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Urban & Renewables

Solar Photovoltaic Glint and Glare Study

Gloyn Byw / Butterfly Solar Farm

Axis P.E.D

September 2025

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ADMINISTRATION PAGE

Job Reference:	11556A
Author:	Jacob Cunningham
Email:	jacob@pagerpower.com

Reviewed By:	Phillip Charhill; James Plumb
Email:	phillip@pagerpower.com; james@pagerpower.com

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1	March 2025	Initial issue
2	April 2025	Considerations of Landscape Plan
3	August 2025	Assessment of updated layout
4	September 2025	Consideration of latest Landscape Masterplan
5	September 2025	Administrative revisions

Stour Valley Business Centre, Brundon Lane, Sudbury, CO10 7GB

T:*+44 (0)1787 319001* E:*info@pagerpower.com* W: *www.pagerpower.com*

EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to assess the potential effects of glint and glare from a ground-mounted solar photovoltaic development located in Wrexham, UK. This assessment pertains to the potential impact upon road safety, residential amenity, and aviation activity.

Overall Conclusions

When considering the proposed screening, no significant impacts are predicted upon road safety and dwelling amenity. Further mitigation is not required.

No significant impact is predicted upon aviation activity, public rights of way or Areas of Natural Beauty. Mitigation is not recommended.

Guidance and Studies

Guidelines exist in the UK (produced by the Civil Aviation Authority) and in the USA (produced by the Federal Aviation Administration) with respect to solar developments and aviation activity. The UK CAA guidance is relatively high-level and does not prescribe a formal methodology. Pager Power has, however, produced guidance for glint and glare and solar photovoltaic developments which was published in early 2017, with the fourth edition published in 2022[1]. This methodology defines a comprehensive process for determining the impact upon road safety, residential amenity, and aviation activity.

Pager Power's approach is to identify receptors, undertake geometric reflection calculations and, where a solar reflection is predicted, consider the screening (existing and/or proposed) between the receptor and the reflecting solar panels, whilst comparing the results against available solar reflection studies. For aviation activity, where a solar reflection is predicted, solar intensity calculations are undertaken where appropriate in line with the Sandia National Laboratories' FAA methodology[2]. The scenario in which a solar reflection can occur for all receptors is then identified and discussed, and a comparison is made against the available solar panel reflection studies to determine the overall impact.

Studies have measured the intensity of solar reflections from various naturally occurring and man-made surfaces. The results show that the intensity of solar reflections from solar panels are slightly higher than those from still water but significantly less than those from steel[3].

[1] Pager Power Glint and Glare Guidance, Fourth Edition, September 2022
[2] Formerly mandatory for on-airfield solar developments in the USA under the FAA's interim policy, superseded in 2021 with a policy that effectively requires individual airports to sign off on their on-airfield development as they see fit.
[3] SunPower, 2009, SunPower Solar Module Glare and Reflectance (appendix to Solargen Energy,2010).

Assessment Results – Aviation Activity

Solar reflections with intensities 'potential for temporary after-image' ('yellow' glare) are predicted towards the splayed approached paths for runway and 01/19 at Plassey Airfield. Due to the reflections coinciding with the sun, a much more significant source of glare, and the low volume of air traffic expected at the private airfield, a low impact is predicted.

Solar reflections with 'low-potential for temporary after-image' ('green' glare) are geometrically possible towards the final sections of the visual circuit and base leg joins for runway thresholds 01 and 19. This intensity of glare is acceptable in accordance with the associated guidance (Appendix D) for licensed aerodromes, and therefore considered acceptable also for these receptors. A low impact is predicted, and mitigation is not required.

It is recommended that this report is shared with the safeguarding team of Plassey Airfield to determine their position on the proposed development.

Assessment Results – Road Safety

Solar reflections are geometrically possible towards sections of the A483, B5426, A528 and the B5130.

Screening in the form of existing vegetation or existing buildings is predicted to significantly obstruct views of reflecting panels such that solar reflections will not be experienced by road users along the A483, the B5426, the BA528 and 1km of the B5130. **No impact is predicted along these sections, and accordingly mitigation is not required.**

For 200m of the B5130, no relevant screening was identified. Reflections do not occur directly in front of the road user. A moderate impact is predicted, mitigation is recommended (see Section 5.5.1). **Review of the Landscape Masterplan shows proposed vegetation screening such that impact will be reduced to low, or no, impact.**

For the remaining 100m section of the B5130, no relevant screening has been identified. A high impact is predicted, and mitigation is required (see Section 5.5.1). **Review of the Landscape Masterplan shows proposed vegetation screening such that impact will be reduced to low, or no, impact.**

Assessment Results – Residential Amenity

Solar reflections are geometrically possible towards 95 of the 123 assessed dwellings.

For 42 of the dwellings, screening in the form of existing vegetation and/or intervening terrain is predicted to significantly obstruct views of reflecting panels such that solar reflections will not be experienced by residents. **No impact is predicted, and mitigation is not required.**

For one of the dwellings, existing vegetation or intervening terrain is predicted to partially obstruct views of reflecting panels for an observer on the ground floor, the remaining visible reflecting panels will have a separation distance of over 900m. **A low impact is predicted, and mitigation is not recommended.**

For 10 of the dwellings, existing vegetation and or intervening terrain is predicted to partially obstruct views of reflecting panels such that for an observer on the ground floor views of the reflecting panels will not be possible. **A low impact is predicted, and mitigation is not recommended.**

For the remaining two dwellings, reflections are predicted to occur for less than an hour on any given day, and for more than three months of the year. No significant screening has been identified. A moderate impact is predicted, and mitigation is recommended (see Section 5.5.2). **Review of the Landscape Masterplan shows proposed vegetation screening such that impact will be reduced to low, or no, impact.**

High-Level Assessment Conclusions - High Level Aviation

For aviation activity associated with Chirk Airfield and Trench Farm Airfield any solar reflections are predicted to be acceptable in accordance with the associated guidance due to the following two factors:

- Glare intensities towards approaches towards thresholds in the direction of the proposed development are predicted to be no greater than 'low potential for temporary after-image';
- Any possible solar reflections will be outside the pilot's field-of-view for pilots approaching runway thresholds directed away from the proposed development.

Therefore, no significant impacts are predicted upon aviation activity Chirk Airfield and Trench Farm Airfield and detailed modelling is not recommended.

High-Level Assessment Conclusions – High-Level Public Rights of Way

No significant impacts upon public rights of way or Areas of Natural Beauty are predicted due to the sensitivity of the receptors (in terms of amenity and safety) being of low significance, existing and proposed screening, and the location and distance of the nearest Area of Natural Beauty relative to the proposed development.

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 62 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 been retained to assess the potential effects of glint and glare from a ground-mounted solar photovoltaic development located in Wrexham, UK. This assessment pertains to the potential impact upon road safety, residential amenity, and aviation activity.

This report contains the following:

- Solar development details;
- Explanation of glint and glare;
- Overview of relevant guidance and studies;
- Overview of Sun movement;
- Assessment methodology;
- Identification of receptors;
- Glint and glare assessment for identified receptors;
- Results discussion;
- Overall conclusions.

1.2 Pager Power's Experience

Pager Power has undertaken over 1,600 Glint and Glare assessments in the UK and internationally. The studies have included assessment of civil and military aerodromes, railway infrastructure and other ground-based receptors including roads and dwellings.

1.3 Glint and Glare Definition

The definition[4] of glint and glare is as follows:

- Glint – a momentary flash of bright light typically received by moving receptors or from moving reflectors;
- Glare – a continuous source of bright light typically received by static receptors or from large reflective surfaces.

The term 'solar reflection' is used in this report to refer to both reflection types i.e. glint and glare.

[4]These definitions are aligned with those presented within the National Policy Statement for Renewable Energy Infrastructure (EN-3) – published by the Department for Energy Security and Net Zero and the Federal Aviation Administration in the USA.

2 SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Proposed Development Site Layout

The site layout[5] is shown in Figure 1 below. Solar panel areas are denoted by areas of blue.

Figure 1 *Site layout*

2.2 Reflector Areas

The bounding coordinates for the proposed development have been extrapolated from the site plans. The data can be found in Appendix G. Figure 2 below shows the assessed reflector areas that have been used for modelling purposes.

Figure 2 *Assessed reflector areas*

[5] Source 'J033_1001_12' PDF, Edited

The Pager Power model has used a resolution of 20m for this assessment. This means that a geometric calculation is undertaken for each identified receptor every 20m from within the defined areas. This resolution is sufficiently high to maximise the accuracy of the results – increasing the resolution further would not significantly change the modelling output. If a reflection is experienced from an assessed panel location, then it is likely that a reflection will be viewable from similarly located panels within the proposed solar development.

Considerations of the Landscape Masterplan have been made where appropriate. The removal of parts of the existing vegetation for access routes or other reasons are not predicted to impact the conclusions of this assessment.

2.3 Solar Panel Technical Information

The technical information of the modelled solar panels used in this assessment is summarised below:

- Azimuth angle[6]: 180°;
- Elevation angle[7]: 20°;
- Assessed height[8]: 1.9m above ground level.

Further information regarding the modelled surface material is presented in Section 5.2.1.

[6] Direction the panels are facing relative to True North (0°)

[7] Pitch above horizontal

[8] Assessed at the midpoint of the panel above ground level

3 GLINT AND GLARE ASSESSMENT METHODOLOGY

3.1 Guidance and Studies

Guidelines exist in the UK (produced by the Civil Aviation Authority) and in the USA (produced by the Federal Aviation Administration) with respect to solar developments and aviation activity. Pager Power has however produced guidance for glint and glare and solar photovoltaic developments, which was published in early 2017, with the fourth edition[9] published in 2022. This methodology defines a comprehensive process for determining the impact upon road safety, residential amenity, and aviation activity.

The Pager Power approach is to identify receptors, undertake geometric reflection calculations and review the scenario under which a solar reflection can occur, whilst comparing the results against available solar reflection studies.

Appendix A and B present a review of relevant guidance and independent studies with regard to glint and glare issues from solar panels and glass. The overall conclusions from the available studies are as follows:

- Specular reflections of the Sun from solar panels and glass are possible;
- The measured intensity of a reflection from solar panels can vary from 2% to 30% depending on the angle of incidence;

Published guidance shows that the intensity of solar reflections from solar panels are equal to or less than those from still water and similar to those from glass. It also shows that reflections from solar panels are significantly less intense than many other reflective surfaces, which are common in an outdoor environment, including steel[10].

3.2 Background

Details of the Sun's movements and solar reflections are presented in Appendix C.

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[9] Pager Power Glint and Glare Guidance, Fourth Edition, September 2022.

[10] SunPower, 2009, SunPower Solar Module Glare and Reflectance (appendix to Solargen Energy,2010).

3.3 Methodology

Information regarding Pager Power's and Sandia National Laboratories' methodology is presented in the following sub-sections 3.3.1 and 3.3.2 respectively.

3.3.1 Pager Power's Methodology

The glint and glare assessment methodology has been derived from the information provided to Pager Power through consultation with stakeholders and by reviewing the available guidance, studies and Pager Power's practical experience. The methodology for this glint and glare assessment is as follows:

- Identify receptors in the area surrounding the proposed development;
- Consider direct solar reflections from the proposed development towards the identified receptors by undertaking geometric calculations;
- Consider the visibility of the reflectors from the receptor's location. If the reflectors are not visible from the receptor then no reflection can occur;
- Based on the results of the geometric calculations, determine whether a reflection can occur, and if so, at what time it will occur;
- Consider the solar reflection intensity, if appropriate;
- Consider both the solar reflection from the proposed development and the location of the direct sunlight with respect to the receptor's position;
- Consider the solar reflection with respect to the published studies and guidance;
- Determine whether a significant detrimental impact is expected in line with Appendix D.

Within the Pager Power model, the reflector area is defined, as well as the relevant receptor locations. The result is a chart that states whether a reflection can occur, the duration and the panels that can produce the solar reflection towards the receptor.

3.3.2 Sandia National Laboratories' Methodology

Sandia National Laboratories developed the Solar Glare Hazard Analysis Tool (SGHAT) which is no longer freely available however it is now developed by Forge Solar. Pager Power uses this model where required for aviation receptors. Whilst strictly applicable in the USA and to solar photovoltaic developments only, the methodology is widely used by aviation stakeholders internationally.

3.4 Assessment Methodology and Limitations

Further technical details regarding the methodology of the geometric calculations and limitations are presented in Appendix E and Appendix F.

4 IDENTIFICATION OF RECEPTORS

4.1 Overview

The following sections present the relevant receptors assessed within this report. Terrain data has been interpolated based on Ordnance Survey of Great Britain (OSGB) 50 Digital Terrain Model (DTM) data. The receptor details for all receptors are presented in Appendix G.

4.2 Aviation Receptors

4.2.1 Plassey Airfield

Plassey Airfield is an unlicensed General Aviation (GA) aerodrome with one operational runway (01/19) and understood not to have an Air Traffic Control (ATC) Tower.

Plassey Airfield is approximately 0.2km east of the closest section of proposed development. The location relative to the proposed development is shown in Figure 3 below.

Figure 3 *Plassey Airfield relative to proposed development*

4.2.2 Runway Approach Paths and Final Sections of Visual Circuits

Plassey is a GA aerodrome where aviation activity is dynamic and does not necessarily follow the typical approaches / flight paths of a larger licensed aerodrome or airport. It is not possible to assess every single location of airspace that an aircraft travels in flight around an aerodrome; however, it is possible to assess the most frequently flown flight paths and the most critical stages of flight, which would cover most, or all, of the relevant locations.

As such, Pager Power's methodology is to assess whether a solar reflection can be experienced on the following characteristics:

- 1-mile approach path with a splay angle of 5 degrees, considering 2.5 degrees either side of the extended runway centreline;
- A descent angle of 5 degrees;
- Circuit width of 1 nautical mile from runway centreline;
- Maximum altitude of 500 feet above the average threshold altitude.

Figure 4 below illustrates the splayed approach and final sections of the visual circuits.

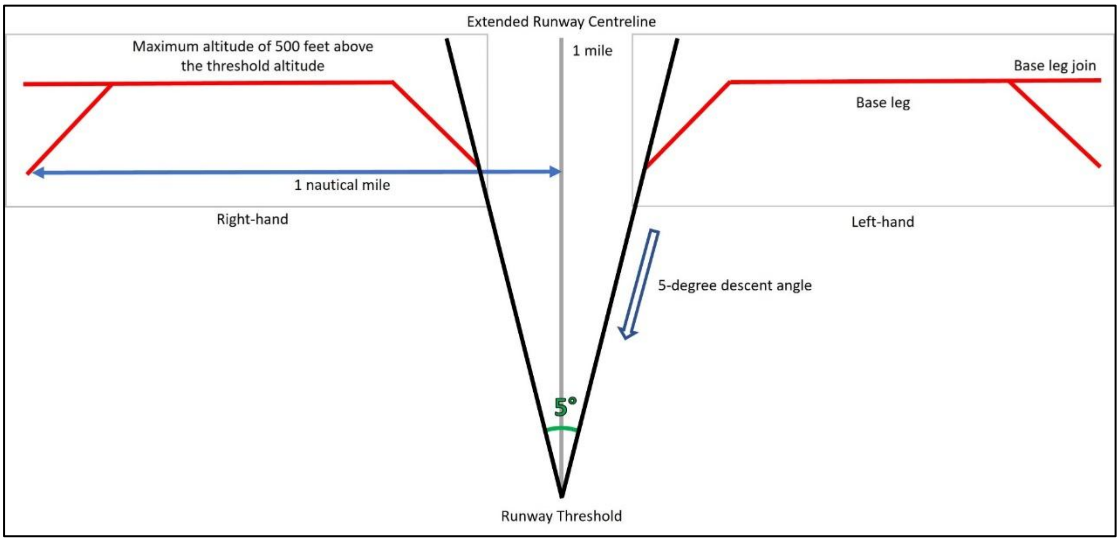

Figure 4 *Splayed approach and final sections of visual circuits*

Figure 5 on the following page shows the assessed aircraft receptor points of the splayed approach and final sections of the visual circuits for runways 01/19 (red/blue) at Plassey Airfield.

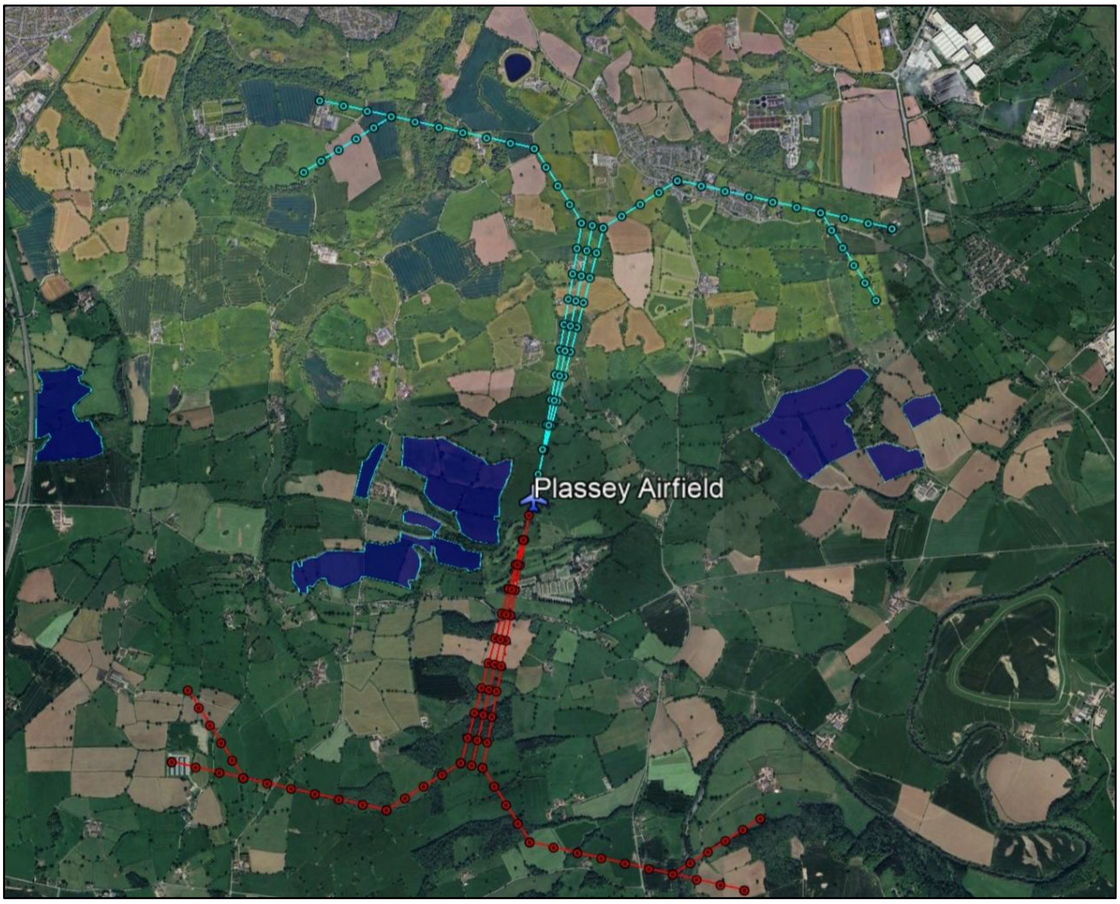

Figure 5 *Assessed receptors for Plassey Airfield*

4.3 Ground Based Receptors Overview

There is no formal guidance with regard to the maximum distance at which glint and glare should be assessed. From a technical perspective, there is no maximum distance for potential reflections. The significance of a reflection however decreases with distance because the proportion of an observer's field of vision that is taken up by the reflecting area diminishes as the separation distance increases. Terrain and shielding by vegetation are also more likely to obstruct an observer's view at longer distances.

The above parameters and industry experience over a significant number of glint and glare assessments undertaken, shows that a 1km assessment area from the proposed development is considered appropriate for glint and glare effects on road users and dwellings. Reflections towards ground-based receptors located further north than any proposed panel are highly unlikely[11]. Therefore, receptors north of the most northern panel areas have not been modelled. The assessment area (yellow outlined area in the following figures) has been designed accordingly as 1km from the proposed development, excluding the area to the north of the north-most solar panels.

[11] For fixed, south-facing panels at this latitude.

Potential receptors within the associated assessment area are identified based on mapping and aerial photography of the region. The initial judgement is made based on high-level consideration of aerial photography and mapping i.e. receptors are excluded if it is clear from the outset that no visibility would be possible. A more detailed assessment is made if the modelling reveals a reflection would be geometrically possible.

4.4 Road Receptors

4.4.1 Road Receptors Overview

Road types can generally be categorised as:

- Major National – Typically a road with a minimum of two carriageways with a maximum speed limit of up to 70mph. These roads typically have fast-moving vehicles with busy traffic;
- National – Typically a road with one or more carriageways with a maximum speed limit of 60mph or 70mph. These roads typically have fast-moving vehicles with moderate to busy traffic density;
- Regional – Typically a single carriageway with a maximum speed limit of up to 60mph. The speed of vehicles will vary with a typical traffic density of low to moderate;
- Local – Typically roads and lanes with the lowest traffic densities. Speed limits vary.

Technical modelling is not recommended for local roads, where traffic densities are likely to be relatively low. Any solar reflections from the proposed development that are experienced by a road user along a local road would be considered low impact in the worst case in accordance with the guidance presented in Appendix D. The analysis has also considered major national, national, and regional roads that:

- Are within the one-kilometre assessment area;
- Have a potential view of the panels.

Receptors along each road are placed circa 100m apart. A height of 1.5 metres above ground level has been used to model the typical eye-level[12] of a road user.

4.4.2 Identified Road Receptors

A 1.2km section of the A525 and a 1.1km section of the B5426 has been identified within the assessment area; however, has not been geometrically modelled in this assessment as potential views of the panels are not considered possible. Screening in the form of existing vegetation and intervening terrain is predicted to significantly obstruct views of the proposed development. No impact is predicted upon the A525 and the 1.1km section of the B5426, and mitigation is not required.

[12] This fixed height for the road receptors is for modelling purposes. Small changes to the modelling height by a few metres is not expected to significantly change the modelling results. Views for elevated drivers are also considered in the results discussion, where appropriate

Figures 6 to 9 on the following pages show the sections of the A525 and B5426 which are significantly screened, outlined in light and dark blue respectively, with vegetation screening highlighted in green, and a point-of-view image of the identified screening for a road user along the road respectively.

Figure 6 *Section of the A525 within assessment area*

Figure 7 *Point-of-view along A525*

Figure 8 *Screened section of the B5426 within assessment area*

Figure 9 *Point-of-view along B5426*

The assessed receptors along 1.6km of the A483 [A1 – A17], 7.4km of the B5426 [B1 – B75], 1.6km of the A528 [C1 – C17] and 1.6km of the B5130 [D1 – D18] are shown in Figures 10 and 11 on the following page.

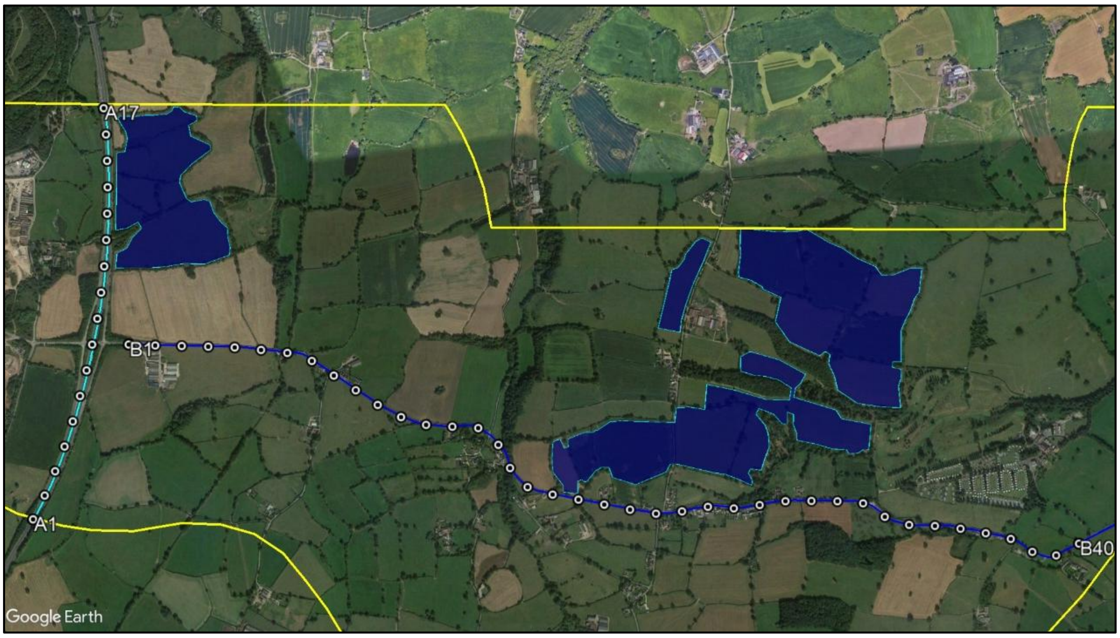

Figure 10 *Assessed road receptors A1 to A17 and B1 to B40*

Figure 11 *Assessed road receptors B41 to B75, C1 to C17 and D1 to D18*

4.5 Dwelling Receptors

4.5.1 Dwelling Receptors Overview

The analysis has considered dwellings that:

- Are within the one-kilometre assessment area; and
- Have a potential view of the panels.

In residential areas with multiple layers of dwellings, only the outer dwellings have been considered for assessment. This is because they will mostly obscure views of the solar panels to the dwellings behind them, which will therefore not be impacted by the proposed development because line of sight will be removed, or they will experience comparable effects to the closest assessed dwelling.

Additionally, in some cases, a single receptor point may be used to represent a small number of separate addresses. In such cases, the results for the receptor will be representative of the adjacent observer locations, such that the overall level of effect in each area is captured reliably.

A height of 1.8 metres above ground level has been used to model the typical eye-level from the ground floor[13].

4.5.2 Identified Dwelling Receptors

In total, 123 dwelling receptors have been assessed. An overview of the dwelling receptors is shown in Figure 12 below. Detailed identification of dwelling receptors is presented in Appendix H.

