Technical Appendix 14.4: Aviation Impact Assessment

Harestanes West Windfarm

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DA	Initial Draft	30 September 2024	Initial Draft
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Executive Summary

Cyrrus Limited has been engaged to provide guidance on aviation issues associated with the proposed Harestanes West Windfarm (the 'proposed Development'), in the Forest of Ae within Dumfries and Galloway. The proposed Development is anticipated to comprise up to 12 wind turbines with a maximum blade tip height of 220 m.

Of the aviation stakeholders consulted at Scoping, objections were noted from the Ministry of Defence (MOD) and NATS (En Route) plc (NERL). The MOD objection is based on unacceptable impact of the proposed Development on the seismological recording station at Eskdalemuir, and the MOD has concerns that wind turbines would create a physical obstruction to military low flying aircraft in the area. NERL's objection is based on the predicted unacceptable impact of wind turbines on Lowther Hill Primary Surveillance Radar (PSR).

Modelling of PSRs at the closest radar equipped airports (Prestwick, Glasgow and Edinburgh) to the proposed Development shows that none of the proposed turbines would be in Radar Line of Sight (RLoS) of these radars and would not be detected by them.

Modelling of the MOD Air Traffic Control (ATC) PSRs at Deadwater Fell and Berry Hill shows that turbines would not be in RLoS of Berry Hill PSR and would not be detected. However, seven of the 12 proposed turbines would be in RLoS of Deadwater Fell PSR and likely to be detected. Deadwater Fell PSR is used to control aircraft engaged in electronic warfare operations within the Spadeadam Range, approximately 40km to the east of the proposed Development site. The distance suggests that the proposed Development is not in an operationally significant area.

Modelling of NERL PSRs indicates that 11 of the 12 proposed turbines would be in RLoS of Lowther Hill PSR and likely to be detected. Modelling also suggests that two of the 12 proposed turbines would be in RLoS of Great Dun Fell PSR, although NERL's assessment has not predicted any impacts on this facility.

The proposed Development would be within the safeguarded zone of Lowther Hill Secondary Surveillance Radar (SSR); however, NERL has not raised any concerns regarding potential SSR impacts.

There are no significant areas for concern specifically in relation to airspace or airspace users. The proposed Development would lie within a volume of uncontrolled airspace predominantly used by General Aviation and military aircraft. Above this airspace is controlled airspace where aircraft are under a Radar Control Service. As noted by the MOD, the site would fall inside Tactical Training Area 20T within which military aircraft may conduct tactical low flying training down to 100 ft above the ground. To alleviate MOD concerns, wind turbine obstructions would be fitted with MOD accredited aviation safety lighting in accordance with legal requirements.

The Lowther Hill PSR is a 3D system with the capability of filtering out wind turbine clutter. Should this mitigation not be feasible for the proposed Development, mitigation involving the blanking of the clutter area combined with infill data from an alternative radar source should be a viable alternative. The NERL PSR at Cumbernauld would be a suitable source of infill radar data.

Abbreviations

agl	above ground level
AIP	Aeronautical Information Publication
amsl	above mean sea level
ATC	Air Traffic Control
ATS	Air Traffic Service
CTA	Control Area
DTM	Digital Terrain Model
ENR	En Route
FL	Flight Level
MOD	Ministry of Defence
NERL	NATS (En Route) plc
nm	nautical miles
PSR	Primary Surveillance Radar
RLoS	Radar Line of Sight
SSR	Secondary Surveillance Radar
TMA	Terminal Manoeuvring Area
TMZ	Transponder Mandatory Zone
TOPA	Technical and Operational Assessment

Contents

EXECUTIVE SUMMARY **2**

ABBREVIATIONS **3**

CONTENTS **4**

1. INTRODUCTION **7**

1.1. Background 7

1.2. Effects of Wind Turbines on Aviation 7

1.3. Scoping Responses 8

1.4. Aviation Modelling Tasks 8

2. DATA **10**

2.1. Harestanes West Windfarm 10

2.2. Radar Data 11

2.3. Analysis Tools 11

2.4. Terrain Data 11

3. AIRPORT PSR MODELLING **13**

3.1. Radar Locations 13

3.2. Radar Line of Sight 16

3.3. Prestwick Terma PSR 16

3.4. Glasgow NASR-10 PSR 17

3.5. Edinburgh NASR-10 PSR 18

4. MOD PSR MODELLING **19**

4.1. Radar Locations 19

4.2. Radar Line of Sight 19

4.3. Berry Hill PSR 20

4.4. Deadwater Fell PSR 20

5. NERL PSR MODELLING **24**

5.1. Radar Locations 24

5.2. Radar Line of Sight 24

5.3. Lowther Hill PSR 25

5.4. Lowther Hill SSR 27

5.5. Great Dun Fell PSR 27

5.6. Cumbernauld PSR 30

5.7. Kincardine PSR 31

6. AIRSPACE ANALYSIS **33**

6.1. Overview 33
6.2. Other Airspace Considerations 35
7. MITIGATION OPTIONS 36
7.1. Mitigation Requirement 36
7.2. NERL Lowther Hill PSR Mitigation 36
7.3. NERL Potential Infill Radar – Cumbernauld PSR 37

List of figures

Figure 1: Harestanes West Windfarm turbine area boundary 7
Figure 2: Harestanes West Windfarm turbine layout 11
Figure 3: 3D view of turbines and terrain from the south west 12
Figure 4: Locations of radar equipped airports and Harestanes West Windfarm 13
Figure 5: Locations of Prestwick Terma and S511 PSRs 14
Figure 6: Locations of Glasgow NASR-10 and Terma PSRs 15
Figure 7: Locations of Edinburgh NASR-10 and Terma PSRs 15
Figure 8: Prestwick Terma PSR RLoS to 220m agl 16
Figure 9: Glasgow NASR-10 PSR RLoS to 220m agl 17
Figure 10: Edinburgh NASR-10 PSR RLoS to 220m agl 18
Figure 11: Locations of MOD radars and Harestanes West Windfarm 19
Figure 12: Berry Hill PSR RLoS to 220m agl 20
Figure 13: Deadwater Fell PSR RLoS to 220m agl 21
Figure 14: Deadwater Fell PSR RLoS to 220m agl – zoomed 22
Figure 15: Deadwater Fell PSR RLoS to 200m agl – zoomed 23
Figure 16: Locations of NERL radars and Harestanes West Windfarm 24
Figure 17: Lowther Hill PSR RLoS to 220m agl 25
Figure 18: Lowther Hill PSR RLoS to 220m agl – zoomed 26
Figure 19: Lowther Hill PSR RLoS to 200m agl – zoomed 27
Figure 20: Great Dun Fell PSR RLoS to 220m agl 28
Figure 21: Great Dun Fell PSR RLoS to 220m agl – zoomed 29
Figure 22: Great Dun Fell PSR RLoS to 200m agl – zoomed 30
Figure 23: Cumbernauld PSR RLoS to 220m agl 31
Figure 24: Kincardine PSR RLoS to 220m agl 32

Figure 25: Airspace structure (extract from AIP chart ENR 6.7).....34
Figure 26: Lower ATS Routes (extract from AIP chart ENR 6-69).....34
Figure 27: Low flying areas (extract from AIP chart ENR 6-20).....35
Figure 28: Cumbernauld PSR RLoS to 4,000ft amsl.....37
Figure 29: Cumbernauld PSR RLoS to 4,000ft amsl – zoomed.....38

List of tables

Table 1: Harestanes West Windfarm turbine coordinates.....10

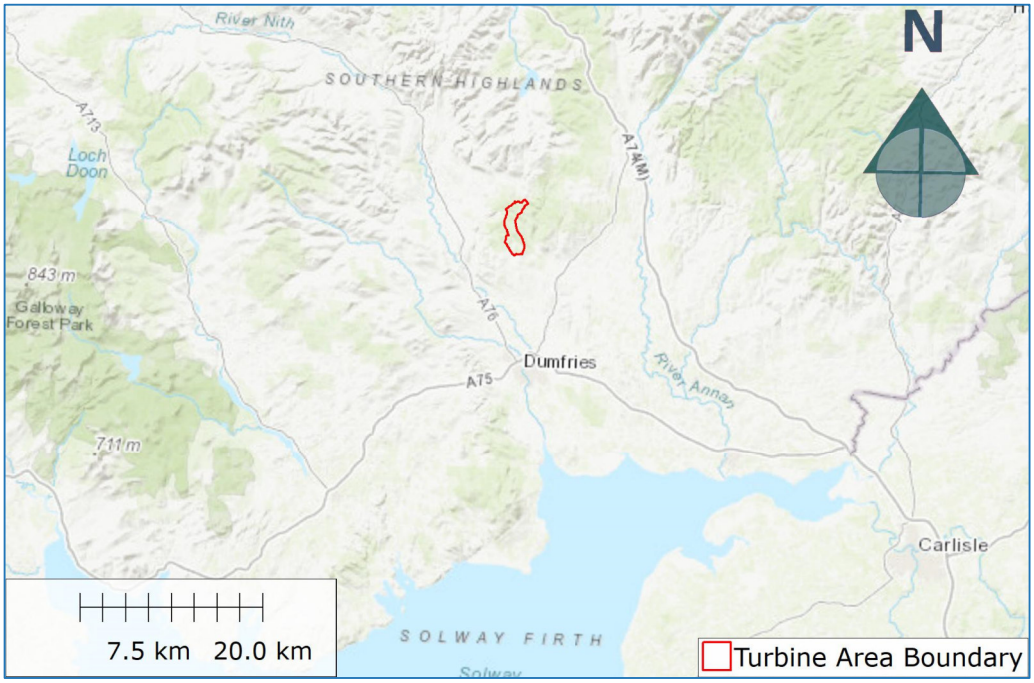
1. Introduction

1.1. Background

1.1.1. ScottishPower Renewables (the 'Applicant') is proposing to develop Harestanes West Windfarm (the 'proposed Development)', in the Forest of Ae, within Dumfries and Galloway. The 'turbine area' (comprising the proposed turbines and associated infrastructure) lies west of the operational Harestanes Windfarm and is anticipated to comprise up to 12 wind turbines with a maximum blade tip height of 220 m above ground level (agl).

1.1.2. The location of the turbine area boundary is indicated in **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

1.1.3. Figure 1.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 1: Harestanes West Windfarm turbine area boundary.

1.1.4. Cyrrus Limited has been engaged to provide guidance on aviation issues to support the Environmental Impact Assessment process for the proposed Development.

1.2. Effects of Wind Turbines on Aviation

1.2.1. Wind turbines are an issue for aviation Primary Surveillance Radars (PSRs) as the characteristics of a moving wind turbine blade are similar to that of an aircraft. The PSR is

unable to differentiate between wanted aircraft targets and unwanted clutter targets introduced by the presence of turbines.

1.2.2. The significance of any radar impact depends on airspace usage in the vicinity of the Site and the nature of the Air Traffic Service (ATS) provided in that airspace.

1.3. Scoping Responses

1.3.1. Following publication of the Scoping Report[1] responses were received from the following aviation stakeholders:

- Glasgow Airport – 18 April 2023;
- Prestwick Airport – 28 March 2023;
- Met Office – 29 March 2023;
- Ministry of Defence (MOD) – 5 May 2023; and
- NATS (En Route) plc (NERL) – 12 April 2023.

1.3.2. Glasgow Airport had no comment to make as the proposed Development would lie outside its consultation zone.

1.3.3. Prestwick Airport stated that its PSRs would not be affected by the proposed turbines due to terrain shielding, and that the proposed Development location is clear of Prestwick's Instrument Flight Procedure routings and the Instrument Landing System safeguarding area.

1.3.4. The Met Office confirmed that the proposed Development would be beyond the 20 km consultation zone of any Met Office radar and that they did not need further consultation.

1.3.5. The MOD noted that the proposed Development would lie within Tactical Training Area 20T, a military low flying area, and that turbines have the potential to create a physical obstruction to low flying. Aviation safety lighting will address this impact, together with sufficient data submitted to the MOD to ensure accurate charting of obstructions. The MOD also stated that it must object due to the unacceptable impact the turbines would have on the seismological recording station at Eskdalemuir.

