Technical Appendix 4.1: Larbrax Access Forestry Report

Appendix 4.1: Larbrax Access Forestry Report
Orsted Onshore UK Ltd
Hazel Boyd, Forestry
August 2024

BIDWELLS

APPENDIX 4.1: LARBRAX ACCESS FORESTRY REPORT ORSTED ONSHORE UK LTD

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1.0 Introduction

Bidwells were instructed by Bojan Jevtic, of Orsted Onshore UK Ltd in August 2024 to carry out baseline surveying of woodland which would require removal to accommodate the formation of access infrastructure to the Larbrax Wind Farm.

Shapefiles were provided with the development footprint area, sightline requirements and associated tree felling activities for the wind farm access.

Surveying was carried out by Hazel Boyd on Tuesday 13th August 2024 using the shapefiles and maps provided. The report focuses on the woodland impacted by the proposed formation of access infrastructure; however, the wider woodland area was also viewed to provide background and context to the condition and structure of the woodland.

2.0 Desk Based Analysis

Desk based analysis using OpenSource datasets for the Ancient Woodland Inventory (AWI) and the Native Woodland Survey of Scotland (NWSS) were used to provide a baseline assessment of the woodland areas or groups of trees which would be affected by the construction of the access infrastructure and compared against contemporary aerial imagery.

2.1 Ancient Woodland Inventory (AWI)

The Ancient Woodland Inventory comprises woods recorded as being of semi-natural origin on either the 1750 Roy maps or the 1st Edition Ordnance Survey maps of 1860 and does not always accommodate or reflect modern features such as housing or roading infrastructure. None of the woodland features within the Larbrax boundary were included on the AWI dataset.

2.2 Native Woodland Survey of Scotland (NWSS)

The Native Woodland Survey of Scotland Inventory, launched in 2014, maps the location, extent, and type of existing woodland to create a baseline for future monitoring. The NWSS categorises native woodland into dominant habitat type and structure. The NWSS is considered an authoritative inventory of native woodlands and a baseline for future monitoring and has therefore been used to compliment the AWI data set.

The area of woodland potentially impacted is the northern most section of native woodland which the NWSS dataset identifies as 21109 - lowland mixed deciduous woodland. The woodland is long and thin in nature, recording a 50% canopy coverage, with a notable component of non-native rhododendron, with the total woodland area measuring approximately 1.92ha, as shown in figure 2 below. The access footprint does not affect any other woodland areas identified.

3.0 Survey Findings

The access for the development runs east-northeast from the B738 public road, with the gross area for the access footprint and sightlines measuring 0.36ha encompassing the public road, verges and immediate adjacent woodland, with the nett area of woodland being 0.28ha as shown in Appendix 3. The wooded area within this was found to be dominated by a dense understorey of rhododendron (*Rhododendron ponticum)* with individual broadleaves trees protruding through the dense thicket structure. Tree coverage within the access footprint area is scant with no more than 20 stems having either grown prior to the rhododendrons developing foliar coverage or having had sufficient vigour to compete for light.

A drainage channel runs alongside the western edge of the B738, with a much smaller and shallower channel on the eastern side of the road. A flush line drains water from the blanket bog area (identified as M17a/M15b in *Figure 7.3.3:NVC Survey Areas and Survey Results),* which was provided by MacArthur Green/Orsted for information and is included as Appendix 4 to this report for context) to the roadside drains/watercourse resulting in waterlogging of the area, where drains are partially choked with rhododendron litter, exacerbating the drainage issue.

Rhododendron forms an understory comprising of a dense thicket which was extremely difficult to access for surveying purposes and as such most of the photography is taken from the carriageway of the B738.

3.1 Woodland Condition Assessment within the Development Footprint

Within the access footprint the canopy cover was approximately 10-20% with the understory dominated by rhododendron which has inhibited the formation of a native understory and regeneration of successive cohorts of native trees. The trees identified within the footprint were sycamore (*Acer pseudoplatanus)*, birch *(Betula pubescens)* and a variety of willows (*Salix caprea or Salix cinerea),* however these were generally sparse and small diameter in nature.

Sycamore, which is not considered a native tree species, was the dominated species within the sparse tree canopy within the access footprint area. Sycamore is shade tolerant when young but is a light demander as trees reach pole stage, which may support the observation that they are the prevailing species within the rhododendron thicket. However, the mature sycamore, along the frontage of the access footprint are multi-stemmed, with thin foliage and limbs which are exhibiting signs of decay (Photos 7 & 8 – multi-stemmed sycamore).

The birch trees present were drawn and thin, again characteristic of birch which have grown through the rhododendron thicket. The light demanding and lower growing willow within the access footprint were located along the edge of the woodland and in small gaps where sufficient light and the wet ground conditions have favoured establishment.

In the wider context of the parcel of native woodland 21109, several trees outside the access footprint were observed to have died and to be in generally poor and declining condition arising from a combination of factors, likely to include the invasive rhododendrons and generally poor, wet ground conditions, due to the flush which drains the bog to the west towards the roadside drain, which is partially blocked with rhododendron litter.

The following series of photos follows the public road from north to south to illustrate the woodland composition and structure along the area in question.

Photo 1 – dense thicket of rhododendron which with characteristic lack of native ground vegetation and tree regeneration

Photo 2 – no ground flora within the rhododendron thicket.

3.2 Location 1

Photograph 3 shows the view south along the bend in the public road leading towards the access felling area. Although there are several mature or semi-mature trees within the access felling footprint the vegetation was dominated by rhododendron.

Photo 3 – Location 1, view south towards the proposed felling area for access on the right-hand side.

3.3 Location 2

Photograph 4 was taken at the northern edge of the proposed felling area and shows a mature willow surrounded by rhododendron.

Photo 4 – Location 2 showing the northern edge of the access felling area.

3.4 Locations 3, 4 and 5

The following photographs show the extent of the rhododendron thicket along the frontage of the proposed area to be felled for access.

Photograph 5 shows Location 5 where the rhododendron was completely impenetrable and went as far back as was visible from the opposite side of the road.

Photograph 6 was taken where there was a gap in the roadside vegetation and the ability to gain slightly more access into the access footprint area. This area had a small group of native broadleaves, mainly birch, which had elongated stems and thin crowns. This small group was surrounded behind by rhododendron thicket.

Photograph 7 shows that some of the woodland trees are clinging onto the roadside structure and may have the potential to eventually damage the infrastructure through instability. The woodland area behind Location 3 is also dominated entirely by rhododendron.

Photo 5 – vegetation was completely impenetrable

Photo 6 – Location 4, slight gap in vegetation, but the background completely covered with thick rhododendron bushes.

Photo 7 – Location 3, multi-stemmed sycamore growing out of the roadside verge above the drainage channel.

3.5 Location 6

Location 6, which is at the southern end of the access footprint, and Photograph 8 provides a closer view of the sycamore and the surrounding vegetation. The rhododendron is over 2 metres in height with an extremely dense and spreading stem structure.

The sycamore has already had limbs removed from the carriageway-facing side and other limbs are defoliated suggesting signs of decline or stress.

Photo 8 – multi-stemmed sycamore at the southern end of the access footprint area.

3.6 Location 7

Photograph 9 was taken just outside of the southern edge of the proposed access footprint area had a large multi-stemmed sycamore tree surrounded by rhododendron. Rhododendron has formed a bank along the road frontage and completely engulfed the woodland area within the access footprint. The mature willow to the right of Photo 2 is defoliating along the lower limbs due to competition from the rhododendron bush which is particularly vigorous in this section.

Photo 9 – Multi-stemmed sycamore on the edge of the proposed felling area, mature willow to right of photograph

Photo 10 –rhododendron dominating the ground vegetation with sparse regeneration along the verge.

4.0 Summary

The access footprint and required visual splays boundaries have been calculated as 0.36ha which comprises 0.28ha of woodland, with the remainder representing the public road and associated verges. The 0.28ha of woodland features are classified on the NWSS, (reference 21109), as lowland mixed deciduous woodland, recording a 50% canopy coverage, however the area comprised mainly non-native broadleaf species swamped by a rhododendron thicket.

The survey of this woodland area confirmed the understory was dominated by rhododendron with sparse individual broadleaves (estimated at less than 20 individual trees) whose crowns have either developed at a similar time to the colonisation of the rhododendron or have been able to penetrate the thicket before it completely closed the understory canopy. Ground conditions for the growth of the principal canopy species (sycamore and birch), are being negatively impacted by the encroachment of the rhododendron compounded by poor drainage/rising water table.

Although the woodland area has a low canopy coverage and is in poor and declining condition due to invasive rhododendron colonisation and poor drainage, the current land use is classified as “woodland” and as such compliance with the Control of Woodland Removal Policy, and National Planning Framework 4 for the development of access infrastructure may require the loss of 0.28ha of woodland to be replaced through Compensatory Planting.

Compensatory Planting should be in line with Scottish Forestry creation of new woodland requirements, be planted and managed through to establishment to achieve a minimum density of 1,600 stems per hectare (448 trees), using appropriate local provenance seed sources and approved as part of the development application. However, the access footprint falls within Area E of the Biodiversity Enhancement and Management Plan (BEMP) (Appendix 7.5). which proposes that 3.70ha of rhododendron removal is carried out within the existing broadleaved woodland. It may be considered acceptable that the removal of the rhododendron within Area E of the BEMP would significantly contribute to the functional connectivity of the woodland habitat features and may be considered appropriate mitigation to meet the terms of Annexe C of the Control of Woodland Removal Policy without the need for compensatory planting. This, however, will be determined through the planning process. Should compensatory planting be required, then this will be secured either within the Site, or at an alternative location to be agreed with the council and Scottish Forestry through the discharging of conditions process.

Removal of the roadside vegetation within the access footprint should be agreed by the Planning Authority and should observe the requirements of Annexe C (Public Safety) of the Control of Woodland Removal Policy. As the shrubbery is within the footprint of the B738, has the potential to undermine the infrastructure with their roots and impact on public safety considerations for road users due to reduced visibility a land use change without compensatory planting should meet the acceptability criteria for woodland removal within the area identified as verge in Appendix 3.

Photo 11 – Rhododendron infestation with native broadleaf canopies above the dense thicket

Prepared by

[redacted]

