Balliemeanoch Pumped Storage Hydro

Environmental Impact Assessment Report

Volume 5: Appendices
Appendix 9.2: Golden Eagle Topographical Modelling

ILI (Borders PSH) Ltd

July 2024

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Quality information

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Revision History

Revision	Revision date	Details	Authorized	Name	Position
1	July 2024	Submission	DL	David Lee	Technical Director

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1. Introduction

This appendix accompanies Chapter 9 of the EIAR (Volume 2). It describes the method and outputs of the Golden Eagle Topographical (GET) modelling exercise carried out for the Development.

The GET modelling technique was developed by Fielding *et al* (2019) as a means of predicting habitat use by golden eagle *Aquila chrysaetos*. The model was developed using data from 92 satellite tagged golden eagles that were tagged as nestlings between 2007 and 2016 and subsequently dispersed from their nest sites.

The GET model is recommended by NatureScot as a tool for estimating the loss of 'preferred' golden eagle habitat to range holding golden eagles (https://www.nature.scot/doc/naturescot-statement-modelling-support-assessment-forestry-and-wind-farm-impacts-golden-eagles). As set out in Table 9.2 of Chapter 9: Ornithology of the EIAR, NatureScot also recommended that GET modelling be carried out for the Development.

This chapter is supported by the following Figures located at the end of this document:

- 9.2.1 Baseline GET Model Results
- 9.2.2 Suitable Golden Eagle Habitat Estimated to be Lost to Development and Cumulative Projects

1.1 Relevant Golden Eagle Territories

As described in detail in Confidential Appendix 9.1: Schedule 1 Birds, there are two golden eagle home ranges that lie within the potential zone of influence (ZoI) of the Development. These are referred to as G/LAE1 and G/LAE1A. The estimated boundaries of these territories were provided by NatureScot in the reports Austin *et al* (2015a) and Austin *et al* (2015b).

Calculations on the availability of suitable habitat and the potential loss of such habitat to the Development were carried out based on the territorial extents of G/LAE1 and G/LAE1A provide by NatureScot.

2. Method

2.1.1 Establishing Baseline Habitat Suitability

The GET model is based on three landscape characteristics which have been shown to influence the occurrence of golden eagles:

- Altitude (metres above sea level);
- Distance to ridge (metres);
- Slope (degrees).

AECOM's analysis was carried out using Python and Ordnance Survey (OS) terrain data at 5m resolution.

Altitude was readily obtained from the OS digital terrain model data.

To find ridges, the height at each location relative to heights 250m away was compared. This was done east to west, north to south, north-west to south-east, and south-west to north-east. The height difference in one direction, say west, was added to the height difference in the other direction, in this case east. If the total of this difference was greater than 54m then the pixel was set as a ridge. The ridge data in each direction was then combined so that any pixel defined as a ridge in any single dataset was defined as a ridge in the combined dataset. A new array was then created which contained the distance between that pixel and the nearest pixel set as a ridge in the combined ridge dataset.

The slope for each pixel was defined as the square root of the sum of the squares of the x and y gradients for the corresponding pixel in the terrain data.

Three Standardised Preference Indices (SPIs) were set for the altitude data, ridge distance and slope. Tables A1-A3 in Annex A provide Preference Indices (PI) and SPI values with lower and upper 95% confidence limits (LCL and UCL, respectively) for altitude, distance to ridge and slope (taken from Fielding *et al* (2019) supporting information).

The SPI for altitude, distance to ridge, and slope were added together to derive the final predicted use value. Table A4 shows the combined SPI values and corresponding predicted use value.

In accordance with Fielding *et al* (2019), pixels that scored a value of 6 or greater were defined as being suitable for golden eagles (sometimes referred to as 'preferred' habitat). Pixels with a value of 5 or lower are considered to be unfavourable for golden eagles. Any land covered by closed canopy woodland (in particular commercial conifer plantation) is also considered to be unfavourable, even if it scores 6 or more due to its topographical characteristics. Furthermore, the area within the red line boundary of the operational Carraig Gheal Wind Farm, on the west side of Loch Awe, was considered to be unavailable to golden eagle due to displacement.

