Manogate Ltd

Ballyfasy Wind Farm:

Collision Risk Modelling Report

APPENDIX 7-2

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Project reference: **P00016266**

Date of issue: **November 2025**

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Revision and Amendment Register

Version Number	Date	Section(s)	Page(s)	Summary of Changes	Approved by
0.1	21/08/2025	All	All	First Draft	BG
0.2	01/09/2025	All	All	Internal Review	MRea
0.3	09/09/2025	All	All	Amendments	BG
1.0	10/09/2025	All	All	Finalisation	BG
1.1	23/10/2025	All	All	Amendments	AF
2.0	12/11/2025	All	All	Document Finalisation	BG

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Glossary

Term	Definition
Avoidance rate	It is acknowledged that birds take avoiding action when flying in the vicinity of turbines, either macro-avoidance (avoidance of an entire wind farm) or micro-avoidance (avoidance of individual turbines). To account for this an 'avoidance rate' is applied, based on guidance, to correct predicted collisions for each species.
Collision Risk Modelling	Collision Risk Modelling (CRM) is the process for predicting avian collisions likely to arise during the operational phase of the development.
Collision Risk Zone	The Collision Risk Zone is the area within 500 m of the turbine layout. A flight which is within this zone (even if only partially) is considered to be at risk of collision.
Potential Collision Height	A flight which is at Potential Collision Height is one which is between the lowest and highest extent of a turbine rotor.
Vantage Point	A location from which Flight Activity Surveys were undertaken to determine flight activity.
Viewshed	The visible area at the lowest rotor swept height of a turbine model within a 2 km, 180° arc from a Vantage Point.

Executive Summary

This Collision Risk Modelling (CRM) Report details the methodology and results for CRM undertaken for the proposed Ballyfasy Wind Farm. CRM has been undertaken following NatureScot (Band, 2024) guidance to predict collisions associated with the operational phase of the development and inform the impact assessment undertaken within the Environmental Impact Assessment Report.

CRM has been undertaken for target species which were present at sufficient levels to allow for robust modelling, using APEM's professional judgement. Species scoped into the CRM were: golden plover, lesser black-backed gull and kestrel.

CRM was undertaken for a best-case and worst-case scenario, based upon the range of turbine parameters provided. CRM was undertaken using the Band (2024) model

For the best-case model, the results generated from this approach predicts one lesser black-backed gull every 0.46 years, one golden plover every 0.02 years, and one kestrel every 0.12 years. Over the operational lifespan of the wind farm, this equates to approximately 191 lesser black-backed gull, 8-9 golden plover, and 49 kestrel.

For the worst-case model, the predicted collision rates are one lesser black-backed gull every 0.66 years, one golden plover every 0.03 years and one kestrel every 0.17 years. Over the operational lifespan of the wind farm, this equates to approximately 278 lesser black-backed gull, 11-12 golden plover and 69-70 kestrel.

1. Introduction

APEM Ltd (APEM) was commissioned by Art Generation Ltd to undertake the Ornithology Environmental Impact Assessment (EIA) for the proposed Ballyfasy Wind Farm (hereafter referred to as 'the Proposed Project'). To support the impact assessment, Collision Risk Modelling (CRM) has been undertaken to determine the predicted collision mortality for Important Ornithological Features (IOFs) during the operational lifespan of the Proposed Project using data collected during Vantage Point Surveys (VPS) undertaken between 2023-2025.

Predicted collisions have been calculated for a 10-turbine layout. Turbine parameters, provided as a range and used for modelling have been supplied to APEM by Tobin.

This report is a Technical Appendix to support the Ornithology Chapter of the EIA Report.

2. Methodology

CRM was undertaken following the latest NatureScot guidance (Band, 2024). VPS used to inform the CRM were undertaken in line with NatureScot (2017) guidance on recommended survey methods for onshore wind farms. CRM has been undertaken for species recorded within the Collision Risk Zone (the CRZ, a 500 m buffer of the turbine layout in line with SNH [2025] guidance) which were present at sufficient levels to allow for robust modelling, using APEM's professional judgement.

Table 2 outlines the target species recorded during VPS within the CRZ and outlines species which have been scoped in or out of CRM.

CRM estimates the number of collisions through a process of six stages:

- Stage A establishes the density of flying birds within the CRZ, and the proportion of birds that are flying at potential collision risk height.
- Stage B estimates the potential number of bird passages through rotors in the relevant season, based on density and the available hours during each season.
- Stage C determines the collision probability during a single bird rotor transit.
- Stage D considers the proportion of time in which the turbines are not in operation.
- Stage E takes into consideration the likely proportion of birds avoiding either the wind farm or its turbines.
- Stage F considers potential uncertainties and an estimate of error in the number of predicted collisions.