1.3.6. NERL indicated it objects to the proposal and provided a Technical and Operational Assessment (TOPA)[2] which predicted that ten of the proposed turbines are likely to cause false primary plots to be generated by Lowther Hill radar. This anticipated impact would be unacceptable to Prestwick Centre Air Traffic Control (ATC) operations.

1.4. Aviation Modelling Tasks

1.4.1. Note that the turbine layout has been revised since the Scoping Report was issued. The revised layout is modelled in this assessment.

1.4.2. The aviation modelling tasks identified are:

- Determine the radar visibility of the proposed Development to airport PSRs;

[1] Harestanes West Scoping Report, March 2023
[2] TOPA for Harestanes West Wind Farm Development, NATS ref: SG35082, Issue 1, April 2023

- Determine the radar visibility of the proposed Development to the MOD's PSRs
- Determine the radar visibility of the proposed Development to NERL's PSRs; and
- Review the nature of the airspace in the vicinity of the proposed Development to determine any potential impact on aviation.

2. Data

2.1. Harestanes West Windfarm

2.1.1. A design freeze layout for the proposed Development has been issued in the following file:

- HSW_Turbines_DL_20240805.shp.

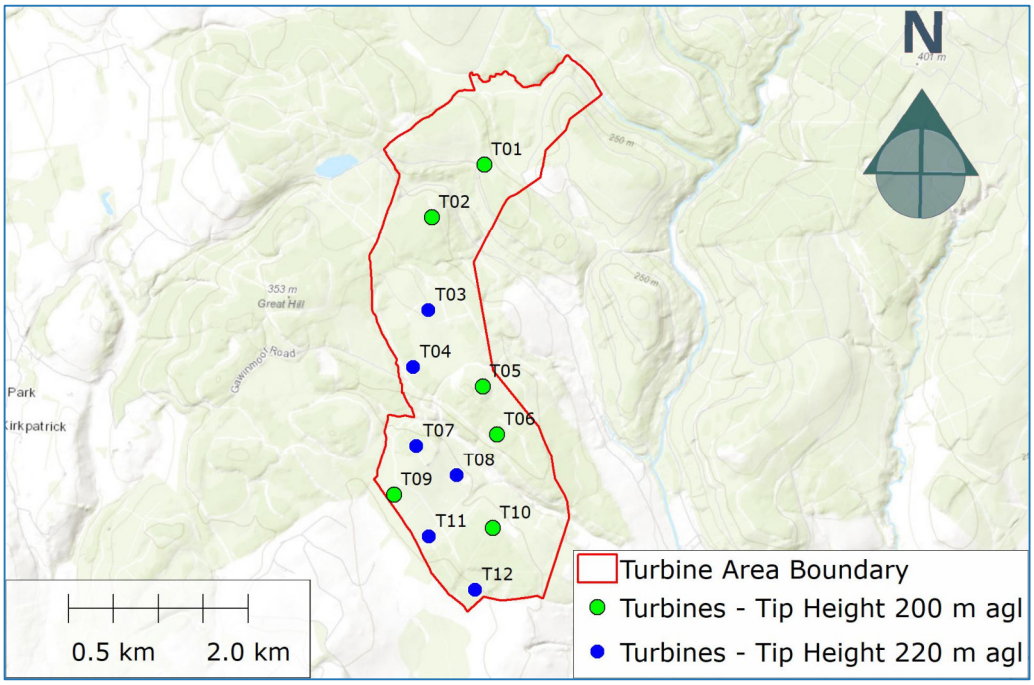
2.1.2. The Ordnance Survey National Grid coordinates for this proposed turbine layout together with proposed turbine tip heights, as used in this assessment, are listed in **Table 1**.

Turbine	Easting	Northing	Tip Height agl
T01	296189.79	593781.82	200 m
T02	295607.37	593196.18	200 m
T03	295562.00	592156.86	220 m
T04	295394.19	591525.68	220 m
T05	296170.46	591307.38	200 m
T06	296330.99	590777.00	200 m
T07	295432.49	590647.62	220 m
T08	295878.49	590314.82	220 m
T09	295181.74	590095.25	200 m
T10	296284.62	589729.70	200 m
T11	295567.53	589632.90	220 m
T12	296082.23	589043.42	220 m

Table 1: Harestanes West Windfarm turbine coordinates

2.1.3. The 12 turbines are planned to have a blade rotor diameter of 162 m.

2.1.4. The proposed turbine layout used for the modelling is shown in **Figure 2**.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 2: Harestanes West Windfarm turbine layout.

2.2. Radar Data

2.2.1. Radar parameters used in this assessment have been taken from data held on file by Cyrrus.

2.3. Analysis Tools

2.3.1. The assessment utilises the following software packages:

- ATDI HTZ communications version 2024.9 radio network analysis tool; and
- Global Mapper v25.1.2 Geographic Information System data processing utility.

2.4. Terrain Data

2.4.1. The following terrain data is used for the radar coverage modelling:

- 25 m ATDI Digital Terrain Model (DTM).

2.4.2. A 3D view of the turbines and the terrain model is shown in **Figure 3**.

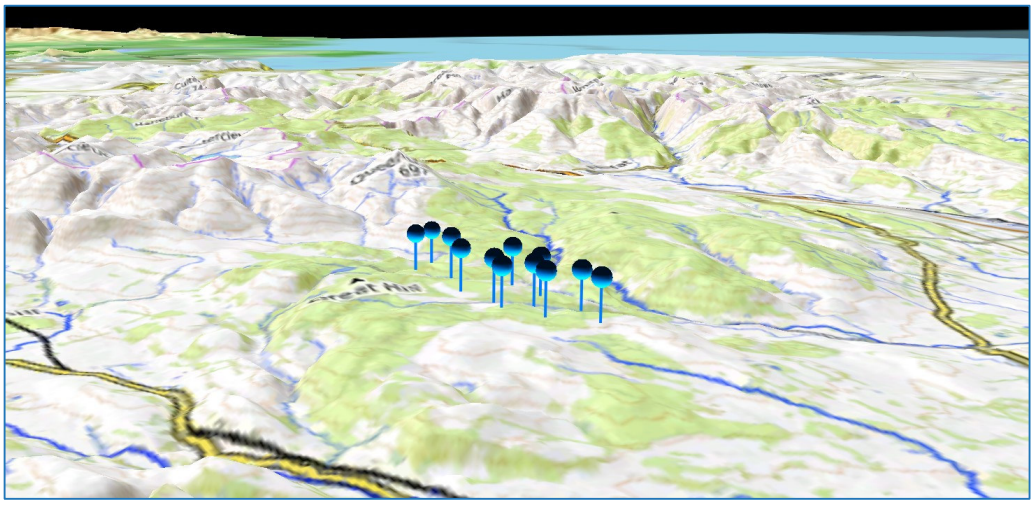


Figure 3: 3D view of turbines and terrain from the south west

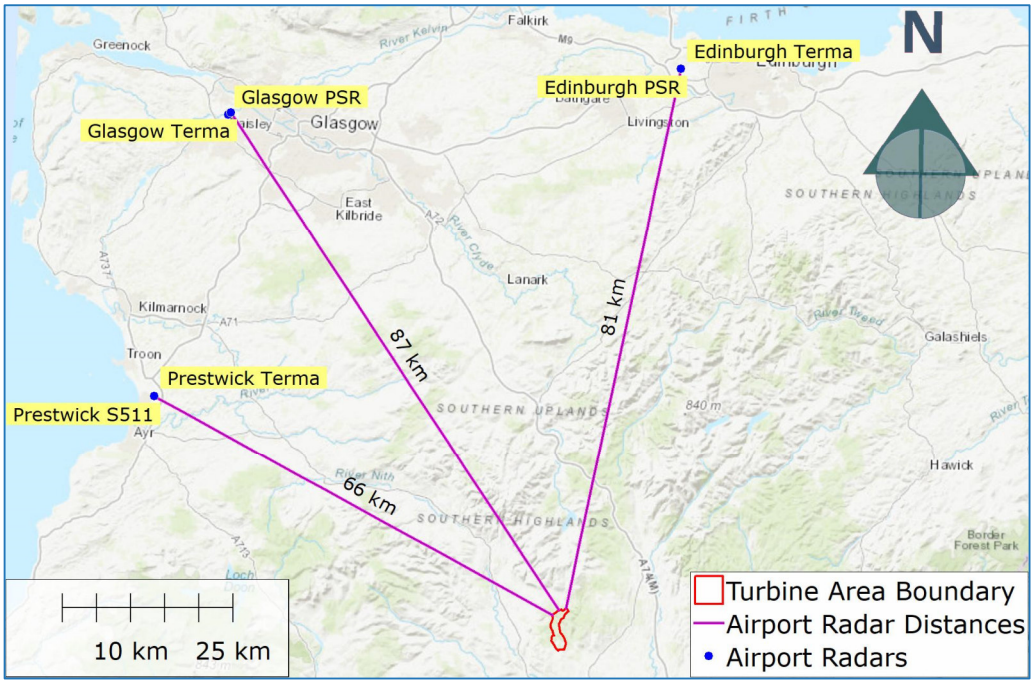
3. Airport PSR Modelling

3.1. Radar Locations

3.1.1. The closest radar equipped airports to the proposed Development turbine area boundary are Prestwick Airport, approximately 66 km to the north west, Glasgow Airport, approximately 87 km to the north, north west, and Edinburgh Airport, approximately 81 km to the north, north east.

The locations of the airports relative to the proposed Development are shown in Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

3.1.2. Figure 4.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 4: Locations of radar equipped airports and Harestanes West Windfarm

3.1.3. There are two PSR facilities at Prestwick Airport: a Marconi S511 radar used for planning purposes while a Terma Scanter 4002 radar is used for approach control. In addition, Prestwick is fed with Secondary Surveillance Radar (SSR) data from NERL's Lowther Hill radar. In the event of PSR failure, Prestwick is authorised to use SSR only.

3.1.4. The locations of the Prestwick PSRs are shown in **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

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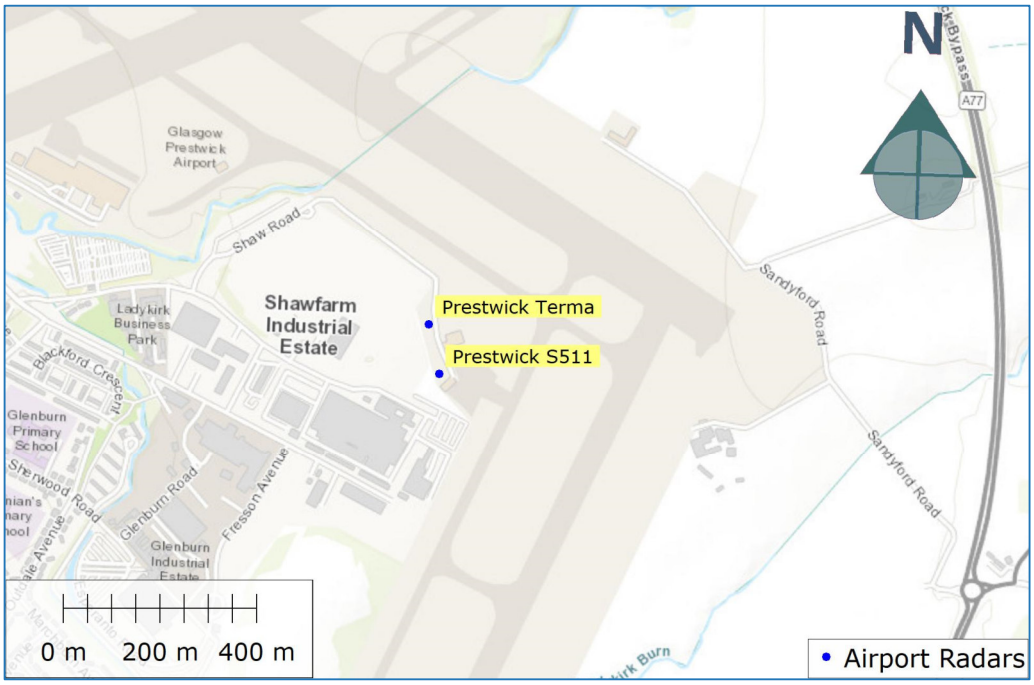
3.1.5. Figure 5.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 5: Locations of Prestwick Terma and S511 PSRs

3.1.6. Both Glasgow Airport and Edinburgh Airport are equipped with NASR-10 PSRs together with Terma Scanter 4002 PSRs which are used to provide mitigation for wind turbines.