The total area of preferred golden eagle habitat (i.e., habitat scoring 6 or greater) within golden eagle ranges G/LAE1 and G/LAE1A was calculated.

2.1.2 Determining Loss of Suitable Habitat

To determine the total loss of suitable/preferred golden eagle habitat, ArcGIS software was used to calculate the total area of habitat scoring 6 or higher in the GET model that lies under the footprint of above-ground infrastructure plus a 300m buffer. This accounts for the direct impact of habitat loss as well as potential indirect effects such as changes to habitat and displacement away from infrastructure. Below-ground infrastructure (which will be within bedrock) was not included in this calculation as habitat above it will be unaffected.

2.1.3 Cumulative Loss of Habitat

There is evidence that golden eagle avoid operational wind farms (e.g. Walker *et al*, 2005). Consequently, the total area of GET 6+ habitat within the red line application boundary of any proposed wind farm(s) which lie within the home range of G/LAE1 and/or G/LAE1A was also calculated. The applicable developments which lie within the ranges of G/LAE1 and G/LAE1A are:

- Blarghour Wind Farm (consented, variation proposed);
- Ladyfield Wind Farm (scoping);
- An Carr Dubh wind Farm (application submitted);

The calculation of the total area of suitable golden eagle habitat within the boundaries of these schemes allowed for consideration in the modelling exercise of the cumulative impacts of habitat loss from other developments.

3. Results

Figure 9.2.1 shows the extent of suitable golden eagle habitat (i.e., habitat scoring 6 or greater in the GET model) within the Development Site and wider area. This figure is also presented as Confidential Figure 9.1.4 in Confidential Appendix 9.1 with the inclusion of the approximate boundaries of the golden eagle home ranges G/LAE1 and G/LAE1A for reference.

Figure 9.2.2 illustrates the area of suitable golden eagle habitat relative to the footprint of above-ground infrastructure associated with the Development plus a 300m buffer. The relevant boundaries of Blarghour, Ladyfield and An Carr Dubh Farms are also shown.

Table 1 presents the following:

- The total area of suitable habitat (GET 6+) within the golden eagle home ranges G/LAE1 and G/LAE1A;
- The area of land within golden eagle home ranges G/LAE1 and G/LAE1A which scores 6 or greater in the GET model and lies within 300m of above-ground Development infrastructure;

- The total area of land within golden eagle home ranges G/LAE1 and G/LAE1A which scores 6 or greater in the GET model and lies within the red line boundaries of Blarghour Wind Farm, Ladyfield Wind Farm, An Carr Dubh Wind Farm and Carraig Gheal Wind Farm.

Table 1 GET Model Results

Golden Eagle Territory	Total Area of Suitable Habitat (GET 6+) Within Home Range (km^2)*	Area of Suitable Habitat (GET 6+) Within Home Range and Which Lies Within 300m of Above-ground Infrastructure (km^2)	Area of Suitable Habitat (GET 6+) Within Home Range and Which Lies Within Red Line Boundary of Operational or Proposed Wind Farms (km^2)
G/LAE1	19.68	2.61	1.26
G/LAE1A	17.77	2.83	0.81

As stated in Methods, afforested land that may otherwise have scored 6 or greater in the GET model was excluded as such areas are avoided by golden eagle.

According to the GET modelling exercise, the Development will result in the loss of approximately 13% of suitable habitat within golden eagle home range G/LAE1. It will also result in the loss of approximately 16% of the suitable habitat within golden eagle range G/LAE1A.

The assessment of cumulative effects is somewhat broad-brush, and likely an over-estimate, as it has assumed the complete displacement of golden eagle from the entire red line boundary of the wind farm developments listed above. In reality, this is not likely to occur, and displacement would only be expected to occur around operational turbines and not necessarily as far as the edge of the wind farm development boundary. However, using this precautionary approach, if the Development and all other proposed wind farms were to be constructed, the total loss of suitable habitat from G/LAE1 and G/LAE1A (including the Development) would be approximately 20% of the existing baseline for each home range.