Table 1. Summary of Target Species Flights Recorded During VPS within the CRZ

Species	Conservation Status*	Number of flights during Year 1 surveys	Number of flights during Year 2 surveys	No. of birds per flight	Include in CRM?
Golden plover	Ann1, Red	0	14	2-26	**Yes, non-breeding season only – Species recorded occasionally within the CRZ during the non-breeding season, is red listed and is included in Annex I. Species was not recorded during the breeding season.**
Curlew	Red	0	1	1	No – Insufficient records available for a robust assessment of collisions risk. The very low number of flights across the two survey years indicate that collision risk for this species is negligible.
Snipe	Red	0	1	2	No – Insufficient records available for a robust assessment of collisions risk. The very low number of flights across the two survey years indicate that collision risk for this species is negligible.
Black-headed gull	Amber	0	6	1-6	No – Insufficient records available for a robust assessment of collisions risk. The very low number of flights across the two survey years indicate that collision risk for this species is negligible.
Great black-backed gull	Green	1	0	1	No – Insufficient records available for a robust assessment of collisions risk. The very low number of flights across the two survey years indicate that collision risk for this species is negligible.
Lesser black-backed gull	Amber	187	62	1-187	**Yes – Species recorded frequently within the CRZ and is amber listed.**
Hen harrier	Ann 1, Amber	3	4	1-2	No – Insufficient records available for a robust assessment of collisions risk. The very low number of flights across the two survey years indicate that collision risk for this species is negligible.
Kestrel	Red	27	14	1	**Yes – Species recorded frequently within the CRZ and is red listed.**

Merlin	Ann 1, Amber	0	5	1	No – Insufficient records available for a robust assessment of collisions risk. The very low number of flights across the two survey years indicate that collision risk for this species is negligible.
Total		187	76		
* Ann1: listed on Annex I of the Bird's Directive, Red/Amber/Green: Birds of Conservation Concern in IE (Ireland) Classification,					

2.1 Stage A- Flight activity

Stage A estimates the number of flights that may potentially be at risk of turbine collision in the absence of the displacement of birds, birds taking other avoidance actions, or birds being attracted towards the wind farm.

In the case of non-directional flights, there are two key parameters derived from survey observations that are needed in order describe the magnitude of flight activity:

- Areal bird density (D_A); and
- Proportion of birds flying at risk height (Q_{2R})

Areal bird density (D_A) is defined as the number of birds in flight, at any height, at a particular time, per unit area (typically per square kilometre, km^2). To calculate D_A, bird occupancy is converted to bird density (per m^2) by dividing by the area watched from each VP viewshed. The flight activity during VP watches is recorded in bird seconds, a unit that captures both abundance and duration of flight and is particularly appropriate where bird numbers are low:

$$D_A = \frac{b}{(t \times A) birds\ m^2}$$

Where b is the number of target species flight seconds recorded from a VP; t is the duration (in seconds) of all VP watches during either a month, season or year and A is the area of the VP viewshed (km^2).

D_A is calculated for each VP separately, with the figure subsequently averaged. However, where there exists a considerable difference in the time and/or area that is covered by relevant VP surveys the average figure should be weighted appropriately. Thus, the weighting factor used acknowledges that the quantity of data collected in a watch is proportional both to the size of the area observed and the duration of the VP watch:

$$Mean\ density\ D_A = \frac{\sum \frac{b_i \sqrt{t_i \times A_i}}{t_i \times A_i}}{\sum \sqrt{t_i \times A_i}}$$

In the case of conditions where a VP viewshed results in a significant difference in mean density D_A (for example, due to a difference in underlying habitat), the bird density should then either be calculated separately for each individual VP site and then applied to determine the likely collision risk within that area. Alternatively, a turbine-weighted average bird density should be employed instead, i.e. the bird density for each VP should be weighted by the number of turbines present within that viewshed. In this case, the average areal bird density ($D_{average}$) was estimated using the following:

$$D_{average} = \frac{\sum N_i \times D_i}{\sum N_i}$$

Where D_i is the areal bird density within the VP viewshed (i), N_i is the number of turbines to be sited in that VP viewshed; and $D_{average}$ is the average areal bird density.