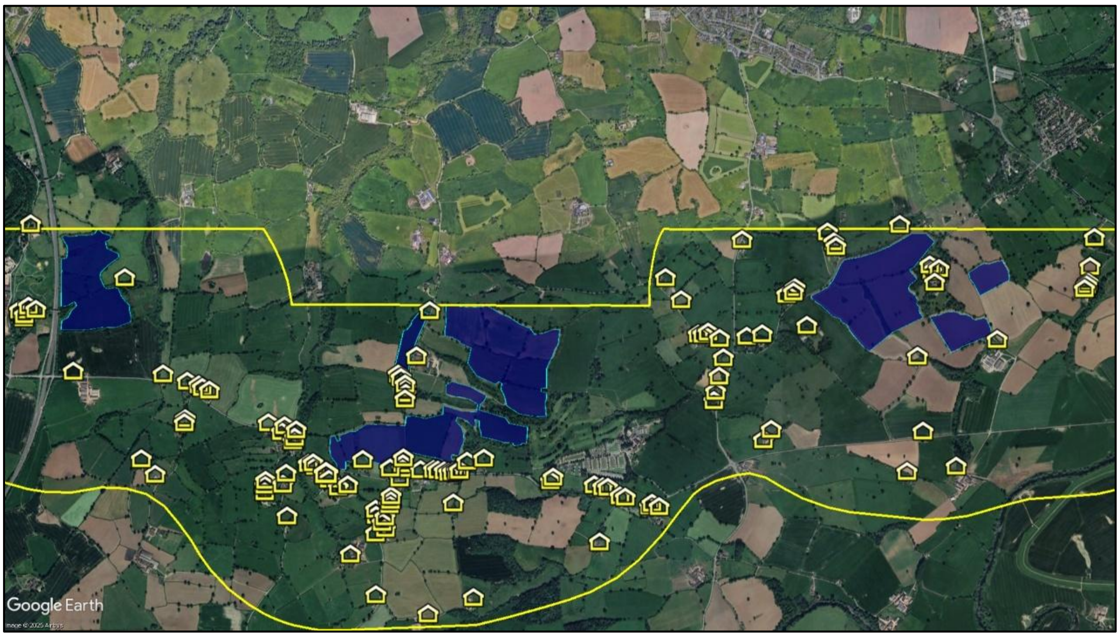

Figure 12 *Dwelling receptors*

[13]Changes to this height are not significant, and views considered above the ground floor are considered where appropriate

5 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

5.1 Overview

The following sub-sections summarise the results of the assessment:

- The key considerations for each receptor type. The criteria are determined by the assessment process for each receptor, which are set out in Appendix D.
- Geometric results of the assessment based solely on bare-earth terrain i.e., without consideration of screening in the form of buildings, dwellings, (existing or proposed) vegetation, and/or terrain. The modelling output for receptors, shown in Appendix H, presents the precise predicted times and the reflecting panel areas.
- Whether a reflection will be experienced in practice. When determining the visibility of the reflecting panels for an observer, a conservative review of the available imagery, landscape strategy plan, google earth viewshed (high-level terrain analysis), and/or site photography (if available) is undertaken, whereby it is assumed views of the panels are possible if it cannot be reliably determined that existing and/or proposed screening will remove effects. Detailed screening analysis may be undertaken to determine visibility, where appropriate.
- The impact significance and any mitigation recommendations/requirements.
- The desk-based review of the available imagery, where appropriate.

5.2 Aviation Receptors

5.2.1 Glare Intensity Categorisation

The Pager Power and Forge models have been used to determine whether reflections are possible for aviation receptors. Intensity calculations (Forge Model) in line with the Sandia National Laboratories methodology have been undertaken. These calculations are routinely required for solar photovoltaic developments on or near aerodromes. The intensity model calculates the expected intensity of a reflection with respect to the potential for an after-image (or worse) occurring. The designation used by the model is presented in Table 1 below along with the associated colour coding.

Coding Used	**Intensity Key**
Glare beyond 50°	'Glare outside a pilot's field-of-view'
'Green'	'Low potential for temporary after-image'
'Yellow'	'Potential for temporary after-image'
'Red'	'Potential for permanent eye damage'

Table 1 *Glare intensity designation*

This coding has been used in the table where a reflection has been calculated and is in accordance with Sandia National Laboratories' methodology.

This coding has been used in the table where a reflection has been calculated and is in accordance with Sandia National Laboratories' methodology. In addition, the intensity model allows for the assessment of a variety of solar panel surface materials. This assessment has considered solar panels with a surface material of 'smooth glass with an anti-reflective coating'. It is understood that this is the most commonly used solar panel surface material. Other surfaces that could be modelled include:

- Smooth glass without an anti-reflective coating;
- Light textured glass without an anti-reflective coating;
- Light textured glass with an anti-reflective coating; or
- Deeply textured glass.

Appendix H presents the results charts showing specific times and dates.

5.2.2 Key Considerations – Runway Approach Paths

The process for determining impact significance is defined in Appendix D. For the runway approach paths, the key considerations are:

- Whether a reflection is predicted to be experienced in practice;
- The location of glare relative to a pilot's primary field of view (50 degrees either side of the approach bearing).
- The intensity of glare for the solar reflections:
  - Glare with 'low potential for temporary after-image' ('green' glare).
  - Glare with 'potential for temporary after-image' ('yellow' glare).
  - Glare with 'potential for permanent eye damage' ('red' glare).
- Whether a reflection is predicted to be operationally significant in practice or not.

Where no solar reflections are geometrically possible or where solar reflections are predicted to be significantly screened, no impact is predicted, and mitigation is not required.

Where solar reflections are of an intensity no greater than 'low potential for temporary after-image' (green glare) or occur outside of a pilot's primary field-of-view (50 degrees either side of the runway approach relative to the approach bearing), the impact significance is low, and mitigation is not required.

Glare with 'potential for a temporary after-image' (yellow glare) was formerly not permissible under the interim guidance provided by the Federal Aviation Administration in the USA[14] for on-airfield solar. Pager Power recommends a pragmatic approach whereby instances of 'yellow' glare are evaluated in a technical and operational context. Where solar reflections are of an

[14] This FAA guidance from 2013 has since been superseded by the FAA guidance in 2021 whereby airports are tasked with determining safety requirements themselves.

intensity no greater than 'low potential for temporary after-image' expert assessment of the following mitigating factors is required to determine the impact significance[15]:

- The likely traffic volumes and level of safeguarding at the aerodrome – licensed aerodromes typically have higher traffic volumes and are formally safeguarded;
- The time of day at which glare is predicted and whether the aerodrome will be operational such that pilots can be on the approach at these times;
- The duration of any predicted glare – glare that occurs for low durations throughout the year is less likely to be experienced than glare that occurs for longer durations throughout the year;
- The location and size of the reflecting panel area relative to a pilot's primary field-of-view;
- The location of the source of glare relative to the position of the Sun at the times and dates in which solar reflections are geometrically possible – effects that coincide with direct sunlight appear less prominent than those that do not;
- The level of predicted effect relative to existing sources of glare – a solar reflection is less noticeable by pilots when there are existing reflective surfaces in the surrounding environment.

Following consideration of these mitigating factors, where the solar reflection does not remain significant, a low impact is predicted, and mitigation is not recommended; however, consultation with the aerodrome is recommended to understand their position along with any feedback or comments regarding the proposed development.

Where the solar reflection remains significant, the impact significance is moderate, and mitigation is recommended. Where solar reflections are of an intensity greater than 'potential for temporary after-image', the impact significance is high, and mitigation is required.

In all cases, however, consultation with the aerodrome is recommended to understand their position pertaining to solar reflections towards the ATC Tower or approach paths, along with any feedback or comments regarding the proposed development.

5.2.3 Assessment Results

Table 2 on the following page presents the geometric modelling results for receptors associated with Plassey Airfield.

[15] This approach taken is reflective of the changes made in the 2021 FAA guidance; however, it should be noted that this guidance states that it is up to the airport to determine the safety requirements themselves. Therefore, an airport may not accept any yellow glare towards approach paths.

Receptor	Geometric Modelling Result	Glare Intensity	Predicted Impact
Splayed Approach Runway 01/19	Solar reflections are geometrically possible	'Yellow'	Low impact Discussed further in Section 5.2.4
Final Sections of Visual Circuits Runway 01/19	Solar reflections are geometrically possible	'Green'	Considering the associated guidance (Appendix D) and industry best practice pertaining to 2-mile approach paths, which states that this level of glare intensity is acceptable, it can be concluded that this level of glare is also acceptable for these receptors Low impact

Table 2 *Geometric modelling results - Plassey Airfield*

5.2.4 Further Considerations and Conclusions

When considering fixed panels, the following can be concluded:

- All instances of 'yellow' glare occur in the early and late hours of the available daylight, and will therefore coincide with direct sunlight, a much more significant source of glare;
- The volume of air traffic at Plassey Airfield is considered very low, and training exercises are not predicted to occur at this airfield;
- The weather would have to be clear and sunny at the specific times when glare is possible. A pilot would also have to be on approach at these times.

Overall, it is judged that 'yellow' glare along the final sections of the approach paths for runways 01 and 19 at Plassey Airfield can be operationally accommodated. Considering the points made above, there are mitigating factors that reduce the overall impact. In particular, solar reflections will coincide with direct sunlight and the volume of air traffic will be very low a it is a small private airstrip.

5.3 Road Results

5.3.1 Key Considerations

The process for quantifying impact significance is defined in the report appendices. The key considerations for road users along major national, national, and regional roads are:

- Whether a reflection is predicted to be experienced in practice;
- The location of the reflecting panel relative to a road user's direction of travel.

Where no solar reflections are geometrically possible or where solar reflections are predicted to be significantly screened, no impact is predicted, and mitigation is not required.

Where reflections originate from outside of a road user's primary field of view (FOV) (50 degrees either side of the direction of travel), or where the separation distance to the nearest visible reflecting panel is over 1km, the impact significance is low, and mitigation is not recommended.

Where reflections are predicted to be experienced from inside of a road user's main field of view, expert assessment of the following factors is required to determine the impact significance:

- Whether visibility is likely for elevated drivers (applicable to dual carriageways and motorways only) – there is typically a higher density of elevated drivers (such as HGVs) along dual carriageways and motorways compared to other types of road;
- Whether a solar reflection is fleeting in nature. Small gap/s in screening (e.g., an access point to the site) may not result in a sustained reflection for a road user;
- The separation distance to the panel area – larger separation distances reduce the proportion of an observer's field of view that is affected by glare;
- The position of the Sun – effects that coincide with direct sunlight appear less prominent than those that do not;
- Whether the solar reflection originates from directly in front of a road user – a solar reflection that is directly in front of a road user is more hazardous than a solar reflection to one side.

Following consideration of these relevant factors, where the solar reflection is not deemed significant, a low impact is predicted, and mitigation is not required. Where the solar reflection is deemed significant, the impact significance is moderate, and mitigation is recommended.

Where reflections originate from directly in front of a road user and there are no mitigating factors, the impact significance is high, and mitigation is required.

5.3.2 Geometric Modelling Results Overview

Table 3 on the following pages presents the following:

- Geometric modelling results (without consideration of screening);
- Desk-based review of identified screening (presented in more detail in the Appendix J);
- Consideration of any mitigating factors (where appropriate);
- Predicted impact significance;
- Results where mitigation is recommended/required have been highlighted in red for ease of reference.

The screening review is presented in Appendix J.

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening)	Mitigating Factors	Predicted Impact Classification
A1 – A9	Solar reflections are **not geometrically possible**	N/A	N/A	N/A	No impact
A10 – A17	Solar reflections are **geometrically possible.** Solar reflections occur **outside** a road user's primary FOV	Existing vegetation Predicted to significantly obstruct views of reflecting panels such that views are not possible in practice	N/A	N/A	No impact
B1 – B12	Solar reflections are **not geometrically possible**	N/A	N/A	N/A	No impact
B13 – B45	Solar reflections are **geometrically possible** Solar reflections occur **inside** a road user's primary FOV	Existing vegetation Predicted to significantly obstruct views of reflecting panels such that views are not possible in practice	N/A	N/A	No impact

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening)	Mitigating Factors	Predicted Impact Classification
B46 – B64	Solar reflections are **not geometrically possible**	N/A	N/A	N/A	No impact
B65 - B70	Solar reflections are **geometrically possible** Solar reflections occur **inside** a road user's primary FOV	Existing vegetation Predicted to significantly obstruct views of reflecting panels such that views are not possible in practice	N/A	N/A	No impact
B71 – B75	Solar reflections are **geometrically possible** Solar reflections occur **inside** a road user's primary FOV	Existing vegetation and buildings Predicted to significantly obstruct views of reflecting panels such that views are not possible in practice	N/A	N/A	No impact

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening)	Mitigating Factors	Predicted Impact Classification
C1 – C5	Solar reflections are **geometrically possible.** Solar reflections occur **outside** a road user's primary FOV	Existing vegetation Predicted to significantly obstruct views of reflecting panels such that views are not possible in practice	N/A	N/A	No impact
C6 – C8	Solar reflections are **geometrically possible** Solar reflections occur **inside** a road user's primary FOV	Existing vegetation Predicted to significantly obstruct views of reflecting panels such that views are not possible in practice	N/A	N/A	No impact
C9 – C17	Solar reflections are **geometrically possible.** Solar reflections occur **outside** a road user's primary FOV	Existing vegetation Predicted to significantly obstruct views of reflecting panels such that views are not possible in practice	N/A	N/A	No impact

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening)	Mitigating Factors	Predicted Impact Classification
D1 – D5	Solar reflections are **geometrically possible** Solar reflections occur **inside** a road user's primary FOV	Existing vegetation Predicted to significantly obstruct views of reflecting panels such that views are not possible in practice	N/A	N/A	No impact
D6	Solar reflections are **geometrically possible** Solar reflections occur **inside** a road user's primary FOV	No significant screening identified	Solar reflections occur **inside** a road user's primary FOV	Reflections do not occur directly in front of road user	Moderate impact Mitigation recommended (see Section 5.5.1)
D7 – D8	Solar reflections are **geometrically possible** Solar reflections occur **inside** a road user's primary FOV	No significant screening identified	Solar reflections occur **inside** a road user's primary FOV	N/A	High impact Mitigation required (see Section 5.5.1)

Road Receptor	Geometric Modelling Results (screening not considered)	Identified Screening and Predicted Visibility (desk-based review)	Whether reflections occur inside a road user's primary FOV (with consideration of screening)	Mitigating Factors	Predicted Impact Classification
D9 – D10	Solar reflections are **geometrically possible** Solar reflections occur **inside** a road user's primary FOV	No significant screening identified	Solar reflections occur **inside** a road user's primary FOV	Reflections do not occur directly in front of road user	Moderate impact Mitigation recommended (see Section 5.5.1)
D11 – D18	Solar reflections are **geometrically possible** Solar reflections occur **inside** a road user's primary FOV	Existing vegetation Predicted to significantly obstruct views of reflecting panels such that views are not possible in practice	N/A	N/A	No impact

Table 3 *Geometric modelling results and assessment of impact significance – road receptors*

5.4 Assessment Results – Dwelling Receptors

5.4.1 Key Considerations

The key considerations for residential dwellings are:

- Whether a reflection is predicted to be experienced in practice;
- The duration of the predicted effects, relative to thresholds of:
    - Three months per year;
    - 60 minutes on any given day.

Where solar reflections are not geometrically possible, or the reflecting panels are predicted to be significantly obstructed from view, no impact is predicted, and mitigation is not required.

Where effects occur for **less** than three months per year and **less** than 60 minutes on any given day, or the closest reflecting panel is over 1km from the dwelling, the impact significance is low, and mitigation is not recommended.

Where reflections are predicted to be experienced for **more** than three months per year and/or for **more** than 60 minutes on any given day, expert assessment of the following factors is required to determine the impact significance and mitigation requirement:

- The separation distance to the panel area – larger separation distances reduce the proportion of an observer's field of view that is affected by glare;
- The position of the Sun – effects that coincide with direct sunlight appear less prominent than those that do not;
- Whether visibility is likely from all storeys – the ground floor is typically considered the main living space and has a greater significance with respect to residential amenity;
- Whether the dwelling appears to have windows facing the reflecting area – factors that restrict potential views of a reflecting area reduce the level of impact.

Following consideration of these mitigating factors, where the solar reflection is not deemed significant, a low impact is predicted, and mitigation is not recommended. Where the solar reflection is deemed significant, the impact significance is moderate, and mitigation is recommended.

If effects last for **more** than three months per year and for **more** than 60 minutes on any given day, and there are no mitigating factors, the impact significance is high, and mitigation is required.

5.4.2 Geometric Modelling Results and Discussion

Table 4 on the following pages presents the geometric modelling results and predicted impact significance for the assessed dwelling receptors, results where mitigation is recommended are highlighted in red for ease of reference. The screening review is presented in Appendix J.

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[16]	Mitigating Factors	Predicted Impact Classification
1	Solar reflections **are geometrically possible** for: **Less** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact
2 – 6	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact
7 – 16	Solar reflections are **not geometrically possible**	N/A	None	N/A	No impact

[16] Assessment scenario may include an initial conservative qualitative consideration of screening in determining the duration of predicated effects in practice. The reflecting area of the solar development may be partially screened such that it does not meet the two key criteria i.e. 1) The solar reflection occurs for more than three months per year 2) and/or for more than 60 minutes on any given day.

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[16]	Mitigating Factors	Predicted Impact Classification
17 – 35	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact
36	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice for an observer on the ground floor	None	N/A	Low impact
37	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[16]	Mitigating Factors	Predicted Impact Classification
38 - 39	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice for an observer on the ground floor	None	N/A	Low impact
40 - 51	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact
52 – 64	Solar reflections are not geometrically possible	N/A	None	N/A	No impact
65	Solar reflections **are geometrically possible** for: **Less** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[16]	Mitigating Factors	Predicted Impact Classification
66 - 68	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice for an observer on the ground floor	None	N/A	Low impact
69 - 71	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact
72 - 73	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice for an observer on the ground floor	None	N/A	Low impact

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[16]	Mitigating Factors	Predicted Impact Classification
74 – 84	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact
85 – 86	Solar reflections **are geometrically possible** for: **Less** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact
87	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact
88	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice for an observer on the ground floor	None	N/A	Low impact

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[16]	Mitigating Factors	Predicted Impact Classification
89 – 90	Solar reflections **are geometrically possible** for: **Less** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact
91	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact
92 – 93	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	None identified	**More** than three months **Less** than 60 minutes	None identified	Moderate impact Mitigation recommended (see Section 5.5.2)
94 - 95	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation and buildings screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[16]	Mitigating Factors	Predicted Impact Classification
96 – 105	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact
106 – 107	Solar reflections are **not geometrically possible**	N/A	None	N/A	No impact
108	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to partially obstruct views of reflecting panels	**Less** than three months **Less** than 60 minutes	N/A	Low impact
109 – 111	Solar reflections are **not geometrically possible**	N/A	None	N/A	No impact

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening and Predicted Visibility (desk-based review)	Duration of effects (with consideration of screening)[16]	Mitigating Factors	Predicted Impact Classification
112	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation screening and intervening terrain Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice for an observer on the ground floor	None	N/A	Low impact
113 – 117	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact
118 – 123	Solar reflections **are geometrically possible** for: **More** than three months **Less** than 60 minutes	Existing vegetation screening Predicted to significantly obstruct views of reflecting panels such that views are **not possible** in practice	None	N/A	No impact

Table 4 *Geometric modelling results - dwelling receptors*

5.5 Mitigation Strategy

5.5.1 Road Mitigation

A moderate impact has been predicted upon a total of 200m of the B5130, and a high impact is predicted for a further 100m.

The locations identified for proposed screening is shown as the pink line in Figure 13 on the following page. This screening could be in the form of planting or a fence and should be of a height such that views of the reflecting panels are obscured from the view of the affected sections of road for a typical road user.

If vegetation is used, it should be ensured that the screening significantly obstructs the reflecting panels during the periods when solar reflections are geometrically possible.

Review of the latest Landscape Masterplan[17] shows proposed vegetation screening of sufficient height between the reflecting panels and the affected receptors such that the impact will be reduced to low, or no, impact, once grown to a sufficient height. The relevant proposed screening has been highlighted in Figure 14 on page 47.

[17] Site Layout Masterplan-Eastern Array PDF

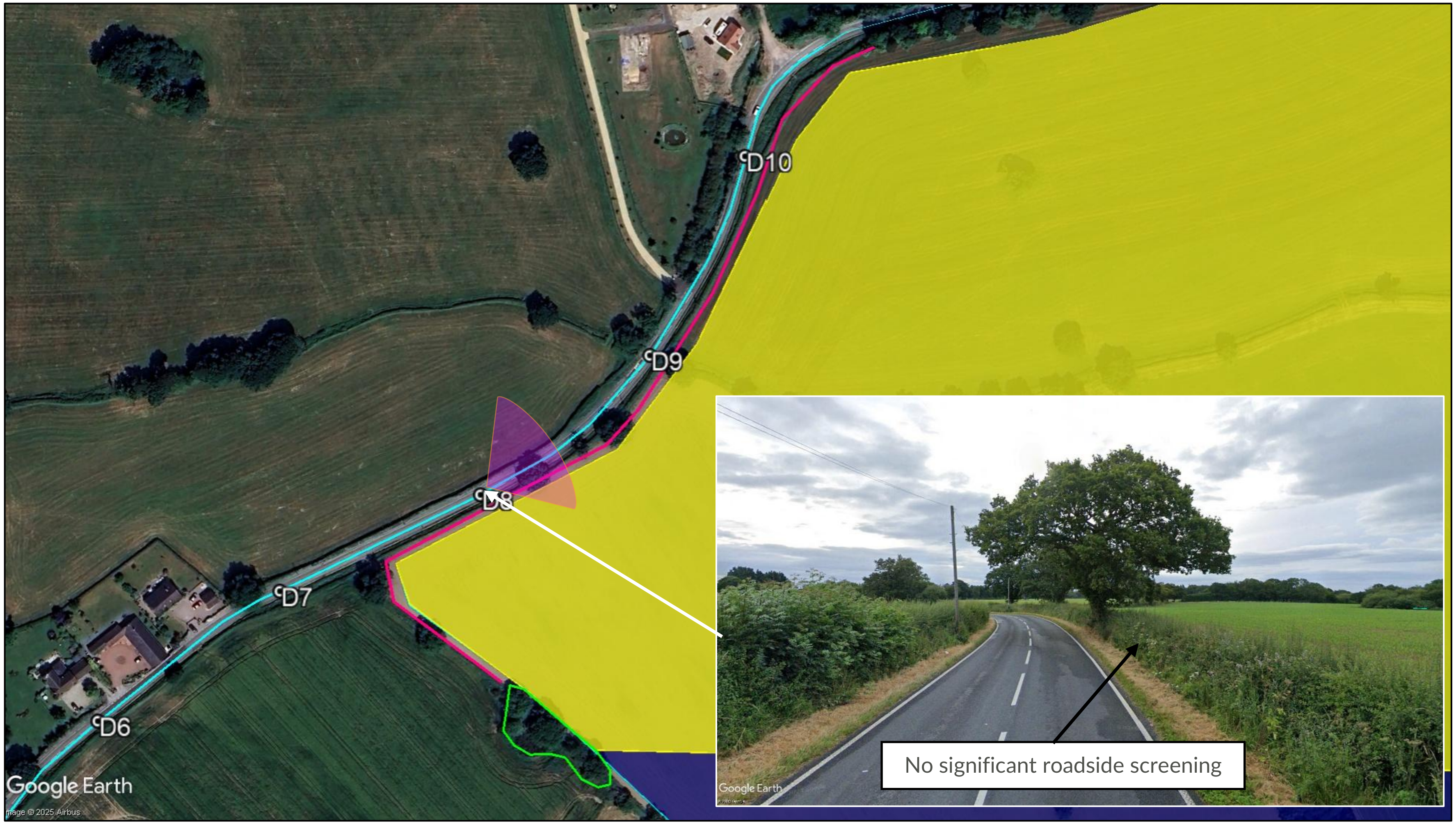

Figure 13 *Reflective panel area and proposed screening for road receptors D6 to D10*

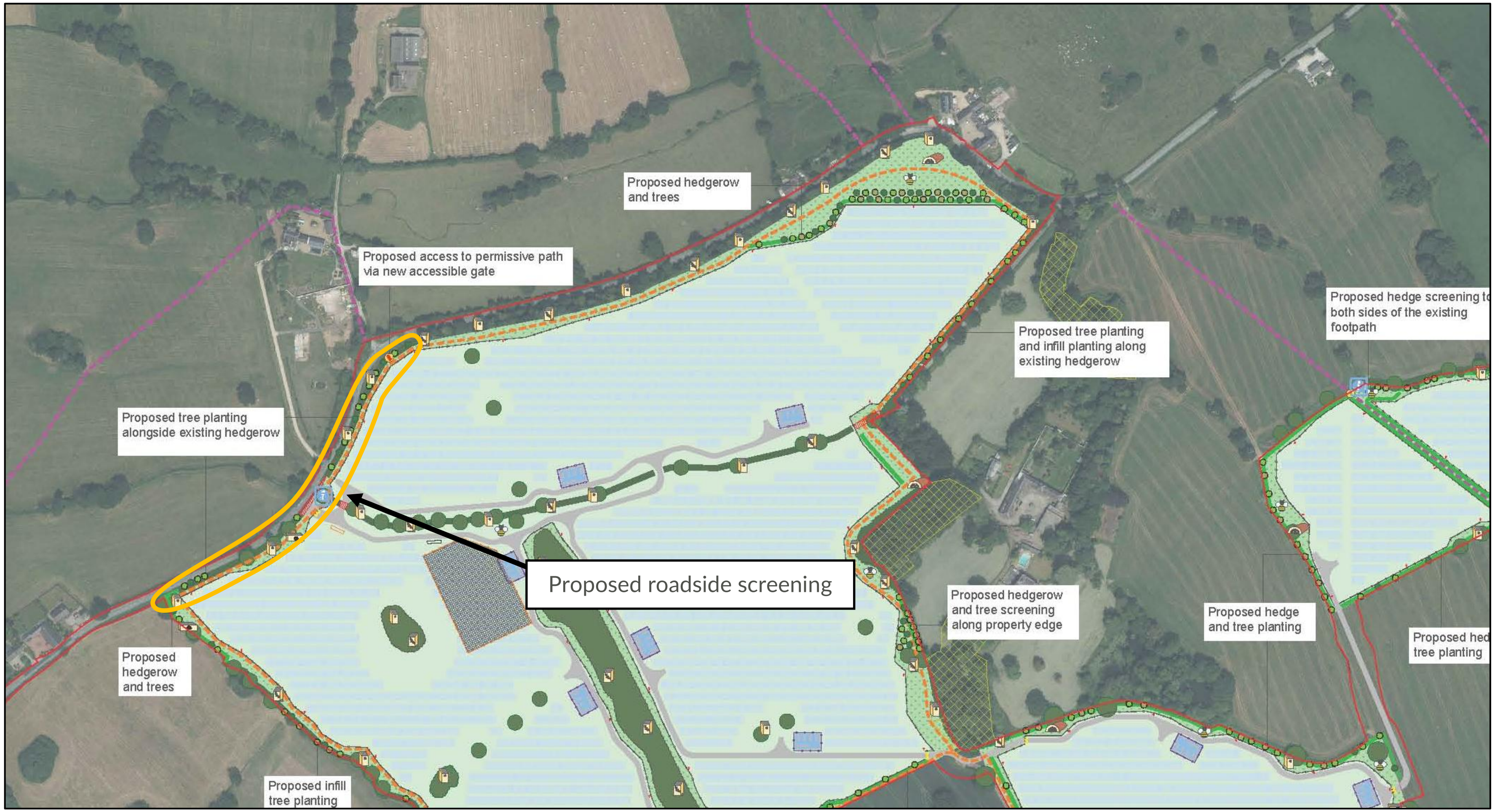

Figure 14 *Proposed screening within mitigation plan relevant to road receptors D6 to D10*

5.5.2 Dwelling Mitigation

A moderate impact has been predicted upon two dwelling receptors.