The results described above are supported by the data obtained between April 2021 and January 2024 from a satellite tagged golden eagle (582) which appears to be associated with the G/LAE1 territory, but which also frequently occurs in habitat within the G/LAE1A territory. This bird was recorded by the satellite tag using habitat across these home ranges which was determined by the GET model to be 6+ and suitable for the species.

4. References

Austin, S., Fielding, A. H. and Haworth, P. F. (2015a). G/LAE1 Golden eagle range report – Natural Heritage Zone 14 “Argyll West and Islands”. Scottish Natural Heritage Commissioned Report No. 860.

Austin, S., Fielding, A. H. and Haworth, P. F. (2015b). G/LAE1A Golden eagle range report – Natural Heritage Zone 14 “Argyll West and Islands”. Scottish Natural Heritage Commissioned Report No. 861.

Fielding, A.H., Haworth, P.F., Anderson, D. and Benn, S. (2019). A simple topographic model to predict Golden Eagle *Aquila chrysaetos* space use during dispersal. *Ibis* **162(2)**.

Walker, D., McGrady, M., McCluskie, A., Madders, M. and McLeod, D.R.A. (2005). Resident golden eagle ranging behaviour before and after construction of a windfarm in Argyll. *Scottish Birds* **25**, pp 24-40.

Annex A Preference Indices and Standard Preference Indices

Tables A1-A3 provide the PI and SPI values for altitude, distance to ridge and slope, respectively.

Table A1 PI and SPI Values for Altitude

Altitude (m)	LCL	PI	UCL	SPI
0-19	0.000	0.000	0.000	0
20-39	0.001	0.003	0.005	0
40-59	0.063	0.084	0.110	1
60-79	0.264	0.311	0.362	4
80-99	0.376	0.434	0.499	5
100-119	0.342	0.404	0.463	5
120-139	0.320	0.374	0.433	4
140-159	0.379	0.440	0.502	5
160-179	0.338	0.397	0.463	5
180-199	0.453	0.511	0.579	6
200-219	0.566	0.640	0.711	7
220-239	0.642	0.717	0.793	8
240-259	0.657	0.732	0.812	8
260-279	0.729	0.809	0.894	9
280-299	0.686	0.757	0.835	9
300-319	0.711	0.793	0.876	9
320-339	0.682	0.765	0.840	9
340-359	0.723	0.801	0.884	9
360-379	0.757	0.844	0.934	10
380-399	0.791	0.869	0.952	10
400-419	0.851	1.000	1.037	11
420-439	1.044	1.145	1.251	13
440-459	1.167	1.292	1.411	15
460-479	1.323	1.449	1.577	17
480-499	1.471	1.608	1.735	18
500-519	1.694	1.848	2.010	21
520-539	1.842	2.007	2.168	23
540-559	2.080	2.263	2.450	26
560-579	2.171	2.365	2.559	27
580-599	2.470	2.679	2.898	31
600-619	2.453	2.659	2.897	30
620-639	2.703	2.916	3.157	33
640-659	3.031	3.270	3.534	37

Altitude (m)	LCL	PI	UCL	SPI
660-679	3.048	3.304	3.559	38
680-699	3.289	3.562	3.842	41
700-719	3.206	3.519	3.811	40
720-739	3.444	3.767	4.082	43
740-759	3.439	3.791	4.134	43
760-779	3.293	3.620	3.967	41
780-799	3.468	3.819	4.191	44
800-819	2.868	3.213	3.597	37
820-839	2.557	2.927	3.311	33
840-859	2.179	2.548	2.952	29
860-879	1.833	2.192	2.570	25
880-899	1.481	1.887	2.269	22
900-919	0.997	1.000	1.807	11
920-939	0.772	1.000	1.543	11
940-959	0.539	1.000	1.324	11
960-979	0.221	0.553	0.941	6
980-999	0.274	0.547	0.958	6
1,000-1,019	0.173	0.432	0.865	5
1,020-1,039	0.000	0.328	0.656	4
1,040-1,059	0.000	0.283	0.708	3
1,060-1,079	0.000	0.333	0.834	4
1,080-1,099	0.000	0.196	0.587	2
1,100-,1,119	0.000	0.248	0.994	3
1,120-1,139	0.000	0.299	0.896	3
1,140-1,159	0.000	1.000	1.163	11
1,160-1,179	0.000	1.000	1.486	11
1,180-1,199	0.000	1.000	1.300	11
1,200-1,219	0.000	0.000	0.000	0
1,220-1,239	0.000	1.000	1.541	11
1,240-1,259	0.000	1.000	1.507	11
1,260-1,279	0.000	1.000	1.750	11
>1,280	0.000	0.000	0.000	0