3.1.7. The locations of the Glasgow and Edinburgh PSRs are shown in **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

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3.1.8. Figure 6 and **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

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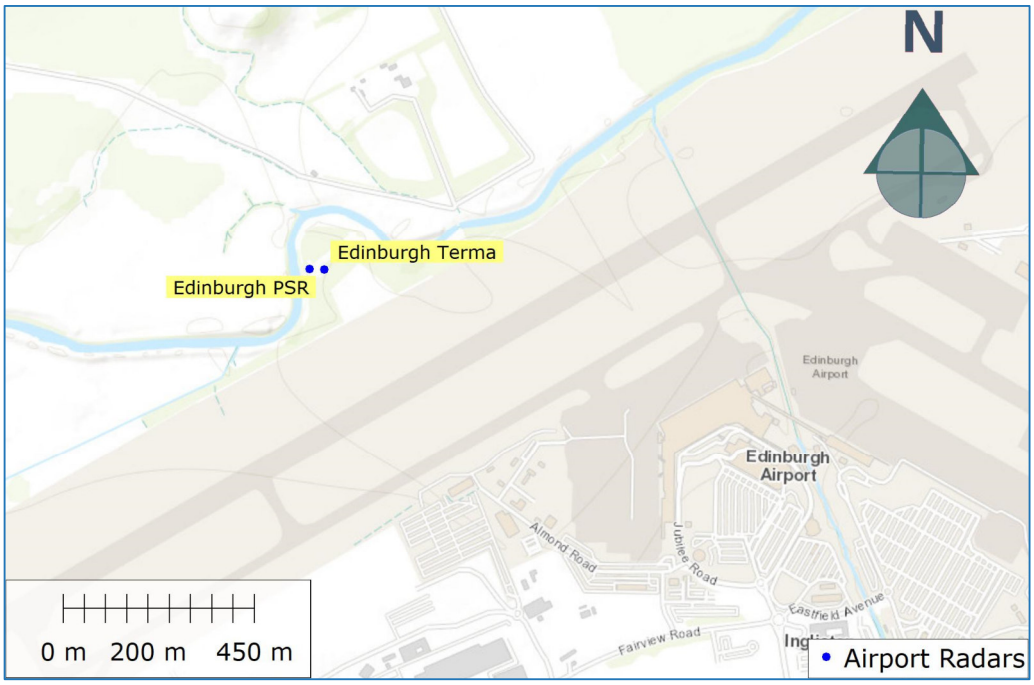
3.1.9. Figure 7 respectively.

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 6: Locations of Glasgow NASR-10 and Terma PSRs



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 7: Locations of Edinburgh NASR-10 and Terma PSRs

3.2. Radar Line of Sight

3.2.1. Radar Line of Sight (RLoS) is determined from a radar propagation model (ATDI HTZ communications) using 3D DTM data with 25 m horizontal resolution. Radar data is entered into the model and RLoS to the turbines from the radar is calculated.

3.2.2. Note that by using a DTM no account is taken of possible further shielding of the turbines due to the presence of structures or vegetation that may lie between the radars and the turbines. Thus, the RLoS assessments are worst-case results.

3.2.3. For PSR, the principal sources of adverse windfarm effects are the turbine blades, so RLoS is calculated for the maximum tip height of the turbines, i.e. 220 m agl.

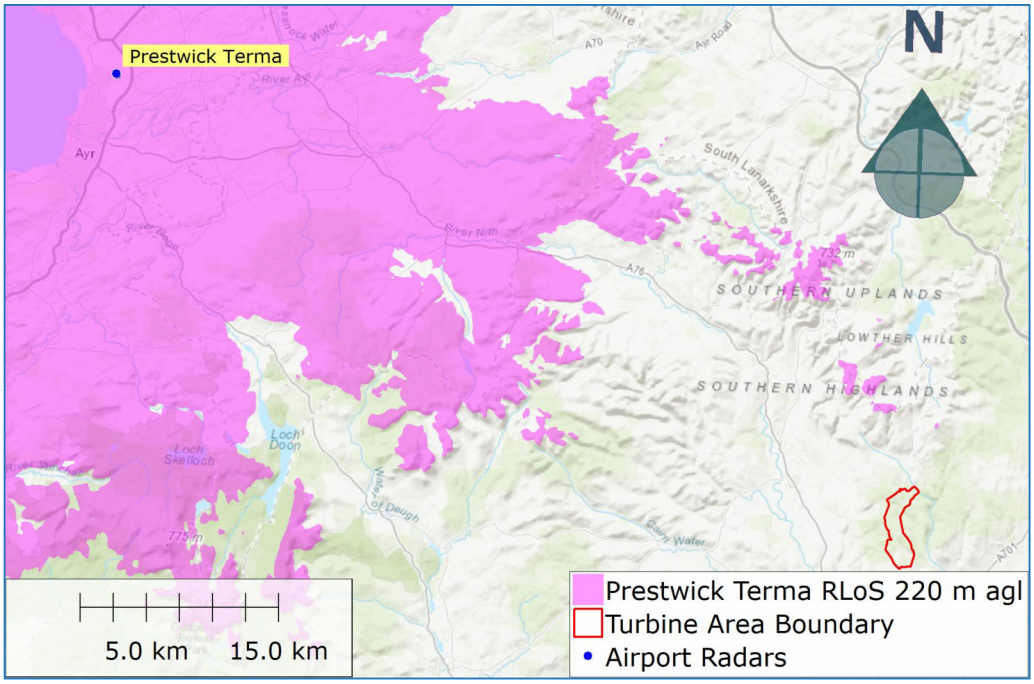
3.3. Prestwick Terma PSR

3.3.1. The S511 PSR was installed in 1990, and today is primarily used as a planning radar. The newly installed Terma PSR is effectively a replacement for this legacy radar but is limited to a range of approximately 40 nautical miles (nm) or 74 km, so the S511 may be used for traffic beyond this range. As the proposed turbines are within the range of the Terma PSR, modelling is focussed on this facility.

3.3.2. The magenta shading in **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

3.3.3. Figure 8 illustrates the RLoS coverage from the Prestwick Terma PSR to turbines with a blade tip height of 220 m agl.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 8: Prestwick Terma PSR RLoS to 220 m agl

3.3.4. **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

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3.3.5. Figure 8 shows that RLoS would not exist between the Prestwick Terma PSR and any of the turbines. Given that RLoS would not exist, it can be assumed that the Prestwick Terma PSR would not detect any of the proposed Development turbines.

3.4. Glasgow NASR-10 PSR

3.4.1. The Terma PSR is limited to a range of approximately 40 nm or 74 km, so at a minimum distance of 87 km it is unlikely that any of the proposed Development turbines would be detected by the Terma PSR. Modelling is therefore focussed on the NASR-10 facility.

3.4.2. The magenta shading in **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

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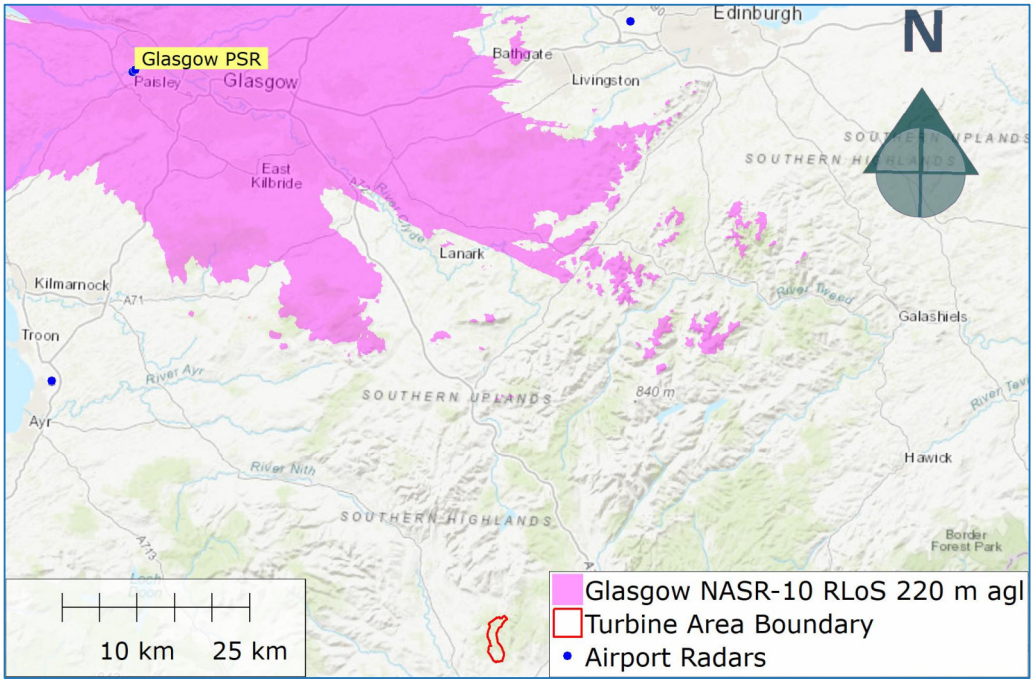
3.4.3. Figure 9 illustrates the RLoS coverage from the Glasgow NASR-10 PSR to turbines with a blade tip height of 220 m agl.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 9: Glasgow NASR-10 PSR RLoS to 220 m agl

3.4.4. **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

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3.4.5. Figure 9 shows that RLoS would not exist between the Glasgow NASR-10 PSR and any of the turbines. Given that RLoS would not exist, it can be assumed that the Glasgow NASR-10 PSR would not detect any of the proposed Development turbines.

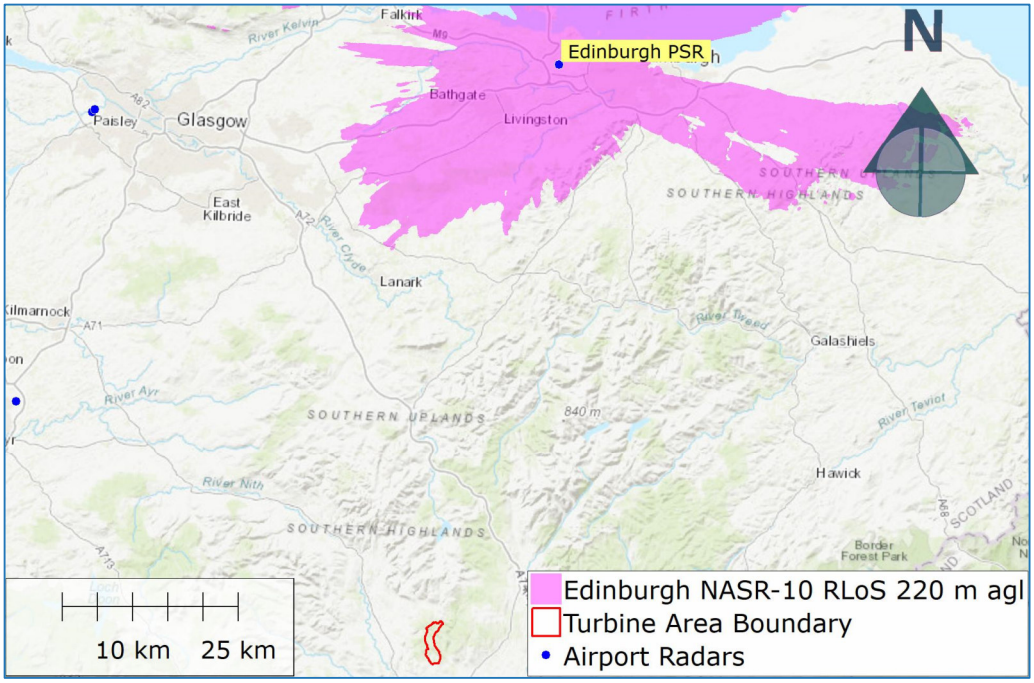
3.5. Edinburgh NASR-10 PSR

3.5.1. The Terma PSR is limited to a range of approximately 40 nm or 74 km, so at a minimum distance of 81 km it is unlikely that any of the proposed Development turbines would be detected by the Terma PSR. Modelling is therefore focussed on the NASR-10 facility.