The locations identified for proposed screening is shown as the pink line in Figure 15 on the following page. This screening could be in the form of planting or a fence and should be of a height such that views of the reflecting panels are obscured from the view of the affected dwellings.

If vegetation is used, it should be ensured that the screening significantly obstructs the reflecting panels during the periods when solar reflections are geometrically possible, mid-March until late-September.

Review of the latest Landscape Masterplan[18] shows proposed vegetation screening of sufficient height between the reflecting panels and the affected receptors such that the impact will be reduced to low, or no, impact, once grown to a sufficient height. The relevant proposed screening has been highlighted in Figure 16 on page 50.

[18] Site Layout Masterplan-Eastern Array PDF

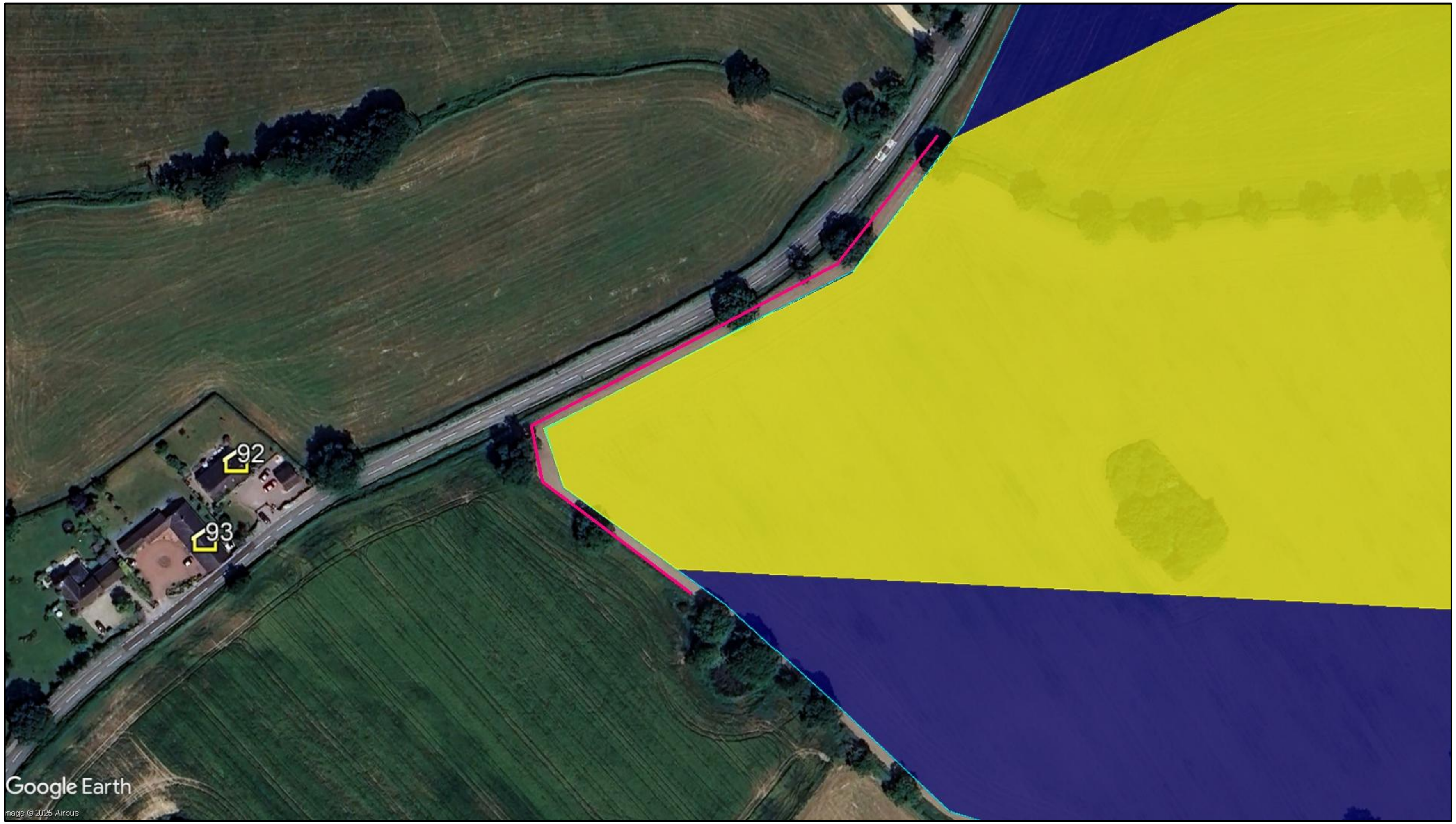

Figure 15 *Reflective panel area and proposed screening for dwelling receptors 92 and 93*

Figure 16 *Proposed screening within mitigation plan relevant to dwelling receptors 92 and 93*

6 HIGH-LEVEL AVIATION CONSIDERATIONS

6.1 Overview

Glint and glare assessment for aviation receptors are typically undertaken for licensed aerodromes within 10km of a proposed solar development. Geometric modelling for GA aerodromes is typically required within 5km of a proposed development. At ranges of 10-20km, the requirement for assessment is much less common particularly for unlicensed aerodromes. Assessment of any aviation effects for developments over 20km is not a usual requirement.

The following section presents an overview of the possible effects of glint and glare concerning aviation activity at Chirk Airfield and Trench Farm Airfield.

The approximate distances of the airfields relative to the proposed development are listed below:

- Chirk Airfield: 6.5km southwest;
- Trench Farm Airfield: 6.5km southeast.

The locations of the aerodromes relative to the proposed development and splayed 1-mile runway approach paths are shown in Figure 17 on the following page.

6.2 Aerodrome Details

6.2.1 Chirk Airfield

Chirk Airfield is an unlicenced airfield and not understood to have an ATC Tower. The aerodrome has one runway, the details of which are presented below[19]:

- 01/19 500 x 20 metres (grass);
- 15/33 measuring 400 x 20 metres (grass).

6.2.2 Trench Farm Airfield

Trench Farm Airfield is an unlicenced airfield and not understood to have an ATC Tower. The aerodrome has one runway, the details of which are presented below[18]:

- 18/36 measuring 500 x 10 metres (grass).

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[19] As determined by aerial imagery.

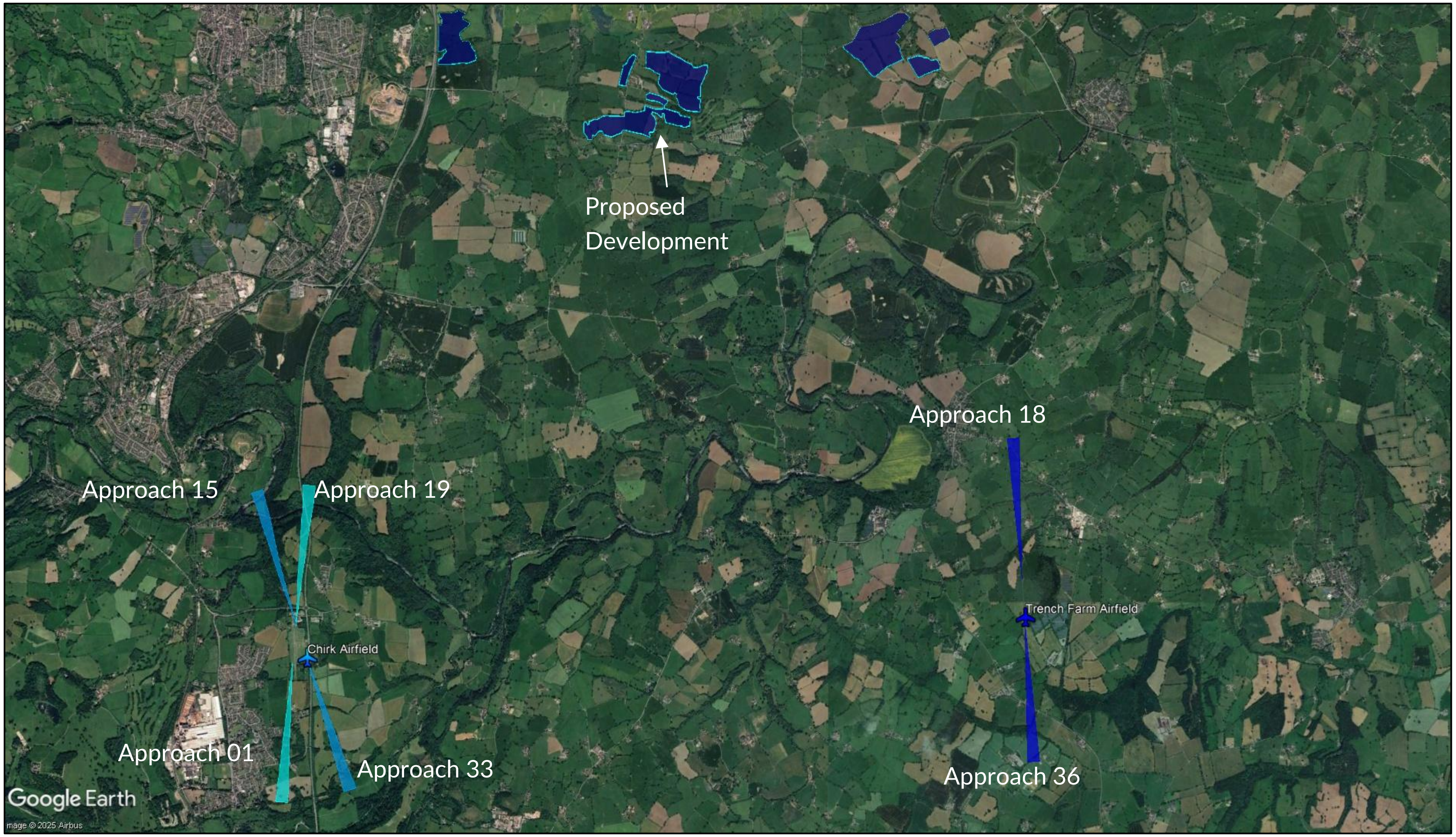

Figure 17 *Location of the aerodromes relative to the proposed solar development*

6.3 High-Level Assessment Conclusions

The proposed development size, distance between the aerodrome and proposed development, geometric results for Plassey Airfield assessed in this report, and industry experience are considered during the assessment.

6.3.1 Chirk Airfield

For aviation activity associated with Chirk Airfield, the following can be concluded:

- Any solar reflections towards pilots approaching runway thresholds 15 and 19 will be outside a pilot's primary field-of-view. This level of glare is acceptable in accordance with the associated guidance and industry best practice;
- It is also predicted that any solar reflections towards pilots approaching runway thresholds 01 and 33 would have intensities no greater than 'low potential for temporary after image'. This level of glare is acceptable in accordance with the associated guidance and industry best practice.

No significant impacts are predicted upon aviation activity associated with Chirk Airfield. Mitigation is not required, and detailed modelling is not recommended.

6.3.2 Trench Farm Airfield

For aviation activity associated with Trench Farm Airfield, the following can be concluded:

- Any solar reflections towards pilots approaching runway threshold 18 will be outside a pilot's primary field-of-view. This level of glare is acceptable in accordance with the associated guidance and industry best practice;
- It is also predicted that any solar reflections towards pilots approaching runway threshold 36 would have intensities no greater than 'low potential for temporary after image'. This level of glare is acceptable in accordance with the associated guidance and industry best practice.

No significant impacts are predicted upon aviation activity associated with Trench Farm Airfield. Mitigation is not required, and detailed modelling is not recommended.

7 HIGH-LEVEL PUBLIC RIGHTS OF WAY ASSESSMENT

7.1 Overview

The following sections present an overview of considerations for public rights of way (PRoW) and Areas of Natural Beauty (AONB) regarding the proposed development.

7.2 Assessment

In Pager Power's experience, significant impacts from glint and glare are not possible upon pedestrians/observers along PRoW. The reasoning is due to the sensitivity of the receptors (in terms of amenity and safety) being concluded to be of low significance due to:

- The typical density of pedestrians at these locations is usually low;
- Any resultant effect is much less serious and has far lesser consequences than, for example, solar reflections experienced towards a road network whereby the resultant impacts of a solar reflection can be much more serious to safety;
- Glint and glare effects towards receptors are transient, and time and location sensitive whereby a pedestrian could move beyond the solar reflection zone with ease with little impact upon safety or amenity;
- There is no safety hazard associated with reflections towards an observer on a footpath.

Furthermore, any impact will be of a low magnitude when considering the worst case due-to:

- The existing and proposed screening is predicted significantly reduce/obstruct the visibility of the proposed development for pedestrian/observers;
- The reflection intensity is similar for solar panels and still water (and significantly less than reflections from glass and steel[20]) which is frequently a feature of the outdoor environment. Therefore, the reflections are likely to be comparable to those from common outdoor sources whilst navigating the natural and built environment on a regular basis.

Figure 18 on the following page[21] shows the boundary of the proposed development (red) and the Clwydian Range and Dee Valley National Landscape (CRDV NL) (orange hash) (previously known as an AONB), the closest part of which is approximately 3.5km northwest of the nearest proposed solar panels. Due to the factors stated above, and that the nearest section of the AONB is over 3.5km from the nearest proposed panels and north of the development (see Section 4.3), no significant effects arising from glint and glare are predicted towards CRDV NL.

7.3 Conclusions

No significant impact is predicted upon public rights of way or Clwydian Range and Dee Valley National Landscape, and mitigation is not required.

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[20] SunPower, 2009, SunPower Solar Module Glare and Reflectance (appendix to Solargen Energy, 2010).

[21] Source 'Figure 6.1 - Landscape Character and Designations_v3' PDF, Edited

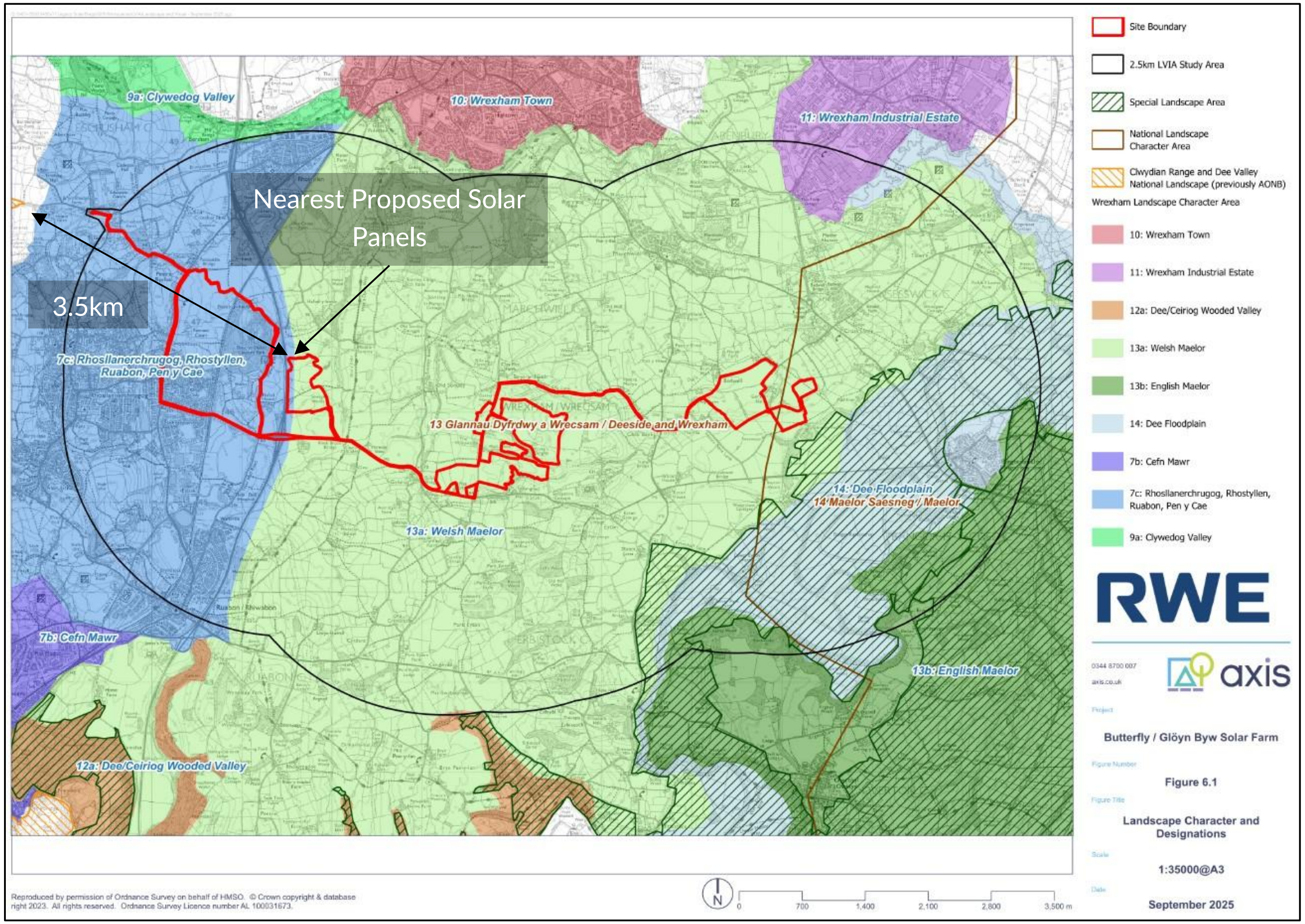

Figure 18 *Location of the Clwydian Range and Dee Valley National Landscape relative to the proposed solar development*

8 OVERALL CONCLUSIONS

8.1 Assessment Results – Aviation Activity

Solar reflections with intensities 'potential for temporary after-image' ('yellow' glare) are predicted towards the splayed approached paths for runway and 01/19 at Plassey Airfield. Due to the reflections coinciding with the sun, a much more significant source of glare, and the low volume of air traffic expected at the private airfield, a low impact is predicted.

Solar reflections with 'low-potential for temporary after-image' ('green' glare) are geometrically possible towards the final sections of the visual circuit and base leg joins for runway thresholds 01 and 19. This intensity of glare is acceptable in accordance with the associated guidance (Appendix D) for licensed aerodromes, and therefore considered acceptable also for these receptors. A low impact is predicted, and mitigation is not required.

It is recommended that this report is shared with the safeguarding team of Plassey Airfield to determine their position on the proposed development.

8.2 Assessment Results – Road Safety

Solar reflections are geometrically possible towards sections of the A483, B5426, A528 and the B5130.

Screening in the form of existing vegetation or existing buildings is predicted to significantly obstruct views of reflecting panels such that solar reflections will not be experienced by road users along the A483, the B5426, the BA528 and 1km of the B5130. **No impact is predicted along these sections, and accordingly mitigation is not required.**

For 200m of the B5130, no relevant screening was identified. Reflections do not occur directly in front of the road user. A moderate impact is predicted, mitigation is recommended (see Section 5.5.1). **Review of the Landscape Masterplan shows proposed vegetation screening such that impact will be reduced to low, or no, impact.**

For the remaining 100m section of the B5130, no relevant screening has been identified. A high impact is predicted, and mitigation is required (see Section 5.5.1). **Review of the Landscape Masterplan shows proposed vegetation screening such that impact will be reduced to low, or no, impact.**

8.3 Assessment Results – Residential Amenity

Solar reflections are geometrically possible towards 95 of the 123 assessed dwellings.

For 42 of the dwellings, screening in the form of existing vegetation and/or intervening terrain is predicted to significantly obstruct views of reflecting panels such that solar reflections will not be experienced by residents. **No impact is predicted, and mitigation is not required.**

For one of the dwellings, existing vegetation or intervening terrain is predicted to partially obstruct views of reflecting panels for an observer on the ground floor, the remaining visible reflecting panels will have a separation distance of over 900m. **A low impact is predicted, and mitigation is not recommended.**

For 10 of the dwellings, existing vegetation and or intervening terrain is predicted to partially obstruct views of reflecting panels such that for an observer on the ground floor views of the reflecting panels will not be possible. **A low impact is predicted, and mitigation is not recommended.**

For the remaining two dwellings, reflections are predicted to occur for less than an hour on any given day, and for more than three months of the year. No significant screening has been identified. A moderate impact is predicted, and mitigation is recommended (see Section 5.5.2). **Review of the Landscape Masterplan shows proposed vegetation screening such that impact will be reduced to low, or no, impact.**

8.4 Assessment Conclusions - High Level Aviation

For aviation activity associated with Chirk Airfield and Trench Farm Airfield any solar reflections are predicted to be acceptable in accordance with the associated guidance due to the following two factors:

- Glare intensities towards approaches towards thresholds in the direction of the proposed development are predicted to be no greater than 'low potential for temporary after-image';
- Any possible solar reflections will be outside the pilot's field-of-view for pilots approaching runway thresholds directed away from the proposed development.

Therefore, no significant impacts are predicted upon aviation activity Chirk Airfield and Trench Farm Airfield and detailed modelling is not recommended.

8.5 Assessment Conclusions – High-Level Public Rights of Way

No significant impacts upon public rights of way or Areas of Natural Beauty are predicted due to the sensitivity of the receptors (in terms of amenity and safety) being of low significance, existing and proposed screening, and the location and distance of the nearest Area of Natural Beauty relative to the proposed development.

8.6 Overall Conclusions

When considering proposed screening, no significant impacts are predicted upon road safety or dwelling amenity. Further mitigation is not required.

No significant impact is predicted upon aviation activity, public rights of way or Areas of Natural Beauty. Mitigation is not recommended.

APPENDIX A – OVERVIEW OF GLINT AND GLARE GUIDANCE

Overview

This section presents details regarding the relevant guidance and studies with respect to the considerations and effects of solar reflections from solar panels, known as 'Glint and Glare'.

This is not a comprehensive review of the data sources, rather it is intended to give an overview of the important parameters and considerations that have informed this assessment.

UK Planning Policy

National Policy Statement for Renewable Energy Infrastructure

The National Policy Statement for Renewable Energy Infrastructure (EN-3)[22] sets out the primary policy for decisions by the Secretary of State for nationally significant renewable energy infrastructure. Sections 2.10.102-106 state:

'2.10.102 Solar panels are specifically designed to absorb, not reflect, irradiation.[23] However, solar panels may reflect the sun's rays at certain angles, causing glint and glare. Glint is defined as a momentary flash of light that may be produced as a direct reflection of the sun in the solar panel. Glare is a continuous source of excessive brightness experienced by a stationary observer located in the path of reflected sunlight from the face of the panel. The effect occurs when the solar panel is stationed between or at an angle of the sun and the receptor.

2.10.103 Applicants should map receptors to qualitatively identify potential glint and glare issues and determine if a glint and glare assessment is necessary as part of the application.

2.10.104 When a quantitative glint and glare assessment is necessary, applicants are expected to consider the geometric possibility of glint and glare affecting nearby receptors and provide an assessment of potential impact and impairment based on the angle and duration of incidence and the intensity of the reflection.

2.10.105 The extent of reflectivity analysis required to assess potential impacts will depend on the specific project site and design. This may need to account for 'tracking' panels if they are proposed as these may cause differential diurnal and/or seasonal impacts.

2.10.106 When a glint and glare assessment is undertaken, the potential for solar PV panels, frames and supports to have a combined reflective quality may need to be assessed, although the glint and glare of the frames and supports is likely to be significantly less than the panels.'

[22] National Policy Statement for Renewable Energy Infrastructure (EN-3), Department for Energy Security & Net Zero, date: January 2024.

[23] *'Most commercially available solar panels are designed with anti-reflective glass or are produced with anti-reflective coating and have a reflective capacity that is generally equal to or less hazardous than other objects typically found in the outdoor environment, such as bodies of water or glass buildings.'*

The EN-3 does not state which receptors should be considered as part of a quantitative glint and glare assessment. Based on Pager Power's extensive project experience, typical receptors include residential dwellings, road users, aviation infrastructure, and railway infrastructure.

Sections 2.10.134-136 state:

'2.10.134 Applicants should consider using, and in some cases the Secretary of State may require, solar panels to comprise of (or be covered with) anti-glare/anti-reflective coating with a specified angle of maximum reflection attenuation for the lifetime of the permission.

2.10.135 Applicants may consider using screening between potentially affected receptors and the reflecting panels to mitigate the effects.