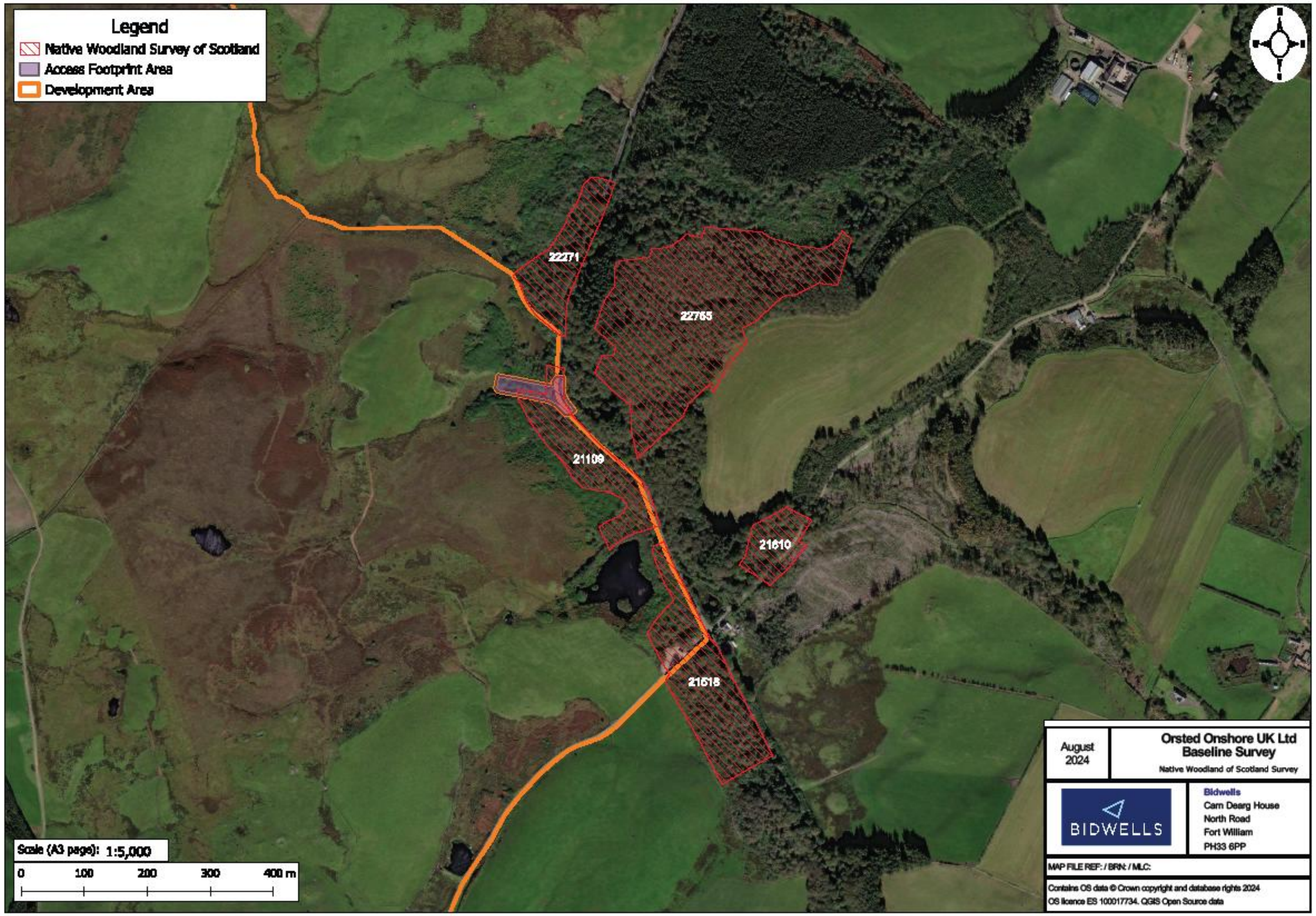
Hazel Boyd
Associate, Forestry

Date: 11/10/2024

APPENDIX 1

BASELINE SURVEY – 13TH AUGUST 2024, PHOTOGRAPH LOCATIONS

APPENDIX 2
NATIVE WOODLAND OF SCOTLAND SURVEY MAP



APPENDIX 3
WOODLAND REMOVAL REQUIREMENTS

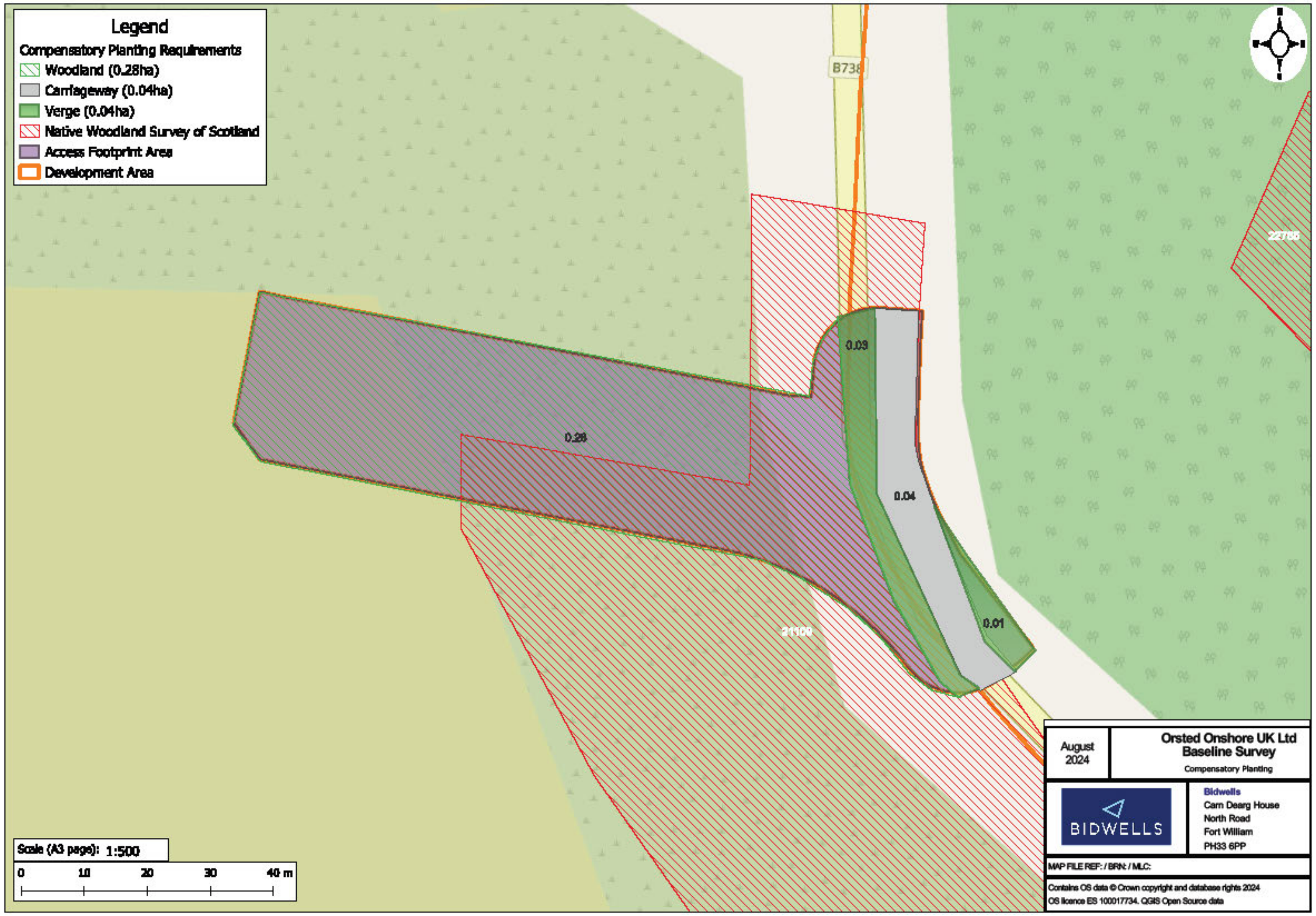


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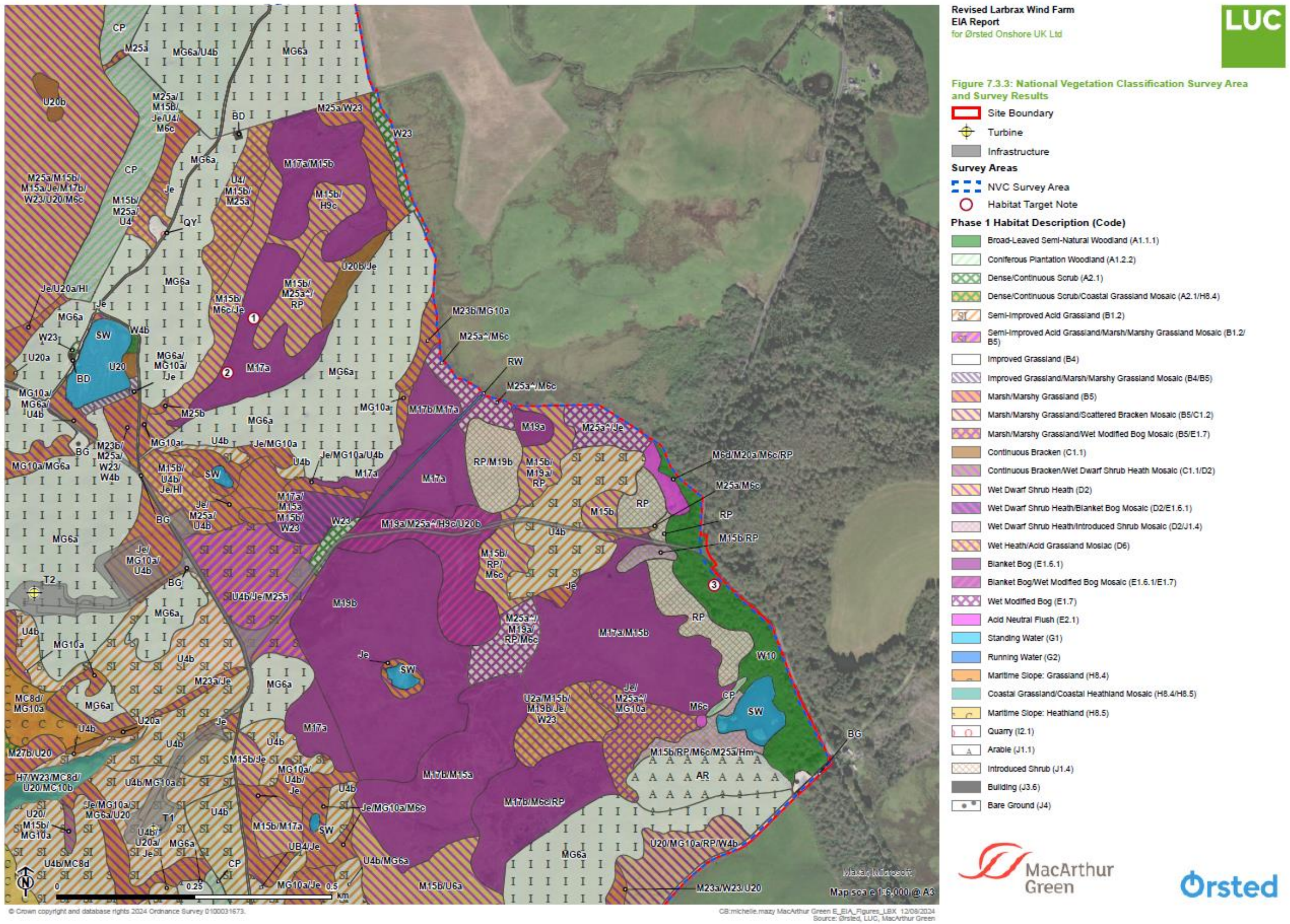
FIGURE 7.3.3 – NVC SURVEY AREAS AND SURVEY RESULTS (PROVIDED BY ORSTED)



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Technical Appendix 4.2: Aviation Risk Assessment

PAGERPOWER
Urban & Renewables

Aviation Risk Assessment

Land Use Consultants

Revised Larbrax Wind Farm

September 2024

EXECUTIVE SUMMARY

Background

Pager Power has conducted an aviation risk assessment for a proposed wind development located in Dumfries and Galloway, Scotland, to determine its potential impact upon aviation activity.

The proposed development has been assessed based on four wind turbines with a maximum tip height of 149.9m above ground level (agl).

Overall Conclusion

The primary risk to the proposed development is the potential impact upon the Belfast City Airport Primary Surveillance Radar (PSR). Technical impacts i.e. false returns are predicted, and it is possible that an objection is raised. Technical mitigation solutions are likely to be available if required.

Assessment Results – Belfast City PSR

The proposed development is significantly within line-of-sight to the Belfast City PSR and therefore technical impacts are predicted.

The proposed development is not understood to be in a sensitive location with respect to Belfast City Airport air traffic services and therefore it is predicted that the impacts can be operationally accommodated.

Consultation with Belfast City Airport is recommended to confirm their position.

Assessment Results – Ministry of Defence

Low Flying Zones and Danger Area

The proposed development is located within an area of low priority for military low flying concerns. No significant impacts upon military low flying operations are predicted.

Aviation Lighting

It is likely the MoD will request that they be fitted with MoD accredited aviation lighting in accordance with the requirements of the Civil Aviation Authority, Air Navigation Order 2016.

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 58 countries within Europe, Africa, America, Asia and Australasia.

The company comprises a team of experts to provide technical expertise and guidance on a range of planning issues for large and small developments.

Pager Power was established in 1997. Initially the company focus was on modelling the impact of wind turbines on radar systems. Over the years, the company has expanded into numerous fields including:

- Renewable energy projects.
- Building developments.
- Aviation and telecommunication systems.

Pager Power prides itself on providing comprehensive, understandable and accurate assessments of complex issues in line with national and international standards. This is underpinned by its custom software, longstanding relationships with stakeholders and active role in conferences and research efforts around the world.

Pager Power's assessments withstand legal scrutiny and the company can provide support for a project at any stage.

1 INTRODUCTION

1.1 Overview

Pager Power has conducted an aviation risk assessment for a proposed wind development located in Dumfries and Galloway, Scotland, to determine its potential impact upon aviation activity.