The definition of **proportion of birds flying at risk height (Q_{2R})** is the proportion of birds present between the lowest and highest points of a rotor, measured relative to the rotor base. In cases where flights are only recorded in the rotor swept height band, Q_{2R} will be 100%.

2.1.1 Daylight hours and nocturnal activity

Bird surveys are generally undertaken diurnally, with recorded levels of flight activity assumed to be representative of flight activity across all daylight hours. Daylight hours depend on the wind farm site's latitude and the time of year. Daylight and night hours per month are provided within the NatureScot CRM spreadsheet when the latitude of a particular site is inputted. The latitude of the wind farm site is 52.38 North

Calculations used in the collision model account for collision risk associated with diurnal and nocturnal flights. Diurnal activity is based on the flight activity recorded for each target species during field surveys while nocturnal flight activity is assumed based on diurnal flight activity, and professional judgement regarding the likely levels of nocturnal activity for each target species.

Levels of nocturnal activity by all target species were estimated, using a one to five scale to approximate nocturnal flight (with a score of one equal to 0% nocturnal activity, two equal to 25% of diurnal activity, three equal to 50% of diurnal activity, four equal to 75% of diurnal activity and five whereby nocturnal activity is equal to diurnal activity, seeTable 3). It should be noted that for truly nocturnal species, this will underestimate nocturnal flight activity, which will be >100% of diurnal activity.

2.2 Stage B- Estimating number of bird flights through rotors

Stage B considers the available figures for bird density (D_A), the proportion of risk height flights (Q_{2R}), the nocturnal activity factor (f_{night}), and the figures for monthly daylight and night hours calculated at **Stage A-** Flight activity**.** In order to estimate the number of birds flying through rotors, the model considers the number of turbines, the turbine rotor radius and the flight speed of the target species. For flight speed, a typical mean flight speed is selected based on standard key literature, acknowledging that flight speed (and thus collision risk) will vary depending on bird behaviour (commuting, migration, foraging etc):

$$Number\ of\ transits = v\left(\frac{D_{average}\ \times\ Q_{2R}}{2R}\right) \times\ (T\pi R2)\ \times\ \left(t_{day}\, f_{night} t_{night}\right)$$

Where v is bird speed, relative to the ground (m sec^{-1}), $D_{average}$ is the average areal bird density (Birds m^2), Q_{2R} is the proportion of birds flying at risk height (%), R is the length of the rotor blades, from axis to tip (m), T is the number of turbines, $f_{night}$is the nocturnal activity factor; and t_{day} and t_{night} are daylight and night time hours respectively, across a year.

2.3 Stage C- Probability of collision for a single rotor transit

Stage C utilises information on turbine dimensions and rotor speed (), as well bird biometrics to calculate the collision risk for birds flying through a turbine rotor (). Upwind flights have a greater collision risk than downwind flights, and an assumption is made that the proportion of upwind and downwind flights

The probability of collision during a rotor transit is calculated by assessing collision risk at various positions across the rotor disc, using increments of radial distance from r/R=0.05 out to r/R=1, and angular intervals (ϕ) of 10 degrees. The model calculates the collision probability at each combination of radius and angle, then averages these values across the entire area of the rotor disc to generate the average collision risk for a passage at any given point across the rotor.

The calculation should be carried out using a mean operational turbine speed. Preferably, the mean speed utilised in the calculation should be measured over time using an analysis of available wind data to determine the likely frequency distribution of turbine speeds. However, in cases where this is not available, the speed used should be based on the most likely value as anticipated by the wind farm developer.

Table 2: Turbine data

Symbol	Description	Units	Turbine Models	
			Worst Case	Best Case
B	Number of blades		3	3
-	Hub height	m	98.5	95
R	Rotor radius	m	81.5	74.5
-	Minimum swept height	m	17.0	21.0
-	Maximum swept height	m	180.0	170.0
C	Maximum blade width	m	4.1	4.1
Γ	Average blade pitch*	°	13.0	13.0
Ω	Average rotation speed	rpm	8.3	8.3
-	Average rotational period	s	7.23	7.23

Table 3: Bird data and avoidance rates for target species

Target species	Bird length* (m)	Wingspan* (m)	Flight speed** (m/s)	Avoidance rate***	Breeding season****	Non-breeding season*****	Nocturnal factor
Golden plover	0.275	0.72	17.9	0.998	May to July	August to April	5
Lesser black-backed gull	0.58	1.43	13.4	0.995	April to August	September to March	2
Kestrel	0.34	0.76	10.1	0.95	March to mid-August	Mid-August to February	2
*Species biometrics are taken from Snow *et al*. (1998)							