2.10.136 Applicants may consider adjusting the azimuth alignment of or changing the elevation tilt angle of a solar panel, within the economically viable range, to alter the angle of incidence. In practice this is unlikely to remove the potential impact altogether but in marginal cases may contribute to a mitigation strategy.'

The mitigation strategies listed within the EN-3 are relevant strategies that are frequently utilised to eliminate or reduce glint and glare effects towards surrounding observers. The most common form of mitigation is the implementation of screening along the site boundary.

Sections 2.10.158-159 state:

2.10.158 Solar PV panels are designed to absorb, not reflect, irradiation. However, the Secretary of State should assess the potential impact of glint and glare on nearby homes, motorists, public rights of way, and aviation infrastructure (including aircraft departure and arrival flight paths).

2.10.159 Whilst there is some evidence that glint and glare from solar farms can be experienced by pilots and air traffic controllers in certain conditions, there is no evidence that glint and glare from solar farms results in significant impairment on aircraft safety. Therefore, unless a significant impairment can be demonstrated, the Secretary of State is unlikely to give any more than limited weight to claims of aviation interference because of glint and glare from solar farms.

The EN-3 goes some way in acknowledging that the issue is more complex than presented in the early draft issues; though, this is still unlikely to be welcomed by aviation stakeholders, who will still request a glint and glare assessment on the basis that glare may lead to a potentially significant impact upon aviation safety.

Finally, the EN-3 relates solely to nationally significant renewable energy infrastructure and therefore does not apply to all planning applications for solar farms.

Assessment Process – Ground-Based Receptors

No process for determining and contextualising the effects of glint and glare has been determined when assessing the impact of solar reflections upon surrounding roads and dwellings. Therefore, the Pager Power approach is to determine whether a reflection from the proposed solar development is geometrically possible and then to compare the results against the relevant guidance/studies to determine whether the reflection is significant.

The Pager Power approach has been informed by the policy presented above, current studies (presented in Appendix B) and stakeholder consultation. Further information can be found in Pager Power's Glint and Glare Guidance document[24] which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

Aviation Assessment Guidance

The UK Civil Aviation Authority (CAA) issued interim guidance relating to Solar Photovoltaic Systems (SPV) on 17 December 2010 and was subject to a CAA information alert 2010/53. The formal policy was cancelled on September 7th, 2012[25] however the advice is still applicable[26] until a formal policy is developed. The relevant aviation guidance from the CAA is presented in the section below.

CAA Interim Guidance

This interim guidance makes the following recommendations (p.2-3):

'8. It is recommended that, as part of a planning application, the SPV developer provide safety assurance documentation (including risk assessment) regarding the full potential impact of the SPV installation on aviation interests.

9. Guidance on safeguarding procedures at CAA licensed aerodromes is published within CAP 738 Safeguarding of Aerodromes and advice for unlicensed aerodromes is contained within CAP 793 Safe Operating Practices at Unlicensed Aerodromes.

10. Where proposed developments in the vicinity of aerodromes require an application for planning permission the relevant LPA normally consults aerodrome operators or NATS when aeronautical interests might be affected. This consultation procedure is a statutory obligation in the case of certain major airports, and may include military establishments and certain air traffic surveillance technical sites. These arrangements are explained in Department for Transport Circular 1/2003 and for Scotland, Scottish Government Circular 2/2003.

11. In the event of SPV developments proposed under the Electricity Act, the relevant government department should routinely consult with the CAA. There is therefore no requirement for the CAA to be separately consulted for such proposed SPV installations or developments.

12. If an installation of SPV systems is planned on-aerodrome (i.e. within its licensed boundary) then it is recommended that data on the reflectivity of the solar panel material should be included in any assessment before installation approval can be granted. Although approval for installation is the responsibility of the ALH[27], as part of a condition of a CAA Aerodrome Licence, the ALH is required to obtain prior consent from CAA Aerodrome Standards Department before any work is begun or approval to the developer or LPA is granted, in accordance with the procedures set out in CAP 791 Procedures for Changes to Aerodrome Infrastructure.

[24] Solar Photovoltaic Development Glint and Glare Guidance, Fourth Edition, September 2022. Pager Power.
[25] Archived at Pager Power
[26] Reference email from the CAA dated 19/05/2014.
[27] Aerodrome Licence Holder.

13. During the installation and associated construction of SPV systems there may also be a need to liaise with nearby aerodromes if cranes are to be used; CAA notification and permission is not required.

14. The CAA aims to replace this informal guidance with formal policy in due course and reserves the right to cancel, amend or alter the guidance provided in this document at its discretion upon receipt of new information.

15. Further guidance may be obtained from CAA's Aerodrome Standards Department via aerodromes@caa.co.uk.'

FAA Guidance

The most comprehensive guidelines available for the assessment of solar developments near aerodromes has been produced by the United States Federal Aviation Administration (FAA). The first guidelines were produced initially in November 2010 and updated in 2013. A final policy was released in 2021, which superseded the interim guidance.

The 2010 document is entitled '*Technical Guidance for Evaluating Selected Solar Technologies on Airports'*[28], the 2013 update is entitled '*Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports'*[29], and the 2021 final policy is entitled '*Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports'*[30].

Key excerpts from the final policy are presented below:

Initially, FAA believed that solar energy systems could introduce a novel glint and glare effect to pilots on final approach. FAA has subsequently concluded that in most cases, the glint and glare from solar energy systems to pilots on final approach is similar to glint and glare pilots routinely experience from water bodies, glass-façade buildings, parking lots, and similar features. However, FAA has continued to receive reports of potential glint and glare from on-airport solar energy systems on personnel working in ATCT cabs. Therefore, FAA has determined the scope of agency policy should be focused on the impact of on-airport solar energy systems to federally-obligated towered airports, specifically the airport's ATCT cab.

The policy in this document updates and replaces the previous policy by encouraging airport sponsors to conduct an ocular analysis of potential impacts to ATCT cabs prior to submittal of a Notice of Proposed Construction or Alteration Form 7460-1 (hereinafter Form 7460-1). Airport sponsors are no longer required to submit the results of an ocular analysis to FAA. Instead, to demonstrate compliance with 14 CFR 77.5(c), FAA will rely on the submittal of Form 7460-1 in which the sponsor confirms that it has analyzed the potential for glint and glare and determined there is no potential for ocular impact to the airport's ATCT cab. This process will enable FAA to evaluate the solar energy system project, with assurance that the system will not impact the ATCT cab.

FAA encourages airport sponsors of federally-obligated towered airports to conduct a sufficient analysis to support their assertion that a proposed solar energy system will not result in ocular impacts. There are several tools available on the open market to airport sponsors that can analyze potential glint and glare to an ATCT cab. For proposed systems that will clearly not impact ATCT cabs (e.g., on-airport solar energy systems that are blocked from the ATCT cab's view by another structure), the use of such tools may not be necessary to support the assertion that a proposed solar energy system will not result in ocular impacts.

The excerpt above states where a solar PV development is to be located on a federally obligated aerodrome with an ATC Tower, it will require a glint and glare assessment to accompany its

[28] Archived at Pager Power

[29] Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports, Department of Transportation, Federal Aviation Administration (FAA), date: 10/2013, accessed on: 08/12/2021.

[30] Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports, Federal Aviation Administration, date: May 2021, accessed on: 08/12/2021.

application. It states that pilots on approach are no longer a specific assessment requirement due to effects from solar energy systems being similar to glint and glare pilots routinely experience from water bodies, glass-façade buildings, parking lots, and similar features. Ultimately it comes down to the specific aerodrome to ensure it is adequately safeguarded, and it is on this basis that glint and glare assessments are routinely still requested.

The policy also states that several different tools and methodologies can be used to assess the impacts of glint and glare, which was previously required to be undertaken by the Solar Glare Hazard Analysis Tool (SGHAT) using the Sandia National Laboratories methodology.

In 2018, the FAA released the latest version (Version 1.1) of the '*Technical Guidance for Evaluating Selected Solar Technologies on Airports'*[31]. Whilst the 2021 final policy also supersedes this guidance, many of the points are still relevant because aerodromes are still safeguarding against glint and glare irrespective of the FAA guidance. The key points are presented below for reference:

- *Reflectivity refers to light that is reflected off surfaces. The potential effects of reflectivity are glint (a momentary flash of bright light) and glare (a continuous source of bright light). These two effects are referred to hereinafter as "glare," which can cause a brief loss of vision, also known as flash blindness*[32]*.*
- *The amount of light reflected off a solar panel surface depends on the amount of sunlight hitting the surface, its surface reflectivity, geographic location, time of year, cloud cover, and solar panel orientation.*
- *As illustrated on Figure 16*[33]*, flat, smooth surfaces reflect a more concentrated amount of sunlight back to the receiver, which is referred to as specular reflection. The more a surface is polished, the more it shines. Rough or uneven surfaces reflect light in a diffused or scattered manner and, therefore, the light will not be received as bright.*
- *Because the FAA has no specific standards for airport solar facilities and potential glare, the type of glare analysis may vary. Depending on site specifics (e.g., existing land uses, location and size of the project) an acceptable evaluation could involve one or more of the following levels of assessment:*
    - *A qualitative analysis of potential impact in consultation with the Control Tower, pilots and airport officials;*
    - *A demonstration field test with solar panels at the proposed site in coordination with FAA Tower personnel;*
    - *A geometric analysis to determine days and times when an impact is predicted.*

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[31] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 08/12/2021.
[32] Flash Blindness, as described in the FAA guidelines, can be described as a temporary visual interference effect that persists after the source of illumination has ceased. This occurs from many reflective materials in the ambient environment.
[33] First figure in Appendix B.

- *The extent of reflectivity analysis required to assess potential impacts will depend on the specific project site and system design.*
- ***1. Assessing Baseline Reflectivity Conditions** – Reflection in the form of glare is present in current aviation operations. The existing sources of glare come from glass windows, auto surface parking, rooftops, and water bodies. At airports, existing reflecting surfaces may include hangar roofs, surface parking, and glassy office buildings. To minimize unexpected glare, windows of air traffic control towers and airplane cockpits are coated with anti-reflective glazing. Operators also wear polarized eye wear. Potential glare from solar panels should be viewed in this context. Any airport considering a solar PV project should first review existing sources of glare at the airport and the effectiveness of measures used to mitigate that glare.*
- ***2. Tests in the Field** – Potential glare from solar panels can easily be viewed at the airport through a field test. A few airports have coordinated these tests with FAA Air Traffic Controllers to assess the significance of glare impacts. To conduct such a test, a sponsor can take a solar panel out to proposed location of the solar project, and tilt the panel in different directions to evaluate the potential for glare onto the air traffic control tower. For the two known cases where a field test was conducted, tower personnel determined the glare was not significant. If there is a significant glare impact, the project can be modified by ensuring panels are not directed in that direction.*
- ***3. Geometric Analysis** – Geometric studies are the most technical approach for reflectivity issues. They are conducted when glare is difficult to assess through other methods. Studies of glare can employ geometry and the known path of the sun to predict when sunlight will reflect off of a fixed surface (like a solar panel) and contact a fixed receptor (e.g., control tower). At any given site, the sun moves across the sky every day and its path in the sky changes throughout year. This in turn alters the destination of the resultant reflections since the angle of reflection for the solar panels will be the same as the angle at which the sun hits the panels. The larger the reflective surface, the greater the likelihood of glare impacts.*
- *Facilities placed in remote locations, like the desert, will be far from receptors and therefore potential impacts are limited to passing aircraft. Because the intensity of the light reflected from the solar panel decreases with increasing distance, an appropriate question is how far you need to be from a solar reflected surface to avoid flash blindness. It is known that this distance is directly proportional to the size of the array in question*[34] *but still requires further research to definitively answer.*
- ***Experiences of Existing Airport Solar Projects** – Solar installations are presently operating at a number of airports, including megawatt-sized solar facilities covering multiple acres. Air traffic control towers have expressed concern about glint and glare from a small number of solar installations. These were often instances when solar installations were sited between the tower and airfield, or for installations with inadequate or no reflectivity analysis.*

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[34] Ho, Clifford, Cheryl Ghanbari, and Richard Diver. 2009. Hazard Analysis of Glint and Glare From Concentrating Solar Power Plants. SolarPACES 2009, Berlin Germany. Sandia National Laboratories.

Adequate reflectivity analysis and alternative siting addressed initial issues at those installations.

Air Navigation Order (ANO) 2016

In some instances, an aviation stakeholder can refer to the ANO 2016[35] with regard to safeguarding. Key points from the document are presented below.

Lights liable to endanger

224. (1) A person must not exhibit in the United Kingdom any light which—

(a) by reason of its glare is liable to endanger aircraft taking off from or landing at an aerodrome; or

(b) by reason of its liability to be mistaken for an aeronautical ground light is liable to endanger aircraft.

(2) If any light which appears to the CAA to be a light described in paragraph (1) is exhibited, the CAA may direct the person who is the occupier of the place where the light is exhibited or who has charge of the light, to take such steps within a reasonable time as are specified in the direction—

(a) to extinguish or screen the light; and

(b) to prevent in the future the exhibition of any other light which may similarly endanger aircraft.

(3) The direction may be served either personally or by post, or by affixing it in some conspicuous place near to the light to which it relates.

(4) In the case of a light which is or may be visible from any waters within the area of a general lighthouse authority, the power of the CAA under this article must not be exercised except with the consent of that authority.

Lights which dazzle or distract

225. A person must not in the United Kingdom direct or shine any light at any aircraft in flight so as to dazzle or distract the pilot of the aircraft.'

The document states that no 'light', 'dazzle' or 'glare' should be produced which will create a detrimental impact upon aircraft safety.

Endangering safety of an aircraft

240. A person must not recklessly or negligently act in a manner likely to endanger an aircraft, or any person in an aircraft.

Endangering safety of any person or property

241. A person must not recklessly or negligently cause or permit an aircraft to endanger any person or property.

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[35] The Air Navigation Order 2016. [online] Available at: <https://www.legislation.gov.uk/uksi/2016/765/contents/made> [Accessed 4 February 2022].

Civil Aviation Authority consolidation of UK Regulation 139/2014

The Civil Aviation Authority (CAA) published a consolidating document[36] of UK regulations, (Implementing Rules, Acceptable Means of Compliance and Guidance Material), in 2023. A summary of material relevant to aerodrome safeguarding is presented below:

(a) The aerodrome operator should have procedures to monitor the changes in the obstacle environment, marking and lighting, and in human activities or land use on the aerodrome and the areas around the aerodrome, as defined in coordination with the CAA. The scope, limits, tasks and responsibilities for the monitoring should be defined in coordination with the relevant air traffic services providers, and with the CAA and other relevant authorities.

(b) The limits of the aerodrome surroundings that should be monitored by the aerodrome operator are defined in coordination with the CAA and should include the areas that can be visually monitored during the inspections of the manoeuvring area.

(c) The aerodrome operator should have procedures to mitigate the risks associated with changes on the aerodrome and its surroundings identified with the monitoring procedures. The scope, limits, tasks, and responsibilities for the mitigation of risks associated to obstacles or hazards outside the perimeter fence of the aerodrome should be defined in coordination with the relevant air traffic services providers, and with the CAA and other relevant authorities.

(d) The risks caused by human activities and land use which should be assessed and mitigated should include:

1. obstacles and the possibility of induced turbulence;
2. the use of hazardous, confusing, and misleading lights;
3. <u>the dazzling caused by large and highly reflective surfaces;</u>
4. sources of non-visible radiation, or the presence of moving, or fixed objects which may interfere with, or adversely affect, the performance of aeronautical communications, navigation and surveillance systems; and
5. non-aeronautical ground light near an aerodrome which may endanger the safety of aircraft and which should be extinguished, screened, or otherwise modified so as to eliminate the source of danger.

[36] https://regulatorylibrary.caa.co.uk/139-2014-pdf/PDF.pdf

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

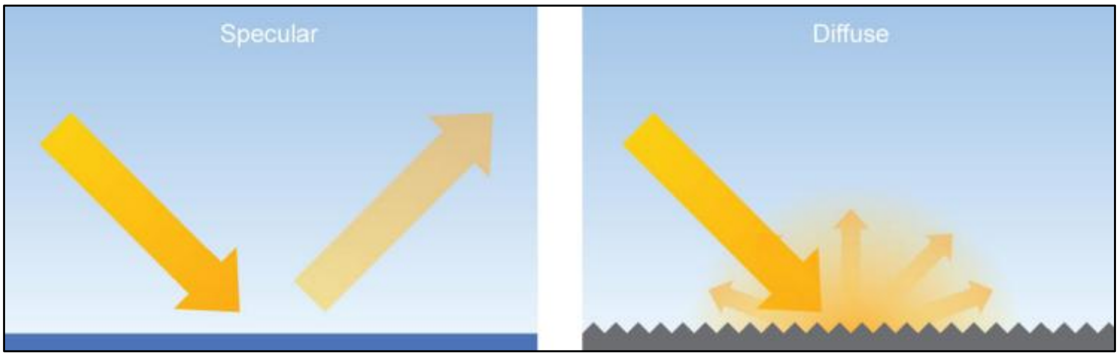
Overview

Studies have been undertaken assessing the type and intensity of solar reflections from various surfaces including solar panels and glass. An overview of these studies is presented below.

The guidelines presented are related to aviation safety. The results are applicable for the purpose of this analysis.

Reflection Type from Solar Panels

Based on the surface conditions reflections from light can be specular and diffuse. A specular reflection has a reflection characteristic similar to that of a mirror; a diffuse will reflect the incoming light and scatter it in many directions. The figure below, taken from the FAA guidance[37], illustrates the difference between the two types of reflections. Because solar panels are flat and have a smooth surface most of the light reflected is specular, which means that incident light from a specific direction is reradiated in a specific direction.



Specular and diffuse reflections

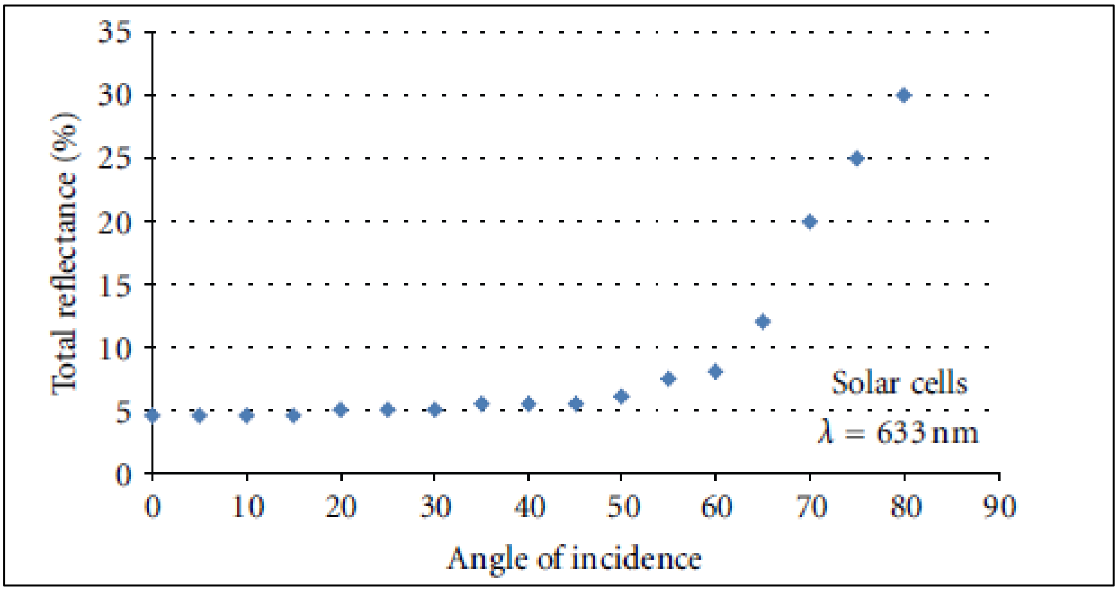
[37] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

Solar Reflection Studies

An overview of content from identified solar panel reflectivity studies is presented in the subsections below.

Evan Riley and Scott Olson, "A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems"

Evan Riley and Scott Olson published in 2011 their study titled: *A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems*[38]". They researched the potential glare that a pilot could experience from a 25 degree fixed tilt PV system located outside of Las Vegas, Nevada. The theoretical glare was estimated using published ocular safety metrics which quantify the potential for a postflash glare after-image. This was then compared to the postflash glare after-image caused by smooth water. The study demonstrated that the reflectance of the solar cell varied with angle of incidence, with maximum values occurring at angles close to 90 degrees. The reflectance values varied from approximately 5% to 30%. This is shown on the figure below.



Total reflectance % when compared to angle of incidence

The conclusions of the research study were:

- The potential for hazardous glare from flat-plate PV systems is similar to that of smooth water;
- Portland white cement concrete (which is a common concrete for runways), snow, and structural glass all have a reflectivity greater than water and flat plate PV modules.

[38] Evan Riley and Scott Olson, "A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems," ISRN Renewable Energy, vol. 2011, Article ID 651857, 6 pages, 2011. doi:10.5402/2011/651857

FAA Guidance – "Technical Guidance for Evaluating Selected Solar Technologies on Airports"[39]

The 2010 FAA Guidance included a diagram which illustrates the relative reflectance of solar panels compared to other surfaces. The figure shows the relative reflectance of solar panels compared to other surfaces. Surfaces in this figure produce reflections which are specular and diffuse. A specular reflection (those made by most solar panels) has a reflection characteristic similar to that of a mirror. A diffuse reflection will reflect the incoming light and scatter it in many directions. A table of reflectivity values, sourced from the figure within the FAA guidance, is presented below.

Surface	Approximate Percentage of Light Reflected[40]
Snow	80
White Concrete	77
Bare Aluminium	74
Vegetation	50
Bare Soil	30
Wood Shingle	17
Water	5
Solar Panels	5
Black Asphalt	2

Relative reflectivity of various surfaces

Note that the data above does not appear to consider the reflection type (specular or diffuse).

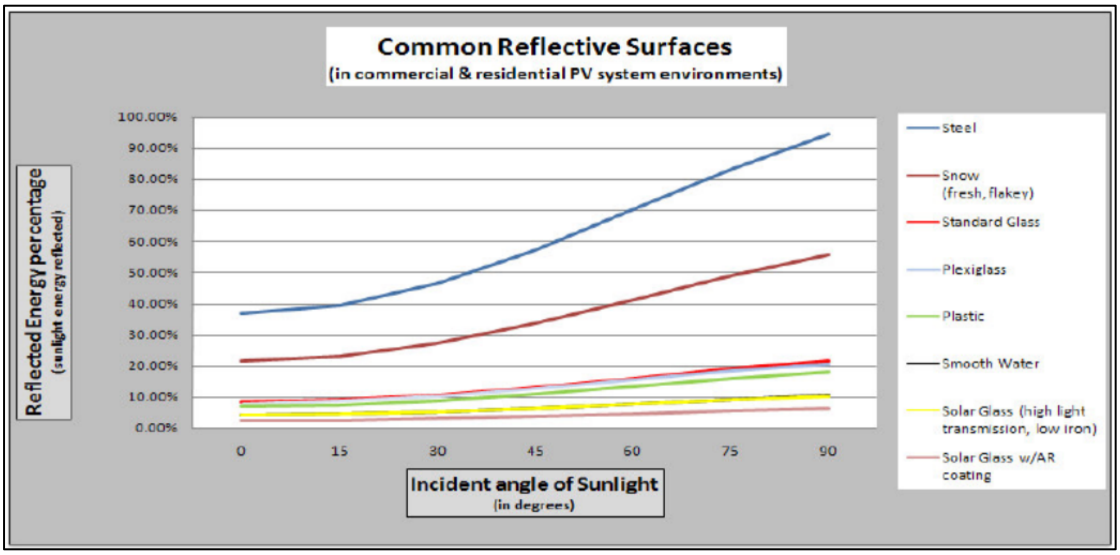
An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel. The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

[39] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.
[40] Extrapolated data, baseline of 1,000 W/m^2 for incoming sunlight.

SunPower Technical Notification (2009)

SunPower published a technical notification[41] to '*increase awareness concerning the possible glare and reflectance impact of PV Systems on their surrounding environment'*.

The figure presented below shows the relative reflectivity of solar panels compared to other natural and manmade materials including smooth water, standard glass and steel.



Common reflective surfaces

The results, similarly to those from Riley and Olsen study (2011) and the FAA (2010), show that solar panels produce a reflection that is less intense than those of '*standard glass and other common reflective surfaces'*.

With respect to aviation and solar reflections observed from the air, SunPower has developed several large installations near airports or on Air Force bases. It is stated that these developments have all passed FAA or Air Force standards with all developments considered "No Hazard to Air Navigation". The note suggests that developers discuss any possible concerns with stakeholders near proposed solar farms.

[41] Source: Technical Support, 2009. SunPower Technical Notification – Solar Module Glare and Reflectance.

APPENDIX C – OVERVIEW OF SUN MOVEMENTS AND RELATIVE REFLECTIONS

The Sun's position in the sky can be accurately described by its azimuth and elevation. Azimuth is a direction relative to true north (horizontal angle i.e. from left to right) and elevation describes the Sun's angle relative to the horizon (vertical angle i.e. up and down).