The proposed development has been assessed based on four wind turbines with tip heights of 149.9m above ground level (agl).

The report includes:

- Identification of relevant aviation infrastructure including:
  - Aerodromes (licensed, unlicensed and military);
  - Radar;
  - Radio navigation aids.
- Overview of relevant safeguarding assessment distances;
- Radio line of sight assessment for the relevant infrastructure, including:
  - Radar installations;
  - Radio navigation aids.
- Overall risk and key issues.

The aim is to identify and assess the aviation risks associated with achieving planning permission and construction of the wind development.

2 PROPOSED DEVELOPMENT INFORMATION

2.1 Proposed Development Details

The coordinates (Eastings and Northings as per British National Grid) and dimensions of the wind turbines are presented in Table 1 below.

Turbine	Easting	Northing	Rotor Diamter (m)	Hub height (m agl)	Tip Height (m agl)
1	196965	561416	133	83.4	149.9
2	196748	561849			
3	196251	562184			
4	196222	562692			

Table 1 *Proposed wind turbine details*

The location of the proposed wind turbines is shown on to aerial imagery in Figure 1 below.

Figure 1 *Proposed wind turbines location*

3 AVIATION RISK ASSESSMENT

3.1 Risk Assessment Results

Table 2 below presents the results of the aviation risk assessment and identified risks.

Stakeholder	Aviation Risk	Distance	Risk Level
Met Office	No aviation risks relating to Met Office radar have been identified		
Civil Airfields	No aviation risks relating to civil airfields have been identified		
NATS NERL	Lowther Hill PSR	104 km	Low
Ministry of Defence (MoD)	West Freugh Range PSR	15.6 km	Low
	Low Flying System / Danger Area	-	Low
Airports and Radar	Belfast City PSR	56.0 km	Medium

Table 2 *Identified aviation risks*

The following risks have been considered further:

- Belfast City PSR;
- MoD Danger Area.

4 AVIATION RISK ASSESSMENT DISCUSSION

4.1 Overview

The following section presents the results and discussion of the aviation infrastructure identified by the risk assessment. The approach taken for the radar installations is as follows:

- Radar line of sight assessment for the proposed development at its maximum height (149.9m agl);
- Consideration of the distance from the radar;
- Sensitivity of the location in which the development is situated.

Additional information regarding the methodology or the additional line-of-sight charts can be provided upon request.

4.2 Airports and Radar

4.2.1 Belfast City PSR

EGAC Belfast City Airport is a Civil Aviation Authority (CAA) licensed aerodrome operating domestic and international flights. The location of the PSR relative to the proposed development is shown in Figure 2 below.

Figure 2 *Belfast City PSR relative to proposed development*

Figure 3 on the following page shows the line-of-sight chart for the Belfast City PSR. The results for Turbine 4 is shown as it is the most visible turbine to the PSR.

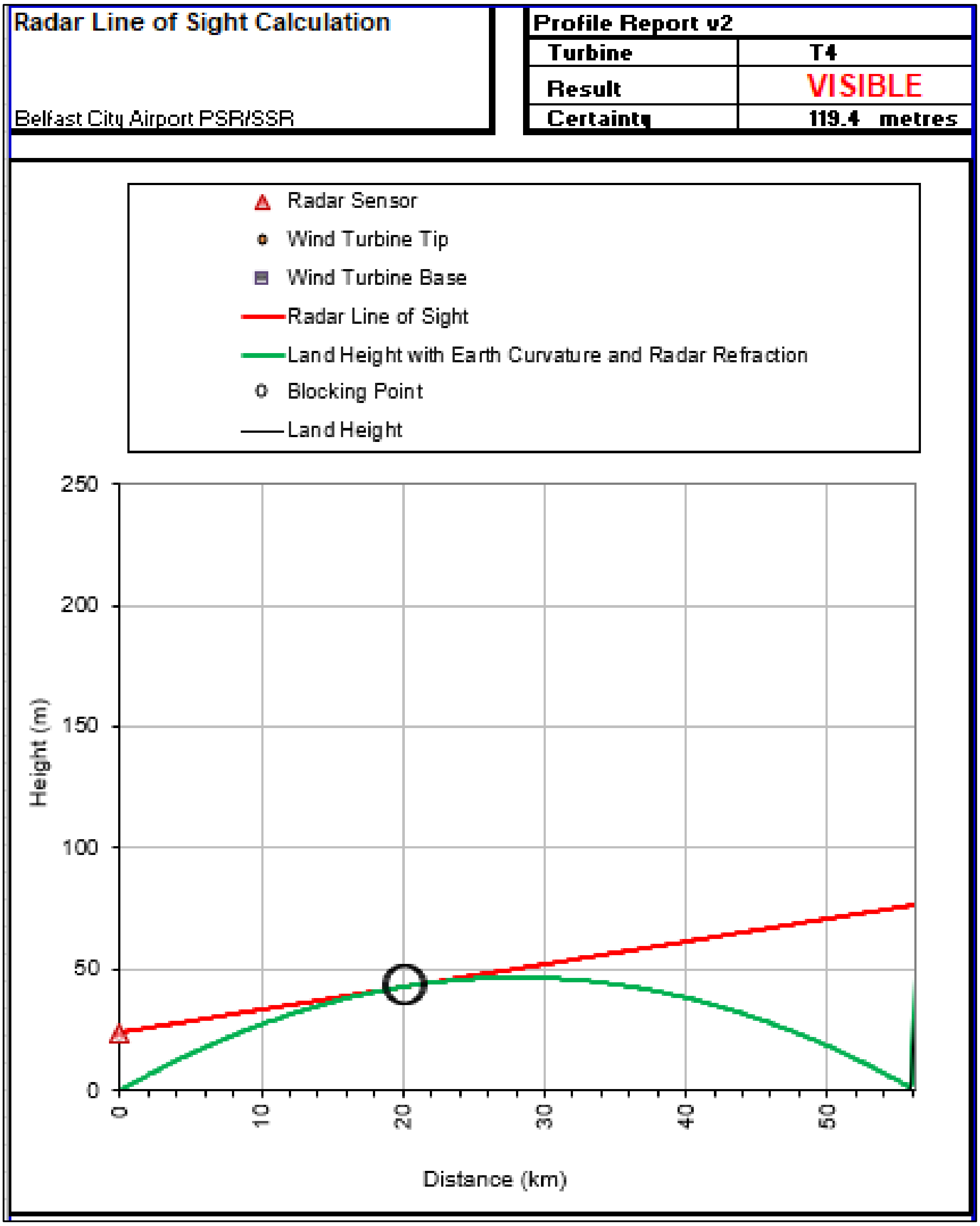

Figure 3 *Belfast City PSR line-of-sight chart relative to proposed development*

Considering the certainty (80%) of the turbine visible to the radar, technical impacts i.e. false returns are predicted upon on the PSR. The proposed development is understood not to be in a sensitive location/operational area with respect to Belfast City Airport air traffic services and therefore it is predicted that the impacts can be operationally accommodated.

The proposed development is located beyond the 30km safeguarding buffer as stated on BCA's website[1], and the Civil Aviation Authority (CAA) had not raised any concerns for the Consented Larbrax Wind Farm. As such, consultation has not been undertaken at this present time (of this report). Consultation with the CAA will be undertaken[2] to reconfirm their position.

4.3 MOD - Ministry of Defence

4.3.1 Military Low Flying

Military low flying can take place throughout the UK. The MoD has published a map indicating areas within the UK where military low flying activities are the most likely to cause an objection. The map is colour coded as follows:

- Green – Area with no military low flying concerns;
- Blue – Low priority military low flying areas less likely to raise concerns;
- Amber – Regular military low flying area where mitigation may be necessary to resolve concerns;
- Red – High priority military low flying area likely to raise considerable and significant concerns.

The location of the proposed wind turbine relative to the military low flying zones is shown in Figure 5 on the following page. The figure shows that the proposed wind turbine is located within the 'blue' zone, which is an area with low priority for military low flying concerns, and outside the D402A Danger Area.

[1] https://www.belfastcityairport.com/Environment-Page
[2] As confirmed by the developer

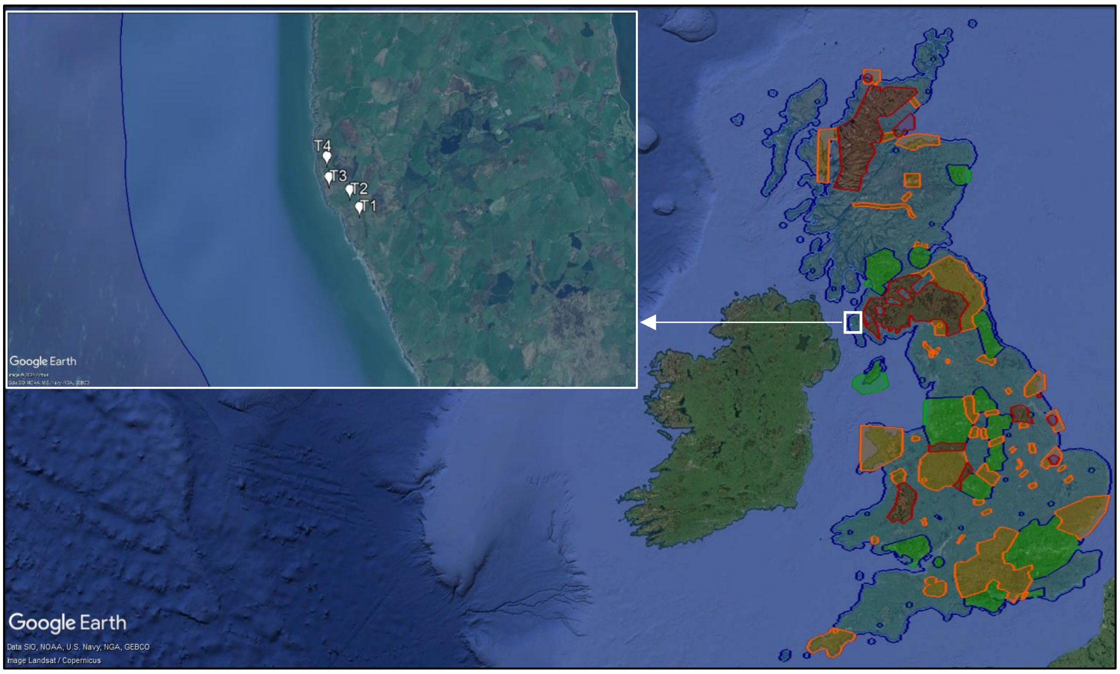

Figure 4 *Military low flying zones relative to proposed development*

No significant impacts upon military low flying operations are predicted.

It is likely the MoD will request that they be fitted with MoD accredited aviation lighting in accordance with the requirements of the Civil Aviation Authority, Air Navigation Order 2016.

5 OVERALL CONCLUSION AND RECOMENDATIONS

5.1 Assessment Results – Belfast City PSR

The proposed development is significantly within line-of-sight to the Belfast City PSR and therefore technical impacts are predicted.

The proposed development is not understood to be in a sensitive location with respect to Belfast City Airport air traffic services and therefore it is predicted that the impacts can be operationally accommodated.

5.2 Assessment Results – Ministry of Defence

5.2.1 Low Flying Zones and Danger Area

The proposed development is located within an area of low priority for military low flying concerns. No significant impacts upon military low flying operations are predicted.

5.2.2 Aviation Lighting

It is likely the MoD will request that they be fitted with MoD accredited aviation lighting in accordance with the requirements of the Civil Aviation Authority, Air Navigation Order 2016.

5.3 Overall Conclusion

The primary risk to the proposed development is the potential impact upon the Belfast City Airport Primary Surveillance Radar (PSR). Technical impacts i.e. false returns are predicted, and it is possible that an objection is raised. Technical mitigation solutions are likely to be available if required.

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Technical Appendix 4.3: Shadow Flicker Assessment

A specialist energy consultancy

Shadow Flicker Assessment

Revised Larbrax Wind Farm EIA Report Technical Appendix 4.3

Orsted

15893-003
27 November 2024

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Executive Summary

TNEI Services Ltd has undertaken an assessment of the likelihood of shadow flicker occurrence resulting from the installation of the proposed Revised Larbrax Wind Farm (the Proposed Development), at the nearest receptors. The Proposed Development comprises four wind turbines and the receptors considered are nearby residential dwellings.

