sunrise and sunset (adjusting for correct latitude) for the survey seasons as defined in Table E-4 below.

Table E-4 Season definitions per species/species group

Species	Breeding season			Non-breeding season		
	Start date	End date	Hours presumed present	Start date	End date	Hours presumed present
Raptors	15 th March	31 st August	2,643	1 st September	14 th March	1,852
Waders	1 st April	31 st July	1,967	1 st August	31 st March	2,528
Other	15 th March	31 st August	2,643	1 st September	14 th March	1,852

Outputs for the CRM for the following species are presented in the following order below:

- Curlew;
 - Golden plover;
 - Goshawk;
 - Hen harrier;
 - Herring gull;
- Hobby;
 - Merlin;
 - Osprey; and
 - Peregrine falcon.

E.1 Curlew

Breeding Season 2020

Table E-5 Curlew flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr ⁻¹)
2	66.98	9586.68	0.000001

Table E-6 Curlew mortality estimates

Mean activity in wind farm at rotor height	0.0010	hr ⁻¹
Total Combined rotor swept volume	298834	m ³
Bird occupancy	1.9286	hrs/season
Bird occupancy of rotor swept volume	1.7847	bird-sec
No. of transits through rotors	22.5565	per season
Estimated collisions	1.5711	per season
Estimated collisions after correction for operation	1.3747	per season
Estimated collisions after avoidance factor	0.0275	per season
Equivalent to 1 bird every	36.37	seasons

Non-Breeding Season 2021/2022

Table E-7 Curlew flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr ⁻¹)
2	53.83	15445.21	0.0000004

Table E-8 Curlew mortality estimates

Mean activity in wind farm at rotor height	0.0003	hr ⁻¹
Total Combined rotor swept volume	298834	m ³
Bird occupancy	0.8035	hrs/season
Bird occupancy of rotor swept volume	0.7435	bird-sec
No. of transits through rotors	9.3977	per season
Estimated collisions	0.6546	per season
Estimated collisions after correction for operation	0.5727	per season
Estimated collisions after avoidance factor	0.0115	per season
Equivalent to 1 bird every	87.30	seasons

E.2 Golden plover

Non-Breeding Season 2020/2021

Table E-9 Golden plover flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr ⁻¹)
2	22.49	24144.24	0.0000001

Table E-10 Golden plover mortality estimates

Mean activity in wind farm at rotor height	0.0001	hr ⁻¹
Total Combined rotor swept volume	205863	m ³
Bird occupancy	0.2686	hrs/season
Bird occupancy of rotor swept volume	0.1712	bird-sec
No. of transits through rotors	4.3254	per season
Estimated collisions	0.2133	per season
Estimated collisions after correction for operation	0.1866	per season
Estimated collisions after avoidance factor	0.0037	per season
Equivalent to 1 bird every	267.94	seasons

Non-Breeding Season 2021/2022

Table E-11 Golden plover flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr ⁻¹)
1	222.20	10393.99	0.000002
2	119.04	15445.21	0.000001

Table E-12 Golden plover mortality estimates

Mean activity in wind farm at rotor height	0.0020	hr ⁻¹
Total Combined rotor swept volume	205863	m ³
Bird occupancy	5.0935	hrs/season
Bird occupancy of rotor swept volume	3.2469	bird-sec
No. of transits through rotors	82.0252	per season
Estimated collisions	4.0443	per season
Estimated collisions after correction for operation	3.5388	per season
Estimated collisions after avoidance factor	0.0708	per season
Equivalent to 1 bird every	14.13	seasons

E.3 Goshawk

Breeding Season 2020

Table E-13 Goshawk flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr ¹)
1	12.86	7961.36	0.0000001
2	93.38	15977.80	0.000001

Table E-14 Goshawk mortality estimates

Mean activity in wind farm at rotor height	0.0011	hr ¹
Total Combined rotor swept volume	304645	m ³
Bird occupancy	2.7847	hrs/season
Bird occupancy of rotor swept volume	2.6269	bird-sec
No. of transits through rotors	24.3011	per season
Estimated collisions	2.0207	per season
Estimated collisions after correction for operation	1.7681	per season
Estimated collisions after avoidance factor	0.0354	per season
Equivalent to 1 bird every	28.28	seasons