Target species	Bird length* (m)	Wingspan* (m)	Flight speed** (m/s)	Avoidance rate***	Breeding season****	Non-breeding season*****	Nocturnal factor
**Species flight speeds are taken from Alerstam *et al*. (2007), Bruderer & Bolt (2001) and Provan & Whitfield (2006) ***Species avoidance rates are taken from NatureScot (SNH, 2018), Gittings (2020) and Furness (2019) ****The breeding season for each species is taken from NatureScot guidance (SNH, 2014). The golden plover breeding season has been reduced to account for spring passage activity during April which is more representative of the non-breeding population. All dates are inclusive. *****Non-breeding seasons are the remaining months of the year. The golden plover non-breeding season has been amended to account for spring passage activity during April which is more representative of the non-breeding population.							

2.4 Stage D- Multiplying to yield expected collisions per year

In this stage, the output from Stage B (number of potential transits through rotors) is multiplied by the output of Stage C (collision risk for a single rotor transit) to yield the projected number of bird collisions per month or year.

However, allowance must first be made for the proportion of time that rotors are not operational due to turbine idleness. The non-operational factor (Q_{op}) has been provided by FEI, based on wind modelling. the single transit risk is multiplied by the factor Q_{op} to allow for the proportion of time that the wind turbines are operational. This is before considering avoidance behaviour, which is stage E.

2.5 Stage E- Applying the avoidance rate

The preceding stages of the model operate on the assumption that birds will not undertake any avoidance action in response to the presence of wind turbines. However, it is accepted that birds do take avoidance action (macro, meso or micro avoidance) based on the results of considerable studies and that avoidance differs between species.

The potential collision mortality, for each month and for a year, after avoidance was calculated using a range of assumed avoidance rates of 95%, 98%, 99% and 99.5%, as well as the recommended avoidance rate for each species if this differs from those listed.

2.6 Stage F- Expressing uncertainty

Within the NatureScot (Band, 2024) guidance, it states that within the CRM there are sources of variability or uncertainty, which should be considered when determining the accuracy of predicted collisions. It is acknowledged that there are various sources of potential error which include inaccuracies when recording flight data, uncertainty over nocturnal flight activity and limitations and assumptions within the collision model.

However, potential error was limited as much as possible through the use of experienced surveyors familiar with the NatureScot (2025) survey guidance, who undertook baseline surveys in accordance with guidance, while the CRM has been undertaken in line with NatureScot (Band, 2024) guidance. Although there is the potential for some error in the predicted collisions, it is considered that this has been minimised as far as possible, and that the results should be considered a best estimate based on current guidance. As it is not possible to quantify the level of uncertainty in the results, this has not been considered further.

3. Collision Risk Modelling Results

All VP locations used during surveys were consistent throughout the two-year survey period. Viewshed analysis was undertaken for each VP, to determine the spatial coverage. This was performed for both the Worst Case and Best Case turbine models. Viewshed analysis was performed using a surface offset equal to the minimum rotor swept height for each proposed turbine model, which mapped visible airspace available to surveyors at the lowest potential collision height.

Spatial coverage of the viewsheds within the 500 m turbine buffer is presented in Table 4.

Table 4. Spatial coverage of VPs

Vantage Point	Viewshed coverage within 500 m of the turbine layout at 17 m (km^2)	Viewshed coverage within 500 m of the turbine layout at 21 m (km^2)
VP1	2.097	2.209
VP2	2.981	3.047
VP3	2.449	2.634
Total of viewshed areas	7.528	7.890
Area within the CRZ which is covered by at least one viewshed	4.672	4.857
Percentage coverage of CRZ by combined viewsheds	88.872 %	92.391 %

3.1 Stage A – Flight Activity

3.1.1 Bird density

VPS were undertaken over two years covering two breeding and two non-breeding seasons between March 2023 to March 2025 from three VPs which covered the turbine locations and a 500 m buffer (the CRZ) in line with NatureScot (2025) guidance. The surveys achieved 88.9 % coverage of the CRZ at a height of 17 m, which is the lowest rotor swept height of the two proposed turbine models.

VP watches were undertaken for a minimum of 36 hours during each breeding and non-breeding season as detailed in Appendix 7-1. All flights of target species were recorded during each watch period, yielding total flying time in bird-seconds throughout the watch. Flying time was divided by the period of the watch (in seconds) and the area watched to give the average density of birds in flight per square kilometre.

The mean density (DA) for each species during the non-breeding and breeding seasons is detailed in **Table 5**.