Under certain combinations of geographical position, time of day and year, wind speed and wind direction, the sun may pass behind the rotor and cast a shadow over neighbouring buildings' windows. When the blades rotate and the shadow passes a window, to a person within that room the shadow appears to flick on and off; this effect is known as shadow flicker. Where moving shadows are cast over the ground (rather than a building's windows), this is known as 'shadow throw'. There are no guidelines to quantify the effect and there is no requirement to assess 'shadow throw', therefore 'shadow throw' has not been assessed in this report.

In the United Kingdom, there is no standard for the assessment of shadow flicker and there are no guidelines which quantify what exposure levels would be acceptable or significant for the purposes of Environmental Impact Assessment (EIA). However some information specific to shadow flicker can be found in the Scottish Government's web based renewables advice on *'Onshore Wind Turbines'* which states:

'Under certain combinations of geographical position, time of day and time of year, the sun may pass behind the rotor and cast a shadow over neighbouring properties. When the blades rotate, the shadow flicks on and off; the effect is known as "shadow flicker". It occurs only within buildings where the flicker appears through a narrow window opening. The seasonal duration of this effect can be calculated from the geometry of the machine and the latitude of the potential site.

Where this could be a problem, developers should provide calculations to quantify the effect. In most cases however, where separation is provided between wind turbines and nearby dwellings (as a general rule 10 rotor diameters), "shadow flicker" should not be a problem. However, there is scope to vary layout / reduce the height of turbines in extreme cases.'

Four wind turbines with a 133 m rotor diameter and an 83.4 m hub height were modelled in this assessment. Six residential buildings located within 1,330 m (10 times rotor diameter) of the proposed wind turbines were found and assessed. Windows for each building were assumed on all façades as a worst-case approach. The full length of the house facades were assumed to be a window, this is known as the 'Greenhouse Model' as it treats the entire structure as a large glass box.

It has been shown that the times of day when shadow flicker could theoretically occur varies between 19:10 and 20:03 during the months of April to August, and between 15:47 and 18:07 during the months of September to November and January to March. The maximum theoretical occurrence of shadow flicker amounts to 47.9 hours per year and up to 0.71 hours per day, experienced at SFAL1 – Larbrax Cottages, located approximately 1169 m to the south east of the nearest proposed wind turbine.

It should be noted that these are the theoretical maximum number of shadow flicker hours and do not take into account weather conditions (i.e. when there is no sun or when there is partial cloud cover), local visual obstructions (such as trees, hedges or other structures), turbine orientation and turbine operation. In reality, the amount of time when shadow flicker occurs will be less than that predicted. Accordingly an assessment has also been undertaken to estimate a more accurate number of shadow flicker hours taking into account typical sunshine hours for the region. A review of historical met data suggests that this typically occurs for 30% of all daylight hours. Considering this, a reduced occurrence of shadow flicker at Larbrax Cottages is predicted to be less than 14.3 hours per year. This value is still overestimated as the windows facing the Proposed Development at Larbrax Cottages are roughly up to 2 m above ground (model assumes 5 m high windows as a worst-case scenario) and the views from the windows are heavily screened by a continuous line of hedge, so the actual shadow flicker impact is likely to be much lower.

No routine mitigation is proposed at this stage. If shadow flicker issues arise during operation, mitigation measures can be incorporated into the operation of the wind turbines at the times when occurrence is predicted in order to reduce the amount of shadow flicker experienced.

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1 Introduction

1.1 Brief

1.1.1 TNEI was commissioned by Land Use Consultants (LUC) on behalf of Orsted to undertake a shadow flicker assessment for the proposed Revised Larbrax Wind Farm (hereafter referred to as the 'Proposed Development'). The assessment aim is to quantify the likely shadow flicker occurrence that would be incident at nearby sensitive receptors (ie residential dwellings).

1.2 Background

1.2.1 The Proposed Development is located approximately 9 km to the west of Stranraer, Scotland. The approximate Ordnance Survey grid reference for Site centre point is 196552, 562190.

1.2.2 This shadow flicker assessment models four wind turbines with a 133 m rotor diameter and 83.4 m hub height.

1.3 Conditions Required for Shadow Flicker

1.3.1 Under certain combinations of geographical position, time of day and year, the sun may pass behind the rotor and cast a shadow over neighbouring buildings' windows. When the blades rotate and the shadow passes a window, the shadow appears to flick on and off; this effect is known as shadow flicker. It occurs only within buildings where the flicker appears through a window aperture and typically only in buildings within 130 degrees either side of north relative to a wind turbine can be affected (though this may vary slightly depending on latitude of a given site location). Shadow flicker can result in a degradation of amenity when people are within the rooms affected by the phenomenon.

1.3.2 Where moving shadows are cast over the ground (rather than a building's windows), this is known as 'shadow throw'. There are no guidelines to quantify the effect and there is no requirement to assess 'shadow throw', therefore it has not been considered further in this assessment.

1.4 Potential Impacts Associated with Photosensitive Epilepsy

1.4.1 The flickering effect caused by shadow flicker also has the potential to induce epileptic seizures through a condition known as photosensitive epilepsy. Around one in one hundred people in the UK have epilepsy although only 3% of these suffer from photosensitive epilepsy. The frequency at which photosensitive epilepsy might be triggered varies from person to person, though generally it is between 3 and 30 flashes per second (hertz (Hz)); sensitivity under 3 hertz is not common (The National Society for Epilepsy, 2018 (1)). The potential impacts associated with the development are considered in Section 5.3.1 of this report.

1.5 Timestamps and Co-ordinates

1.5.1 Please note that unless otherwise stated, all times are presented in GMT (Greenwich Mean Time) and all grid coordinates refer to the British National Grid using Eastings and Northings.

1.5.2 The variation in the earth's orbit around the sun over time means that predictions of shadow flicker will differ slightly from year to year. All predictions presented in this report have been calculated for the year 2024.

2 Planning Policy and Guidance

2.1 Overview of Shadow Flicker Policy and Guidance

2.1.1 There is no standard for the assessment of shadow flicker in the UK and there are no guidelines which quantify what exposure levels would be acceptable or significant in EIA terms. In assessing the likely shadow flicker effects of the Proposed Development the following guidance and policy documents have been considered:

- Local Planning Policy;
- National Planning Policy (NPF4);
- Web Based Renewables Advice: *'Onshore Wind Turbines'* (2); and
- An update of the UK shadow flicker evidence base produced by the (former) Department for Energy and Climate Change (DECC) (3).

2.2 Local Planning Policy

Dumfries and Galloway Local Development Plan 2

2.2.1 The adopted Development Plan for the area comprises the Dumfries and Galloway Local Development Plan 2 (LDP2) which was adopted in October 2019. The LDP2 provides the planning framework and guides the future use and development of land in town, villages and rural areas. It sets out the Council's vision to build on sustainable principles, leveraging its distinctive landscape and promotes positive growth.

2.2.2 The LDP2 contains a number of overarching polices, the aim of which is that all development proposals should support sustainable development, including the reduction of carbon and other greenhouse gas emissions. Policy OP1 : development Considerations, states:

2.2.3 'Development will be assessed against the following considerations where relevant to the scale, nature and location of the proposal:

a) General Amenity Development proposals should be compatible with the character and amenity of the area and should not conflict with nearby land uses.'

2.2.4 This general development policy takes into account the need to mitigate and adapt to the causes of climate change. It also aims to ensure the amenity of those adjacent users affected by development proposals.

2.2.5 Policy IN1 covers the principal policy guidance in relation to renewable energy. It states:

2.2.6 'The Council has been supportive of the development of renewable energy and continues to be supportive of a diverse range of renewable energy sources. However support for renewable energy proposals must be balanced against the impacts that such developments can have on the environment and communities.'

2.2.7 The policy also states that, *'The acceptability of any proposed development will be assessed against the following considerations:*

- *impact on local communities and individual dwellings, including visual impact, residential amenity, noise and shadow flicker;'*

2.3 National Planning Policy

National Planning Framework 4 ('NPF4') was adopted on 13 February 2023 and supersedes National Planning Framework 3 and Scottish Planning Policy. Policy 11 – Energy states that renewable energy projects must be able to demonstrate how any shadow flicker impacts on communities have been addressed through the project's design and any associated mitigation. **Web Based Planning Advice - Onshore Wind Turbines**

2.3.1 The 'Onshore Wind Turbines' web based document states that, as a general rule, flicker effects have been proven to occur only within ten rotor diameters of a wind turbine. The guidance states:

2.3.2 'Under certain combinations of geographical position, time of day and time of year, the sun may pass behind the rotor and cast a shadow over neighbouring properties. When the blades rotate, the shadow flicks on and off; the effect is known as "shadow flicker". It occurs only within buildings where the flicker appears through a narrow window opening. The seasonal duration of this effect can be calculated from the geometry of the machine and the latitude of the potential site.

2.3.3 Where this could be a problem, developers should provide calculations to quantify the effect. In most cases however, where separation is provided between wind turbines and nearby dwellings (as a general rule 10 rotor diameters), "shadow flicker" should not be a problem. However, there is scope to vary layout / reduce the height of turbines in extreme cases.'

2.4 Department of Energy and Climate Change (DECC) - Update of UK Shadow Flicker Evidence Base

2.4.1 In March 2011, the Department of Energy and Climate Change issued a report titled *'Update of UK Shadow Flicker Evidence Base.'* The report was prepared for DECC by Parsons Brinckerhoff (PB). The report summarised the findings of research undertaken by PB with a view to enabling DECC to *'advance current understanding of the shadow flicker effect.'* The report:

'Presents an update of the evidence base which has been produced by carrying out a thorough review of international guidance on shadow flicker, an academic literature review and by investigating current assessment methodologies employed by developers and case study evidence.'

2.4.2 The PB report concludes that an assessment area covering a distance of 10 rotor diameters from each wind turbine and 130 degrees either side of north is appropriate.

2.4.3 PB found that a worst-case scenario is usually reported but noted that this is sometimes accompanied by a more 'accurate' approximation which takes account of variables like sunshine hours. The report confirms that the industry software packages WindPro, WindFarm and WindFarmer provide similar outputs.

3 Methodology

3.1.1 It is possible to calculate the total theoretical number of hours per year that shadow flicker may occur in a building. The likelihood of shadow flicker occurring and the duration of such an effect depends upon the following factors:

- the location and dimensions of the nearby sensitive receptor's property windows;
- the distance from the wind turbines;
- the wind turbines hub-height and rotor diameter;
- the time of year (which impacts the trajectory of suns path across the sky);
- the proportion of daylight hours in which the turbines operate;
- the frequency of bright sunshine and cloudless skies (particularly at low elevations above the horizon); and
- the wind direction (which impacts on wind turbine orientation).

3.1.2 Several specialist software packages are available which can take account of the variables listed above to determine the maximum theoretical number of shadow flicker hours which could occur at each window location. For this assessment details regarding the wind turbine dimensions / locations and the size position and orientation of the windows at the properties being assessed were entered into the 'Windfarm' software which is produced by ReSoft (5).

3.1.3 The Windfarm software was then used to predict all periods when shadow flicker can theoretically occur.

3.1.4 When the sun is close to the horizon, at dawn and dusk, the intensity of the sun's rays are reduced and are less likely to cast distinct shadows. It is generally considered that when the sun is lower than 2° above the horizon, that shadow flicker is unlikely to occur to any significant extent. This has been accounted for in the modelling by excluding periods where the sun is less than 2° above the horizon.

3.1.5 Buildings located beyond 130° either side of north are generally unaffected by shadow flicker as there is usually no direct path between the sun, the wind turbines and any buildings located within this area. In addition, differences in topography can cause shadows to be cast at either greater or shorter distances, depending on the character of the terrain; shadows cast down a slope may extend further than on flat ground, while shadows cast up a slope are unlikely to reach as far as those cast upon flat ground.

3.1.6 The assessment is based on a "Glasshouse" model which assumes 5 m high windows across all facades to produce a worst-case scenario, and it does not consider number and dimensions of actual windows and local visual obstructions (such as trees, hedges or other structures) at each property.