Non-Breeding Season 2020/2021

Table E-15 Goshawk flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr ¹)
2	61.84	15977.80	0.0000004
3	3.72	13249.94	0.00000003

Table E-16 Goshawk mortality estimates

Mean activity in wind farm at rotor height	0.0004	hr ¹
Total Combined rotor swept volume	304645	m ³
Bird occupancy	0.7530	hrs/season
Bird occupancy of rotor swept volume	0.7103	bird-sec
No. of transits through rotors	6.5710	per season
Estimated collisions	0.5464	per season
Estimated collisions after correction for operation	0.4781	per season
Estimated collisions after avoidance factor	0.0096	per season
Equivalent to 1 bird every	104.58	seasons

Breeding Season 2021

Table E-17 Goshawk flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr ¹)
2	104.73	12782.24	0.000001
3	30.40	12421.81	0.0000003

Table E-18 Goshawk mortality estimates

Mean activity in wind farm at rotor height	0.0010	hr ¹
Total Combined rotor swept volume	304645	m ³
Bird occupancy	2.5565	hrs/season
Bird occupancy of rotor swept volume	2.4117	bird-sec
No. of transits through rotors	22.3100	per season
Estimated collisions	1.8551	per season
Estimated collisions after correction for operation	1.6232	per season
Estimated collisions after avoidance factor	0.0325	per season
Equivalent to 1 bird every	30.80	seasons

Non-Breeding Season 2021/2022

Table E-19 Goshawk flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr ¹)
2	33.09	12959.77	0.0000003

Table E-20 Goshawk mortality estimates

Mean activity in wind farm at rotor height	0.0002	hr ¹
Total Combined rotor swept volume	304645	m ³
Bird occupancy	0.4551	hrs/season
Bird occupancy of rotor swept volume	0.4293	bird-sec
No. of transits through rotors	3.9714	per season
Estimated collisions	0.3302	per season
Estimated collisions after correction for operation	0.2890	per season
Estimated collisions after avoidance factor	0.0058	per season
Equivalent to 1 bird every	173.04	seasons

E.4 Hen harrier

Non-Breeding Season 2021/2022

Table E-21 Hen harrier flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr ¹)
2	41.67	12959.77	0.0000004

Table E-22 Hen harrier mortality estimates

Mean activity in wind farm at rotor height	0.0003	hr ⁻¹
Total Combined rotor swept volume	263970	m ³
Bird occupancy	0.5730	hrs/season
Bird occupancy of rotor swept volume	0.4684	bird-sec
No. of transits through rotors	6.1859	per season
Estimated collisions	0.4075	per season
Estimated collisions after correction for operation	0.3565	per season
Estimated collisions after avoidance factor	0.0036	per season
Equivalent to 1 bird every	280.47	seasons

E.5 Herring gull

Breeding Season 2021

Table E-23 Herring gull flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr ¹)
3	0.53	12421.81	0.000000004

Table E-24 Herring gull mortality estimates

Mean activity in wind farm at rotor height	0.000004	hr ⁻¹
Total Combined rotor swept volume	310455	m ³
Bird occupancy	0.0099	hrs/season
Bird occupancy of rotor swept volume	0.0096	bird-sec
No. of transits through rotors	0.1145	per season
Estimated collisions	0.0084	per season
Estimated collisions after correction for operation	0.0074	per season
Estimated collisions after avoidance factor	0.0001	per season
Equivalent to 1 bird every	6774.92	seasons

E.6 Hobby

Breeding Season 2021

Table E-25 Hobby flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr ¹)
1	20.70	7961.36	0.0000002

Table E-26 Hobby mortality estimates

Mean activity in wind farm at rotor height	0.0001	hr ⁻¹
Total Combined rotor swept volume	229106	m ³
Bird occupancy	0.3916	hrs/season
Bird occupancy of rotor swept volume	0.2778	bird-sec
No. of transits through rotors	3.9811	per season
Estimated collisions	0.2391	per season
Estimated collisions after correction for operation	0.2092	per season
Estimated collisions after avoidance factor	0.0042	per season
Equivalent to 1 bird every	239.02	seasons