3.5.2. The magenta shading in **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

3.5.3. Figure 10 illustrates the RLoS coverage from the Edinburgh NASR-10 PSR to turbines with a blade tip height of 220 m agl.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 10: Edinburgh NASR-10 PSR RLoS to 220 m agl

3.5.4. **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

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3.5.5. Figure 10 shows that RLoS would not exist between the Edinburgh NASR-10 PSR and any of the turbines. Given that RLoS would not exist, it can be assumed that the Edinburgh NASR-10 PSR would not detect any of the proposed Development turbines.

4. MOD PSR Modelling

4.1. Radar Locations

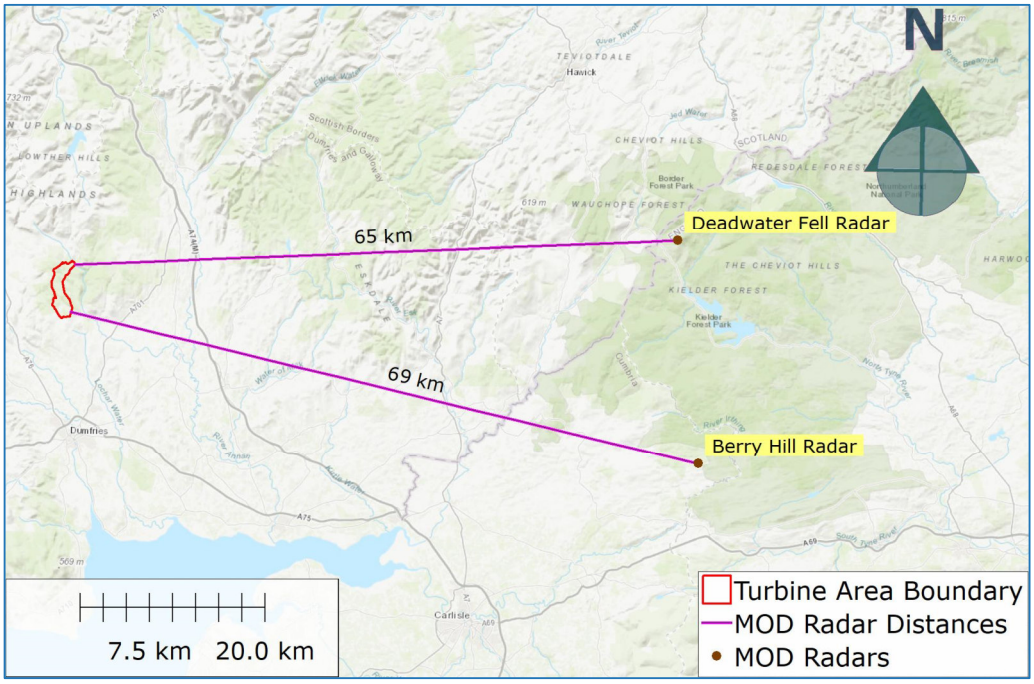
4.1.1. The closest MOD radars to the proposed Development site are the ATC PSRs at Berry Hill and Deadwater Fell utilised by Royal Air Force Spadeadam.

4.1.2. At its closest points, the proposed turbine area boundary is approximately 69 km west, north west of Berry Hill PSR and 65 km west of Deadwater Fell PSR.

The locations of the MOD PSRs relative to the proposed Development are shown in

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

4.1.3. Figure 11.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 11: Locations of MOD radars and Harestanes West Windfarm

4.2. Radar Line of Sight

4.2.1. RLoS is determined from a radar propagation model (ATDI HTZ communications) using 3D DTM data with 25 m horizontal resolution. Radar data is entered into the model and RLoS to the turbines from the radar is calculated.

4.2.2. Note that by using a DTM no account is taken of possible further shielding of the turbines due to the presence of structures or vegetation that may lie between the radars and the turbines. Thus, the RLoS assessments are worst-case results.

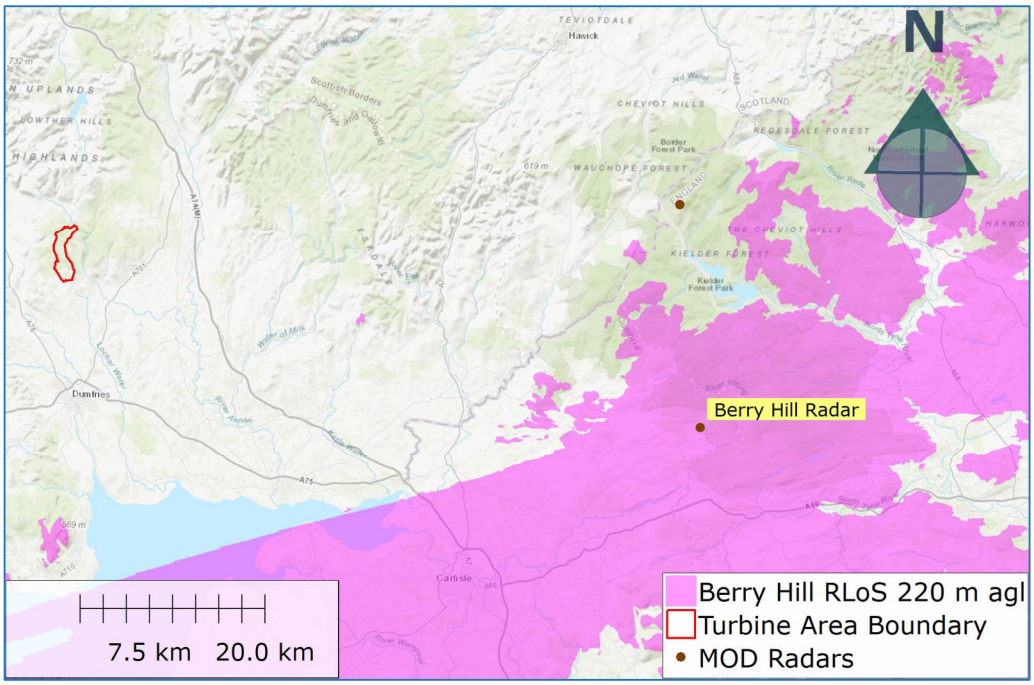
4.2.3. For PSR, the principal sources of adverse windfarm effects are the turbine blades, so RLoS is calculated for the maximum tip height of the turbines, i.e. 220 m agl.

4.3. Berry Hill PSR

4.3.1. The magenta shading in **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

4.3.2. Figure 12 illustrates the RLoS coverage from Berry Hill PSR to turbines with a blade tip height of 220 m agl.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 12: Berry Hill PSR RLoS to 220 m agl

4.3.3. **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

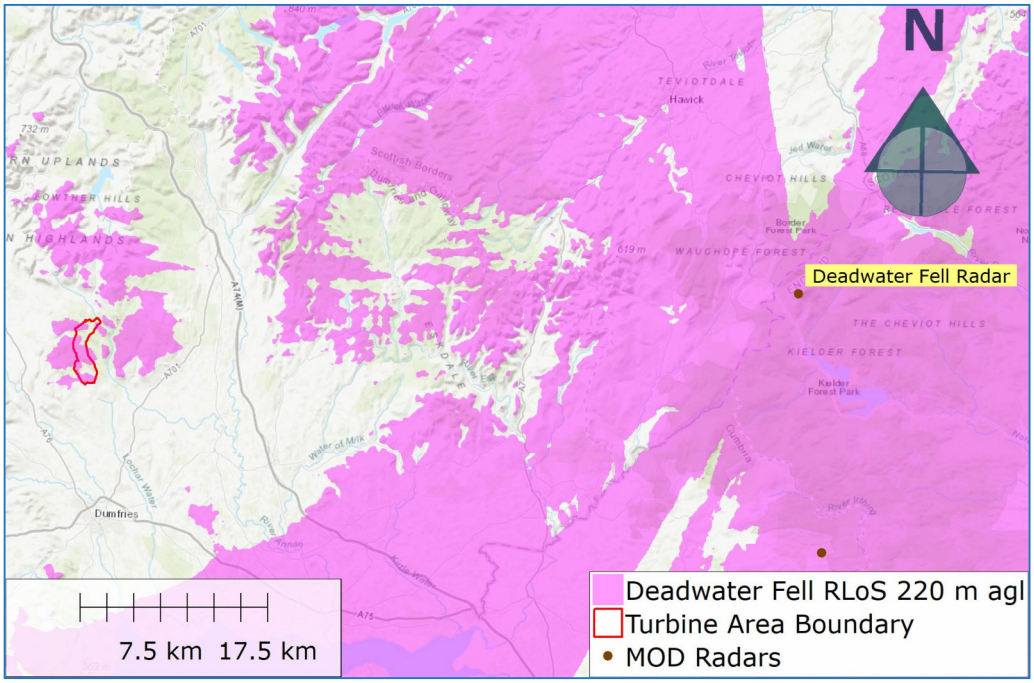
4.3.4. Figure 12 shows that RLoS would not exist between Berry Hill PSR and any of the turbines. Given that RLoS would not exist, it can be assumed that Berry Hill PSR would not detect any of the proposed Development turbines.

4.4. Deadwater Fell PSR

4.4.1. The magenta shading in **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

4.4.2. Figure 13 illustrates the RLoS coverage from Deadwater Fell PSR to turbines with a blade tip height of 220 m agl.



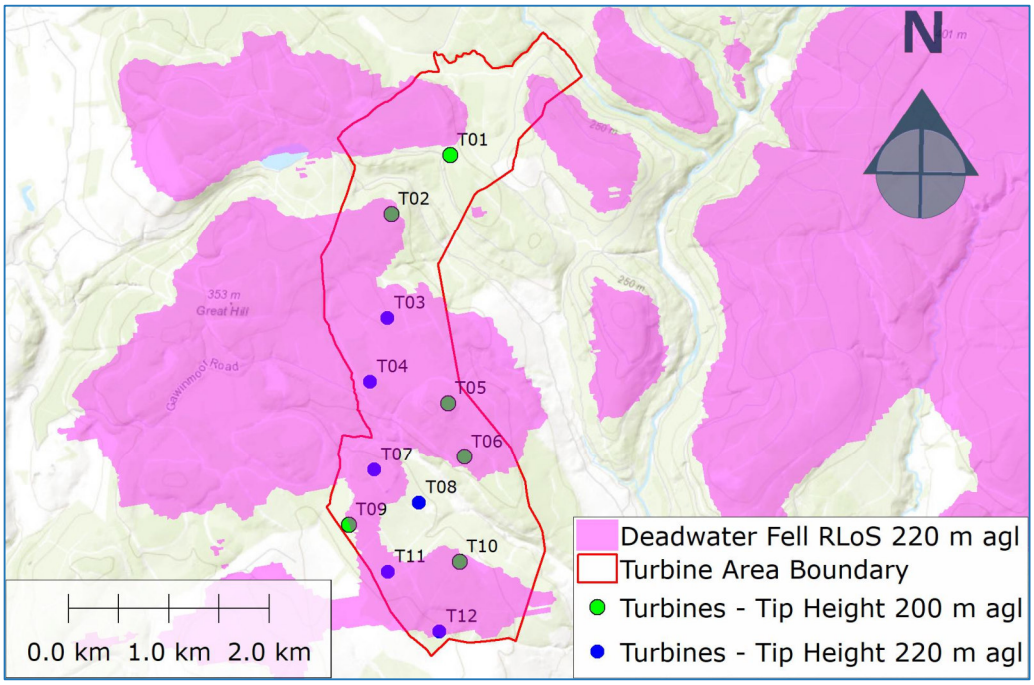
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 13: Deadwater Fell PSR RLoS to 220 m agl

4.4.3. The zoomed view of the proposed Development in **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

4.4.4. Figure 14 shows that, of the six proposed 220 m tip height turbines, RLoS would exist between Deadwater Fell PSR and turbine IDs T03, T04, T07, T11 and T12 in the design freeze layout.