4 Baseline

4.1 Study Area and Identification of Potential Receptors

4.1.1 The immediate area surrounding the Proposed Development is a rural coastal setting, with only a few scattered buildings. There are a small number of residential buildings which would be theoretically susceptible to shadow flicker.

4.1.2 The candidate wind turbines modelled in this assessment each have a rotor diameter of 133 m, therefore the Study Area has been limited to 1,330 m as shown on Figure A1.1 (Appendix 1).

4.1.3 A desk based assessment was undertaken using Ordnance Survey mapping data and aerial photography to identify potential receptors within the study area. Six residential dwellings were found and windows for each were assumed on all façades as a worst-case approach. The full length of the house facades were assumed to be a window, this is known as the 'Greenhouse Model' as it treats the entire structure as a large glass box.

4.1.4 Details of the identified buildings selected for this assessment are provided in Table 4.1 and they have been labelled as Shadow Flicker Assessment Locations (SFAL).

Table 4.1 – Shadow Flicker Assessment Locations

SFAL	Easting (m)	Northing (m)	Bearing from nearest proposed turbine	Approximate Distance to nearest proposed turbine* (m)
SFAL 1 - Larbrax Cottages	197784	560975	South east	1169
SFAL 2 - Larbrax Lodge	198229	561558	East	1317
SFAL 3 - Greenburn	197350	563088	North east	919
SFAL 4 - Meikle Galdenoch	197372	563233	North east	1047
SFAL 5 - Drumwhistley	197294	563349	North east	1112
SFAL 6 - Galdenoch Mill Cottage	197342	563475	North east	1246

* *Please note the distance to nearest turbine quoted above is approximate and may differ from those reported elsewhere. Distances for the shadow flicker assessment are taken from the nearest turbine to the centre of the building.*

4.2 Information Gaps

4.2.1 The process has been as inclusive as possible with all identified receptors within the study area being assessed.

4.2.2 Where access and/or imagery were not available in order to quantify the number, location and dimension of windows, the orientation and dimensions of windows was estimated on a conservative basis.

5 Assessment Results

5.1 Prediction of Likely Effects

5.1.1 Table 5.1 below details the shadow flicker modelling results and summarises the theoretical predicted occurrences of shadow flicker at the SFALs. The values shown in the Table are cumulative from all windows in the dwelling. In addition, Figure A1.2a and A1.2f (in Appendix 1) also illustrates on graphics the times of year and times of day when shadow flicker could theoretically occur.

Table 5.1 – Theoretical Maximum Predicted Occurrences of Shadow Flicker

SFAL	Frequency of Shadow Occurrence (days per year)	Max Hours of Shadow per Day	Mean Hours of Shadow per Day out of the days where shadow is predicted to occur	Theoretical Maximum Hours per Year
SFAL 1 - Larbrax Cottages	105	0.71	0.46	47.9
SFAL 2 - Larbrax Lodge	34	0.47	0.37	12.6
SFAL 3 - Greenburn	42	0.53	0.41	17.1
SFAL 4 - Meikle Galdenoch	39	0.51	0.39	15.0
SFAL 5 - Drumwhistley	54	0.54	0.41	22.1
SFAL 6 - Galdenoch Mill Cottage	0	0	0	0

5.1.2 The calculations used to determine the 'Total Theoretical Hours' assume a 'worst case' scenario with the following assumptions:

- the sun always shines in a clear sky (i.e. no account of climatic conditions such as clouds or precipitation has been made);
- objects surrounding the windows that may block the view to turbines such as trees, buildings have been disregarded;
- the turbine rotors are always aligned face-on to the window, providing the maximum opportunity for shadow flicker; and
- the rotors are always turning (i.e. no account has been taken of calm winds or shut-down periods).

5.1.3 It is important to note however that the instances of shadow flicker will always be less than that predicted by the model as these are based on a worst case scenario. The occurrence of shadow flicker is only possible during the operation of the wind turbines (i.e. when the rotor blades are turning) and when the sky is clear enough for the sun to cast shadows. It is important to consider the following facts when making an assessment:

- Climatic conditions dictate that the sky is not always clear. Regional Met Office data gives actual sunshine hours for the Dumfries and Galloway region to be approximately 30%[1] of total daylight hours. Cloud cover during other times may obscure the sun and prevent shadow flicker occurrence. While some shadow may still be cast under slightly overcast conditions, no shadow at all would be cast when heavy cloud cover prevails. It is considered that weather conditions will reduce actual occurrence of shadow flicker by at least 70% compared to calculated levels;
- objects such as trees or walls may surround windows and obscure the view of the turbines and hence prevent shadow flicker;
- during operation, the wind turbine rotors would automatically orientate themselves to face the prevailing wind direction. This means the wind turbine rotors would not always be facing the affected window and in fact would sometimes be 'side-on' to the window. Very little of the blade movement would be visible during such occurrences and therefore the potential for shadow flicker is reduced; and
- the turbines would not be rotating for 100% of daylight hours. During periods of very low wind speed, very high wind speed or maintenance shut-downs, the rotors do not turn. During such periods shadow flicker is not possible.

5.1.4 As detailed above, shadow flicker can only occur during daylight hours and when the sun is shining. The total theoretical hours per year assume all hours of daylight are sunny with clear skies. Using historical data provided by the Met Office, the total theoretical maximum hours have been reduced by 70% to provide a more accurate estimate, as shown in Table 5.2.

Table 5.2 – More Accurate Predicted Occurrences of Shadow Flicker

SFAL	Theoretical Maximum Hours per Year	Sunshine Hours %	More Accurate Hours of Shadow per Year	Comment
SFAL 1 - Larbrax Cottages	47.9	30%	14.3	Other factors such as actual windows number and dimensions, local visual obstructions (such as trees, hedges or other structures), turbine orientation and turbine operation would reduce levels further.
SFAL 2 - Larbrax Lodge	12.6		3.7	
SFAL 3 - Greenburn	17.1		5.1	
SFAL 4 - Meikle Galdenoch	15.0		4.5	
SFAL 5 - Drumwhistley	22.1		6.6	

[1] https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gcv3mcrf9

SFAL 6 - Galdenoch Mill Cottage	0		0	

5.2 Evaluation of the Likely Effects

5.2.1 SFAL1- Larbrax Cottages has the most theoretical hours predicted in a year. The times of day when shadow flicker could theoretically occur varies between 19:35 and 19:43 during the month of April, 19:10 to 19:53 during the month of May, 19:20 to 19:43 during the month of June, 19:20 to 20:03 during the month of July, and 19:20 to 20:02 during the month of August. All times are in GMT.

5.2.2 The maximum theoretical occurrence of shadow flicker for SFAL1 – Larbrax Cottages amounts to 47.9 hours per year and up to 0.71 hours per day (on the days it may occur), however, if the sunshine hours are considered then this figure reduces to 14.3 hours per year. This value is still overestimated as the windows facing the Proposed Development at Larbrax Cottages are roughly up to 2 m above ground (model assumes 5 m high windows as a worst-case scenario) and the views from the windows are heavily screened by a continuous line of hedge, so the actual shadow flicker impact is likely to be much lower.

5.2.3 At the other properties considered, more accurate values between only 0 to 6.6 hours per year have been calculated. As such no routine mitigation is proposed at this stage.

5.3 Potential Cumulative Effects

5.3.1 It has been assumed that, should the Proposed Development gain consent, the three operational small turbines at Meikle Galdenoch and the two operational small turbines at Meikle Larbrax will be decommissioned. This assumption is consistent with the original EIA undertaken dated 2020 for the existing consent of Larbrax Wind Farm.

5.3.2 No potential cumulative shadow effect with other nearby wind turbines of the scale assessed in this report is likely to occur.

5.4 Photosensitive Epilepsy

5.4.1 The possibility that shadow flicker could induce photosensitive epilepsy has also been considered. Most wind turbines of the scale assessed in this report have a maximum rotational speed of around 16-17 RPM. Given that the wind turbines would have three blades, the blade pass frequency (and therefore the frequency of any shadow flicker effects) will be up to approximately 0.85 flashes per second (hertz). This is significantly less than the 3 to 30 hertz frequency range generally thought to induce photosensitive epilepsy. Consequently, shadow flicker caused by the Proposed Development is predicted to have no adverse health effects. While some people are sensitive at higher frequencies, it is uncommon to have photosensitivity below 3 hertz and consequently shadow flicker caused by this development is predicted to have no adverse health effects.

5.5 Mitigation Measures

5.5.1 There is no guidance relevant within Scotland to quantify what exposure levels of shadow flicker are acceptable or significant in EIA terms.

5.5.2 No routine mitigation is proposed at this stage, however, mitigation measures will be available to counteract shadow flicker occurrence during operation should the Applicant receive complaints from nearby residents. These include planting tree belts between the affected window and the turbines and shutting down the turbines using turbine control systems during periods when shadow flicker could occur.

6 Conclusions

6.1.1 A shadow flicker assessment has been undertaken for six Shadow Flicker Assessment Locations (SFALs) which are all the residential buildings found within 1,330 m of the proposed wind turbine locations. Windows for each building were assumed on all façades as a worst-case approach. The full length of the house facades were assumed to be a window, this is known as the 'Greenhouse Model' as it treats the entire structure as a large glass box.

6.1.2 The turbines modelled in this assessment each have a rotor diameter of 133 m and an 83.4 m hub height.

6.1.3 It has been shown that the times of day when shadow flicker could theoretically occur varies between 19:10 and 20:03 during the months of April to August, and between 15:47 and 18:07 during the months of September to November and January to March for the SFALs.

6.1.4 The maximum theoretical occurrence of shadow flicker amounts to 47.9 hours per year and up to 0.71 hours per day, experienced at SFAL1 – Larbrax Cottages, located approximately 1169 m to the south east of the nearest proposed wind turbine. It is important, however, to note that these are the theoretical maximum number of shadow flicker hours per year. They do not take into account weather conditions (i.e. no sun or partial cover), local visual obstructions (such as trees, hedges or other structures), wind turbine orientation and wind turbine operation. In reality, the amount of time when shadow flicker occurs would be less than that predicted. It is also important to note that affected windows may well be in rooms that are not generally in use at the times when the effect may occur.

6.1.5 Taking into account of sunshine hours only, a more accurate estimate of occurrence has been predicted to be at most 14.3 hours per year at SFAL1 - Larbrax Cottages. This value is still overestimated as the windows facing the Proposed Development at Larbrax Cottages are roughly up to 2 m above ground (model assumes 5 m high windows as a worst-case scenario) and the views from the windows are heavily screened by a continuous line of hedge, so the actual shadow flicker impact is likely to be much lower.

6.1.6 No routine mitigation is proposed at this stage. If the Applicant receives complaints for residents about shadow flicker occurrence during operation, then mitigation measures can be incorporated into the operation of the wind turbines to reduce the amount of shadow flicker experienced.

7 Glossary of Terms

Blade Pass Frequency: The rate at which the blades of a wind turbine pass by a fixed position during rotation.

Photosensitive Epilepsy: A form of epilepsy in which seizures are triggered by visual stimuli that form patterns in time or space, such as flashing lights, bold, regular patterns, or regular moving patterns.

Shadow Flicker: The term 'shadow flicker' refers to the flickering effect caused when rotating wind turbine blades periodically cast shadows over neighbouring properties as they turn, through constrained openings such as windows.

Shadow Throw: Shadow throw occurs when wind turbine shadows are cast across the ground at frequent intervals.

8 References

1. **Epilepsy Society.** https://www.epilepsysociety.org.uk/photosensitive-epilepsy#.Wo1uz6jFLcs.