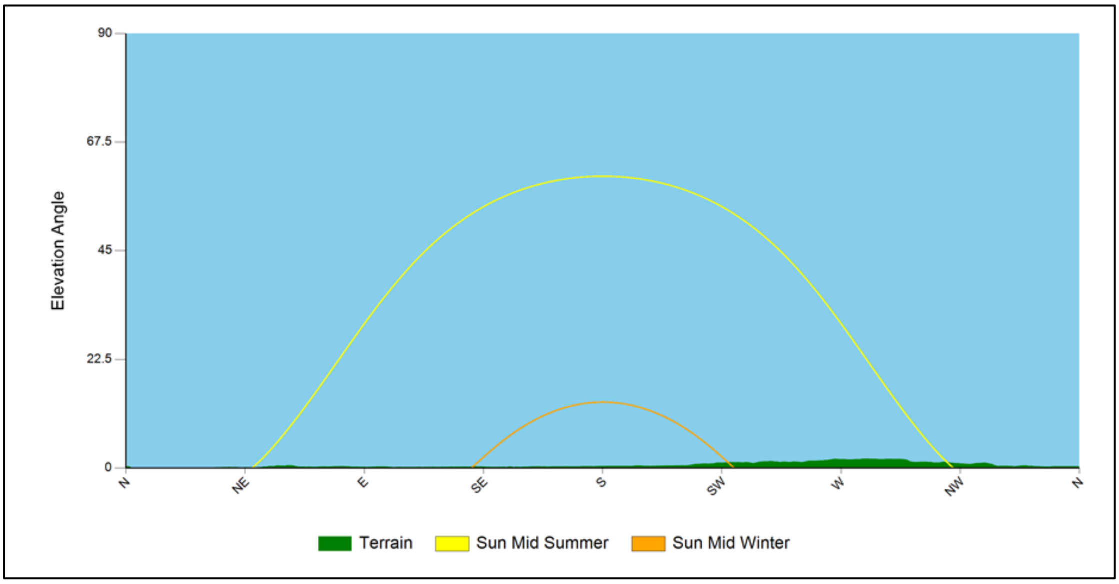
The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

- Time;
- Date;
- Latitude;
- Longitude.

The following is true at the location of the solar development:

- The Sun is at its highest around midday and is to the south at this time;
- The Sun rises highest on 21 June (longest day);
- On 21 December, the maximum elevation reached by the Sun is at its lowest (shortest day).

The combination of the Sun's azimuth angle and vertical elevation will affect the direction and angle of the reflection from a reflector. The figure below shows terrain at the horizon from the proposed development location as well as the sunrise and sunset curves throughout the year.



Terrain at Sun horizon at location of the proposed development

APPENDIX D – GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

The significance of glint and glare will vary for different receptors. The following section presents a general overview of the significance criteria with respect to experiencing a solar reflection.

Impact Significance Definition

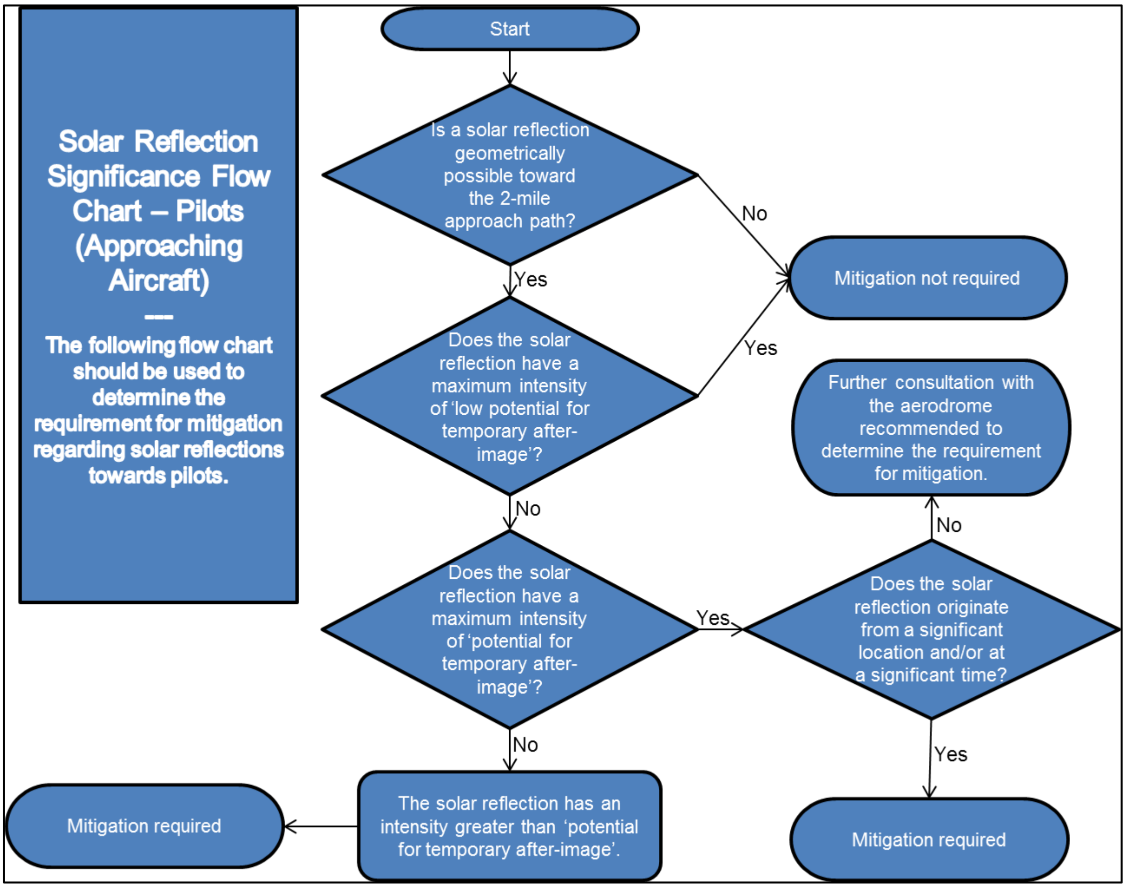
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

Impact Significance	Definition	Mitigation Requirement
No Impact	A solar reflection is not geometrically possible or will not be visible from the assessed receptor.	No mitigation required.
Low	A solar reflection is geometrically possible however any impact is considered to be small such that mitigation is not required e.g. intervening screening will limit the view of the reflecting solar panels significantly.	No mitigation recommended.
Moderate	A solar reflection is geometrically possible and visible however it occurs under conditions that do not represent a worst-case given individual receptor criteria.	Mitigation recommended.
High	A solar reflection is geometrically possible and visible under worst-case conditions that will produce a significant impact given individual receptor criteria	Mitigation will be required if the proposed development is to proceed.

Impact significance definition

Impact Significance Determination for Approaching Aircraft

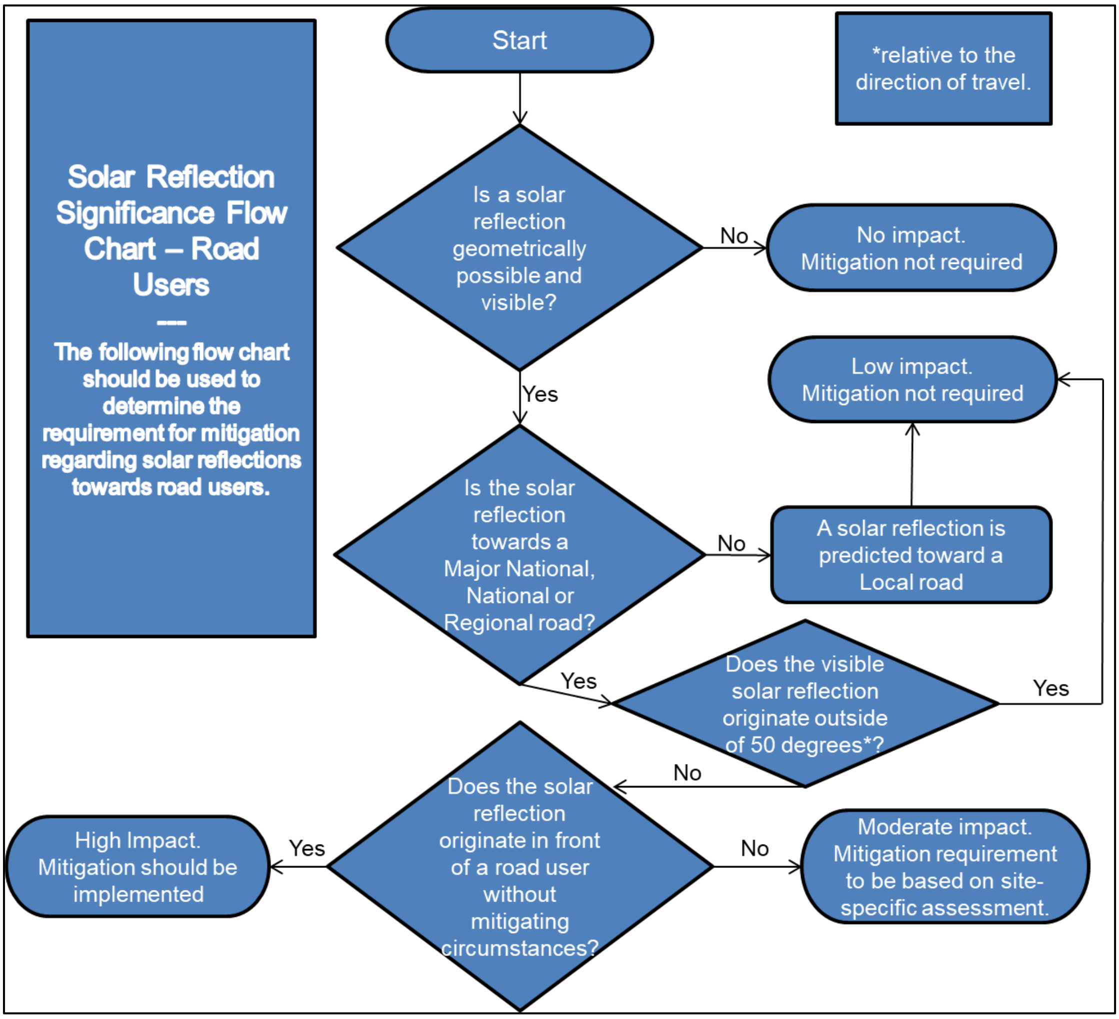
The flow chart presented below has been followed when determining the mitigation requirement for approaching aircraft.



Approaching aircraft receptor mitigation requirement flow chart

Impact Significance Determination for Road Receptors

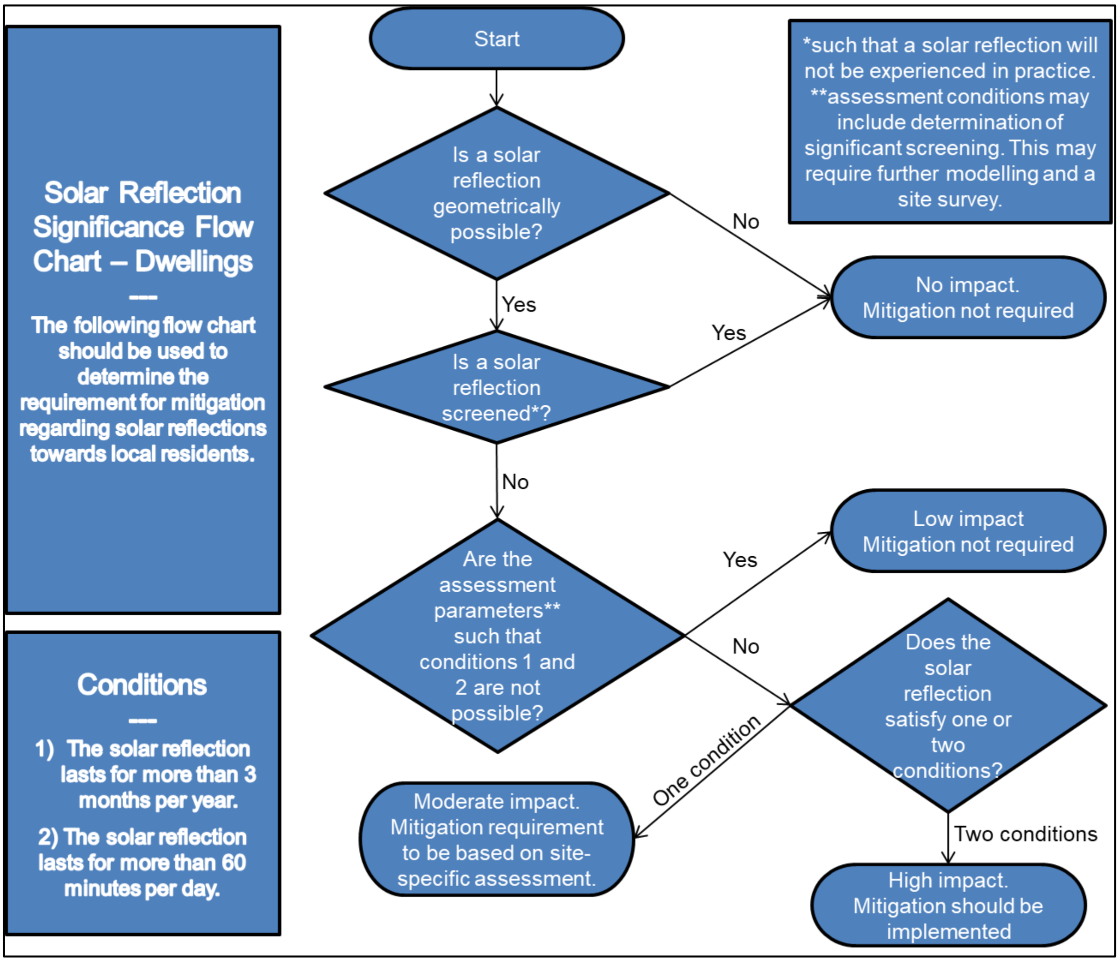
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



Road user impact significance flow chart

Impact Significance Determination for Dwelling Receptors

The flow chart presented below has been followed when determining the mitigation requirement for dwelling receptors.



Dwelling impact significance flow chart

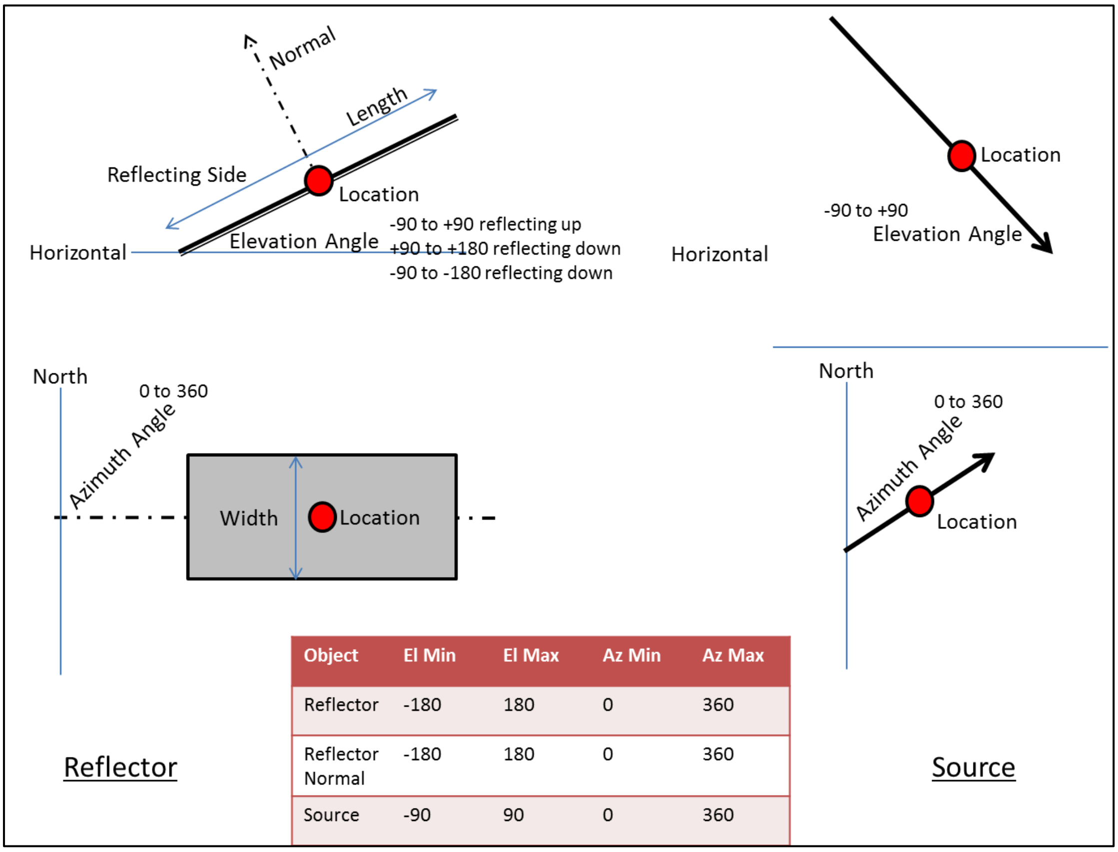
APPENDIX E – REFLECTION CALCULATIONS METHODOLOGY

Pager Power Methodology

The calculations are three dimensional and complex, accounting for:

- The Earth's orbit around the Sun;
- The Earth's rotation;
- The Earth's orientation;
- The reflector's location;
- The reflector's 3D Orientation.

Reflections from a flat reflector are calculated by considering the normal which is an imaginary line that is perpendicular to the reflective surface and originates from it. The diagram below may be used to aid understanding of the reflection calculation process.



Object	El Min	El Max	Az Min	Az Max
Reflector	-180	180	0	360
Reflector Normal	-180	180	0	360
Source	-90	90	0	360

Reflection calculation process

The following process is used to determine the 3D Azimuth and Elevation of a reflection:

- Use the Latitude and Longitude of reflector as the reference for calculation purposes;
- Calculate the Azimuth and Elevation of the normal to the reflector;
- Calculate the 3D angle between the source and the normal;

- If this angle is less than 90 degrees a reflection will occur. If it is greater than 90 degrees no reflection will occur because the source is behind the reflector;
- Calculate the Azimuth and Elevation of the reflection in accordance with the following:
    - The angle between source and normal is equal to angle between normal and reflection;

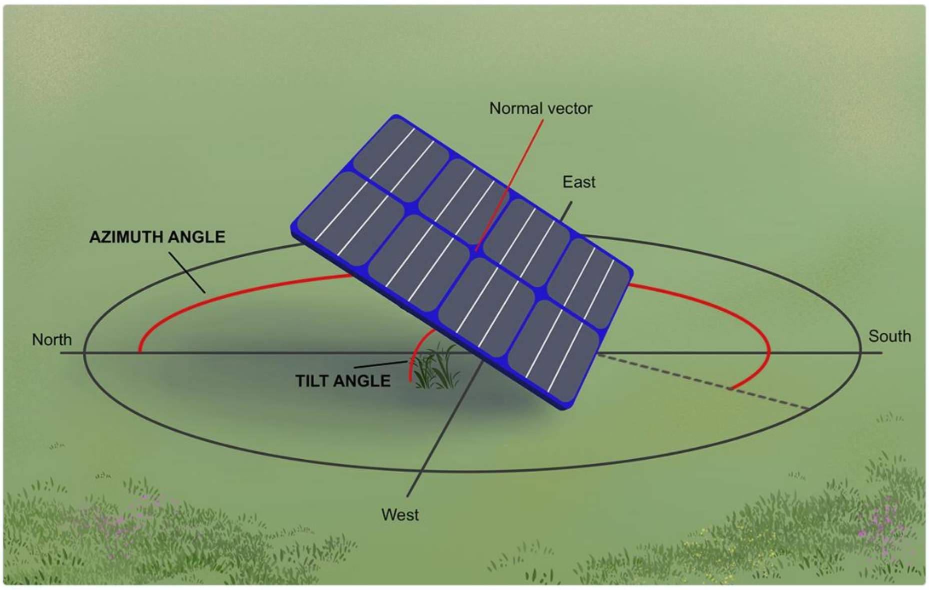
Source, Normal and Reflection are in the same plane.

Forge Reflection Calculations Methodology

Extracts taken from the Forge Solar Model are shown in the figures below and on the following page.

Fixed-Mount Parameters

Fixed-mount PV panels are described by a tilt and orientation. These parameters are referred to as the **module configuration** of the PV array.



PV module orientation/azimuth and tilt. Sample illustrates south-facing module typical in northern hemisphere

Module orientation/azimuth (°)
The azimuthal facing or direction toward which the PV panels are positioned. Orientation is measured clockwise from true north. Panels which face north, which is typical in the southern hemisphere, have an orientation of 0°. Panels which face south, which is typical in the northern hemisphere, have an orientation of 180°. If a known orientation is based on magnetic north, the location-specific declination must be used to determine the orientation from true north.

Module tilt (°)
The elevation angle of the panels, measured up from flat ground. Panels lying flat on the ground (facing up) have a tilt of 0°. Tilt values between 0° and 40° are typical.

Fixed System Parameters

APPENDIX F – ASSESSMENT LIMITATIONS AND ASSUMPTIONS

Forge's Sandia National Laboratories' (SGHAT) Model[42]

Summary of assumptions and abstractions required by the SGHAT/ForgeSolar analysis methodology

1. Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
2. Result data files and plots are now retained for two years after analysis completion. Files should be downloaded and saved if additional persistence is required.
3. The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.
4. Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare. This primarily affects analyses of path receptors.
5. Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including ATCTs. Note that the SGHAT/ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.
6. The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
7. The algorithm assumes that the PV array is aligned with a plane defined by the total heights of the coordinates outlined in the Google map. For more accuracy, the user should perform runs using minimum and maximum values for the vertex heights to bound the height of the plane containing the solar array. Doing so will expand the range of observed solar glare when compared to results using a single height value.
8. The algorithm does not consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
9. The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.
10. The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results. The speed of SGHAT allows expedited sensitivity and parametric analyses.
11. The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
12. Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
13. Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
14. Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
15. PV array tracking assumes the modules move instantly when tracking the sun, and when reverting to the rest position.

[42] https://www.forgesolar.com/help/#assumptions

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Aviation Receptor Data

Full receptor data is available upon request.

Threshold	Longitude (°)	Latitude (°)	Elevation (m amsl)
01	-2.97353	53.00634	61
19	-2.97441	53.00398	65

Aviation Receptor Data

Road Receptor Data

The road receptor data is presented in the tables below. An additional 1.5m height has been added to the elevation to account for the eye-level of a road user.

A483

No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)	No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)
A1	52.99852	-3.02668	101.50	A10	53.00625	-3.02287	101.12
A2	52.99933	-3.02603	101.50	A11	53.00714	-3.02270	101.50
A3	53.00016	-3.02545	101.50	A12	53.00804	-3.02259	101.50
A4	53.00100	-3.02492	101.50	A13	53.00894	-3.02254	101.50
A5	53.00185	-3.02446	101.45	A14	53.00984	-3.02251	101.50
A6	53.00272	-3.02405	100.93	A15	53.01074	-3.02255	101.12
A7	53.00359	-3.02369	100.50	A16	53.01163	-3.02261	101.50
A8	53.00447	-3.02337	99.97	A17	53.01253	-3.02274	101.06
A9	53.00535	-3.02308	99.50				

A483 receptor data

B5436

No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)	No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)
B1	53.00448	-3.02131	99.50	B39	52.99718	-2.96834	41.50
B2	53.00444	-3.01982	98.50	B40	52.99758	-2.96701	39.50
B3	53.00443	-3.01832	97.50	B41	52.99798	-2.96567	38.50
B4	53.00441	-3.01683	97.13	B42	52.99839	-2.96433	38.03
B5	53.00438	-3.01533	95.00	B43	52.99879	-2.96300	37.39
B6	53.00429	-3.01384	94.11	B44	52.99920	-2.96167	37.29
B7	53.00419	-3.01236	92.94	B45	52.99960	-2.96034	36.15
B8	53.00392	-3.01097	93.50	B46	52.99994	-2.95897	35.50
B9	53.00342	-3.00973	93.50	B47	53.00016	-2.95752	34.36
B10	53.00292	-3.00848	93.32	B48	53.00031	-2.95605	33.50
B11	53.00242	-3.00724	93.40	B49	53.00044	-2.95457	31.85
B12	53.00200	-3.00592	91.82	B50	53.00056	-2.95308	31.50
B13	53.00174	-3.00450	92.50	B51	53.00065	-2.95160	31.50
B14	53.00167	-3.00301	91.61	B52	53.00073	-2.95011	31.61
B15	53.00163	-3.00154	90.74	B53	53.00080	-2.94862	31.63
B16	53.00105	-3.00040	84.14	B54	53.00087	-2.94713	31.70
B17	53.00026	-2.99973	86.66	B55	53.00095	-2.94564	32.50
B18	52.99961	-2.99874	91.50	B56	53.00102	-2.94415	32.50
B19	52.99935	-2.99731	94.20	B57	53.00110	-2.94266	32.50
B20	52.99918	-2.99585	93.84	B58	53.00118	-2.94117	30.71
B21	52.99901	-2.99438	92.50	B59	53.00125	-2.93967	21.50

No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)	No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)
B22	52.99883	-2.99291	91.50	B60	53.00133	-2.93818	20.50
B23	52.99869	-2.99144	88.50	B61	53.00140	-2.93669	19.50
B24	52.99877	-2.98995	85.90	B62	53.00148	-2.93520	18.50
B25	52.99893	-2.98848	80.80	B63	53.00156	-2.93371	17.50
B26	52.99887	-2.98699	81.11	B64	53.00163	-2.93222	17.50
B27	52.99898	-2.98552	77.02	B65	53.00171	-2.93073	16.50
B28	52.99911	-2.98404	72.56	B66	53.00178	-2.92924	16.50
B29	52.99911	-2.98254	72.43	B67	53.00186	-2.92775	16.50
B30	52.99910	-2.98105	72.35	B68	53.00194	-2.92626	16.50
B31	52.99902	-2.97957	69.87	B69	53.00201	-2.92477	16.50
B32	52.99855	-2.97831	64.48	B70	53.00209	-2.92328	15.50
B33	52.99827	-2.97691	61.63	B71	53.00216	-2.92179	15.50
B34	52.99823	-2.97542	61.50	B72	53.00224	-2.92030	15.50
B35	52.99813	-2.97394	54.95	B73	53.00232	-2.91881	15.50
B36	52.99797	-2.97247	53.01	B74	53.00239	-2.91732	15.50
B37	52.99777	-2.97101	50.72	B75	53.00245	-2.91610	15.50
B38	52.99731	-2.96974	49.73				

B5426 receptor data

A528

No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)	No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)
C1	52.99908	-2.95979	34.96	C9	53.00580	-2.96022	54.89
C2	52.99982	-2.96060	36.92	C10	53.00670	-2.96016	55.05
C3	53.00059	-2.96135	38.30	C11	53.00760	-2.96017	54.72
C4	53.00145	-2.96170	40.24	C12	53.00850	-2.96018	55.04
C5	53.00234	-2.96181	41.26	C13	53.00940	-2.96021	55.04
C6	53.00322	-2.96149	43.05	C14	53.01030	-2.96024	55.25
C7	53.00408	-2.96107	50.27	C15	53.01119	-2.96003	55.50
C8	53.00493	-2.96056	51.50	C16	53.01204	-2.95954	53.83
C1	52.99908	-2.95979	34.96				

A528 receptor data

B5130

No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)	No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)
D1	53.00581	-2.96001	53.78	D10	53.01064	-2.95073	51.42
D2	53.00579	-2.95851	50.95	D11	53.01120	-2.94970	50.77
D3	53.00609	-2.95715	50.51	D12	53.01141	-2.94824	50.90
D4	53.00677	-2.95626	49.60	D13	53.01167	-2.94682	49.50
D5	53.00765	-2.95598	52.01	D14	53.01208	-2.94548	48.66
D6	53.00835	-2.95507	52.50	D15	53.01256	-2.94422	48.50
D7	53.00887	-2.95386	51.50	D16	53.01259	-2.94239	47.20
D8	53.00926	-2.95251	51.50	D17	53.01229	-2.94117	45.97

No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)	No.	Latitude (°)	Longitude (°)	Assessed Height (m amsl)
D9	53.00983	-2.95137	51.50	D18	53.01261	-2.94011	45.50
D9	53.00983	-2.95137	51.50				

B5130 receptor data

Dwelling Receptor Data

The dwelling receptor data is presented in the table below. An additional 1.8m height has been added to the terrain height to account for the eye-level of an observer at these dwellings.