Table 5. Target species mean bird density

Species	Worst -Case Turbine Model				Best-Case Turbine Model			
	Non-breeding season mean density (birds/km2)	Non-breeding season standard deviation	Breeding season mean density (birds/km2)	Breeding season standard deviation	Non-breeding season mean density (birds/km2)	Non-breeding season standard deviation	Breeding season mean density (birds/km2)	Breeding season standard deviation
Lesser black-backed gull	0.05433	0.09888	0.01423	0.03598	0.04912	0.02849	0.01279	0.01121
Golden plover	0.00259	0.01125	0.00000	0.00000	0.00247	0.00427	0.00000	0.00000
Kestrel	0.00115	0.00199	0.00127	0.00249	0.00118	0.00086	0.00129	0.00101

Table 6. Proportion of observed birds flying at rotor risk height (%Q2R)

Species	Number of birds observed		%Q2R Worst Case		%Q2R Best Case	
	NB	B	NB	B	NB	B
Lesser black-backed gull	1220	312	100.00	100.00	94.84	59.94
Golden plover	141	0	100.00	0.00	98.58	0.00
Kestrel	15	20	100.00	100.00	100.00	90.00

3.1.2 Proportion of flights at risk height

The proportion of observed birds at rotor risk height for each turbine model is shown above in **Table 6**.

The mean density (DA) is given in Table 5 for each target species and was calculated for each period (breeding and non-breeding) during each survey year, in line with NatureScot guidance (NatureScot, 2025).

The watches were divided into sessions of three hours in duration with breaks between sessions to limit observer fatigue, and the sessions spread to include a representative sample of daylight hours. All flights of target species were recorded during each watch period, yielding total flying time in bird-seconds throughout the watch. Flying time was divided by the period of the watch (in seconds) and the area watched to give the average density of birds in flight per square kilometre.

3.2 Stage B – Estimating number of flights through rotors

The output from Stage B is the potential number of bird transits through the rotor swept area, presented seasonally. The total number of bird transits expected through rotors is proportional to the number and cross-sectional area of the rotors, and to the density of birds in the airspace within the CRZ at potential collision height. Total number of transits each month, for each species, is detailed in Table 7 below.

Table 7. Potential number of bird transits through rotors

Species	Model	Number of Transits												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Lesser black-backed gull	Best Case	3395.270	2944.075	3091.414	467.038	456.864	428.356	448.698	471.019	2917.074	3188.716	3239.438	3436.996	24484.957
	Worst Case	4490.754	3893.980	4088.859	977.425	956.133	896.472	939.043	985.756	3858.269	4217.555	4284.642	4545.944	34134.832
Golden plover	Best Case	491.610	411.573	411.169	0.000	0.000	0.000	0.000	346.099	378.151	436.928	463.493	502.657	3441.680
	Worst Case	625.524	523.684	523.170	0.000	0.000	0.000	0.000	440.375	481.159	555.946	589.747	639.579	4379.185
Kestrel	Best Case	57.166	49.569	51.535	47.037	46.012	43.141	45.190	71.393	49.115	53.688	54.542	57.869	626.257
	Worst Case	71.706	62.177	71.825	65.556	64.128	60.126	62.982	96.164	61.607	67.344	68.415	72.587	824.618

3.3 Stage C – Probability of Collision for a single rotor transit

Data relating to the likelihood of a bird being hit when flying through the rotor is derived from the NatureScot CRM spreadsheet. The collision probability for each species and turbine model is detailed in Table 8.

Table 8. Probability of collision for a single rotor transit of each turbine model

Species	Probability of Collision (%)	
	Best Case	Worst Case
Lesser black-backed gull	5.54%	5.82%
Golden plover	4.13%	4.28%
Kestrel	4.88%	5.20%

3.4 Stage D – Multiplying to yield expected collisions per year

Following the above steps, the number of bird transits per year through the rotors can be combined with the probability of a bird being hit when flying through the rotor to give a likely collision rate per month and per year (assuming no avoidance).

This stage considers the proportion of time that turbines are likely to be operational. The 85% default operational time is considered industry standard, originally stemming from guidance by the British Wind Energy Association (BWEA), now known as Renewable UK and is a widely used assumption in CRM.

The collision rate for each species, for each turbine model, before accounting for avoidance is detailed in Table 9.