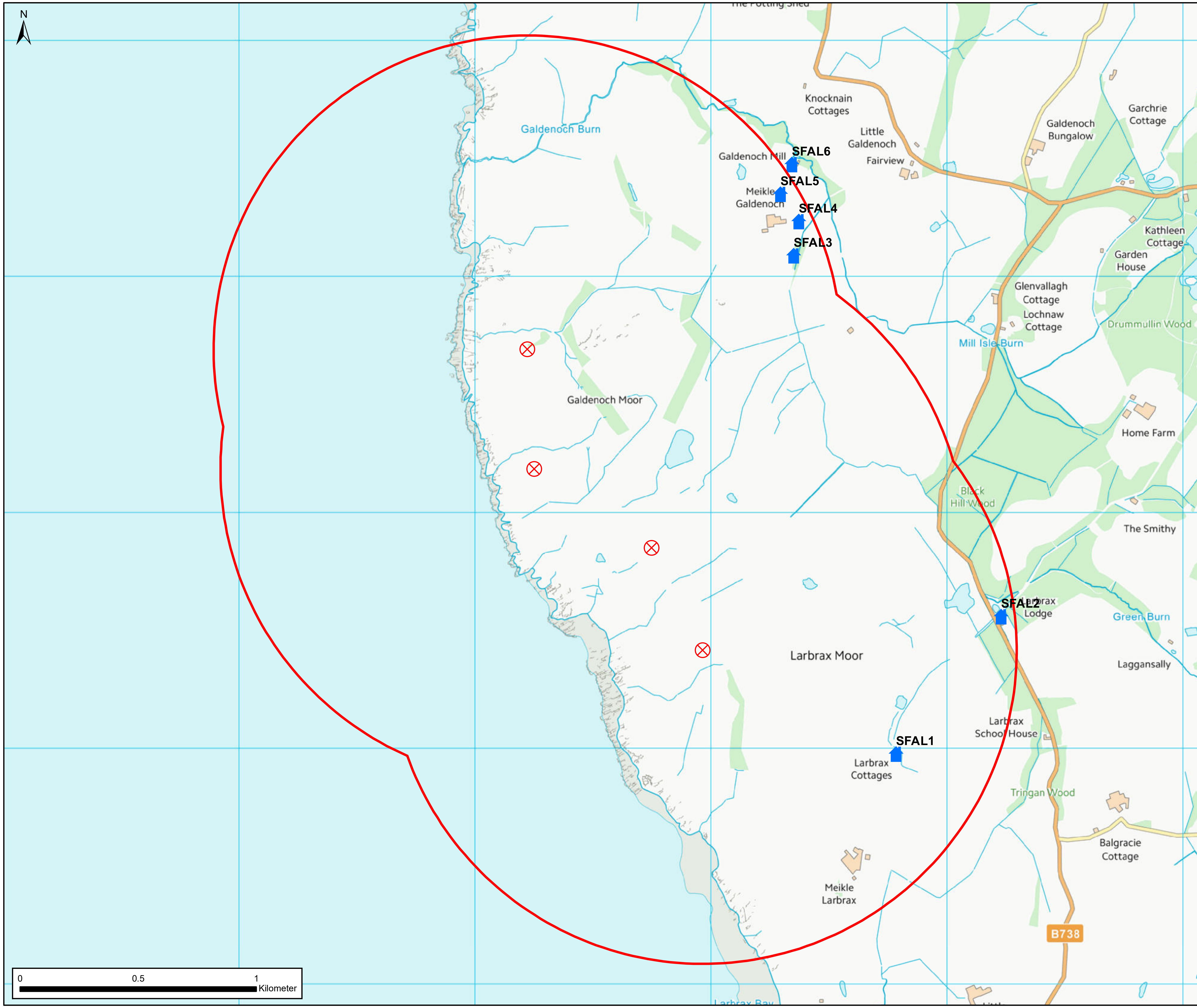
2. **Scottish Government.** Web Bases Renewables Advice 'Onshore Wind Turbines'. *Scottish Government.* [Online] 2014. http://www.gov.scot/Topics/Built-Environment/planning/Policy/Subject-Policies/Utilities/Delivering-heat-electricity/renewables-advice.

3. Parsons Brinckerhoff prepared for the Department of Energy and Climate Change, Update of UK Shadow Flicker Evidence Base, March 2011. [Online] http://webarchive.nationalarchives.gov.uk/20110405153950/http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/planning/on_off_wind/shadow_flicker/shadow_flicker.aspx.

4. **Scottish Government.** Scottish Planning Policy. *Scottish Government.* [Online] http://www.gov.scot/Publications/2014/06/5823.

5. **ReSoft Ltd.** WindFarm Release 4.2.1.9. (1997-2014).

Appendix 1 – Figures



LEGEND

- Larbrax Turbines
- Study Area (10 Rotor Diameters, 1330m)
- Shadow Flicker Assessment Locations (SFALs)

Rev.	Date	Amendment Details	Drw'n	Chk'd	App'd
01	16/06/24	For Information	MR	MC	MC

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Client: Ørsted

Drawing Status: FOR INFORMATION

Project Title: Larbrax Wind Farm

Drawing Title: Figure A1.1: Shadow Flicker Study Area

Scale	Designed	Drawn	Checked	Approved
1:15,000	MR	MR	MC	MC
Original Size	Date	Date	Date	Date
A3	12/06/2024	12/06/2024	12/06/2024	12/06/2024