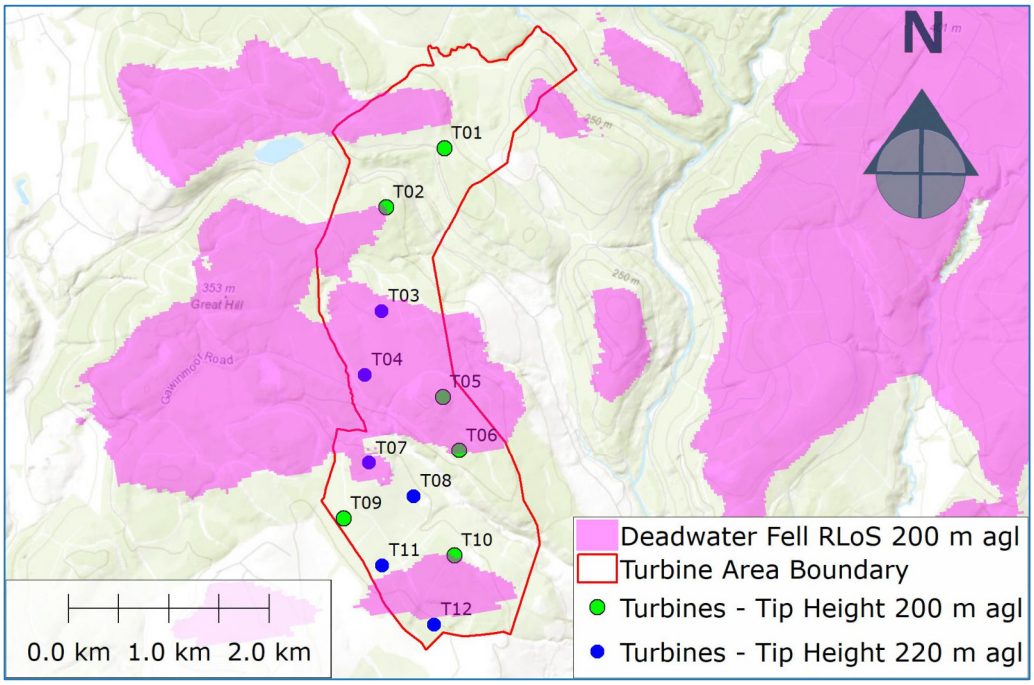


Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 14: Deadwater Fell PSR RLoS to 220 m agl – zoomed

4.4.5. **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

4.4.6. Figure 15 illustrates a zoomed view of the RLoS coverage from Deadwater Fell PSR to turbines with a blade tip height of 200 m agl. The magenta shading shows that, of the six proposed 200 m tip height turbines, RLoS would exist between Deadwater Fell PSR and turbine IDs T05 and T06 in the design freeze layout.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 15: Deadwater Fell PSR RLoS to 200 m agl – zoomed

4.4.7. Given that RLoS would exist between Deadwater Fell PSR and seven of the 12 proposed turbines, it can be assumed that Deadwater Fell PSR would detect at least seven of the proposed Development turbines.

4.4.8. Spadeadam Range, where Deadwater Fell PSR is used to control aircraft engaged in electronic warfare exercises, is approximately 40 km to the east of the proposed Development site. The distance from the range boundary suggests that the proposed Development site location is not in an operationally significant area in terms of required Deadwater Fell PSR coverage for ATC purposes. The MOD has not raised any concerns regarding potential impacts on its radar facilities.

5. NERL PSR Modelling

5.1. Radar Locations

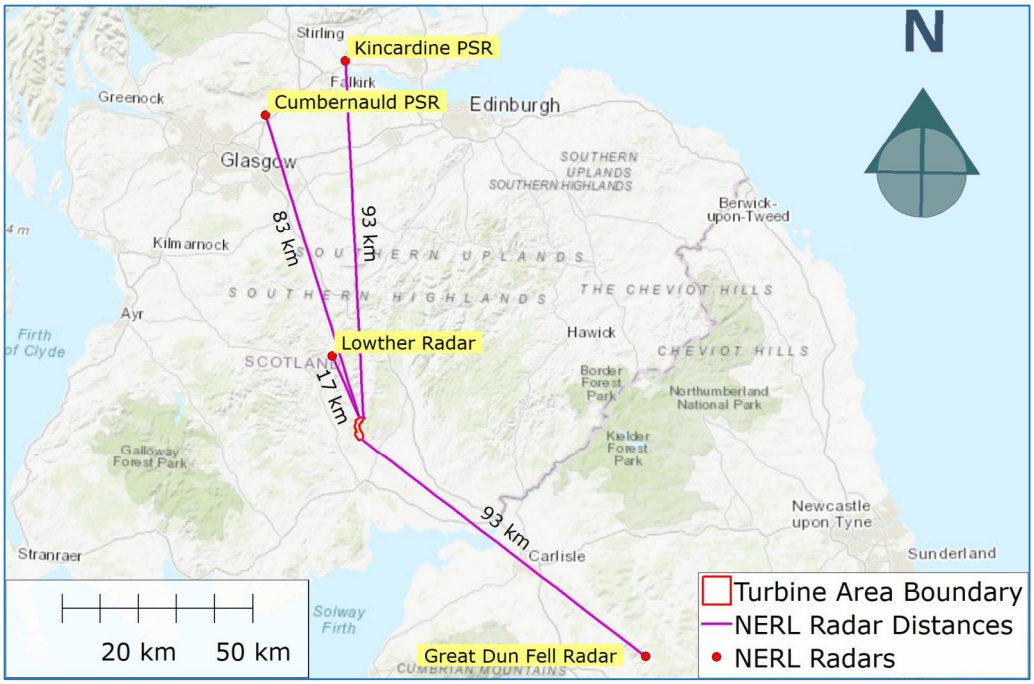
5.1.1. Four NERL PSRs have been identified that may be technically impacted by the proposed Development turbines: Lowther Hill, Great Dun Fell, Cumbernauld and Kincardine.

5.1.2. At its closest points, the proposed turbine area boundary is approximately 17 km south of Lowther Hill PSR, 93 km north west of Great Dun Fell PSR, 83 km south of Cumbernauld PSR, and 93 km south of Kincardine PSR.

5.1.3. The locations of the NERL PSRs relative to the proposed Development are shown in **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

5.1.4. Figure 16**.**



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 16: Locations of NERL radars and Harestanes West Windfarm

5.2. Radar Line of Sight

5.2.1. RLoS is determined from a radar propagation model (ATDI HTZ communications) using 3D DTM data with 25 m horizontal resolution. Radar data is entered into the model and RLoS to the turbines from the radar is calculated.

5.2.2. Note that by using a DTM no account is taken of possible further shielding of the turbines due to the presence of structures or vegetation that may lie between the radars and the turbines. Thus, the RLoS assessments are worst-case results.

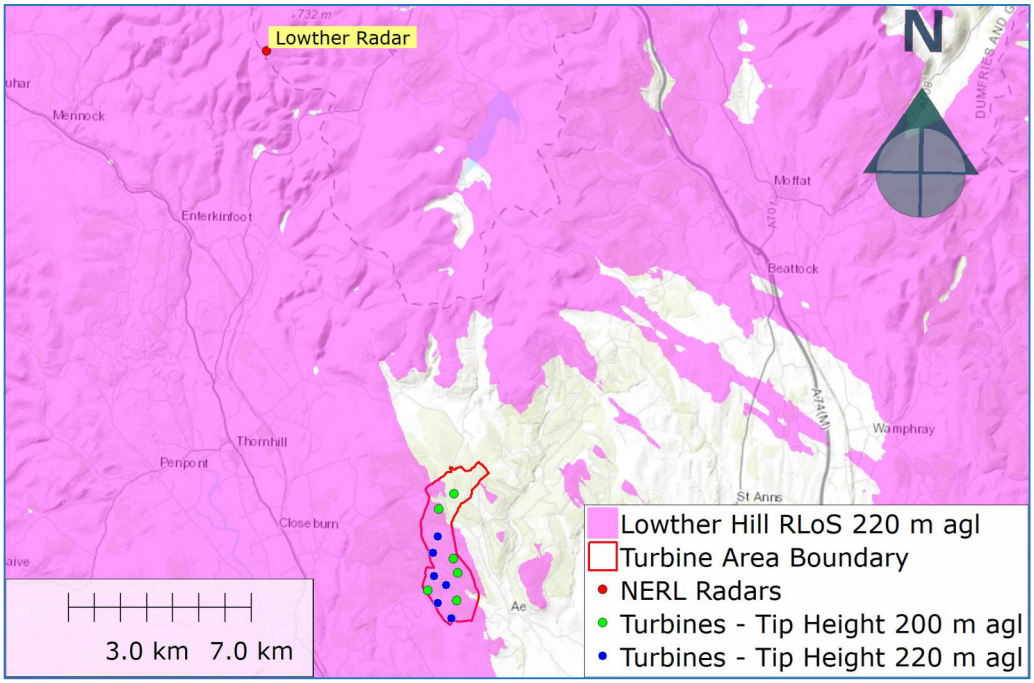
5.2.3. For PSR, the principal sources of adverse windfarm effects are the turbine blades, so RLoS is calculated for the maximum tip height of the turbines, i.e. 220 m agl.

5.3. Lowther Hill PSR

5.3.1. The magenta shading in **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

5.3.2. Figure 17 illustrates the RLoS coverage from Lowther Hill PSR to turbines with a blade tip height of 220 m agl.



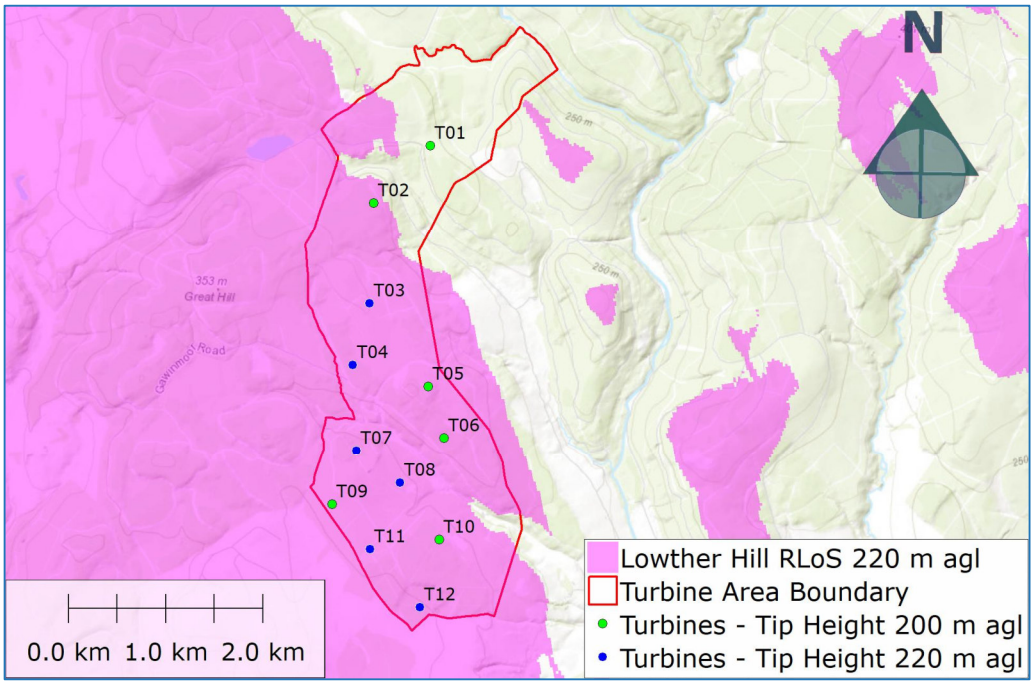
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 17: Lowther Hill PSR RLoS to 220 m agl

5.3.3. The zoomed view of the proposed Development in **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

5.3.4. Figure 18 shows that, of the six proposed 220 m tip height turbines, RLoS would exist between Lowther Hill PSR and turbine IDs T03, T04, T07, T08, T11 and T12 in the design freeze layout.