Table 9. Predicted collisions before avoidance rate

Species	Model	Number of collisions before avoidance												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Lesser black-backed gull	Best Case	159.96	138.70	145.64	22.00	21.52	20.18	21.14	22.19	137.43	150.22	152.61	161.92	1153.52
	Worst Case	222.25	192.72	202.36	48.37	47.32	44.37	46.47	48.79	190.95	208.73	212.05	224.99	1689.38
Golden plover	Best Case	17.26	14.45	14.44	0.00	0.00	0.00	0.00	12.15	13.28	15.34	16.27	17.65	120.83
	Worst Case	22.74	19.04	19.02	0.00	0.00	0.00	0.00	16.01	17.50	20.21	21.44	23.26	159.23
Kestrel	Best Case	2.37	2.06	2.14	1.95	1.91	1.79	1.87	2.96	2.04	2.23	2.26	2.40	25.98
	Worst Case	3.17	2.75	3.18	2.90	2.84	2.66	2.78	4.25	2.72	2.98	3.02	3.21	36.46

3.5 Stage E- Applying the avoidance rate

There are a range of guidance documents which propose species-specific avoidance rates to use in CRM. Predicted collisions have been calculated for avoidance rates of 95%, 98%, 99%, and 99.5% during the breeding and non-breeding seasons. The avoidance rates recommended by NatureScot (2018) and Furness (2019) (see Table 10 and Table 11) were applied to estimate the number of bird collisions per annum for each proposed turbine model.

Table 10. Predicted collisions per annum considering 95%, 98%, 99% and 99.5% avoidance rate

Species	Model	Predicted Collisions – 95% avoidance			Predicted Collisions – 98% avoidance			Predicted Collisions – 99% avoidance			Predicted Collisions – 99.5% avoidance		
		B	NB	Year	B	NB	Year	B	NB	Year	B	NB	Year
Lesser black-backed gull	Best Case	5.35	52.32	57.68	2.14	20.93	23.07	1.07	10.46	11.54	0.54	5.23	5.77
	Worst Case	11.766	72.703	84.469	4.706	29.081	33.788	2.353	14.541	16.894	1.18	7.27	8.45
Golden plover	Best Case	0.00	6.04	6.04	0.00	2.42	2.42	0.00	1.21	1.21	0.00	0.60	0.60
	Worst Case	0.000	7.961	7.961	0.000	3.185	3.185	0.000	1.592	1.592	0.00	0.80	0.80
Kestrel	Best Case	0.56	0.74	1.30	0.22	0.30	0.52	0.11	0.15	0.26	0.06	0.07	0.13
	Worst Case	0.824	0.999	1.823	0.330	0.400	0.729	0.165	0.200	0.365	0.08	0.10	0.18

Table 11. Predicted collisions considering NatureScot avoidance rates

Species	Model	Predicted collisions per breeding season*	Predicted collisions per non-breeding season	Predicted annual collisions**	Predicted years per collision	Predicted collisions during Proposed Development operational lifespan
Lesser black-backed gull	Best Case	0.535	5.232	5.768	0.48	201.866
	Worst Case	1.177	7.270	8.447	0.70	295.642
Golden plover*	Best Case	0.000	2.417	2.417	0.02	8.458
	Worst Case	0.000	3.185	3.185	0.03	11.146
Kestrel	Best Case	0.557	0.742	1.299	0.11	45.458
	Worst Case	0.824	0.999	1.823	0.15	63.804
*An avoidance rate of 0.998% was used for golden plover, as detailed in Gittings (2020)						

4. Conclusion

The results generated by running NatureScot's recommended approach for CRM moderate levels of predicted collisions for target species; lesser black-backed gull, golden plover and kestrel. Turbine parameters were provided as a range and therefore two turbine models were used, a best-case and worst-case model.

Based on the best-case model, the predicted collision rates are 5.77 lesser black-backed gulls annually, 0.5 during the breeding season and 5.23 during the non-breeding season. 0.60 golden plover annually, all during the non-breeding season. 0.14 kestrel annually, 0.06 during the breeding season and 0.07 during the non-breeding season. Over the operational lifespan of the wind farm, this equates to approximately 202 lesser black-backed gull, 8-9 golden plover, and 45 kestrel.

Based on the worst-case model, the predicted collision rates are 8.45 lesser black-backed gull annually, 1.18 during the breeding season and 7.27 during the non-breeding season. 0.80 golden plover annually, all during the non-breeding season. 0.18 kestrel annually, 0.08 during the breeding season and 0.10 during the non-breeding season. Over the operational lifespan of the wind farm, this equates to approximately 296 lesser black-backed gull, 11 golden plover and 64 kestrel.