E.7 Merlin

Non-Breeding Season 2020/2021

Table E-27 Merlin flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr ¹)
2	6.1	15977.8	0.00000004

Table E-28 Merlin mortality estimates

Mean activity in wind farm at rotor height	0.00004	hr ⁻¹
Total Combined rotor swept volume	205863	m ³
Bird occupancy	0.0701	hrs/season
Bird occupancy of rotor swept volume	0.0447	bird-sec
No. of transits through rotors	0.8195	per season
Estimated collisions	0.0428	per season
Estimated collisions after correction for operation	0.0375	per season
Estimated collisions after avoidance factor	0.0007	per season
Equivalent to 1 bird every	1334.87	seasons

E.8 Osprey

Breeding Season 2021

Table E-29 Osprey flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr ¹)
1	4.20	7961.36	0.00000004
2	17.59	12782.24	0.0000001

Table E-30 Osprey mortality estimates

Mean activity in wind farm at rotor height	0.00016	hr ¹
Total Combined rotor swept volume	293023	m ³
Bird occupancy	0.41223	hrs/season
Bird occupancy of rotor swept volume	0.37405	bird-sec
No. of transits through rotors	4.22793	per season
Estimated collisions	0.31685	per season
Estimated collisions after correction for operation	0.27725	per season
Estimated collisions after avoidance factor	0.00554	per season
Equivalent to 1 bird every	180.346	seasons

E.9 Peregrine falcon

Breeding Season 2020

Table E-31 Peregrine falcon flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr ¹)
2	7.08	15977.8	0.0000001

Table E-32 Peregrine falcon mortality estimates

Mean activity in wind farm at rotor height	0.0001	hr ¹
Total Combined rotor swept volume	263970	m ³
Bird occupancy	0.1855	hrs/season
Bird occupancy of rotor swept volume	0.1516	bird-sec
No. of transits through rotors	2.0195	per season
Estimated collisions	0.1326	per season
Estimated collisions after correction for operation	0.1160	per season
Estimated collisions after avoidance factor	0.0023	per season
Equivalent to 1 bird every	430.94	seasons

ⁱ Scottish Natural Heritage (2017). Recommended Bird Survey Methods to inform impact assessment of Onshore Windfarms.

Breeding Season 2021

Table E-33 Peregrine falcon flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr ¹)
2	1.84	12782.24	0.00000002

Table E-34 Peregrine falcon mortality estimates

Mean activity in wind farm at rotor height	0.00001	hr ¹
Total Combined rotor swept volume	263970	m ³
Bird occupancy	0.0348	hrs/season
Bird occupancy of rotor swept volume	0.0284	bird-sec
No. of transits through rotors	0.3787	per season
Estimated collisions	0.0249	per season
Estimated collisions after correction for operation	0.0218	per season
Estimated collisions after avoidance factor	0.0004	per season
Equivalent to 1 bird every	2298.04	seasons

Non-Breeding Season 2021/2022

Table E-35 Peregrine falcon flight activity

VP	Seconds at risk height	Observation effort (HaHr)	Flying time at risk height (secsHahr ¹)
2	11.38	12959.77	0.0000001
3	7.28	9959.53	0.0000001

Table E-36 Peregrine falcon mortality estimates

Mean activity in wind farm at rotor height	0.0001	hr ¹
Total Combined rotor swept volume	263970	m ³
Bird occupancy	0.2566	hrs/season
Bird occupancy of rotor swept volume	0.2098	bird-sec
No. of transits through rotors	2.7938	per season
Estimated collisions	0.1834	per season
Estimated collisions after correction for operation	0.1605	per season
Estimated collisions after avoidance factor	0.0032	per season
Equivalent to 1 bird every	311.50	seasons

ⁱⁱ Band, W. 2024. Using a collision risk model to assess bird collision risks for onshore wind farms. NatureScot Research Report 909.

ⁱⁱⁱ Scottish Natural Heritage (2018). Avoidance rates for the onshore SNH wind farm collision risk model.