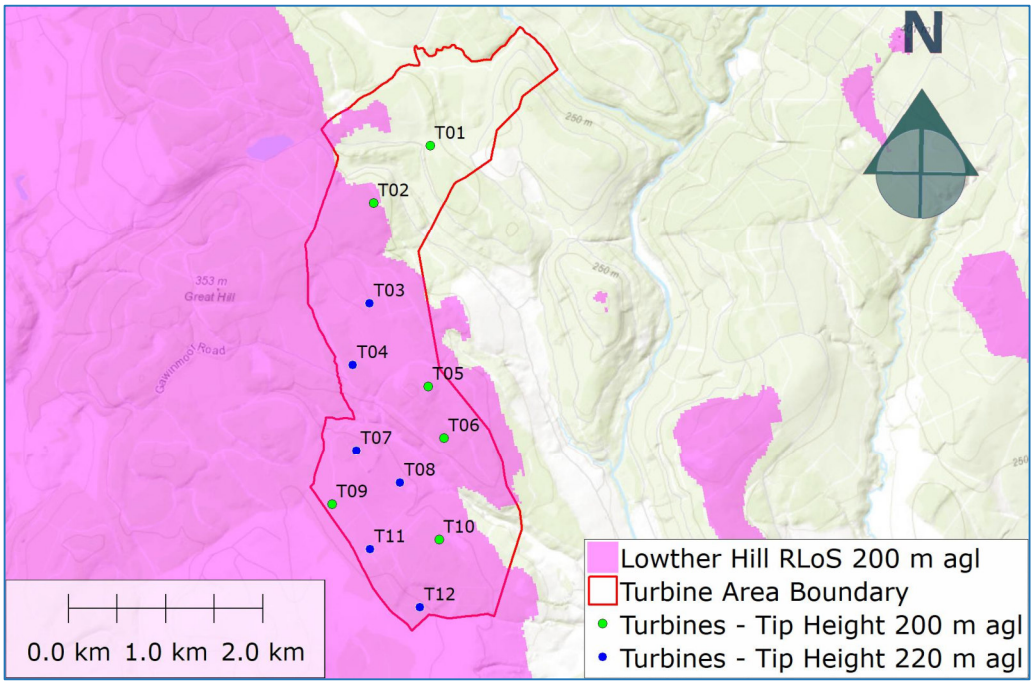
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 18: Lowther Hill PSR RLoS to 220 m agl – zoomed

5.3.5. **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

5.3.6. Figure 19 illustrates a zoomed view of the RLoS coverage from Lowther Hill PSR to turbines with a blade tip height of 200 m agl. The magenta shading shows that, of the six proposed 200 m tip height turbines, RLoS would exist between Lowther Hill PSR and turbine IDs T02, T05, T06, T09 and T10 in the design freeze layout.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 19: Lowther Hill PSR RLoS to 200 m agl – zoomed

5.3.7. Given that RLoS would exist between Lowther Hill PSR and 11 of the 12 proposed turbines, it can be assumed that Lowther Hill PSR would detect at least 11 of the proposed Development turbines.

5.4. Lowther Hill SSR

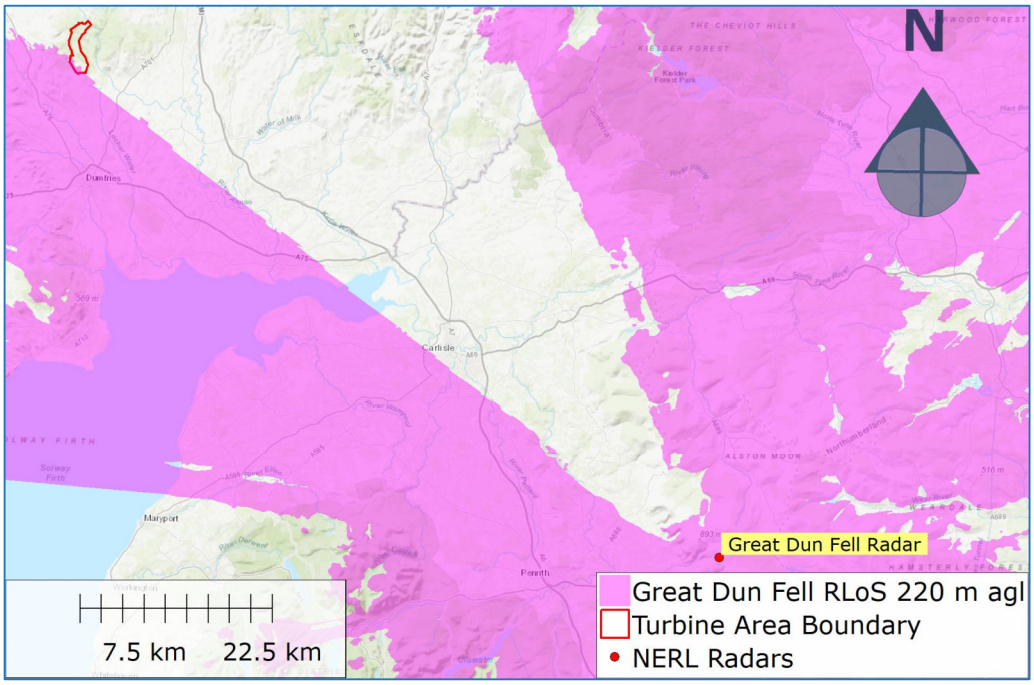
5.4.1. The effects of wind turbines on SSR are considerably less than effects on PSRs. Turbine towers can physically blank and diffract SSR signals, but these effects are typically only considered when turbines are within 10 km of the facility. At greater ranges, SSR signals reflected from wind turbines can result in the radar generating a false target in a direction that is different to where the intended aircraft target is.

5.4.2. In order to protect their SSR facilities from the impact of windfarms, NATS establish a safeguarded zone of radius 15 nm (28 km) around them. The proposed Development site is within this range from Lowther Hill SSR; however, NERL has not raised any concerns regarding potential SSR impacts.

5.5. Great Dun Fell PSR

The magenta shading in Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

5.5.1. Figure 20 illustrates the RLoS coverage from Great Dun Fell PSR to turbines with a blade tip height of 220 m agl.



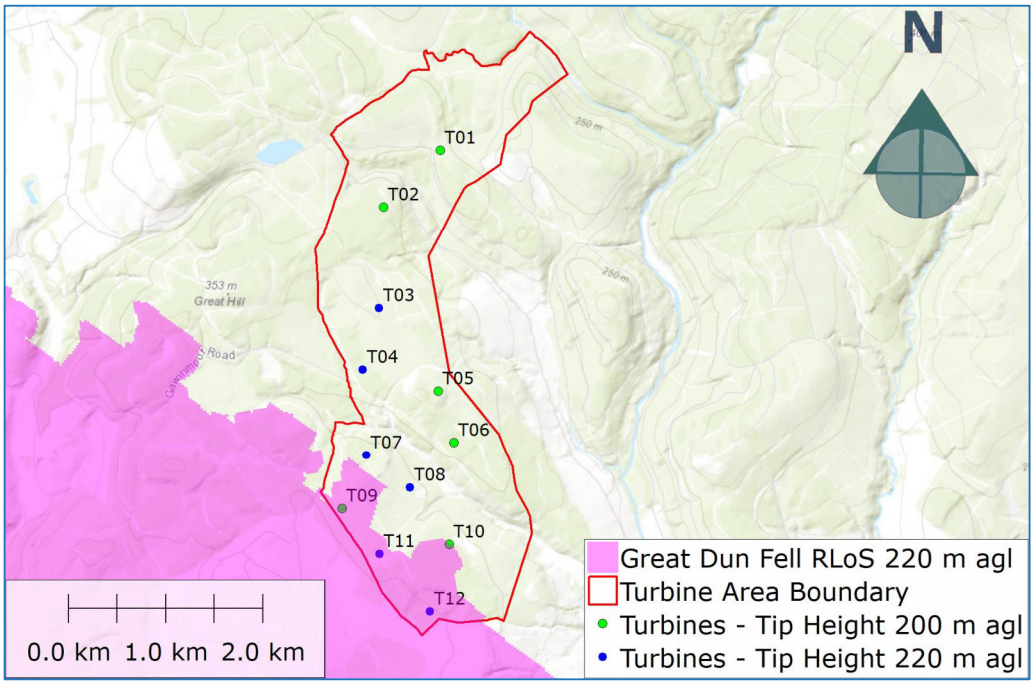
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 20: Great Dun Fell PSR RLoS to 220 m agl

5.5.2. The zoomed view of the proposed Development in **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

5.5.3. Figure 21 shows that, of the six proposed 220 m tip height turbines, RLoS would exist between Great Dun Fell PSR and turbine IDs T11 and T12 in the design freeze layout.



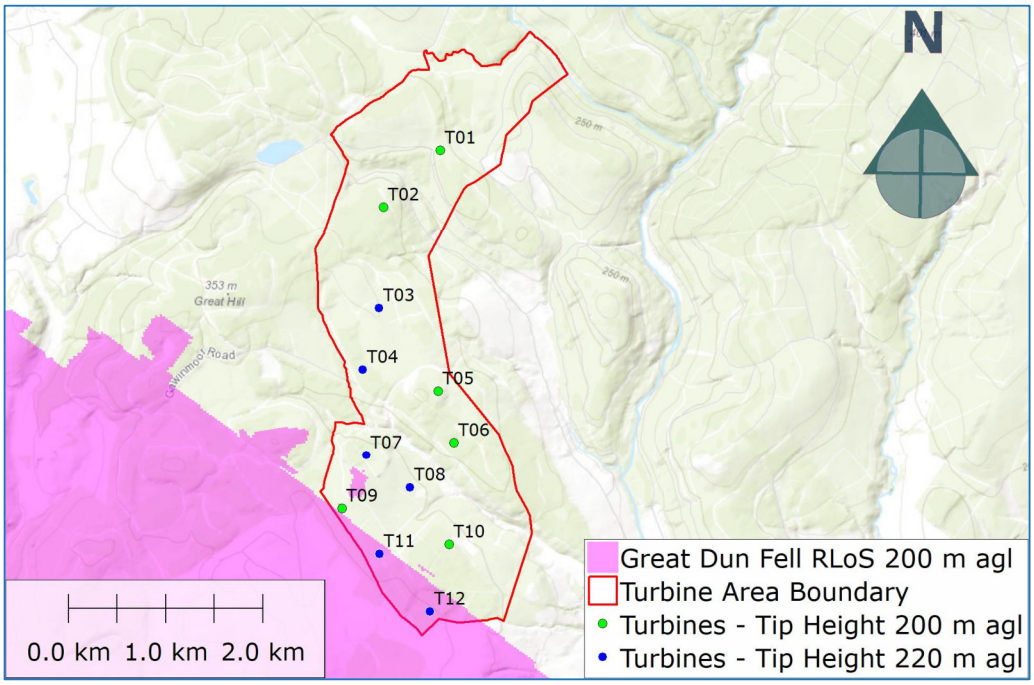
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 21: Great Dun Fell PSR RLoS to 220 m agl – zoomed.