No.	Latitude (°)	Longitude (°)	Assessed Height (m)	No.	Latitude (°)	Longitude (°)	Assessed Height (m)
1	53.01235	-3.02492	104.61	62	52.99185	-2.99312	94.91
2	53.00757	-3.02593	103.80	63	52.99079	-2.98833	85.25
3	53.00780	-3.02511	102.95	64	52.99170	-2.98416	72.29
4	53.00762	-3.02443	102.48	65	52.99693	-2.98601	81.67
5	53.00732	-3.02549	101.80	66	53.00268	-2.99047	86.20
6	53.00715	-3.02553	101.80	67	53.00299	-2.99039	85.06
7	53.00420	-3.02098	99.66	68	53.00331	-2.99040	83.97
8	53.00406	-3.01272	93.28	69	53.00351	-2.99045	83.19
9	53.00365	-3.01049	93.80	70	53.00387	-2.99083	86.80
10	53.00345	-3.00942	93.80	71	53.00406	-2.99108	86.80
11	53.00331	-3.00911	93.34	72	53.00507	-2.98941	84.07
12	53.00316	-3.00846	93.08	73	53.00757	-2.98820	83.70
13	53.00158	-3.01067	96.32	74	52.99817	-2.97707	61.80
14	53.00136	-3.01075	96.53	75	52.99836	-2.97684	61.96

No.	Latitude (°)	Longitude (°)	Assessed Height (m)	No.	Latitude (°)	Longitude (°)	Assessed Height (m)
15	52.99936	-3.01471	100.80	76	52.99794	-2.97305	52.24
16	52.99850	-3.01344	102.36	77	52.99783	-2.97228	52.05
17	53.00136	-3.00303	91.80	78	52.99780	-2.97181	51.10
18	53.00120	-3.00154	91.53	79	52.99733	-2.97068	49.70
19	53.00087	-3.00183	91.80	80	52.99726	-2.97020	49.71
20	53.00097	-3.00047	84.19	81	52.99677	-2.96796	40.23
21	53.00056	-3.00061	84.28	82	52.99692	-2.96773	40.69
22	53.00036	-3.00077	85.13	83	52.99673	-2.96709	39.10
23	52.99856	-3.00139	92.80	84	52.99477	-2.97256	60.48
24	52.99796	-3.00169	94.18	85	53.01235	-2.94496	48.80
25	52.99817	-3.00328	95.59	86	53.01193	-2.95161	48.92
26	52.99791	-3.00336	95.80	87	53.01138	-2.95103	50.06
27	52.99754	-3.00336	95.93	88	53.01113	-2.95083	50.76
28	52.99620	-3.00130	101.42	89	53.01150	-2.95946	55.16
29	52.99911	-2.99935	90.15	90	53.00940	-2.96651	60.35
30	52.99914	-2.99891	92.57	91	53.00818	-2.96507	55.63
31	52.99895	-2.99871	93.25	92	53.00884	-2.95459	52.80
32	52.99847	-2.99772	93.58	93	53.00861	-2.95474	52.80
33	52.99824	-2.99744	93.01	94	53.00848	-2.95535	52.80
34	52.99781	-2.99659	93.07	95	53.00676	-2.95350	46.04
35	52.99794	-2.99572	93.80	96	53.00630	-2.95761	51.30

No.	Latitude (°)	Longitude (°)	Assessed Height (m)	No.	Latitude (°)	Longitude (°)	Assessed Height (m)
36	52.99934	-2.99435	92.80	97	53.00616	-2.95903	52.89
37	52.99886	-2.99182	88.80	98	53.00604	-2.96153	59.47
38	52.99942	-2.99060	87.80	99	53.00639	-2.96259	61.80
39	52.99910	-2.99066	87.80	100	53.00627	-2.96307	61.80
40	52.99884	-2.99072	87.80	101	53.00628	-2.96349	61.80
41	52.99831	-2.99094	87.80	102	53.00497	-2.96118	53.93
42	52.99877	-2.98902	82.66	103	53.00395	-2.96157	50.20
43	52.99879	-2.98783	82.49	104	53.00311	-2.96189	42.57
44	52.99875	-2.98744	81.89	105	53.00260	-2.96205	41.80
45	52.99871	-2.98686	81.25	106	53.00101	-2.95678	35.59
46	52.99863	-2.98643	80.88	107	53.00043	-2.95749	35.26
47	52.99866	-2.98606	79.84	108	53.00506	-2.94332	32.45
48	52.99871	-2.98565	78.77	109	53.00091	-2.94282	32.80
49	52.99873	-2.98545	78.51	110	52.99868	-2.94429	27.95
50	52.99924	-2.98476	74.11	111	52.99898	-2.93977	22.25
51	52.99941	-2.98321	72.53	112	53.00598	-2.93600	23.10
52	52.99733	-2.99174	90.80	113	53.00880	-2.92796	23.80
53	52.99707	-2.99178	90.80	114	53.00900	-2.92776	24.78
54	52.99684	-2.99187	91.23	115	53.00914	-2.92763	25.03
55	52.99658	-2.99316	92.80	116	53.01003	-2.92745	27.72
56	52.99624	-2.99311	92.54	117	53.01163	-2.92705	30.90

No.	Latitude (°)	Longitude (°)	Assessed Height (m)	No.	Latitude (°)	Longitude (°)	Assessed Height (m)
57	52.99616	-2.99230	91.80	118	53.00991	-2.94135	44.80
58	52.99585	-2.99256	91.80	119	53.01001	-2.94176	45.20
59	52.99552	-2.99226	91.80	120	53.01011	-2.94219	45.96
60	52.99526	-2.99316	92.27	121	53.00978	-2.94200	44.86
61	52.99410	-2.99547	91.62	122	53.00915	-2.94175	45.30

Dwelling receptor data

Modelled Reflector Areas

The modelled reflector areas are presented in the table below.

Panel Area 1

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-3.02162	53.01172	25	-3.01687	53.00936
2	-3.02153	53.01150	26	-3.01718	53.00942
3	-3.02167	53.01105	27	-3.01792	53.00933
4	-3.02212	53.01100	28	-3.01819	53.00946
5	-3.02212	53.01029	29	-3.01858	53.00999
6	-3.02216	53.00836	30	-3.01853	53.01024
7	-3.02156	53.00842	31	-3.01789	53.01063
8	-3.02091	53.00864	32	-3.01685	53.01111
9	-3.02072	53.00842	33	-3.01684	53.01128
10	-3.02121	53.00812	34	-3.01795	53.01159
11	-3.02155	53.00774	35	-3.01806	53.01195
12	-3.02209	53.00758	36	-3.01760	53.01212
13	-3.02217	53.00706	37	-3.01763	53.01229
14	-3.02136	53.00708	38	-3.01830	53.01242

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
15	-3.02024	53.00707	39	-3.01857	53.01257
16	-3.01938	53.00711	40	-3.01890	53.01260
17	-3.01826	53.00722	41	-3.01900	53.01245
18	-3.01713	53.00720	42	-3.01930	53.01234
19	-3.01574	53.00752	43	-3.02001	53.01230
20	-3.01570	53.00778	44	-3.02049	53.01230
21	-3.01584	53.00814	45	-3.02109	53.01225
22	-3.01587	53.00845	46	-3.02195	53.01226
23	-3.01624	53.00865	47	-3.02207	53.01218
24	-3.01662	53.00897			

Panel Area 1

Panel Area 2

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-2.99731	53.00008	42	-2.98054	53.00083
2	-2.99672	52.99962	43	-2.98041	53.00069
3	-2.99672	52.99940	44	-2.97984	53.00072
4	-2.99591	52.99935	45	-2.97959	53.00082
5	-2.99591	52.99965	46	-2.97925	53.00084
6	-2.99593	52.99978	47	-2.97914	53.00170
7	-2.99568	52.99983	48	-2.98029	53.00184
8	-2.99552	52.99976	49	-2.98084	53.00190
9	-2.99539	52.99977	50	-2.98117	53.00220
10	-2.99488	53.00014	51	-2.98360	53.00264
11	-2.99463	53.00024	52	-2.98350	53.00296
12	-2.99419	53.00025	53	-2.98319	53.00314

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
13	-2.99397	52.99990	54	-2.98292	53.00344
14	-2.99265	52.99965	55	-2.98444	53.00393
15	-2.99092	53.00008	56	-2.98613	53.00422
16	-2.99067	53.00036	57	-2.98668	53.00404
17	-2.99026	53.00035	58	-2.98665	53.00355
18	-2.98830	53.00007	59	-2.98584	53.00339
19	-2.98752	53.00000	60	-2.98527	53.00337
20	-2.98687	52.99985	61	-2.98450	53.00325
21	-2.98602	52.99962	62	-2.98375	53.00297
22	-2.98597	52.99976	63	-2.98386	53.00255
23	-2.98621	53.00003	64	-2.98519	53.00257
24	-2.98610	53.00018	65	-2.98699	53.00289
25	-2.98547	53.00014	66	-2.98860	53.00309
26	-2.98526	53.00055	67	-2.98871	53.00223
27	-2.98501	53.00095	68	-2.98961	53.00231
28	-2.98507	53.00140	69	-2.99034	53.00228
29	-2.98525	53.00168	70	-2.99043	53.00178
30	-2.98577	53.00205	71	-2.99142	53.00180
31	-2.98561	53.00226	72	-2.99345	53.00184
32	-2.98477	53.00207	73	-2.99409	53.00181
33	-2.98425	53.00172	74	-2.99506	53.00144
34	-2.98396	53.00174	75	-2.99553	53.00145
35	-2.98397	53.00213	76	-2.99646	53.00122
36	-2.98361	53.00206	77	-2.99645	53.00095

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
37	-2.98362	53.00168	78	-2.99668	53.00090
38	-2.98342	53.00139	79	-2.99690	53.00120
39	-2.98342	53.00117	80	-2.99710	53.00118
40	-2.98231	53.00103	81	-2.99732	53.00111
41	-2.98135	53.00086	82	-2.99738	53.00054

Panel Area 2

Panel Area 3

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-2.97743	53.00228	22	-2.98339	53.00836
2	-2.97755	53.00302	23	-2.98455	53.00834
3	-2.97740	53.00333	24	-2.98668	53.00846
4	-2.97743	53.00361	25	-2.98671	53.00784
5	-2.97791	53.00367	26	-2.98667	53.00758
6	-2.97790	53.00386	27	-2.98680	53.00695
7	-2.97740	53.00386	28	-2.98676	53.00677
8	-2.97741	53.00494	29	-2.98610	53.00668
9	-2.97718	53.00527	30	-2.98542	53.00645
10	-2.97686	53.00564	31	-2.98538	53.00637
11	-2.97663	53.00604	32	-2.98436	53.00609
12	-2.97635	53.00627	33	-2.98468	53.00525
13	-2.97619	53.00710	34	-2.98387	53.00456
14	-2.97685	53.00710	35	-2.98211	53.00407
15	-2.97783	53.00687	36	-2.98181	53.00422
16	-2.97852	53.00685	37	-2.98153	53.00412
17	-2.97891	53.00716	38	-2.98160	53.00380

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
18	-2.97990	53.00742	39	-2.98127	53.00338
19	-2.98082	53.00778	40	-2.98107	53.00289
20	-2.98159	53.00797	41	-2.97993	53.00243
21	-2.98292	53.00844	42	-2.97851	53.00230

Panel Area 3

Panel Area 4

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-2.98888	53.00812	9	-2.99138	53.00503
2	-2.98925	53.00800	10	-2.99013	53.00488
3	-2.98982	53.00756	11	-2.99005	53.00530
4	-2.98990	53.00738	12	-2.98981	53.00582
5	-2.99026	53.00710	13	-2.98934	53.00660
6	-2.99061	53.00703	14	-2.98879	53.00733
7	-2.99070	53.00673	15	-2.98837	53.00797
8	-2.99095	53.00610			

Panel Area 4

Panel Area 5

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-2.93796	53.00764	35	-2.95039	53.01071
2	-2.93817	53.00769	36	-2.95106	53.00987
3	-2.93835	53.00782	37	-2.95159	53.00944
4	-2.93888	53.00795	38	-2.95310	53.00898
5	-2.93926	53.00793	39	-2.95300	53.00881
6	-2.93965	53.00807	40	-2.95221	53.00846
7	-2.94035	53.00811	41	-2.95166	53.00816

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
8	-2.94094	53.00802	42	-2.95112	53.00785
9	-2.94125	53.00792	43	-2.95047	53.00772
10	-2.94174	53.00787	44	-2.95027	53.00751
11	-2.94199	53.00769	45	-2.94983	53.00739
12	-2.94199	53.00745	46	-2.94968	53.00728
13	-2.94267	53.00744	47	-2.94958	53.00709
14	-2.94277	53.00775	48	-2.94891	53.00657
15	-2.94309	53.00803	49	-2.94812	53.00605
16	-2.94321	53.00840	50	-2.94770	53.00593
17	-2.94338	53.00855	51	-2.94560	53.00694
18	-2.94332	53.00875	52	-2.94501	53.00711
19	-2.94348	53.00897	53	-2.94354	53.00607
20	-2.94410	53.00926	54	-2.94294	53.00573
21	-2.94413	53.00944	55	-2.94214	53.00558
22	-2.94394	53.00963	56	-2.94107	53.00560
23	-2.94335	53.00991	57	-2.94088	53.00574
24	-2.94390	53.01030	58	-2.94070	53.00574
25	-2.94403	53.01044	59	-2.93940	53.00608
26	-2.94365	53.01057	60	-2.93910	53.00620
27	-2.94175	53.01198	61	-2.93805	53.00645
28	-2.94250	53.01242	62	-2.93741	53.00662
29	-2.94322	53.01267	63	-2.93687	53.00668
30	-2.94472	53.01211	64	-2.93645	53.00676
31	-2.94596	53.01169	65	-2.93660	53.00724

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
32	-2.94716	53.01139	66	-2.93692	53.00767
33	-2.94857	53.01113	67	-2.93719	53.00775
34	-2.95003	53.01098			

Panel Area 5

Panel Area 6

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-2.93847	53.00994	7	-2.93614	53.01085
2	-2.93812	53.00967	8	-2.93674	53.01074
3	-2.93753	53.00899	9	-2.93713	53.01078
4	-2.93482	53.00987	10	-2.93760	53.01066
5	-2.93493	53.01035	11	-2.93857	53.01026
6	-2.93547	53.01093			

Panel Area 6

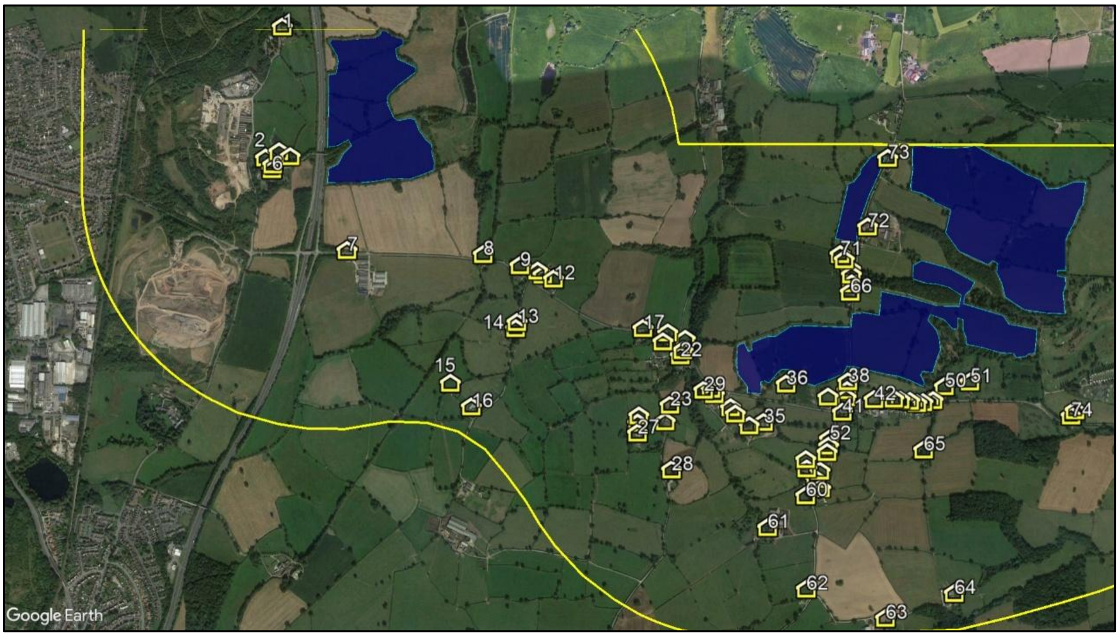
Panel Area 7

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-2.93412	53.00563	10	-2.92948	53.00627
2	-2.93230	53.00492	11	-2.92944	53.00636
3	-2.93180	53.00532	12	-2.92933	53.00643
4	-2.93110	53.00553	13	-2.92907	53.00689
5	-2.93051	53.00586	14	-2.92926	53.00702
6	-2.92981	53.00590	15	-2.93058	53.00744
7	-2.92974	53.00595	16	-2.93126	53.00770
8	-2.92961	53.00593	17	-2.93191	53.00731
9	-2.92943	53.00618	18	-2.93343	53.00620

Panel Area 7

APPENDIX H – DETAILED IDENTIFICATION OF DWELLING RECEPTORS

Detailed identification of dwelling receptors is presented in the following figures in this section.



Dwelling receptors 1 to 74

Dwelling receptors 74 to 122

Dwelling receptor 123

APPENDIX I – DETAILLED MODELLING RESULTS

Overview

The Pager Power charts for the assessed receptors are shown on the following pages. Each chart shows:

- The receptor (observer) location – top right image. This also shows the azimuth range of the Sun itself at times when reflections are possible. If sunlight is experienced from the same direction as the reflecting panels, the overall impact of the reflection is reduced as discussed within the body of the report;
- The reflecting panels – bottom right image. The reflecting area is shown in yellow. If the yellow panels are not visible from the observer location, no issues will occur in practice. Additional obstructions which may obscure the panels from view are considered separately within the analysis;
- The reflection date/time graph – left hand side of the page. The blue line indicates the dates and times at which geometric reflections are possible. This relates to reflections from the yellow areas.
- The sunrise and sunset curves throughout the year (red and yellow lines).

The Forge charts for the aviation receptors are shown on the following pages. Each chart shows:

- The annual predicted solar reflections.
- The daily duration of the solar reflections.
- The location of the proposed development where glare will originate.
- The calculated intensity of the predicted solar reflections.

Aviation Receptors

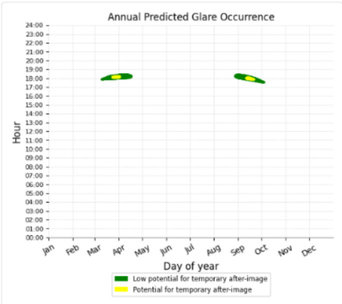
Selective results are presented for reference. Full modelling results are available upon request.

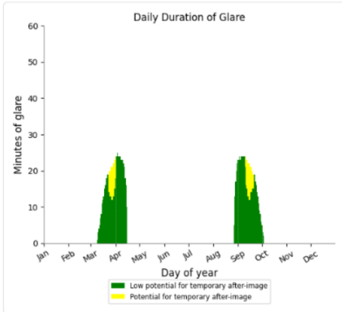
Forge

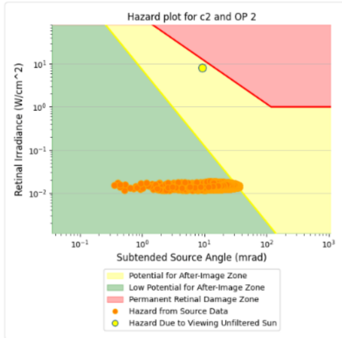
C2: OP 2

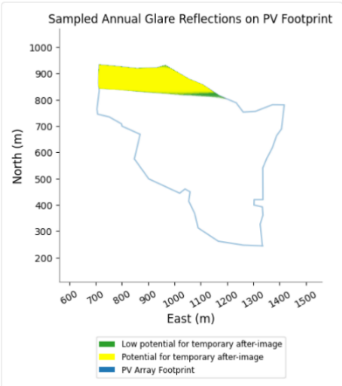
PV array is expected to produce the following glare for this receptor:

- 1,180 minutes of "green" glare with low potential to cause temporary after-image.
- 153 minutes of "yellow" glare with potential to cause temporary after-image.





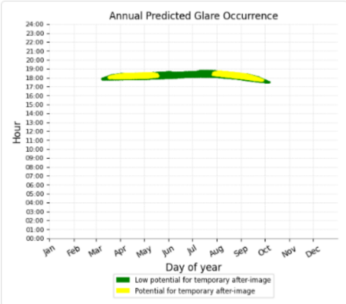


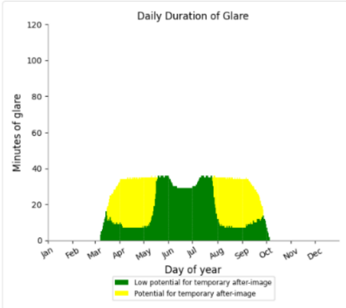


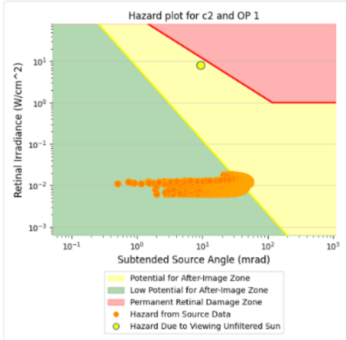
C2: OP 1

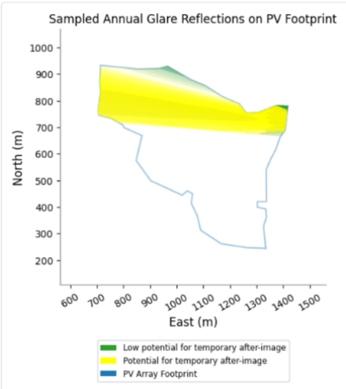
PV array is expected to produce the following glare for this receptor:

- 3,648 minutes of "green" glare with low potential to cause temporary after-image.
- 2,858 minutes of "yellow" glare with potential to cause temporary after-image.