Table A2 PI and SPI Values for Distance to Ridge

Distance to Ridge (m)	LCL	PI	UCL	SPI
0-50	1.459	1.490	1.521	65
51-100	1.714	1.794	1.874	78
101-150	1.506	1.573	1.874	68
151-200	1.284	1.354	1.422	59
201-250	1.128	1.195	1.255	52
251-300	0.966	1.000	1.113	43
301-350	0.841	0.920	0.991	40
351-400	0.795	0.871	0.943	38
401-450	0.739	0.809	0.886	35
451-500	0.682	0.763	0.841	33
501-550	0.639	0.726	0.821	32
551-600	0.611	0.713	0.816	31
601-650	0.631	0.737	0.832	32
651-700	0.669	0.786	0.909	34
701-750	0.673	0.785	0.903	34
751-800	0.593	0.738	0.874	32
801-850	0.592	0.723	0.861	31
851-900	0.553	0.694	0.853	30
901-950	0.552	0.695	0.848	30
951-1,00	0.559	0.730	0.901	32
1,001-1050	0.578	0.745	0.958	32
1,051-1,100	0.655	1.000	1.055	43
1,101-1,150	0.594	1.000	1.045	43
1,151-1,200	0.594	1.000	1.045	43
>1,200	0.179	0.194	0.208	8

Table A3 PI and SPI Values for Slope

Slope (degrees)	LCL	PI	UCL	SPI
0-4	0.000	0.000	0.000	0
5-9	0.357	0.370	0.383	17
10-14	1.030	1.058	1.090	50
15-19	1.346	1.386	1.426	65
20-24	1.669	1.730	1.790	81
25-29	1.959	2.052	2.148	97
30-34	1.869	1.988	2.102	94
35-39	1.871	2.019	2.188	95
40-44	1.766	1.973	2.194	93
45-49	1.612	1.950	2.306	92
50-54	1.541	2.281	2.959	107
55-59	1.104	2.428	3.974	113
60-64	0.000	1.000	3.802	47
65-69	0.000	1.000	10.266	47
70-90	0.000	0.000	0.000	0

Tables A4 sets out the combined SPI scores and corresponding predicted use value assigned to each pixel by the GET model.

Table A4 Combined SPI scores and corresponding predicted use value

Combined SPI score	Predicted Use Value*
0.0-30.0	1
30.1-54.0	2
54.1-61.0	3
61.1-81.0	4
81.1-94.0	5
94.1-111.0	6
111.1-127.0	7
127.1-145.0	8
145.1-167.0	9
167.1-236.0	10

* Predicted use values of 6 or greater, highlighted in green, are considered to be suitable or ‘preferred’ golden eagle habitat.