Drawing Number: 15893-004

Revision: 0

Figure A1.2a – Predicted Theoretical Shadow Flicker Times at SFAL1

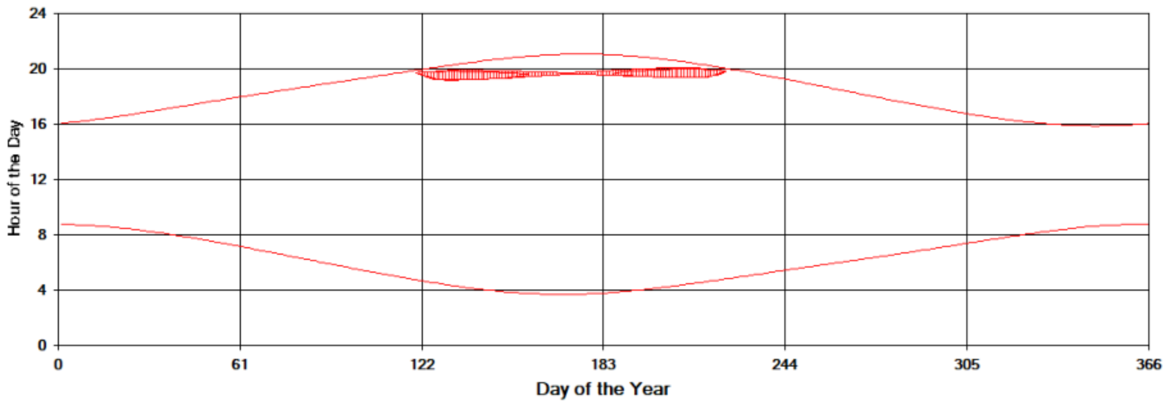


Figure A1.2b – Predicted Theoretical Shadow Flicker Times at SFAL2

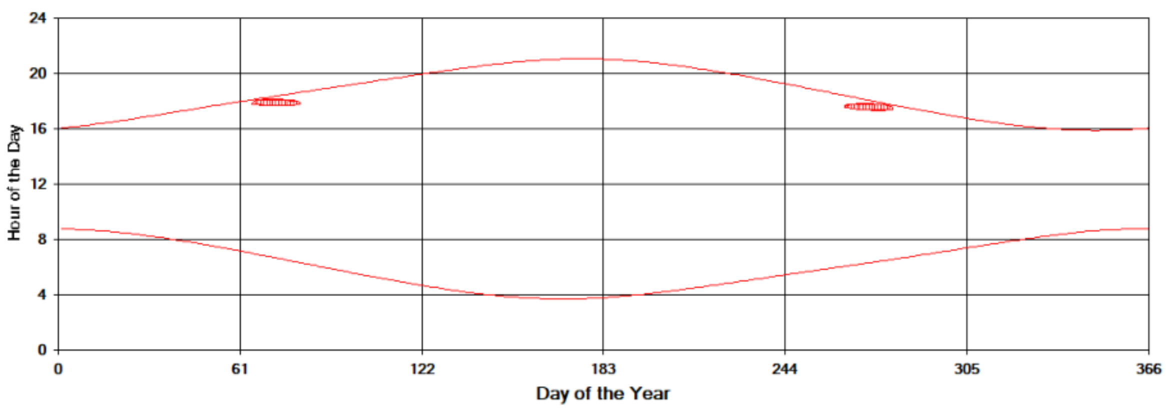


Figure A1.2c – Predicted Theoretical Shadow Flicker Times at SFAL3

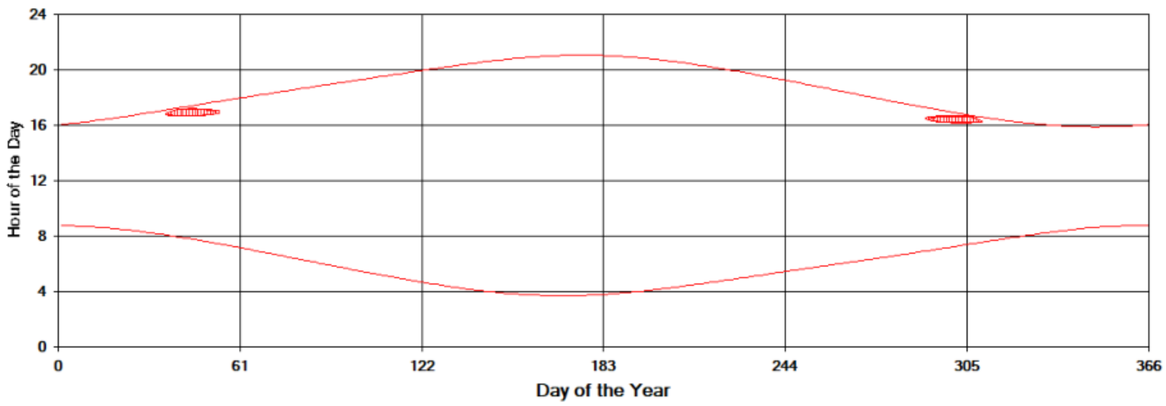


Figure A1.2d – Predicted Theoretical Shadow Flicker Times at SFAL4

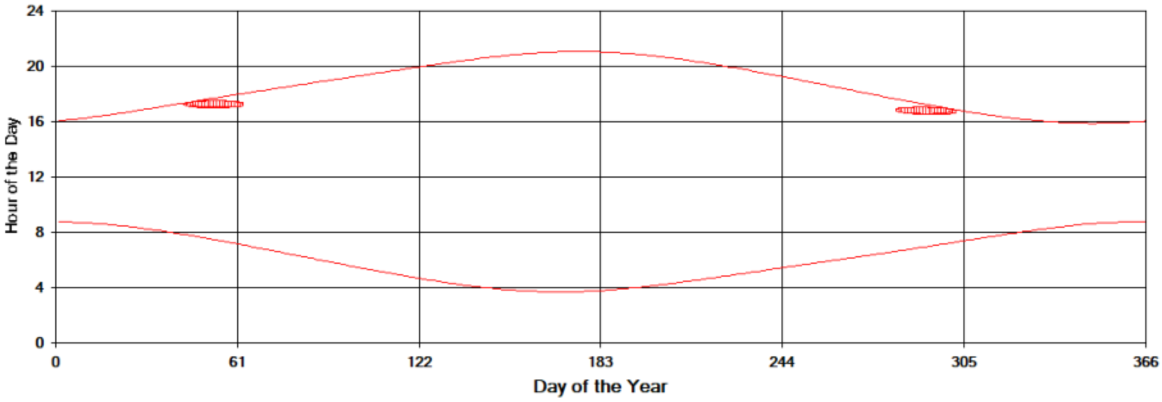


Figure A1.2e – Predicted Theoretical Shadow Flicker Times at SFAL5

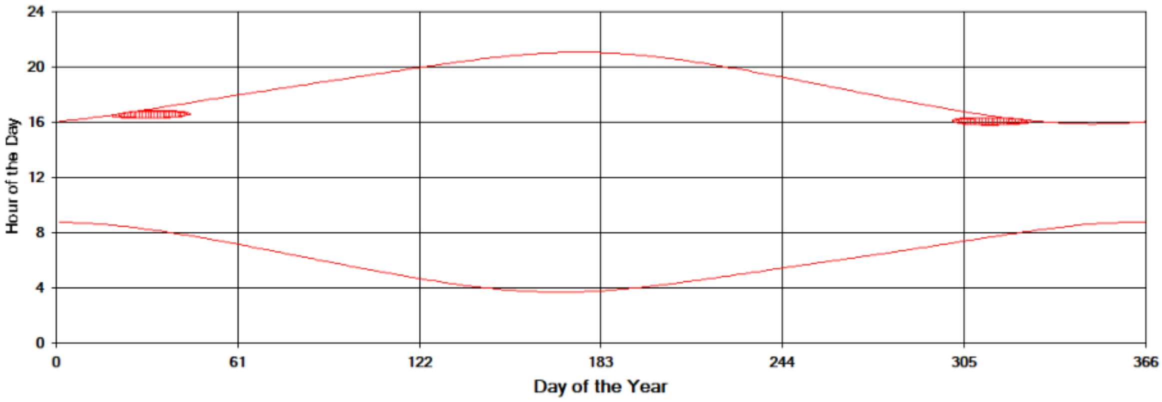
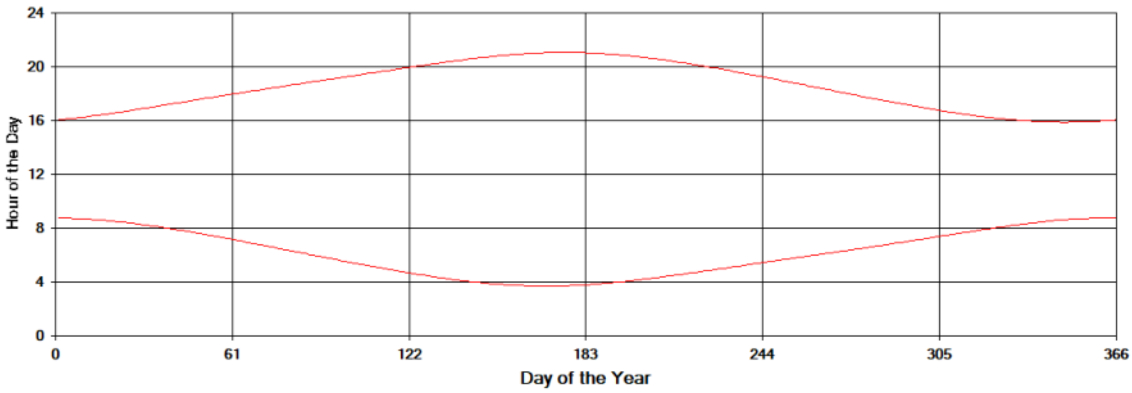


Figure A1.2f – Predicted Theoretical Shadow Flicker Times at SFAL6



Appendix 2 – Detailed Listing

Project : LARBRAX
Run Name : KLARBRAX007.WFK
Title : 26-11-2024 Revised Layout
Time : 10:54:19, 26 Nov 2024

SHADOW TIMES ON EACH HOUSE

House	Easting	Northing
1	197784	560975

Turbine	Easting	Northing	Date	Start Time	End Time	Duration	% Cover
1	196965	561416	30-04	19:37:10	19:43:07	00:05:56	100.00
1	196965	561416	01-05	19:32:21	19:44:09	00:11:48	100.00
1	196965	561416	02-05	19:27:48	19:44:59	00:17:12	100.00
1	196965	561416	03-05	19:23:30	19:45:42	00:22:12	100.00
1	196965	561416	04-05	19:19:26	19:46:17	00:26:50	100.00
1	196965	561416	05-05	19:15:37	19:46:45	00:31:08	100.00
1	196965	561416	06-05	19:11:59	19:47:08	00:35:08	100.00
1	196965	561416	07-05	19:11:22	19:51:30	00:40:08	100.00
1	196965	561416	08-05	19:11:05	19:51:58	00:40:53	100.00
1	196965	561416	09-05	19:10:53	19:52:21	00:41:28	100.00
1	196965	561416	10-05	19:10:45	19:52:39	00:41:54	100.00
1	196965	561416	11-05	19:10:42	19:52:53	00:42:11	100.00
1	196965	561416	12-05	19:10:43	19:53:04	00:42:21	100.00
1	196965	561416	13-05	19:10:48	19:53:12	00:42:23	100.00
1	196965	561416	14-05	19:10:57	19:53:16	00:42:19	100.00
1	196965	561416	15-05	19:11:10	19:53:18	00:42:08	100.00
1	196965	561416	16-05	19:11:26	19:53:17	00:41:51	100.00
1	196965	561416	17-05	19:11:46	19:53:13	00:41:28	100.00
1	196965	561416	18-05	19:12:09	19:53:07	00:40:59	100.00
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1	196965	561416	21-05	19:13:38	19:52:38	00:38:59	100.00
1	196965	561416	22-05	19:14:12	19:52:24	00:38:12	100.00
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1	196965	561416	24-05	19:15:29	19:51:52	00:36:23	100.00
1	196965	561416	25-05	19:16:12	19:51:33	00:35:22	100.00
1	196965	561416	26-05	19:16:58	19:51:14	00:34:15	100.00
1	196965	561416	27-05	19:17:48	19:50:52	00:33:04	100.00
1	196965	561416	28-05	19:18:42	19:50:30	00:31:48	100.00
1	196965	561416	29-05	19:19:41	19:50:06	00:30:26	100.00
1	196965	561416	30-05	19:20:44	19:49:41	00:28:58	100.00
1	196965	561416	31-05	19:21:53	19:49:15	00:27:22	96.31
1	196965	561416	01-06	19:23:09	19:48:48	00:25:39	72.02
1	196965	561416	02-06	19:24:37	19:48:20	00:23:43	48.92
1	196965	561416	03-06	19:25:31	19:47:50	00:22:19	100.00
1	196965	561416	04-06	19:26:21	19:47:20	00:20:58	100.00
1	196965	561416	05-06	19:27:13	19:46:48	00:19:34	100.00
1	196965	561416	06-06	19:28:07	19:46:15	00:18:07	100.00
1	196965	561416	07-06	19:29:04	19:45:40	00:16:37	83.14
1	196965	561416	08-06	19:30:02	19:45:04	00:15:02	67.36
1	196965	561416	09-06	19:31:03	19:44:26	00:13:23	52.82
1	196965	561416	10-06	19:32:07	19:43:45	00:11:38	39.53
1	196965	561416	11-06	19:33:15	19:43:00	00:09:45	27.49
1	196965	561416	12-06	19:34:31	19:42:08	00:07:37	16.71
1	196965	561416	13-06	19:36:02	19:41:02	00:05:01	7.18
1	196965	561416	27-06	19:39:11	19:43:52	00:04:42	6.28
1	196965	561416	28-06	19:38:03	19:45:26	00:07:23	15.65
1	196965	561416	29-06	19:37:11	19:46:43	00:09:32	26.26
1	196965	561416	30-06	19:36:26	19:47:52	00:11:26	38.11
1	196965	561416	01-07	19:35:45	19:48:57	00:13:12	51.21
1	196965	561416	02-07	19:35:07	19:49:59	00:14:51	65.53
1	196965	561416	03-07	19:34:32	19:50:58	00:16:26	81.09
1	196965	561416	04-07	19:33:58	19:51:54	00:17:57	97.86
1	196965	561416	05-07	19:33:25	19:52:49	00:19:24	100.00
1	196965	561416	06-07	19:32:54	19:53:42	00:20:48	100.00

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1	196965	561416	07-07	19:32:24	19:54:32	00:22:08	100.00
1	196965	561416	08-07	19:31:55	19:55:21	00:23:26	100.00
1	196965	561416	09-07	19:30:46	19:56:08	00:25:22	68.33
1	196965	561416	10-07	19:29:46	19:56:53	00:27:07	92.25
1	196965	561416	11-07	19:28:53	19:57:36	00:28:43	100.00
1	196965	561416	12-07	19:28:05	19:58:17	00:30:12	100.00
1	196965	561416	13-07	19:27:21	19:58:56	00:31:34	100.00
1	196965	561416	14-07	19:26:41	19:59:32	00:32:51	100.00
1	196965	561416	15-07	19:26:04	20:00:07	00:34:03	100.00
1	196965	561416	16-07	19:25:29	20:00:39	00:35:10	100.00
1	196965	561416	17-07	19:24:56	20:01:08	00:36:12	100.00
1	196965	561416	18-07	19:24:26	20:01:35	00:37:09	100.00
1	196965	561416	19-07	19:23:58	20:01:59	00:38:02	100.00
1	196965	561416	20-07	19:23:32	20:02:21	00:38:50	100.00
1	196965	561416	21-07	19:23:05	20:02:40	00:39:35	100.00
1	196965	561416	22-07	19:22:40	20:02:56	00:40:16	100.00
1	196965	561416	23-07	19:22:17	20:03:09	00:40:51	100.00
1	196965	561416	24-07	19:21:57	20:03:18	00:41:21	100.00
1	196965	561416	25-07	19:21:39	20:03:25	00:41:46	100.00
1	196965	561416	26-07	19:21:23	20:03:28	00:42:04	100.00
1	196965	561416	27-07	19:21:10	20:03:27	00:42:17	100.00
1	196965	561416	28-07	19:20:59	20:03:22	00:42:23	100.00
1	196965	561416	29-07	19:20:51	20:03:13	00:42:23	100.00
1	196965	561416	30-07	19:20:45	20:03:00	00:42:15	100.00
1	196965	561416	31-07	19:20:42	20:02:43	00:42:00	100.00
1	196965	561416	01-08	19:20:43	20:02:20	00:41:37	100.00
1	196965	561416	02-08	19:20:46	20:01:52	00:41:06	100.00
1	196965	561416	03-08	19:20:53	20:01:18	00:40:25	100.00
1	196965	561416	04-08	19:21:05	20:00:38	00:39:33	100.00
1	196965	561416	05-08	19:23:36	19:56:13	00:32:38	100.00
1	196965	561416	06-08	19:27:06	19:55:36	00:28:30	100.00
1	196965	561416	07-08	19:30:48	19:54:52	00:24:04	100.00
1	196965	561416	08-08	19:34:42	19:53:59	00:19:18	100.00
1	196965	561416	09-08	19:38:49	19:52:58	00:14:09	100.00
1	196965	561416	10-08	19:43:11	19:51:45	00:08:34	100.00
1	196965	561416	11-08	19:47:48	19:50:05	00:02:17	100.00

House	Easting	Northing
2	198229	561558

Turbine	Easting	Northing	Date	Start Time	End Time	Duration	% Cover
1	196965	561416	06-03	17:45:35	17:51:31	00:05:55	100.00
1	196965	561416	07-03	17:43:45	18:03:28	00:19:43	100.00
1	196965	561416	08-03	17:42:21	18:05:33	00:23:12	100.00
1	196965	561416	09-03	17:41:15	18:06:26	00:25:12	100.00
1	196965	561416	10-03	17:40:24	18:07:01	00:26:37	100.00
1	196965	561416	11-03	17:39:46	18:07:20	00:27:35	100.00
1	196965	561416	12-03	17:39:19	18:07:26	00:28:07	100.00
1	196965	561416	13-03	17:39:04	18:07:20	00:28:16	100.00
1	196965	561416	14-03	17:39:00	18:07:02	00:28:01	100.00
1	196965	561416	15-03	17:39:09	18:06:32	00:27:23	100.00
1	196965	561416	16-03	17:39:30	18:05:49	00:26:19	100.00
1	196965	561416	17-03	17:40:07	18:04:53	00:24:46	100.00
1	196965	561416	18-03	17:40:50	18:03:40	00:22:50	100.00
1	196965	561416	19-03	17:41:55	18:02:11	00:20:16	100.00
1	196965	561416	20-03	17:43:34	18:00:14	00:16:40	100.00
1	196965	561416	21-03	17:46:05	17:57:27	00:11:21	61.46
1	196965	561416	20-09	17:32:50	17:43:11	00:10:21	50.21
1	196965	561416	21-09	17:29:34	17:45:30	00:15:56	88.58
1	196965	561416	22-09	17:27:08	17:46:51	00:19:43	100.00
1	196965	561416	23-09	17:25:20	17:47:45	00:22:24	100.00