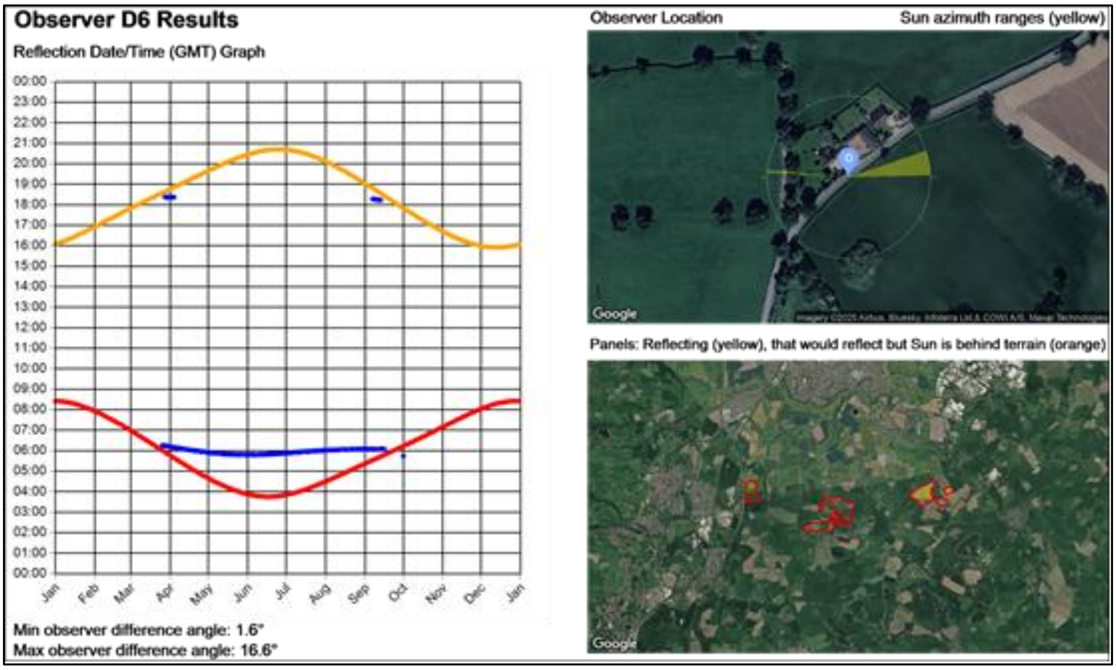


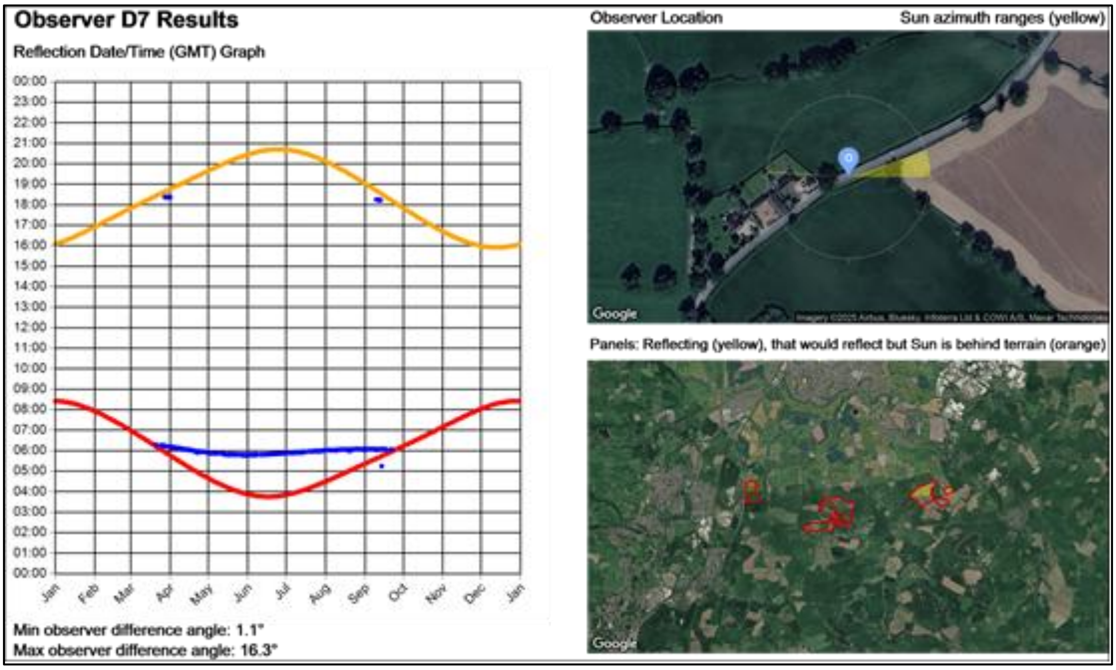


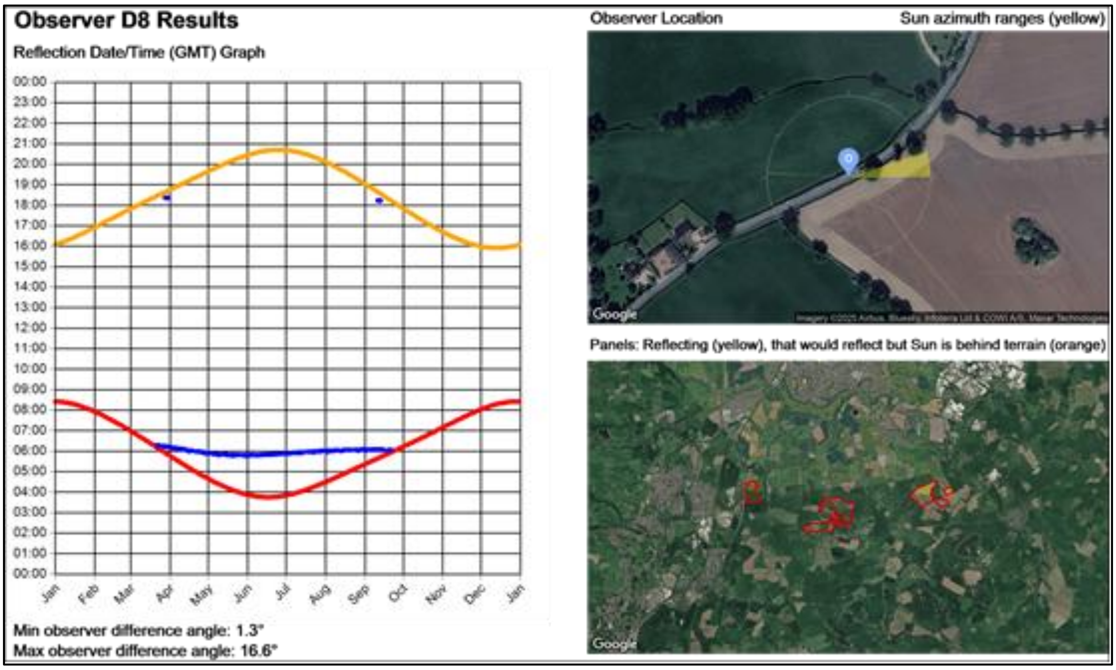


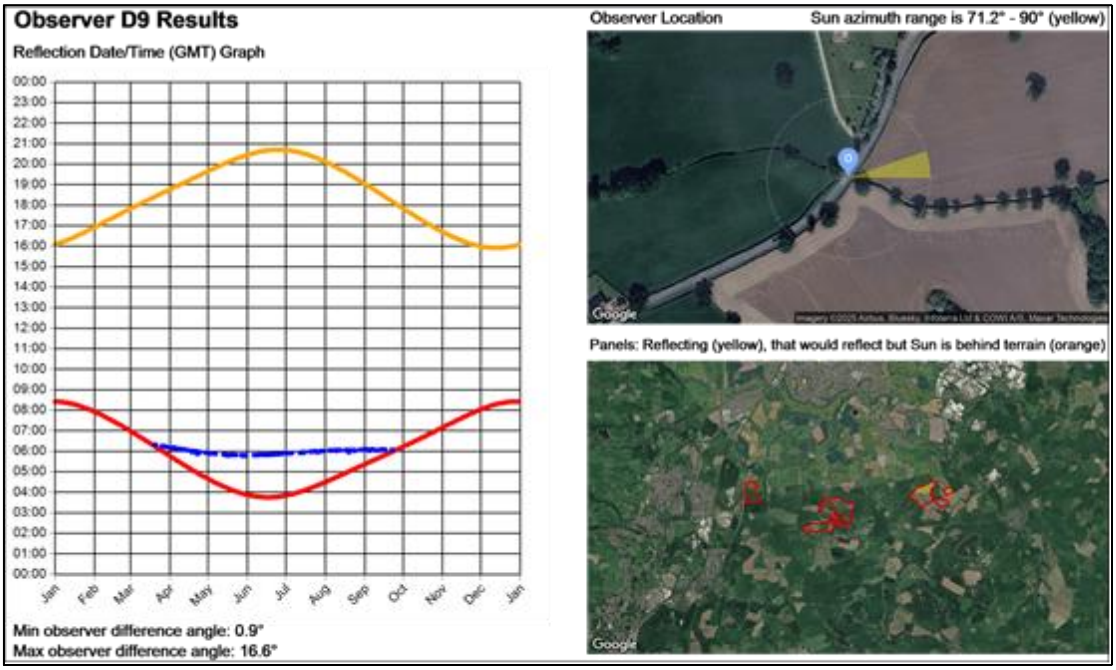
Road Receptors

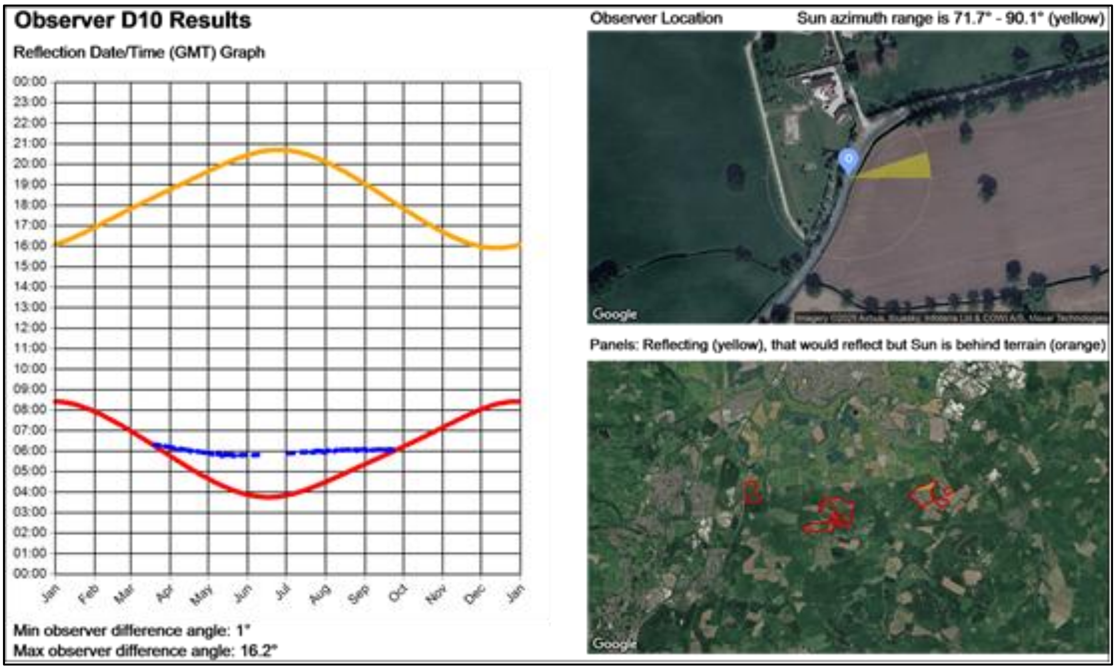
Results have been included for all road receptors where a high or moderate impact has been predicted prior to proposed screening.





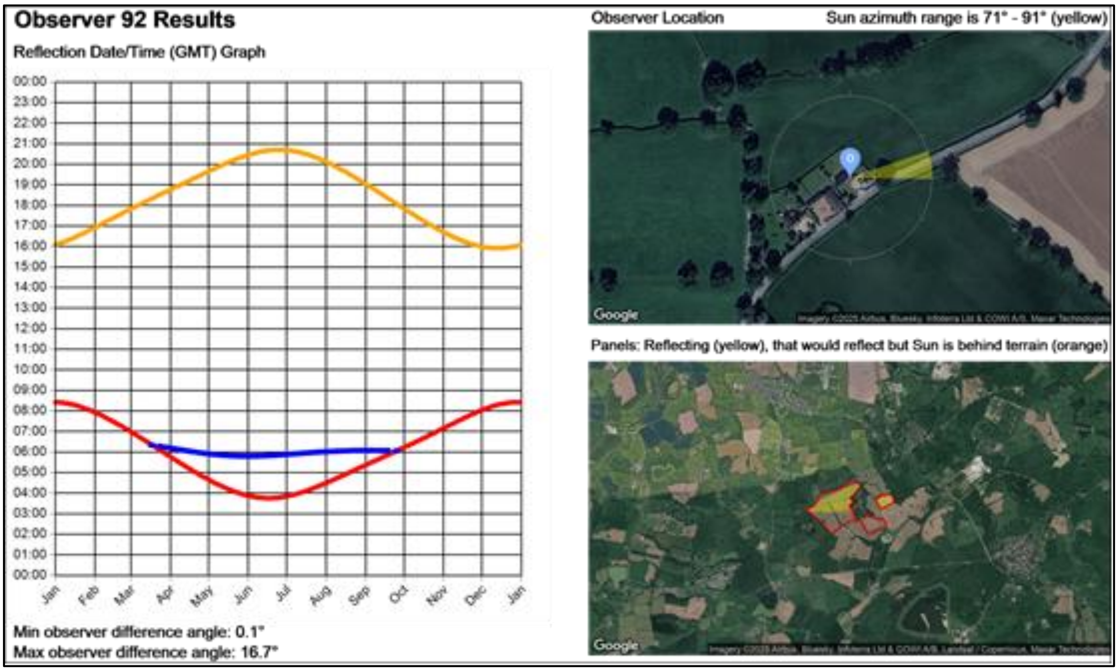

Observer D8 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth ranges (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 1.3°
Max observer difference angle: 16.6°

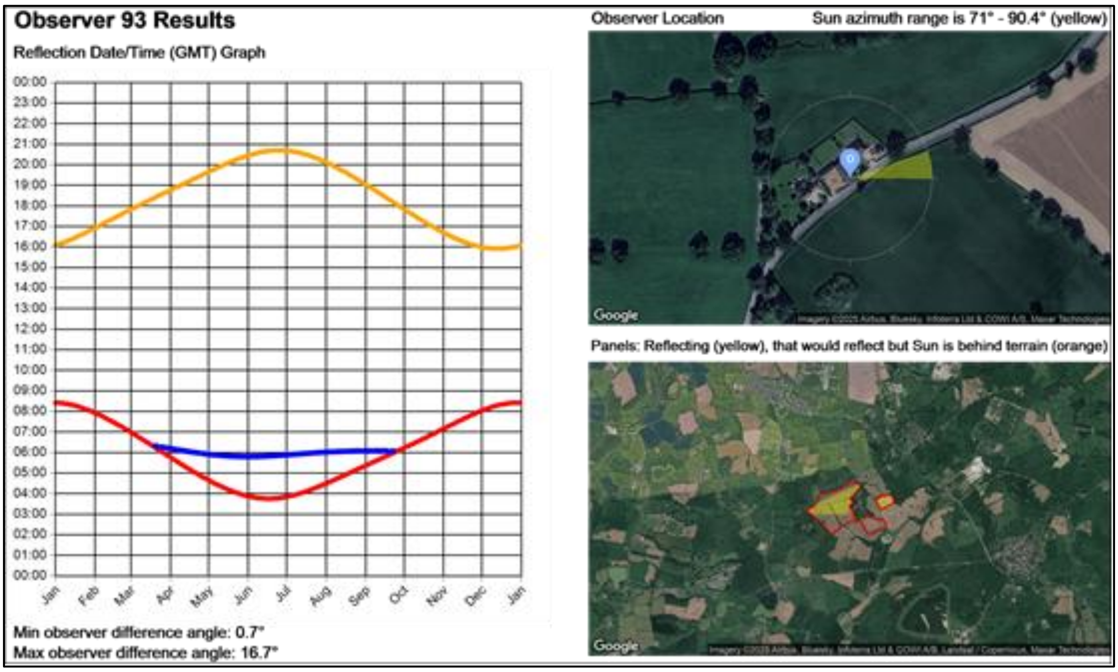

Observer D9 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 71.2° - 90° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 0.9°
Max observer difference angle: 16.6°


Observer D10 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 1°
Max observer difference angle: 16.2°
Observer Location
Sun azimuth range is 71.7° - 90.1° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

Dwelling Receptors

Modelling results are shown below for receptors where a moderate impact has been predicted prior to proposed screening.





APPENDIX J – SCREENING REVIEW

Overview

A desk-based review of the available imagery is presented in the following subsections.

Road Receptors

The identified screening in the form of existing vegetation is outlined green, with cumulative reflecting panel areas shown in yellow in the figures (in this Appendix) on the following pages. Street view imagery represents views of the proposed development along the sections of road where the reflecting panels are predicted to be significantly obstructed.

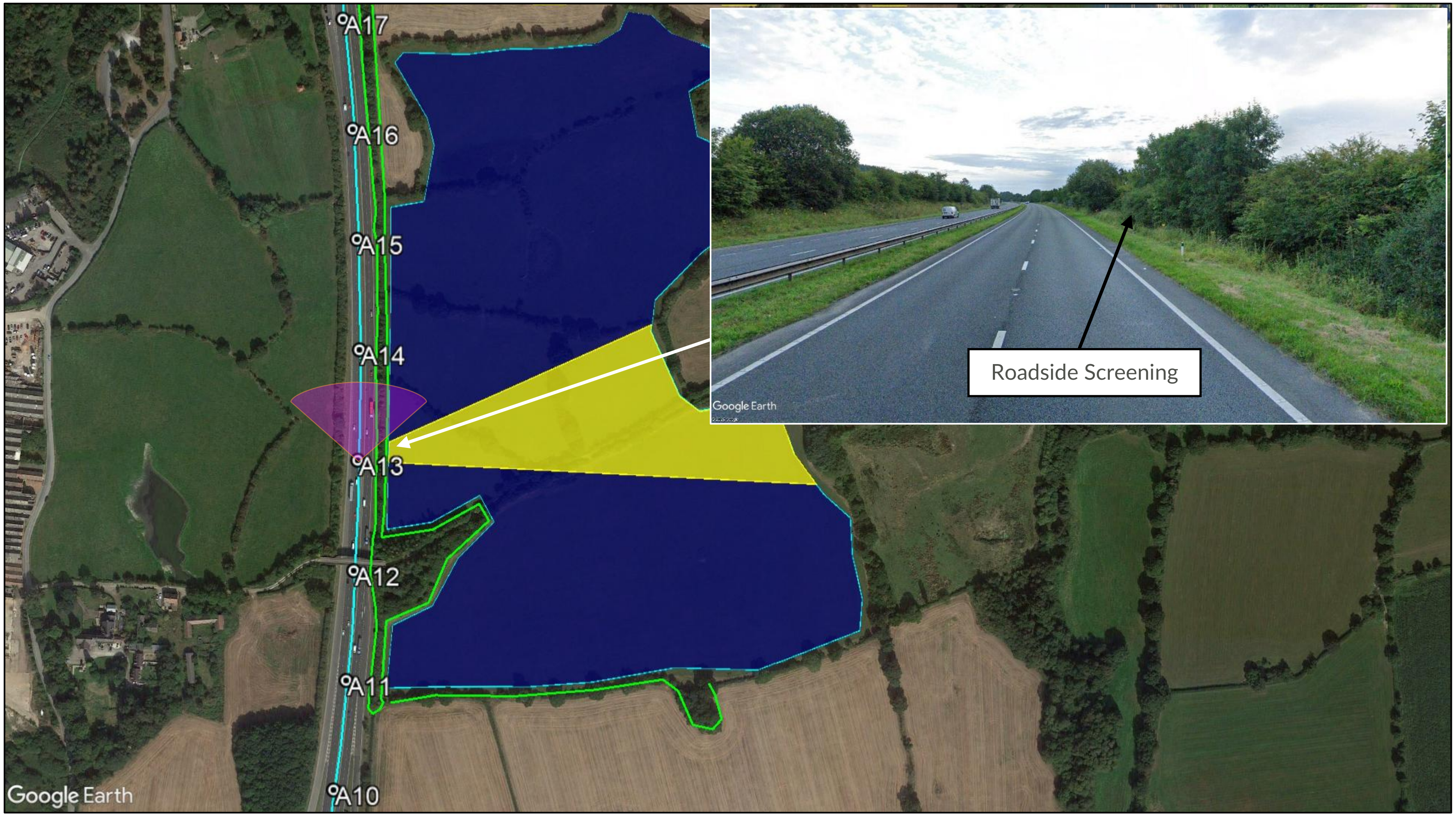
Screening review – Roads: List

Dwelling Receptors

A desk-based review of the available imagery is presented in the figures (in this Appendix) on the following pages. The cumulative reflecting panel areas are indicated by regions of yellow within the figures. The identified screening in the form of existing vegetation and buildings is outlined in green and blue respectively. High-level zones of theoretical visibility (ZTV Viewshed) generated by Google Earth have been used[43] to show the terrain screening.

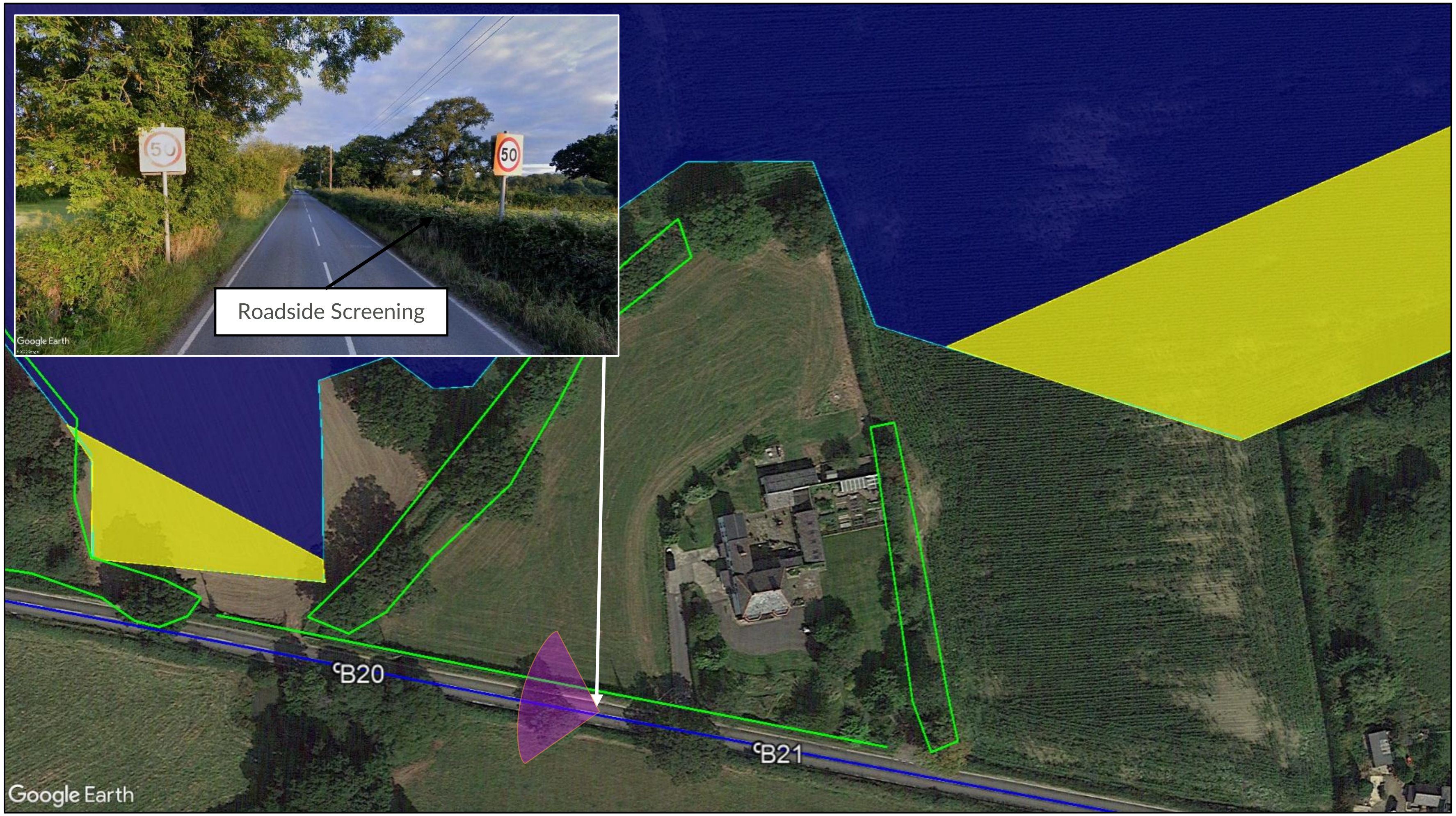
Screening review – Dwellings: List

[43] The green highlighted areas denote sections that are potentially visible to the observer at a height of 2m agl