5.5.4. **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

5.5.5. Figure 22 illustrates a zoomed view of the RLoS coverage from Great Dun Fell PSR to turbines with a blade tip height of 200 m agl. The magenta shading shows that, of the six proposed 200 m tip height turbines, RLoS would not exist between Great Dun Fell PSR and any of the 200 m tip height turbines in the design freeze layout.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 22: Great Dun Fell PSR RLoS to 200 m agl – zoomed

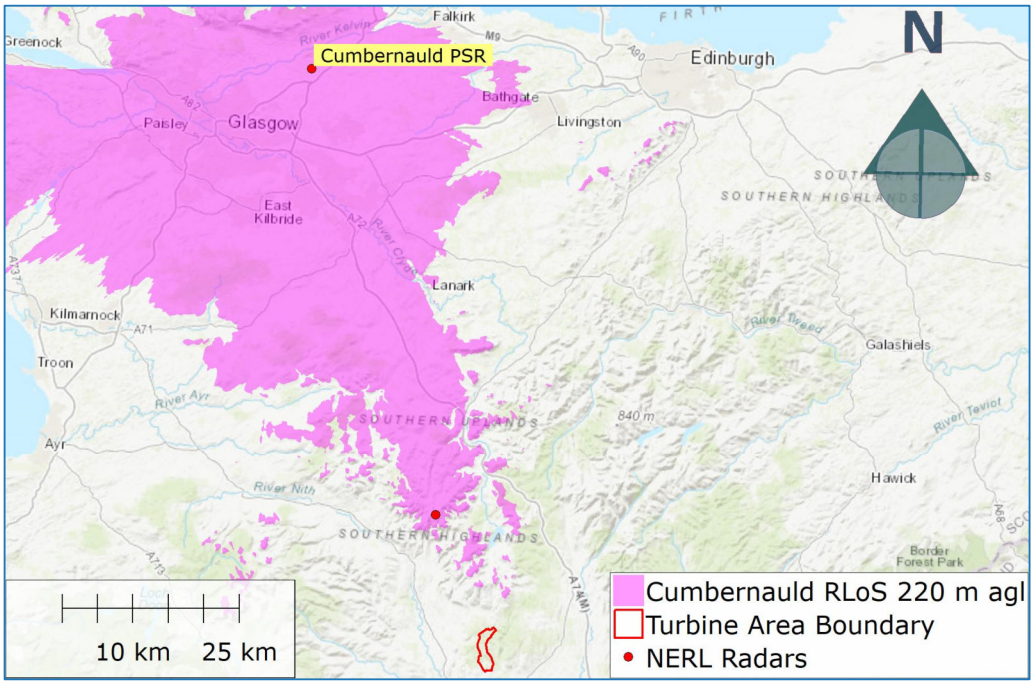
5.5.6. Given that RLoS would exist between Great Dun Fell PSR and two of the 12 proposed turbines, it can be assumed that Great Dun Fell PSR would detect at least two of the proposed Development turbines.

5.6. Cumbernauld PSR

5.6.1. The magenta shading in **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

5.6.2. Figure 23 illustrates the RLoS coverage from Cumbernauld PSR to turbines with a blade tip height of 220 m agl.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 23: Cumbernauld PSR RLoS to 220 m agl

5.6.3. **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

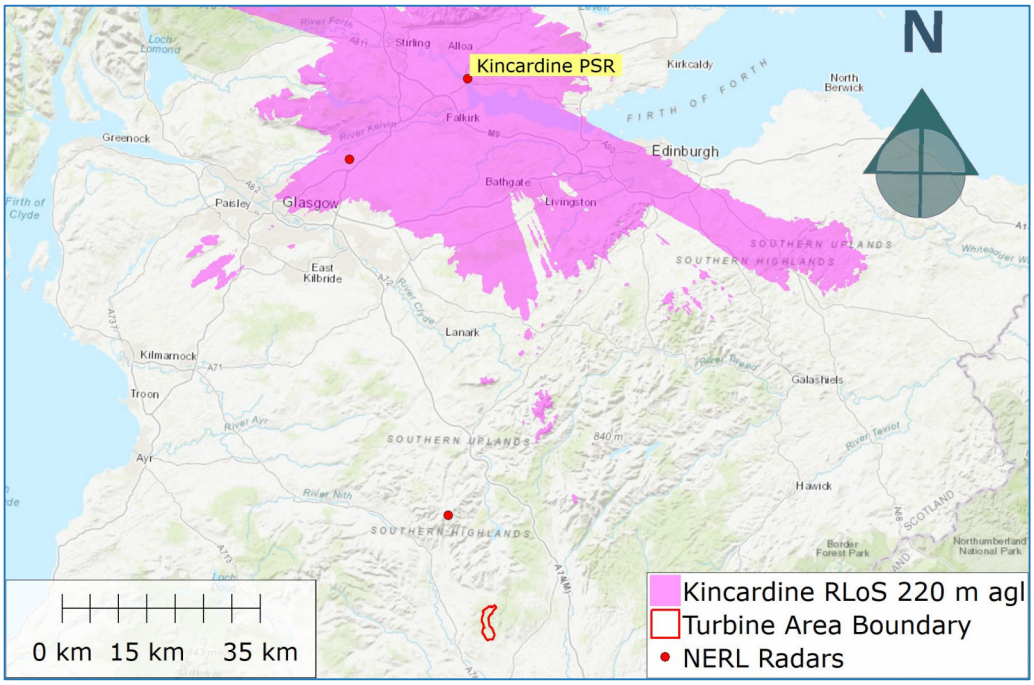
5.6.4. Figure 23 shows that RLoS would not exist between Cumbernauld PSR and any of the turbines. Given that RLoS would not exist, it can be assumed that Cumbernauld PSR would not detect any of the proposed Development turbines.

5.7. Kincardine PSR

5.7.1. The magenta shading in **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

5.7.2. Figure 24 illustrates the RLoS coverage from Kincardine PSR to turbines with a blade tip height of 220 m agl.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 24: Kincardine PSR RLoS to 220 m agl

5.7.3. **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

5.7.4. Figure 24 shows that RLoS would not exist between Kincardine PSR and any of the turbines. Given that RLoS would not exist, it can be assumed that Kincardine PSR would not detect any of the proposed Development turbines.

6. Airspace Analysis

6.1. Overview

6.1.1. As already noted, the significance of any radar impact depends on airspace usage in the vicinity of the proposed Development and the nature of the ATS provided in that airspace.

6.1.2. The airspace surrounding the proposed Development is detailed in the UK Aeronautical Information Publication (AIP)[3]. The type (airspace classification), usage and dimensions are contained within various sections of the En Route (ENR) section of the AIP.

6.1.3. The airspace immediately above the proposed Development consists of two types of airspace. The first portion is classified as Class G and extends from ground level to Flight Level (FL) 85 (standard atmospheric pressure equivalent to 8,500 ft above mean sea level (amsl). Class G airspace is commonly referred to as 'uncontrolled airspace' and is predominantly used by General Aviation and military aircraft. In uncontrolled airspace the responsibility to see and avoid other traffic and obstacles rests with the pilots in command of civilian and military aircraft and any ATS provided is essentially advisory. Services within the area are provided in accordance with CAP 774[4].

6.1.4. Above the uncontrolled airspace is Class A controlled airspace, Borders Control Area 2 (CTA 2), which extends from FL85 to FL195 (standard atmospheric pressure equivalent to 19,500 ft amsl). Lower ATS Routes L612, N601, N864 and T256 pass through the Borders CTA 2 airspace. Aircraft within Class A airspace are under the control of Scottish Control (NERL) based at NATS Prestwick Centre and are required to be SSR transponder equipped[5].

6.1.5. Approximately 3.5 km north of the proposed Development is Scottish Terminal Manoeuvring Area 2 (TMA 2). This airspace is Class D controlled airspace, and extends from 5,500 ft amsl to FL195. The airspace is also managed by NERL and between 6,000 ft amsl and FL100 (standard atmospheric pressure equivalent to 10,000 ft amsl) is a Transponder Mandatory Zone (TMZ). Carriage and operation of an SSR transponder is mandatory within a TMZ.

6.1.6. Aircraft within Class A and Class D airspace are under a Radar Control Service. Clearance from the controlling authority is required to enter the controlled airspace and ATC instructions are mandatory. It provides a 'known traffic environment' meaning that ATC is aware of all traffic operating within the designated airspace.

6.1.7. The airspace structure in the vicinity of the proposed Development is depicted in Figure 25, and Lower ATS Routes are shown in **Figure 26**.

[3] CAP 032: UK Aeronautical Information Publication, September 2024
[4] CAP 774: UK Flight Information Services, December 2021
[5] UK AIP, GEN 1.5, 5.3 Carriage of Transponder Equipment

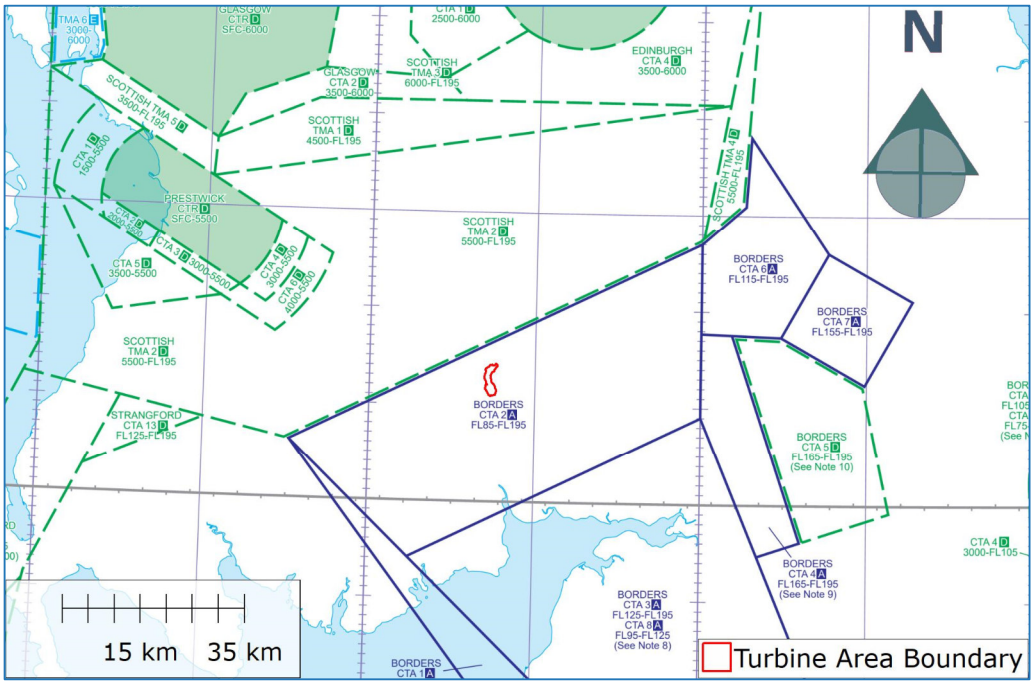


Figure 25: Airspace structure (extract from AIP chart ENR 6.7)

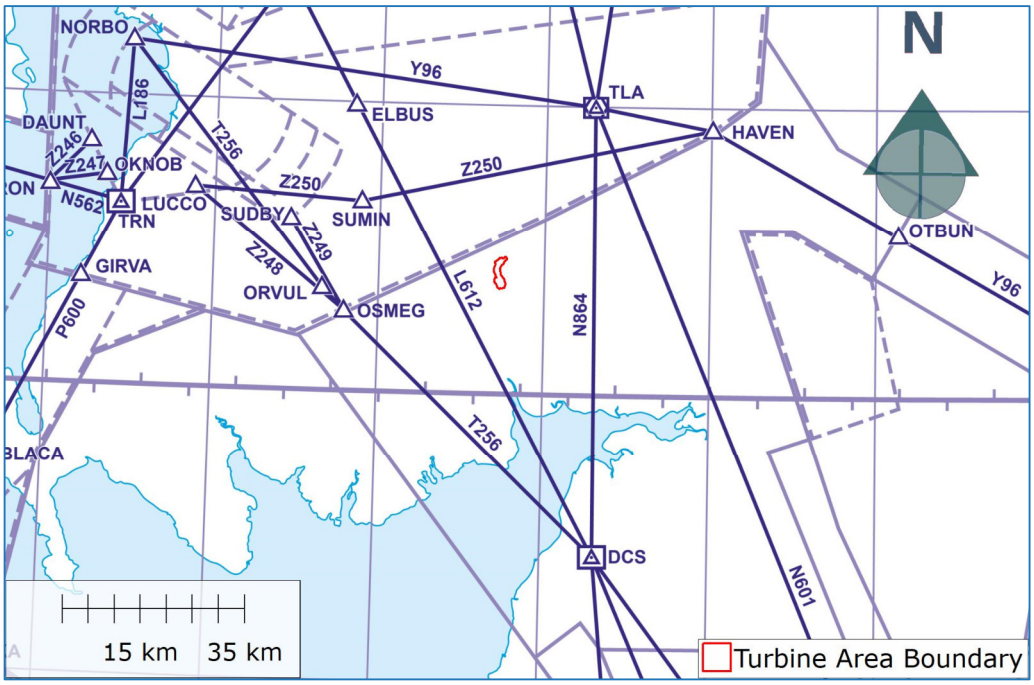


Figure 26: Lower ATS Routes (extract from AIP chart ENR 6-69)

6.1.8. The published Area Minimum Altitude in the vicinity of the proposed Development is 4,000 ft amsl. This provides a minimum obstacle clearance of 1,000 ft above all obstacles within the specified area. The maximum terrain elevation within the turbine area boundary is 321 m amsl, so the maximum possible turbine tip elevation is 321 + 220 = 541 m amsl, or

1,775 ft amsl. With a maximum possible tip elevation of less than 1,800 ft amsl, the minimum clearance would be maintained above the proposed turbines.