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1	196965	561416	24-09	17:23:56	17:48:21	00:24:25	100.00
1	196965	561416	25-09	17:22:41	17:48:42	00:26:01	100.00
1	196965	561416	26-09	17:21:39	17:48:49	00:27:11	100.00
1	196965	561416	27-09	17:20:50	17:48:45	00:27:54	100.00
1	196965	561416	28-09	17:20:14	17:48:29	00:28:15	100.00
1	196965	561416	29-09	17:19:50	17:48:02	00:28:13	100.00
1	196965	561416	30-09	17:19:37	17:47:25	00:27:48	100.00
1	196965	561416	01-10	17:19:36	17:46:35	00:26:59	100.00
1	196965	561416	02-10	17:19:47	17:45:32	00:25:45	100.00
1	196965	561416	03-10	17:20:13	17:44:12	00:23:59	100.00
1	196965	561416	04-10	17:20:55	17:42:06	00:21:11	100.00
1	196965	561416	05-10	17:22:01	17:35:19	00:13:18	100.00

House	Easting	Northing
3	197350	563088

Turbine	Easting	Northing	Date	Start Time	End Time	Duration	% Cover
4	196222	562692	12-02	17:13:14	17:14:16	00:01:02	0.43
4	196222	562692	13-02	17:07:39	17:19:50	00:12:11	64.00
4	196222	562692	14-02	17:05:20	17:22:06	00:16:47	100.00
4	196222	562692	15-02	17:03:41	17:23:41	00:19:59	100.00
4	196222	562692	16-02	17:02:25	17:26:13	00:23:47	100.00
4	196222	562692	17-02	17:01:25	17:27:43	00:26:18	100.00
4	196222	562692	18-02	17:00:38	17:28:46	00:28:08	100.00
4	196222	562692	19-02	17:00:01	17:29:33	00:29:31	100.00
4	196222	562692	20-02	16:59:34	17:30:06	00:30:31	100.00
4	196222	562692	21-02	16:59:16	17:30:27	00:31:11	100.00
4	196222	562692	22-02	16:59:06	17:30:37	00:31:31	100.00
4	196222	562692	23-02	16:59:05	17:30:37	00:31:32	100.00
4	196222	562692	24-02	16:59:14	17:30:26	00:31:13	100.00
4	196222	562692	25-02	16:59:32	17:30:06	00:30:34	100.00
4	196222	562692	26-02	17:00:01	17:29:34	00:29:33	100.00
4	196222	562692	27-02	17:00:44	17:28:51	00:28:06	100.00
4	196222	562692	28-02	17:01:45	17:27:54	00:26:09	100.00
4	196222	562692	29-02	17:03:03	17:26:43	00:23:40	100.00
4	196222	562692	01-03	17:04:03	17:25:21	00:21:18	100.00
4	196222	562692	02-03	17:05:28	17:23:33	00:18:05	100.00
4	196222	562692	03-03	17:07:37	17:21:02	00:13:25	73.83
4	196222	562692	04-03	17:12:32	17:15:56	00:03:25	4.98
4	196222	562692	08-10	16:44:56	16:55:02	00:10:07	38.69
4	196222	562692	09-10	16:41:38	16:57:41	00:16:02	100.00
4	196222	562692	10-10	16:39:29	16:59:16	00:19:48	100.00
4	196222	562692	11-10	16:37:51	17:00:22	00:22:31	100.00
4	196222	562692	12-10	16:36:19	17:01:10	00:24:50	100.00
4	196222	562692	13-10	16:34:43	17:01:49	00:27:06	100.00
4	196222	562692	14-10	16:33:27	17:02:14	00:28:47	100.00
4	196222	562692	15-10	16:32:27	17:02:28	00:30:02	100.00
4	196222	562692	16-10	16:31:40	17:02:33	00:30:53	100.00
4	196222	562692	17-10	16:31:05	17:02:28	00:31:23	100.00
4	196222	562692	18-10	16:30:40	17:02:14	00:31:34	100.00
4	196222	562692	19-10	16:30:26	17:01:52	00:31:26	100.00
4	196222	562692	20-10	16:30:21	17:01:21	00:30:59	100.00
4	196222	562692	21-10	16:30:26	17:00:40	00:30:14	100.00
4	196222	562692	22-10	16:30:41	16:59:49	00:29:08	100.00
4	196222	562692	23-10	16:31:07	16:58:45	00:27:38	100.00
4	196222	562692	24-10	16:31:45	16:57:25	00:25:40	100.00
4	196222	562692	25-10	16:32:38	16:55:39	00:23:01	100.00
4	196222	562692	26-10	16:33:48	16:53:04	00:19:15	100.00
4	196222	562692	27-10	16:35:26	16:51:15	00:15:49	100.00
4	196222	562692	28-10	16:37:53	16:48:21	00:10:28	48.70

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House	Easting	Northing
4	197372	563233

Turbine	Easting	Northing	Date	Start Time	End Time	Duration	% Cover
4	196222	562692	06-02	16:43:16	16:46:53	00:03:37	100.00
4	196222	562692	07-02	16:42:26	16:52:52	00:10:27	100.00
4	196222	562692	08-02	16:41:47	16:58:02	00:16:15	100.00
4	196222	562692	09-02	16:41:17	17:03:29	00:22:12	100.00
4	196222	562692	10-02	16:40:56	17:09:15	00:28:19	100.00
4	196222	562692	11-02	16:40:42	17:10:36	00:29:54	100.00
4	196222	562692	12-02	16:40:36	17:10:58	00:30:22	100.00
4	196222	562692	13-02	16:40:38	17:11:10	00:30:32	100.00
4	196222	562692	14-02	16:40:47	17:11:13	00:30:25	100.00
4	196222	562692	15-02	16:41:05	17:11:06	00:30:00	100.00
4	196222	562692	16-02	16:41:33	17:10:49	00:29:16	100.00
4	196222	562692	17-02	16:42:11	17:10:21	00:28:10	100.00
4	196222	562692	18-02	16:43:04	17:09:42	00:26:38	100.00
4	196222	562692	19-02	16:44:14	17:08:49	00:24:34	100.00
4	196222	562692	20-02	16:44:32	17:07:46	00:23:14	100.00
4	196222	562692	21-02	16:46:01	17:06:26	00:20:25	100.00
4	196222	562692	22-02	16:48:15	17:04:39	00:16:24	63.34
4	196222	562692	23-02	16:50:58	17:02:02	00:11:04	56.76
4	196222	562692	17-10	16:25:42	16:31:01	00:05:19	12.54
4	196222	562692	18-10	16:21:37	16:34:44	00:13:07	80.74
4	196222	562692	19-10	16:18:42	16:36:39	00:17:57	85.95
4	196222	562692	20-10	16:16:31	16:37:56	00:21:26	100.00
4	196222	562692	21-10	16:16:04	16:38:52	00:22:49	100.00
4	196222	562692	22-10	16:14:22	16:39:37	00:25:15	100.00
4	196222	562692	23-10	16:13:05	16:40:12	00:27:07	100.00
4	196222	562692	24-10	16:12:05	16:40:35	00:28:30	100.00
4	196222	562692	25-10	16:11:20	16:40:49	00:29:30	100.00
4	196222	562692	26-10	16:10:46	16:40:54	00:30:09	100.00
4	196222	562692	27-10	16:10:23	16:40:52	00:30:29	100.00
4	196222	562692	28-10	16:10:09	16:40:41	00:30:32	100.00
4	196222	562692	29-10	16:10:04	16:40:22	00:30:18	100.00
4	196222	562692	30-10	16:10:09	16:39:56	00:29:47	100.00
4	196222	562692	31-10	16:10:22	16:37:35	00:27:13	100.00
4	196222	562692	01-11	16:10:45	16:31:57	00:21:12	100.00
4	196222	562692	02-11	16:11:17	16:26:39	00:15:22	100.00
4	196222	562692	03-11	16:12:00	16:21:39	00:09:39	100.00
4	196222	562692	04-11	16:12:56	16:15:51	00:02:55	100.00

House	Easting	Northing
5	197294	563349

Turbine	Easting	Northing	Date	Start Time	End Time	Duration	% Cover
4	196222	562692	19-01	16:24:16	16:31:29	00:07:13	21.11
4	196222	562692	20-01	16:22:08	16:34:15	00:12:08	61.67
4	196222	562692	21-01	16:20:47	16:36:12	00:15:25	100.00
4	196222	562692	22-01	16:19:48	16:38:13	00:18:25	100.00
4	196222	562692	23-01	16:19:01	16:39:54	00:20:53	100.00
4	196222	562692	24-01	16:18:24	16:41:43	00:23:19	100.00
4	196222	562692	25-01	16:17:54	16:43:25	00:25:31	100.00
4	196222	562692	26-01	16:17:31	16:44:48	00:27:17	100.00
4	196222	562692	27-01	16:17:13	16:45:58	00:28:44	100.00
4	196222	562692	28-01	16:17:01	16:46:56	00:29:55	100.00
4	196222	562692	29-01	16:16:53	16:47:46	00:30:53	100.00
4	196222	562692	30-01	16:16:51	16:48:27	00:31:36	100.00
4	196222	562692	31-01	16:16:53	16:49:01	00:32:08	100.00
4	196222	562692	01-02	16:17:01	16:49:27	00:32:26	100.00

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4	196222	562692	02-02	16:17:13	16:49:46	00:32:33	100.00
4	196222	562692	03-02	16:17:32	16:49:57	00:32:26	100.00
4	196222	562692	04-02	16:17:56	16:50:01	00:32:05	100.00
4	196222	562692	05-02	16:18:28	16:49:57	00:31:29	100.00
4	196222	562692	06-02	16:19:08	16:49:45	00:30:37	100.00
4	196222	562692	07-02	16:19:57	16:49:23	00:29:26	100.00
4	196222	562692	08-02	16:20:59	16:48:52	00:27:52	100.00
4	196222	562692	09-02	16:21:59	16:48:09	00:26:09	100.00
4	196222	562692	10-02	16:23:07	16:47:19	00:24:12	100.00
4	196222	562692	11-02	16:24:35	16:46:13	00:21:38	100.00
4	196222	562692	12-02	16:26:38	16:44:45	00:18:07	76.50
4	196222	562692	13-02	16:29:47	16:42:40	00:12:52	76.02
4	196222	562692	14-02	16:33:35	16:38:47	00:05:11	11.72
4	196222	562692	27-10	16:02:05	16:09:37	00:07:32	24.83
4	196222	562692	28-10	15:58:53	16:12:42	00:13:49	87.80
4	196222	562692	29-10	15:55:41	16:14:32	00:18:51	87.11
4	196222	562692	30-10	15:53:45	16:15:52	00:22:07	100.00
4	196222	562692	31-10	15:52:20	16:16:52	00:24:32	100.00
4	196222	562692	01-11	15:51:16	16:17:40	00:26:25	100.00
4	196222	562692	02-11	15:50:17	16:18:23	00:28:06	100.00
4	196222	562692	03-11	15:49:21	16:18:56	00:29:36	100.00
4	196222	562692	04-11	15:48:38	16:19:21	00:30:44	100.00
4	196222	562692	05-11	15:48:06	16:19:39	00:31:34	100.00
4	196222	562692	06-11	15:47:43	16:19:50	00:32:07	100.00
4	196222	562692	07-11	15:47:29	16:19:55	00:32:27	100.00
4	196222	562692	08-11	15:47:22	16:19:55	00:32:33	100.00
4	196222	562692	09-11	15:47:23	16:19:49	00:32:26	100.00
4	196222	562692	10-11	15:47:30	16:19:37	00:32:07	100.00
4	196222	562692	11-11	15:47:44	16:19:20	00:31:36	100.00
4	196222	562692	12-11	15:48:04	16:18:56	00:30:52	100.00
4	196222	562692	13-11	15:48:31	16:18:26	00:29:55	100.00
4	196222	562692	14-11	15:49:04	16:17:49	00:28:45	100.00
4	196222	562692	15-11	15:49:44	16:17:03	00:27:18	100.00
4	196222	562692	16-11	15:50:32	16:16:05	00:25:33	100.00
4	196222	562692	17-11	15:51:27	16:14:50	00:23:24	100.00
4	196222	562692	18-11	15:52:31	16:13:29	00:20:58	100.00
4	196222	562692	19-11	15:53:45	16:12:19	00:18:33	100.00
4	196222	562692	20-11	15:55:14	16:10:49	00:15:35	100.00
4	196222	562692	21-11	15:57:05	16:09:28	00:12:23	64.20
4	196222	562692	22-11	15:59:40	16:07:23	00:07:42	24.01

House	Easting	Northing
6	197342	563475

There are no shadows cast on this window