Screening Review - Roads 1 *Screening relevant to road receptors A10 to A17*

Screening Review - Roads 2 *Screening relevant to road receptors B13 to B19*

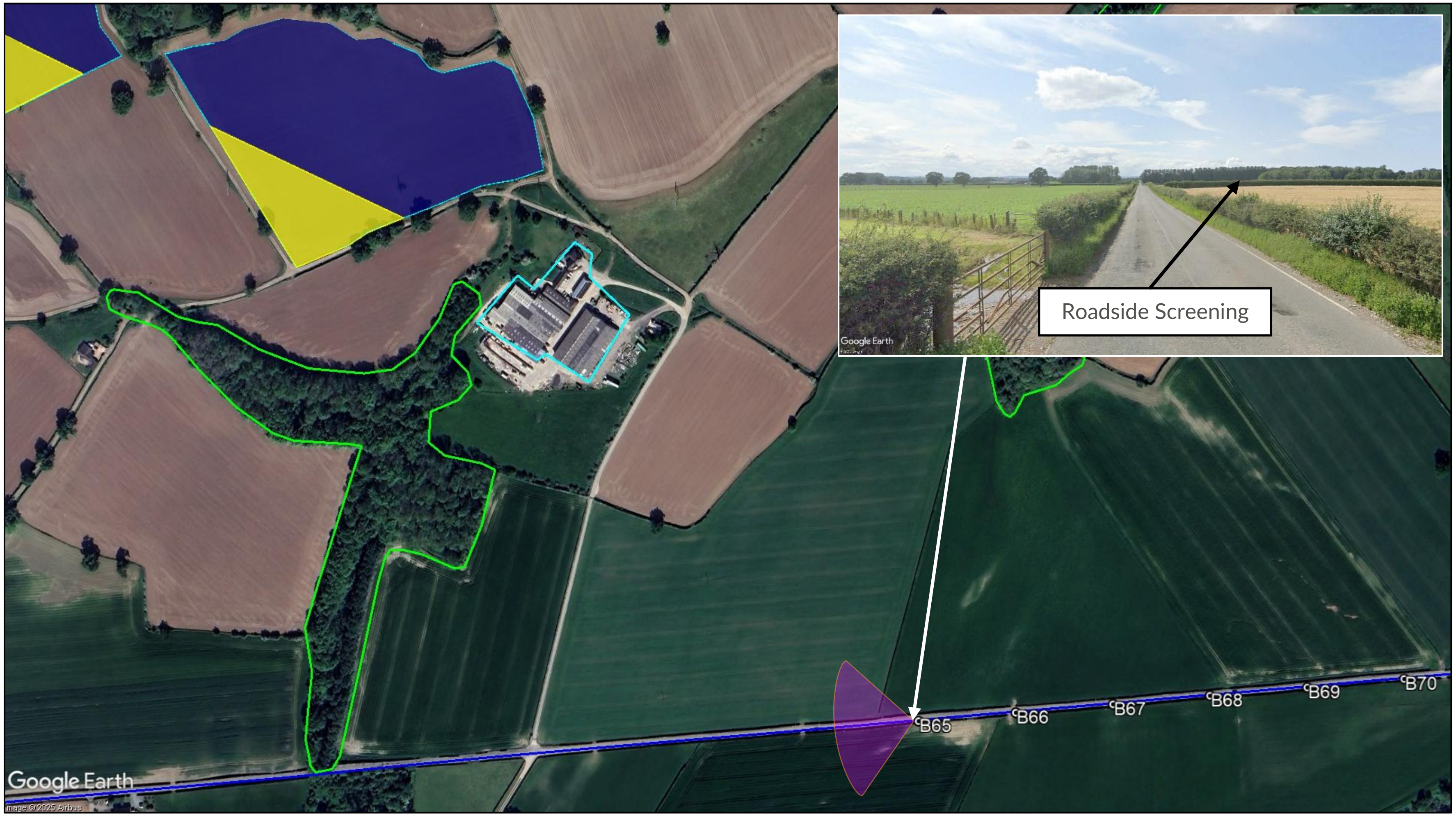


Screening Review - Roads 3 *Screening relevant to road receptors B20 to B21*

Screening Review - Roads 4 *Screening relevant to road receptors B22 to B24*

Screening Review - Roads 5 *Screening relevant to road receptors B25 to B27*

Screening Review - Roads 6 *Screening relevant to road receptors B28 to B45*



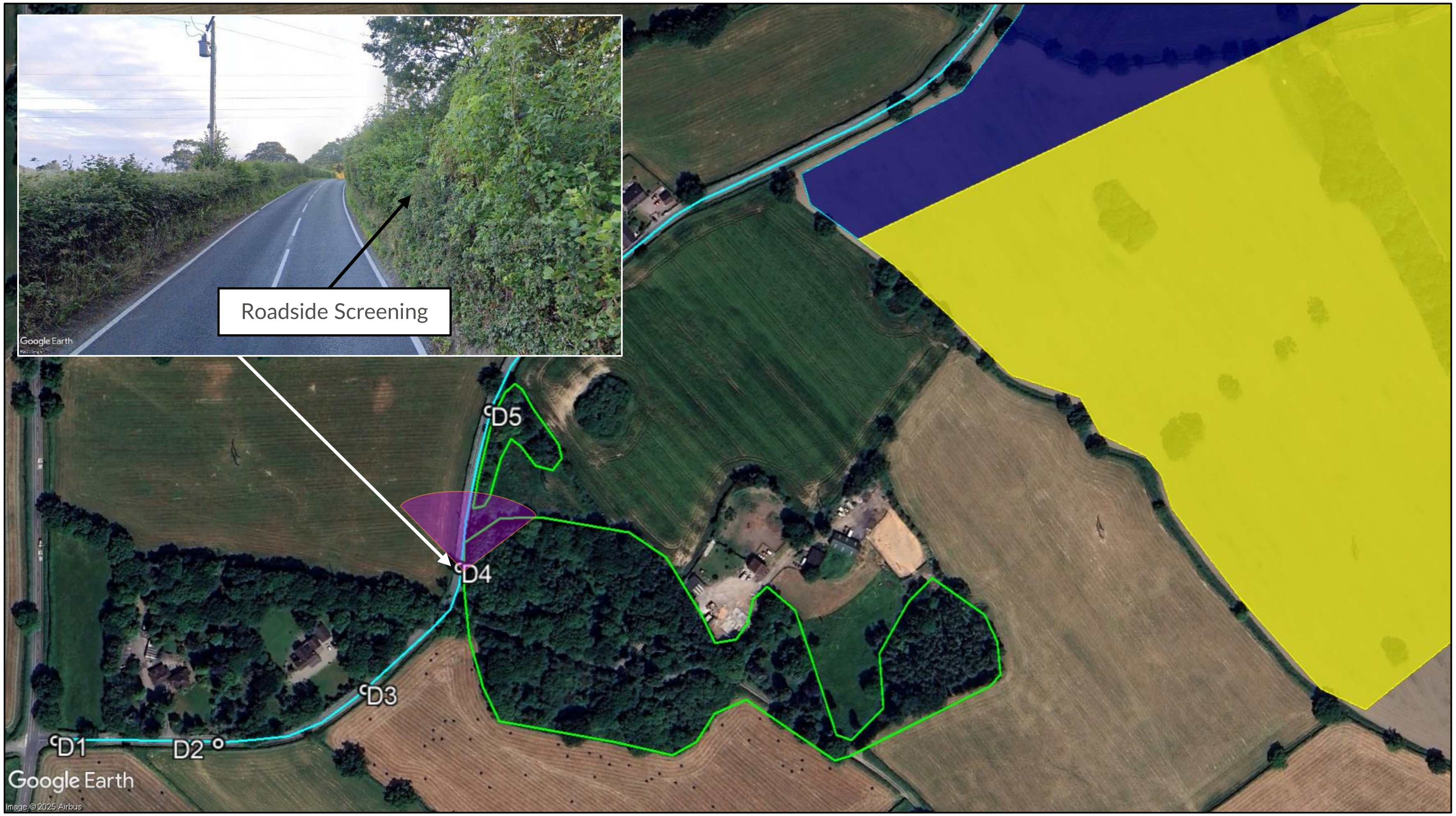
Screening Review - Roads 7 *Screening relevant to road receptors B65 to B70*

Screening Review - Roads 8 *Screening relevant to road receptors B71 to B75*

Screening Review - Roads 9 *Screening relevant to road receptors C1 to C5*

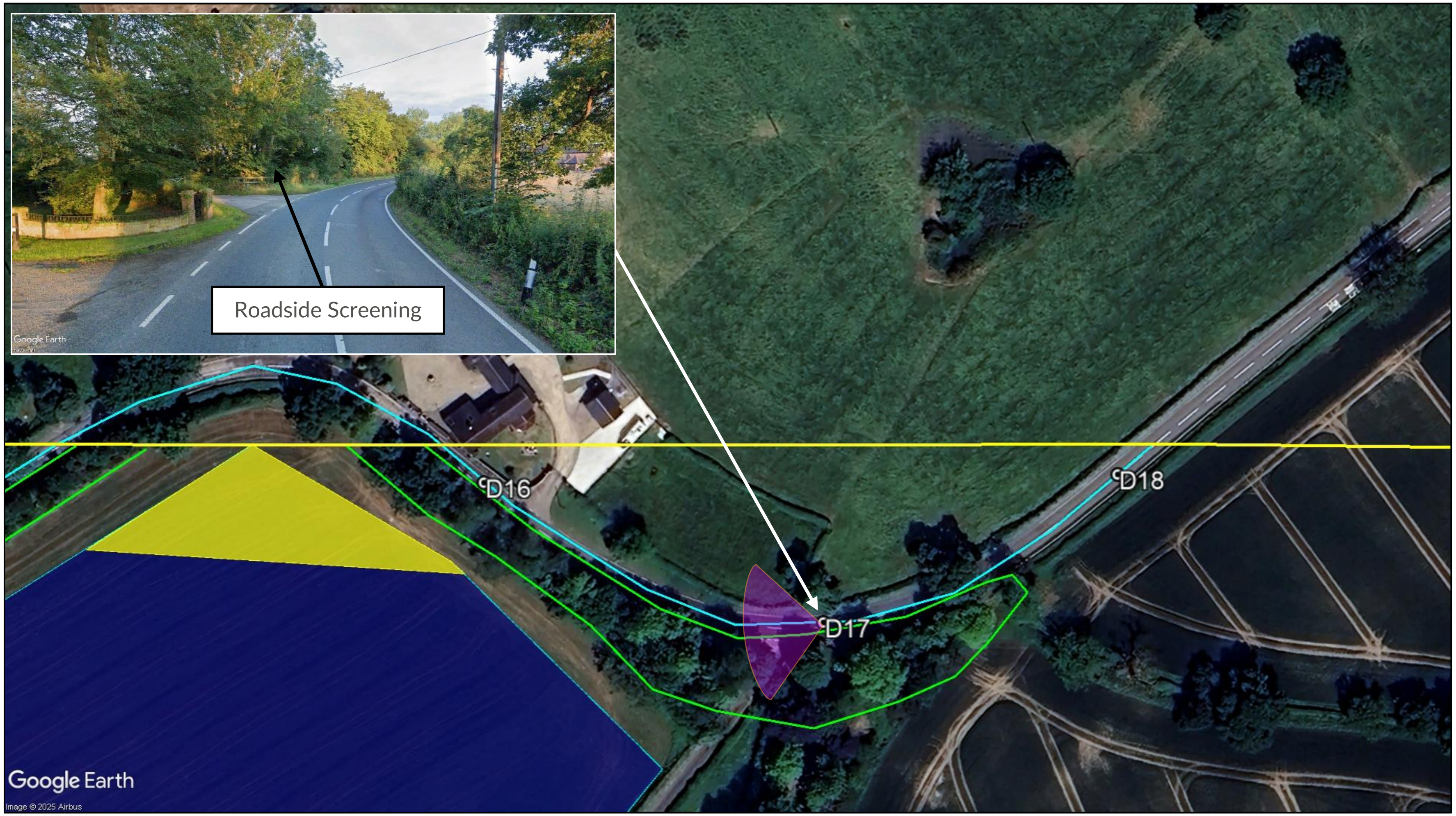
Screening Review - Roads 10 *Screening relevant to road receptors C6 to C8*

Screening Review - Roads 11 *Screening relevant to road receptors C9 to C17*



Screening Review - Roads 12 *Screening relevant to road receptors D1 to D5*

Screening Review - Roads 13 *Screening relevant to road receptors D11 to D15*



Screening Review - Roads 14 *Screening relevant to road receptors D16 to D18*

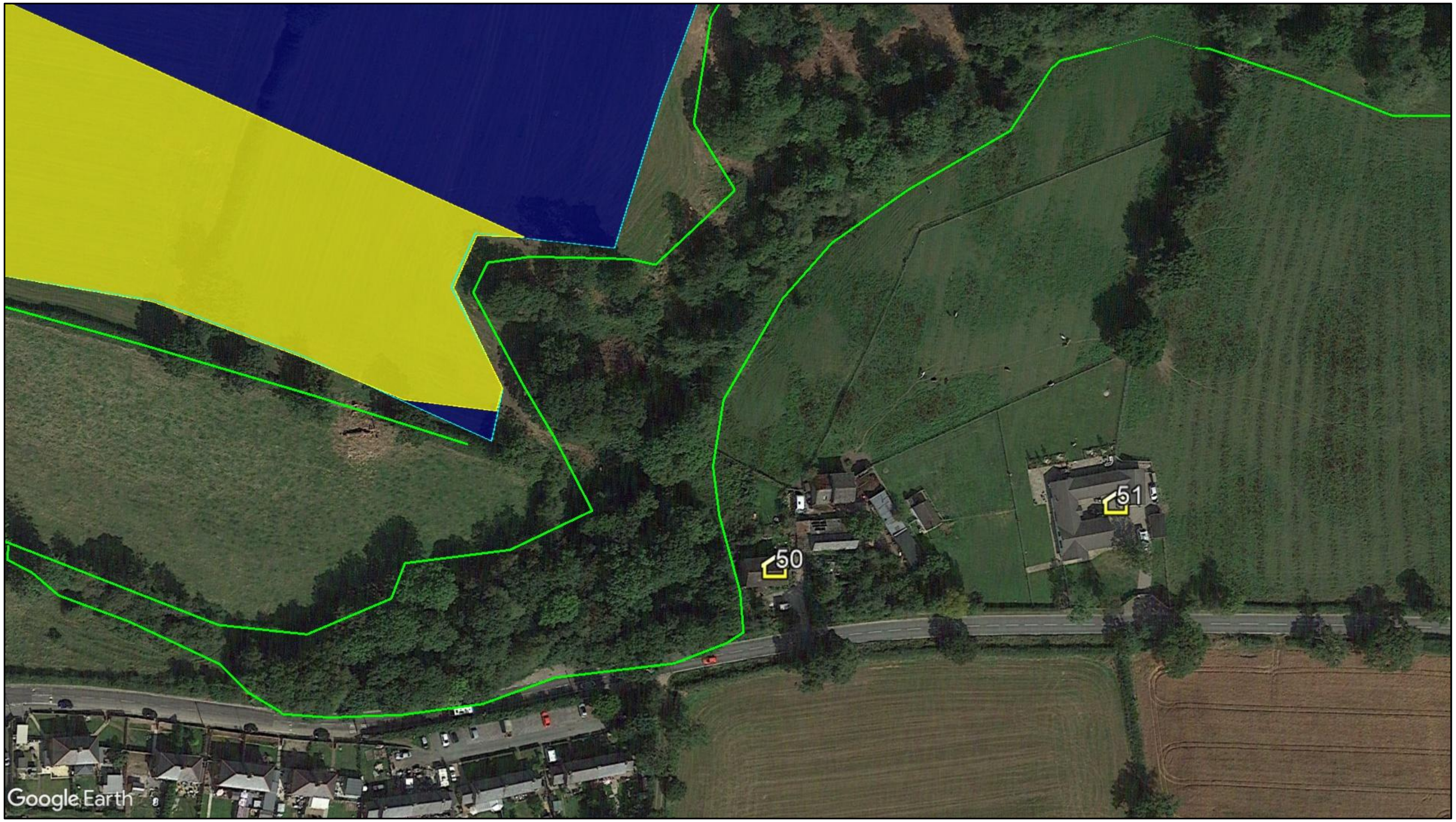
Screening Review - Dwellings 1 *Screening relevant to dwelling receptor 1*

Screening Review - Dwellings 2 *Screening relevant to dwelling receptors 2 to 6*

Screening Review - Dwellings 3 *Screening relevant to dwelling receptors 17 to 35*

Screening Review - Dwellings 4 *Screening relevant to dwelling receptor 36*

Screening Review - Dwellings 5 *Screening relevant to dwelling receptors 37 to 49*

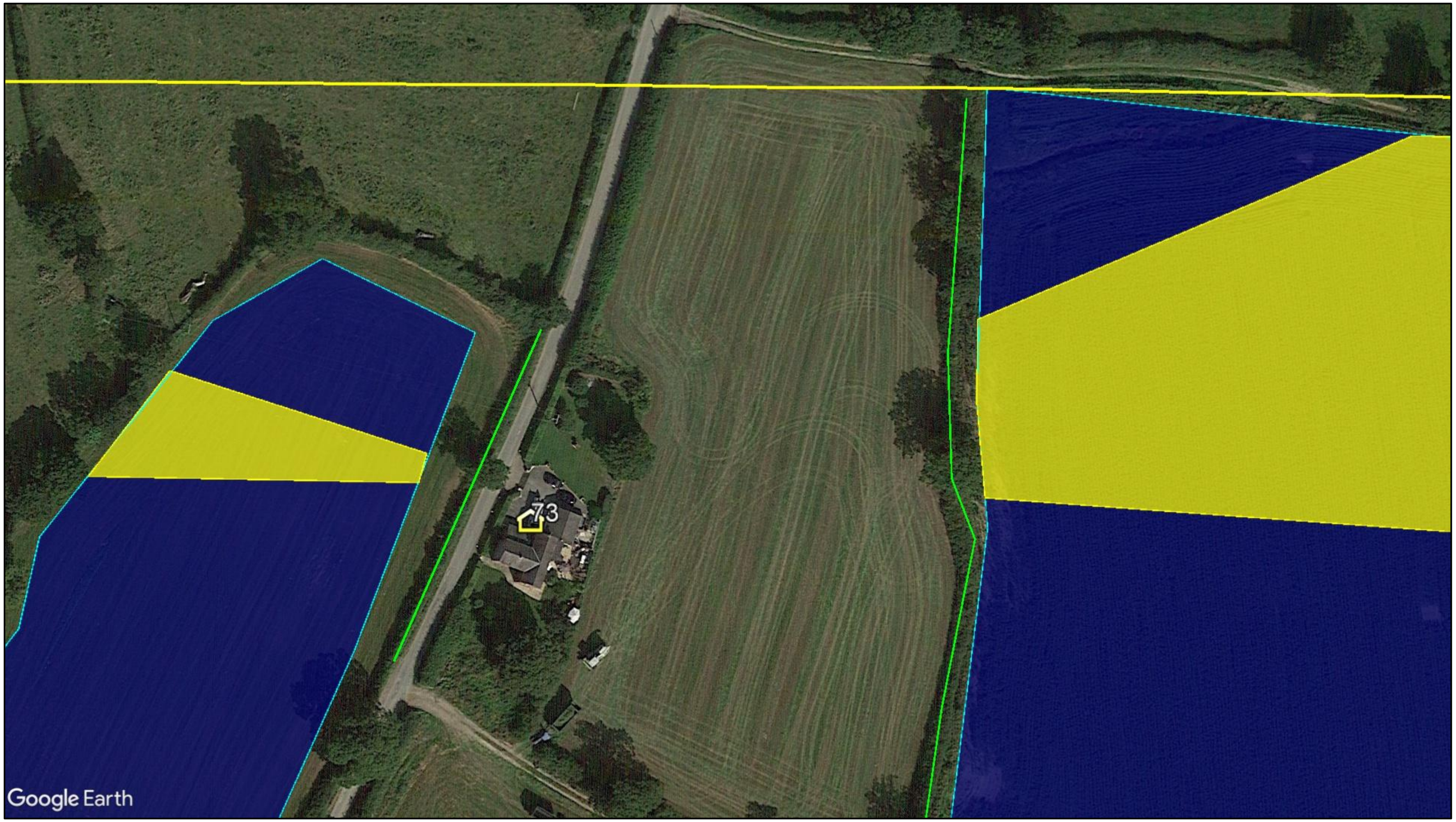


Screening Review - Dwellings 6 *Screening relevant to dwelling receptors 50 to 51*

Screening Review - Dwellings 7 *Screening relevant to dwelling receptor 65*

Screening Review - Dwellings 8 *Screening relevant to dwelling receptors 66 to 71*

Screening Review - Dwellings 9 *Screening relevant to dwelling receptor 72*



Screening Review - Dwellings 10 *Screening relevant to dwelling receptor 73*

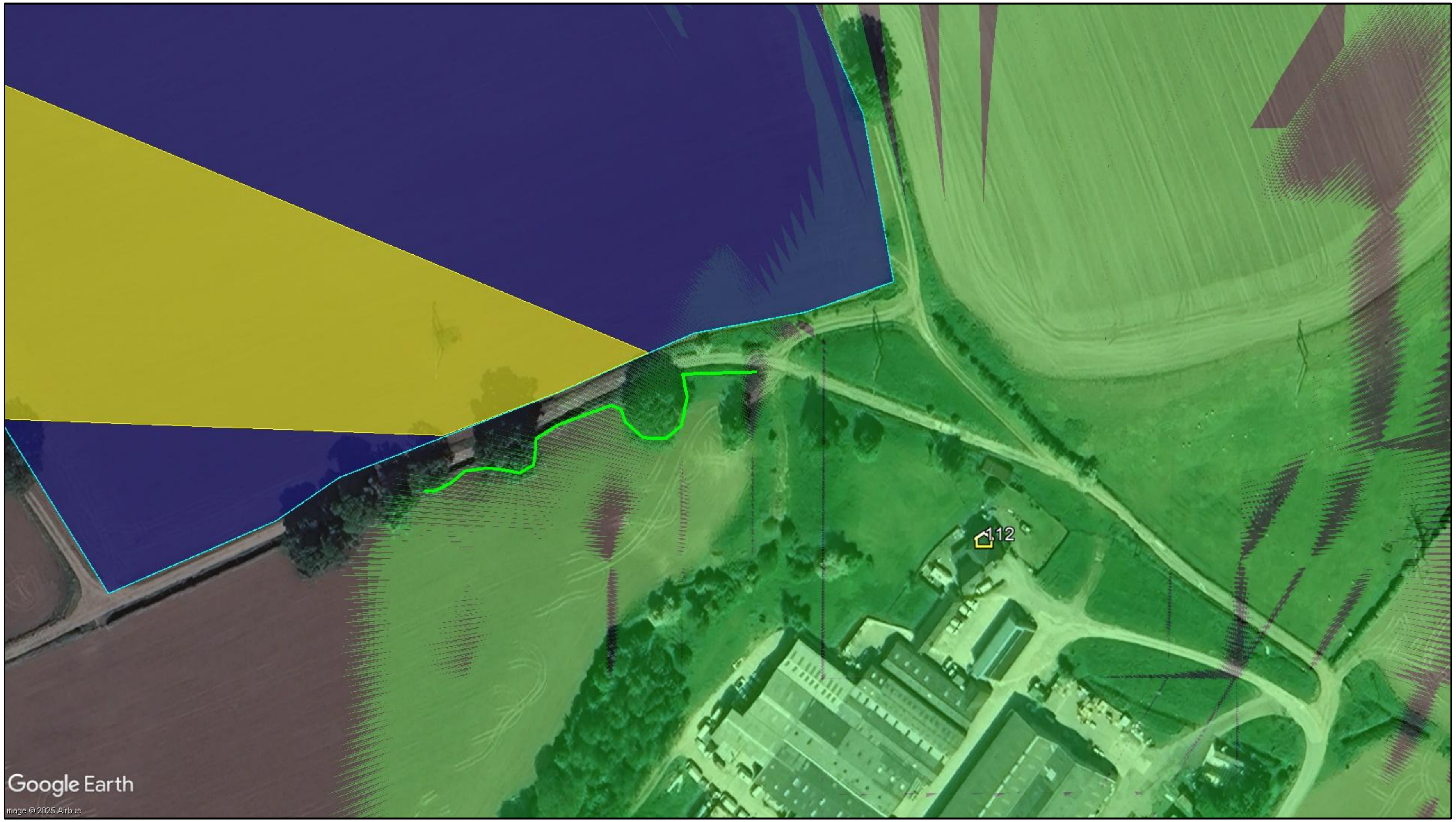
Screening Review - Dwellings 11 *Screening relevant to dwelling receptors 74 to 84*

Screening Review - Dwellings 12 *Screening relevant to dwelling receptors 85 to 89*

Screening Review - Dwellings 13 *Screening relevant to dwelling receptor 94*

Screening Review - Dwellings 14 *Screening relevant to dwelling receptors 95 to 105*

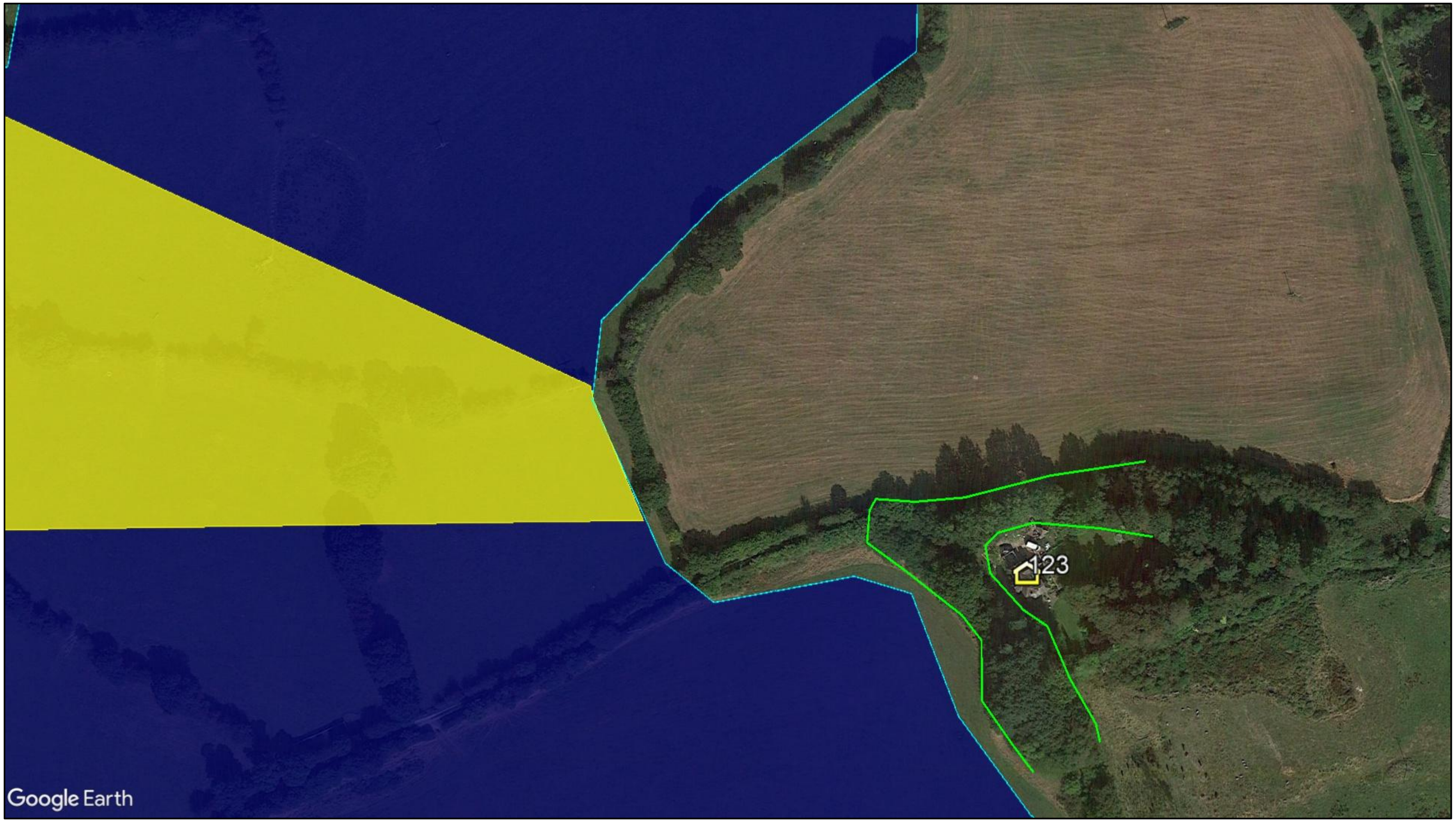
Screening Review - Dwellings 15 *Screening relevant to dwelling receptor 108*



Screening Review - Dwellings 16 *Screening relevant to dwelling receptor 108*

Screening Review - Dwellings 17 *Screening relevant to dwelling receptors 113 to 117*

Screening Review - Dwellings 18 *Screening relevant to dwelling receptors 119 to 122*



Screening Review - Dwellings 19 *Screening relevant to dwelling receptor 123*

PAGERPOWER
Urban & Renewables

Pager Power Limited
Stour Valley Business Centre
Sudbury
Suffolk
CO10 7GB

Tel: +44 1787 319001 **Email:** info@pagerpower.com **Web:** www.pagerpower.com