It is important to note that, as is always the case with a modelled approach, the collision risk model outputs are only considered to be indicative of the number of fatalities resulting from the Proposed Project and should be considered in conjunction with other impacts. For example, the outputs from the model do not take account of potential displacement of birds from the wind farm site, which would reduce collision risk. In addition, due to the VPS methodology, the predicted collisions are likely to be an overestimate.

The height bands selected at the commencement of surveys were not aligned with the final turbine specifications, resulting in some discrepancies in how bird flight heights were categorised in the collision risk models, therefore some assumptions were required. Specifically, if any bird(s) were flying above the rotor tip height, these would be included in both the best-case and worst-case models. Similarly, if any flight(s) were below the blade tip clearance, these were incorporated into the worst-case scenario. For example, a bird flight recorded at 200 m would be assigned to the >120 m height band and consequently included in both models, despite being above the actual rotor swept zone. As a result, it is likely that a proportion of the flight seconds and individuals considered to be at collision height were actually flying above or below rotor swept height. This suggests that the predicted collision rates are likely overestimated in both models.

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Appendix 1 – Figures

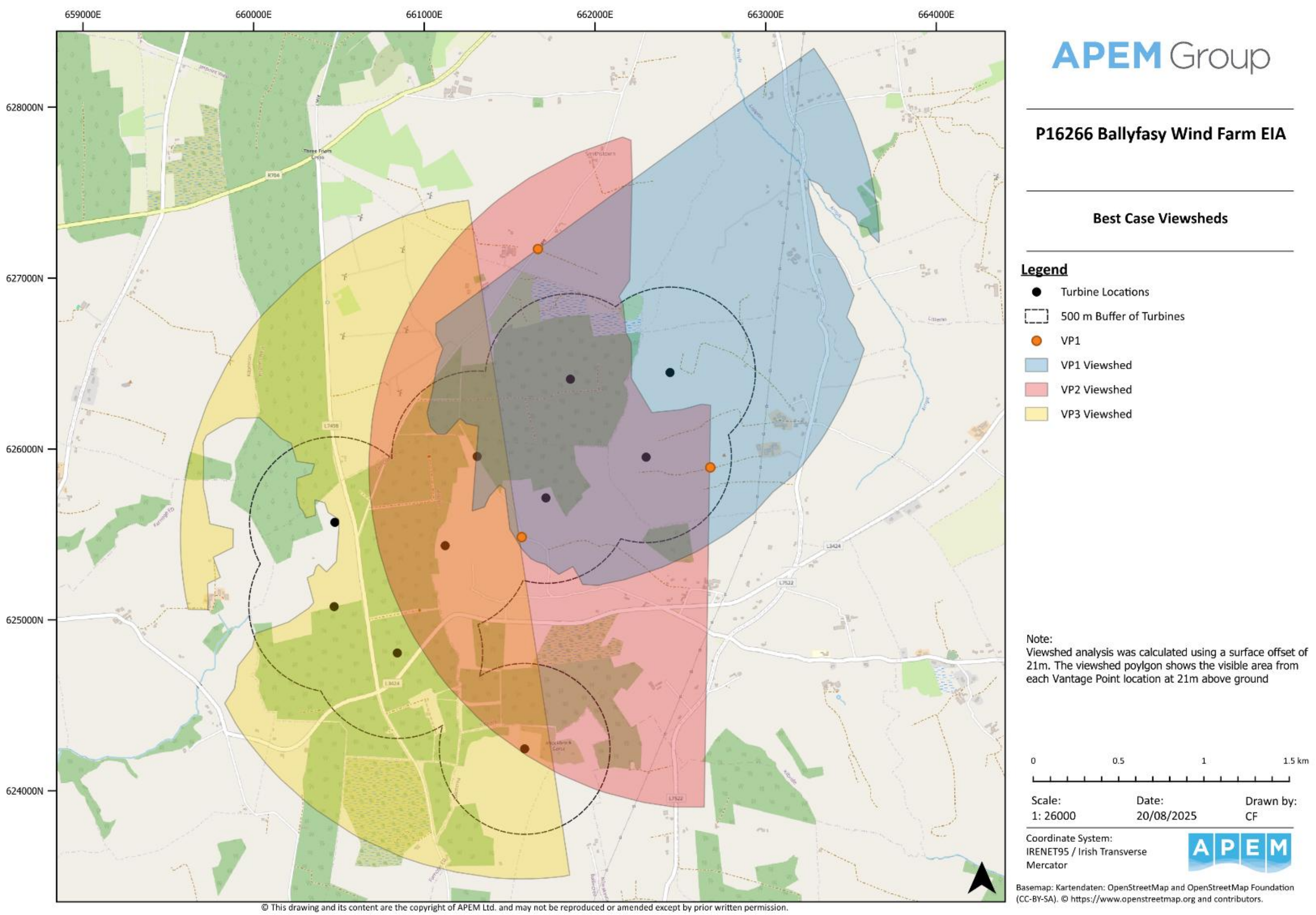

Figure 1. Vantage Points and Viewsheds for Best-Case Model

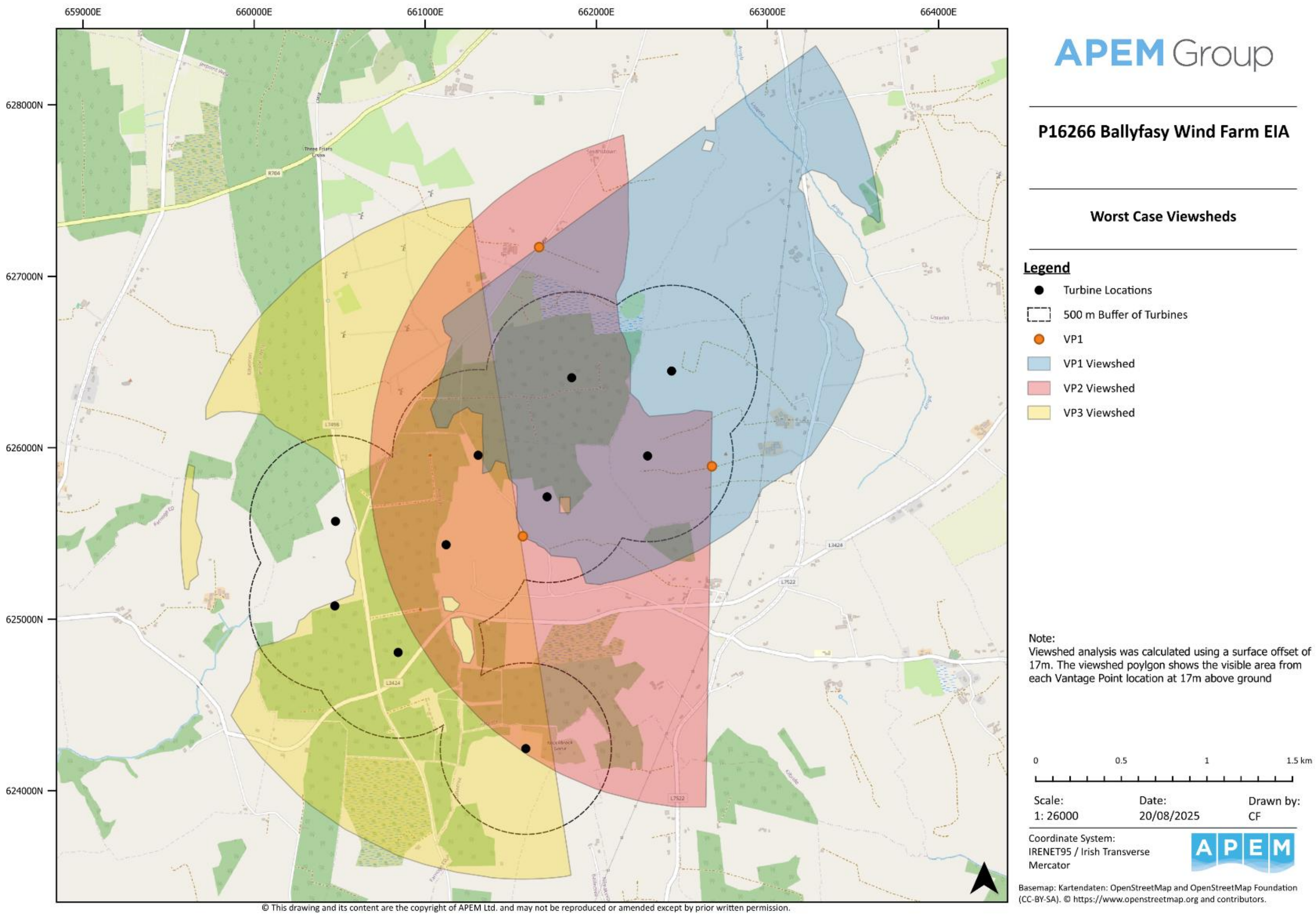

Figure 2. Vantage Points and Viewsheds for Worst-Case Model