6.2. Other Airspace Considerations

6.2.1. The proposed Development site is not in the immediate vicinity of any aerodromes. It is situated between Carlisle Lake District Airport, 58 km to the south east, and Prestwick Airport, 66 km to the north west, but does not impact upon the procedures associated with either. The nearest minor aerodromes identified are the private airstrip at Glenswinton, 29 km to the south west, and the glider launch site at Falgunzeon, 27 km to the south, south west. Operations at these sites would not be impacted by the proposed Development.

6.2.2. As shown in Figure 27, the proposed Development would be within a military low flying area known as Tactical Training Area 20T (and within low flying Area 2B at night). Within Area 20T military aircraft may conduct tactical low flying training down to 100 ft agl. To alleviate MOD concerns, wind turbines would be fitted with MOD accredited aviation safety lighting in accordance with Air Navigation Order Article 222[6].

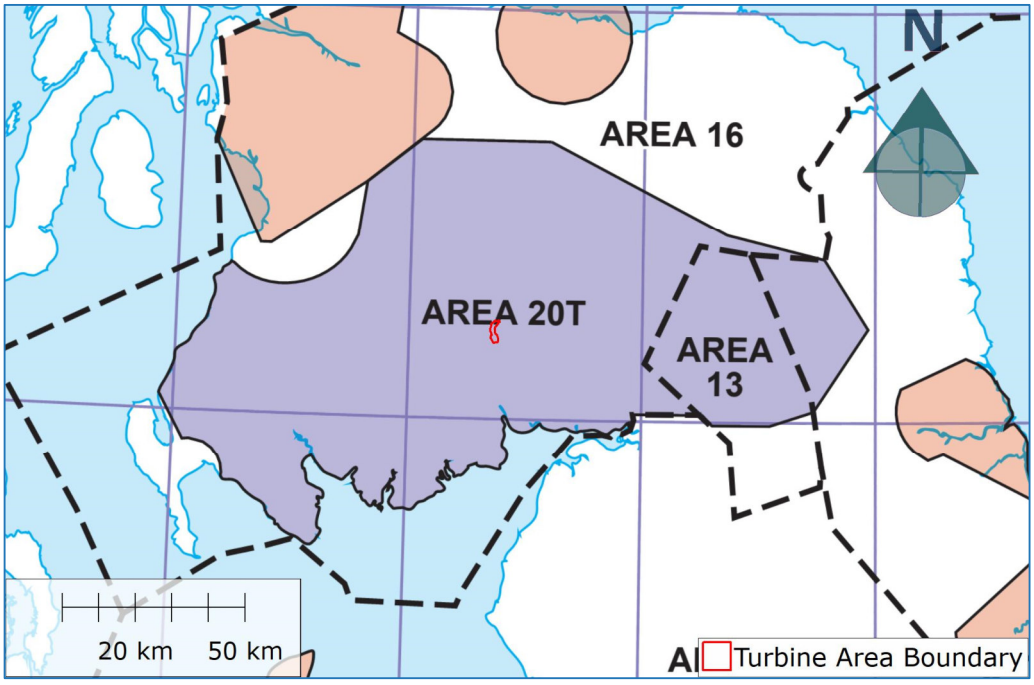


Figure 27: Low flying areas (extract from AIP chart ENR 6-20)

[6] Air Navigation Order 2016/765, April 2022

7. Mitigation Options

7.1. Mitigation Requirement

7.1.1. Mitigation may be required where radar clutter generated by the proposed wind turbines has a detrimental impact on the ATS provided. RLoS modelling indicates that the NERL PSRs at Lowther Hill and Great Dun Fell, and the MOD PSR at Deadwater Fell, may be impacted by the proposed Development. NERL has determined an unacceptable impact on Lowther Hill PSR, but made no comment regarding Great Dun Fell PSR. To date, the MOD has not raised any concerns regarding impacts to radar facilities.

7.2. NERL Lowther Hill PSR Mitigation

7.2.1. A new 3D PSR system has recently been deployed at Lowther Hill that has the capability to mitigate the impact of wind turbines by better filtering out the clutter the turbines generate. The new Lowther Hill PSR went online in September 2022 and optimisation to mitigate the impact of the proposed Development may be a feasible option.

7.2.2. Should optimisation of the Lowther Hill PSR prove to be inappropriate in this case, then a potential option for mitigating the impact on Lowther Hill PSR is to blank the area of clutter and use an infill radar feed that does not have RLoS of the proposed turbines but has adequate coverage over the proposed Development to satisfy ATC requirements.

7.2.3. The base of controlled airspace immediately above the proposed Development is approximately 8,500 ft amsl and drops to 5,500 ft amsl in Scottish TMA 2, approximately 3.5 km north of the turbine area boundary. Cyrrus understands that NERL units optimally require 2,000 ft of additional PSR coverage below the base of TMA controlled airspace to provide a safety buffer for controllers. In controlled airspace outside of the Scottish TMA, the NERL requirement is for a 3,000 ft coverage buffer. The coverage buffer is to enable lateral incursions into the TMA, by aircraft that are below controlled airspace, to be predicted.

7.2.4. As the proposed turbines would be south of the Scottish TMA, this means that PSRs must be capable of detecting airborne targets at a minimum altitude of 5,500 ft over the proposed Development.

7.2.5. Surveillance coverage requirements in the enroute environment are summarised in the document CAP 670[7]. Section 3: SUR 01 states that below Flight Level 100 (approximately 10,000 ft amsl) in areas of high traffic density and/or complexity, coverage shall be provided with at least a single layer of coverage by a non-cooperative surveillance technique, i.e. PSR, together with data from a suitable co-operative surveillance technique (e.g. SSR). Redundancy is only required for the co-operative surveillance provision, e.g. in the form of dual SSR, which suggests that a single layer of infill PSR coverage is sufficient to provide coverage over a blanked area.

7.2.6. A candidate radar for infill coverage over the proposed Development is Cumbernauld PSR.

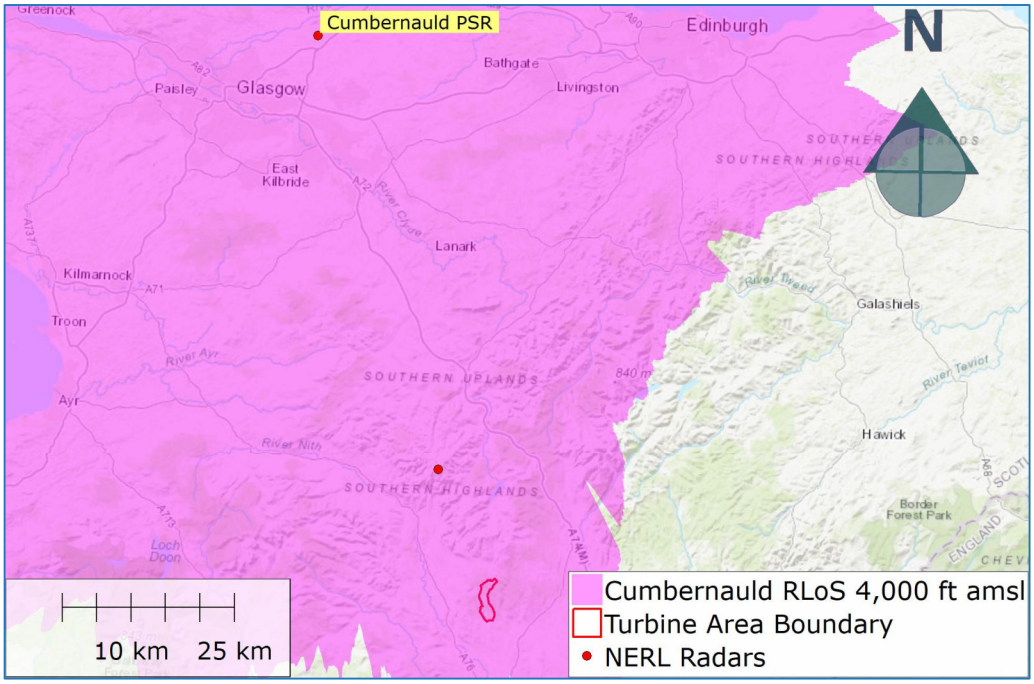
[7] CAP 670: Air Traffic Services Safety Requirements, June 2019

7.3. NERL Potential Infill Radar – Cumbernauld PSR

7.3.1. The magenta shading in **Sources:** Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,

Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

7.3.2. Figure 28 illustrates RLoS coverage for Cumbernauld PSR at an altitude of 4,000 ft. It can be seen that Cumbernauld PSR can provide radar coverage down to 4,000 ft amsl in the vicinity of the proposed Development.

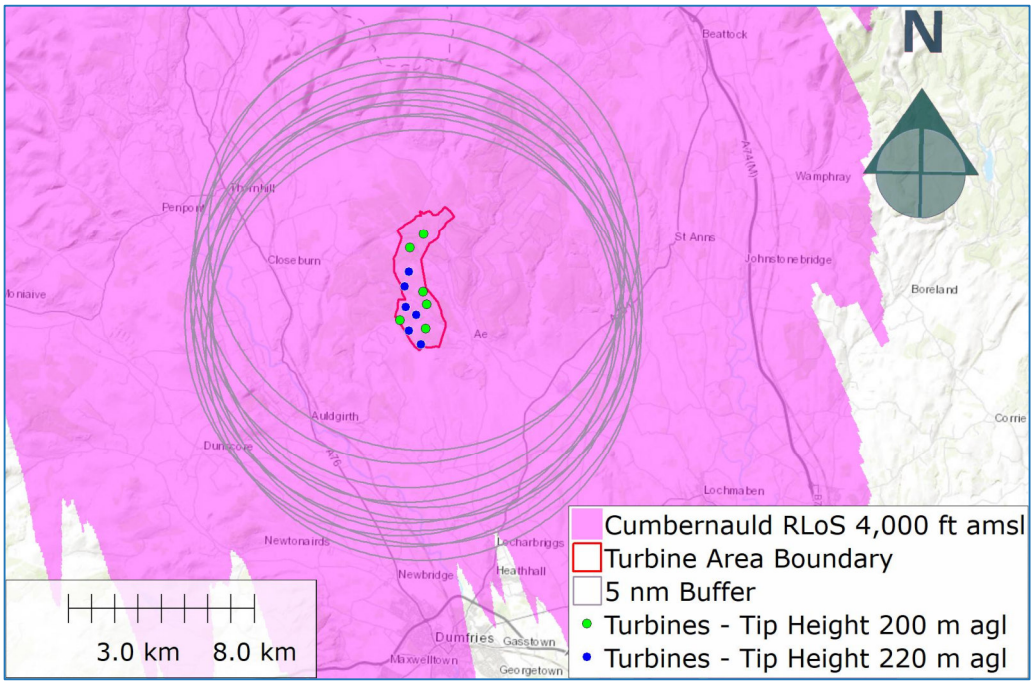


Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 28: Cumbernauld PSR RLoS to 4,000 ft amsl

Historically there has been a NERL requirement that infill coverage is extended to include a 5 nm buffer on all the mitigated wind turbines. The zoomed view of the Cumbernauld PSR 4,000 ft amsl coverage in Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL,
Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

7.3.3. Figure 29 includes 5 nm rings centred on each of the design freeze turbines to illustrate where the buffer may be required to extend to.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community

Figure 29: Cumbernauld PSR RLoS to 4,000 ft amsl – zoomed.

7.3.4. As can be seen, coverage at 4,000 ft amsl extends to beyond 5 nm south of the design freeze turbines. Cumbernauld PSR can provide a minimum of 4,000 ft amsl infill coverage over the proposed Development and is integrated into NERL's Multi-Radar Tracking infrastructure.

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