Figures

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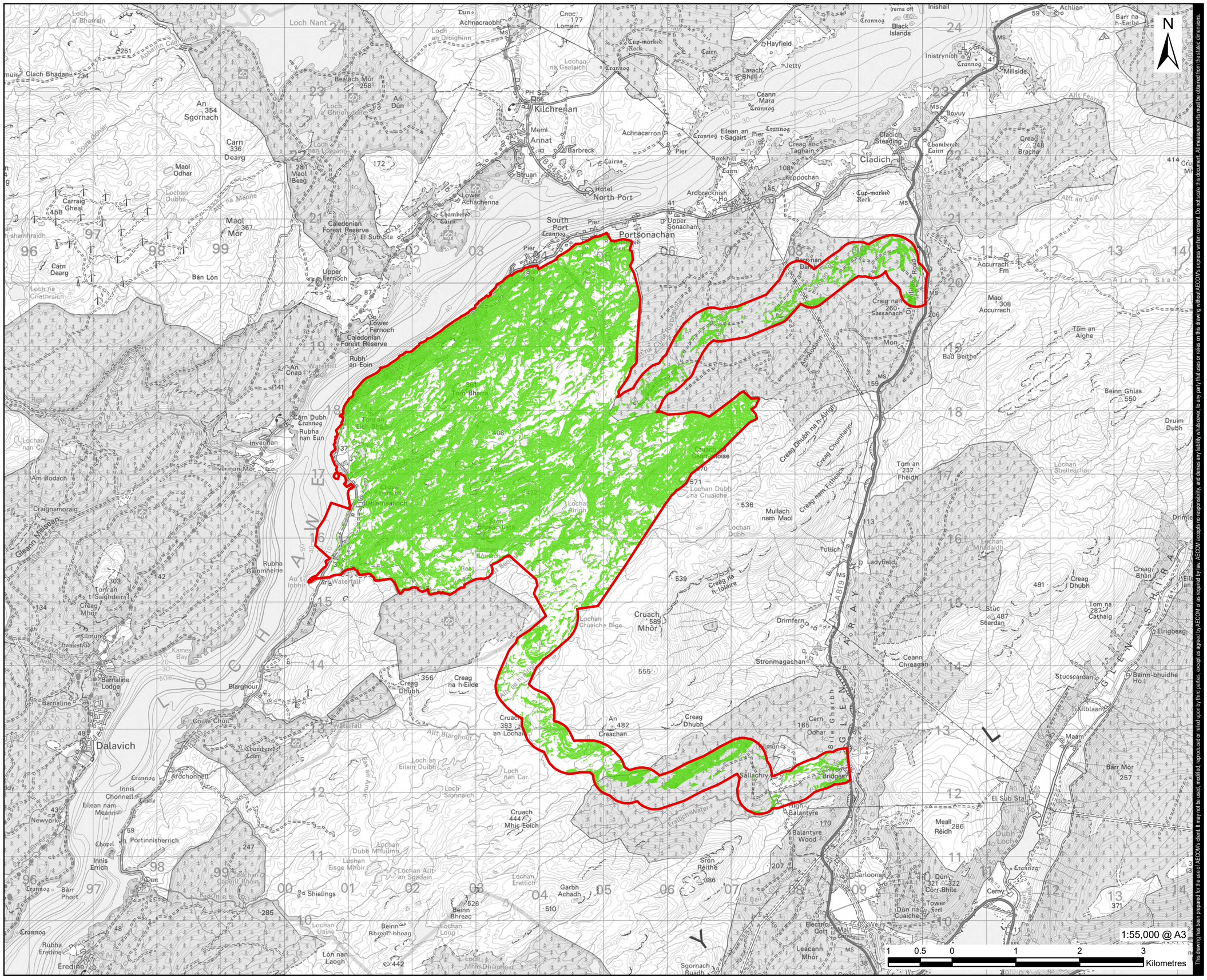

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LEGEND

- Development Boundary
- 6+ Habitat

NOTES

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FIGURE TITLE

Baseline GET Model Results

FIGURE NUMBER

Figure 9.2.1

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G/LAE1A

G/LAE1

Blarghour Wind Farm - Consented

Blarghour Wind Farm - Variation

An Carr Dubh Wind Farm

Ladyfield Wind Farm

N

1:55,000 @ A3

1 0.5 0 1 2 3 Kilometres

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LEGEND

- Development Boundary
- Golden Eagle Territories
- Wind Farm Boundaries
- 6+ Habitat

NOTES

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FIGURE TITLE

Suitable Golden Eagle Habitat Estimated to be Lost to Development and Cumulative Projects

FIGURE NUMBER

Figure 9.2.2