OAKLANDS FARM SOLAR PARK

Applicant: Oaklands Farm Solar Ltd

Environmental Statement
Appendix 14.1 – Solar Photovoltaic Glint and Glare Study
January 2024
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Oaklands Farm Solar Park - Environmental Statement Volume 3

Appendix 14.1: Solar Photovoltaic Glint and Glare Study

Final report
Prepared by LUC
January 2024

PAGERPOWER

Urban & Renewables

Solar Photovoltaic Glint and Glare Study

Land Use Consultants

Oaklands Farm Solar Park

January 2024

ADMINISTRATION PAGE

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Issue	Date	Detail of Changes
1 - 3	July – November 2021	Initial issues
4	02 March 2022	Minor amendments and consideration of public rights of way and bridleways
5	05 April 2022	Added recommended screening locations
6	20 April 2023	Assessment of finalised layout
7	26 July 2023	Inclusion of finalised site layout
8	11 August 2023	Minor amendment
9	22 November 2023	Addressed comments following legal review and assessment of Coton Road
10	15 January 2024	Reference to latest National Policy Statement

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EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to assess the possible effects of glint and glare from a proposed solar photovoltaic (PV) development to be located southeast of Walton-on-Trent in Derbyshire, south of Drakelow Power Station, in South Derbyshire local authority area.

This assessment pertains to the possible impact upon of glint and glare upon road safety, residential amenity, and aviation activity associated with Grangewood Airfield, Sittles Farm Airstrip, Fisherwick Airfield, Streethay Farm Airstrip, and Tatenhill Airfield.

Overall Conclusions

No significant impacts upon road safety, residential amenity, aviation activity are predicted following the implementation of mitigation measures. No further mitigation is recommended.

Assessment conclusions for each receptor type are presented on the following pages.

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 reviewed existing guidelines and the available studies to define its own glint and glare assessment guidance document and methodology[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 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. For aviation activity, where a solar reflection is predicted, solar intensity calculations are undertaken 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.

The available studies have measured the intensity of reflections from solar panels with respect to other naturally occurring and manmade surfaces. The results show that the reflections

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[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.

produced are of intensity similar to or less than those produced from still water and significantly less than reflections from glass and steel[3].

Conclusions – Aviation

The modelling has shown that solar reflections with a maximum intensity of 'low potential for temporary after-image' are predicted towards pilots using the final approaches, base legs, or base leg joins at Grangewood Airfield. This level of glare is acceptable in accordance with the associated guidance and industry best practice.

Considering the distance between the aerodromes and the proposed development, Pager Power's extensive project experience, and the results of the assessment for Grangewood Airfield, no significant impacts upon aviation activity associated with Sittles Farm Airstrip, Fisherwick Airfield, Streethay Farm Airstrip, or Tatenhill Airfield are predicted.

No significant impacts upon aviation activity are predicted.

Conclusions – Roads

The results of the modelling indicate that solar reflections are geometrically possible towards a total of 5.4km of road, including an unnamed regional road, Church Street, Coton Lane, Main Street, Burton Road, and Rosliston Road.

For road users along approximately 4.7km of the assessed roads, views of the reflecting panels are predicted to be significantly obstructed due to screening in the form of existing vegetation, proposed screening, surrounding buildings, and/or intervening terrain.

Solar reflections are predicted to be experienced from within a road user's primary horizontal field of view along approximately 300m of Rosliston Road. A low impact is predicted upon this section of road following expert assessment of the glare scenario, and mitigation is therefore not recommended.

A low impact upon approximately 100m of the unnamed regional road is predicted prior to the implementation of mitigation measures. This reduces to no impact once the proposed screening has reached maturity.

A high impact upon two sections of the unnamed regional road and a section of Coton Road is predicted prior to the implementation of mitigation measures and reduces to no impact following the implementation of screening. Temporary screening will be utilised where necessary to mitigate impacts prior to the proposed planting reaching maturity.

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

Conclusions – Dwellings

The results of the modelling indicate that solar reflections are geometrically possible towards 85 of the 89 assessed dwelling receptors.

Views of the reflecting panels are predicted to be significantly obstructed at 44 of these dwellings due to screening in the form of existing vegetation, surrounding buildings, surrounding dwellings and/or intervening terrain.

For the final 41 dwellings, solar reflections are predicted to be experienced for more than three months per year but less than 60 minutes on any given day. A low impact is predicted upon these dwellings following expert assessment of the glare scenario.

No significant impacts upon residential amenity are predicted.

Conclusions – Community Uses, PRoW, and Bridleways

Community uses, Public Rights of Way (PRoW) and bridleways are located in the surrounding area. Reflections towards observers at these community uses or along these PRoW and Bridleways could therefore be experienced under certain conditions (typically when the Sun is low in the sky beyond the panels).

Significant impacts on pedestrians/observers at community uses or along PRoW and bridleways due to glint and glare effects from the proposed development are not predicted. The reasoning is due to the sensitivity of the receptors (in terms of amenity and safety) being concluded to be of low significance.

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ABOUT PAGER POWER

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

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

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

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

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

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

1 INTRODUCTION

1.1 Overview

Pager Power has been retained to assess the possible effects of glint and glare from a proposed solar photovoltaic (PV) development to be located southeast of Walton-on-Trent in Derbyshire, south of Drakelow Power Station, in South Derbyshire local authority area.

This assessment pertains to the possible impact upon of glint and glare upon road safety, residential amenity, and aviation activity associated with Grangewood Airfield, Sittles Farm Airstrip, Fisherwick Airfield, Streethay Farm Airstrip, and Tatenhill Airfield.

This report therefore contains the following:

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

1.2 Pager Power's Experience

Pager Power has undertaken over 1,200 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 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.

These definitions are aligned with those of the National Policy Statement for Renewable Energy Infrastructure (EN-3). The term 'solar reflection' is used in this report to refer to both reflection types i.e. glint and glare.

2 SOLAR DEVELOPMENT LAYOUT AND DETAILS

2.1 Illustrative Module Layout

The illustrative module layout used in this assessment is shown in Figure 1[4] below.

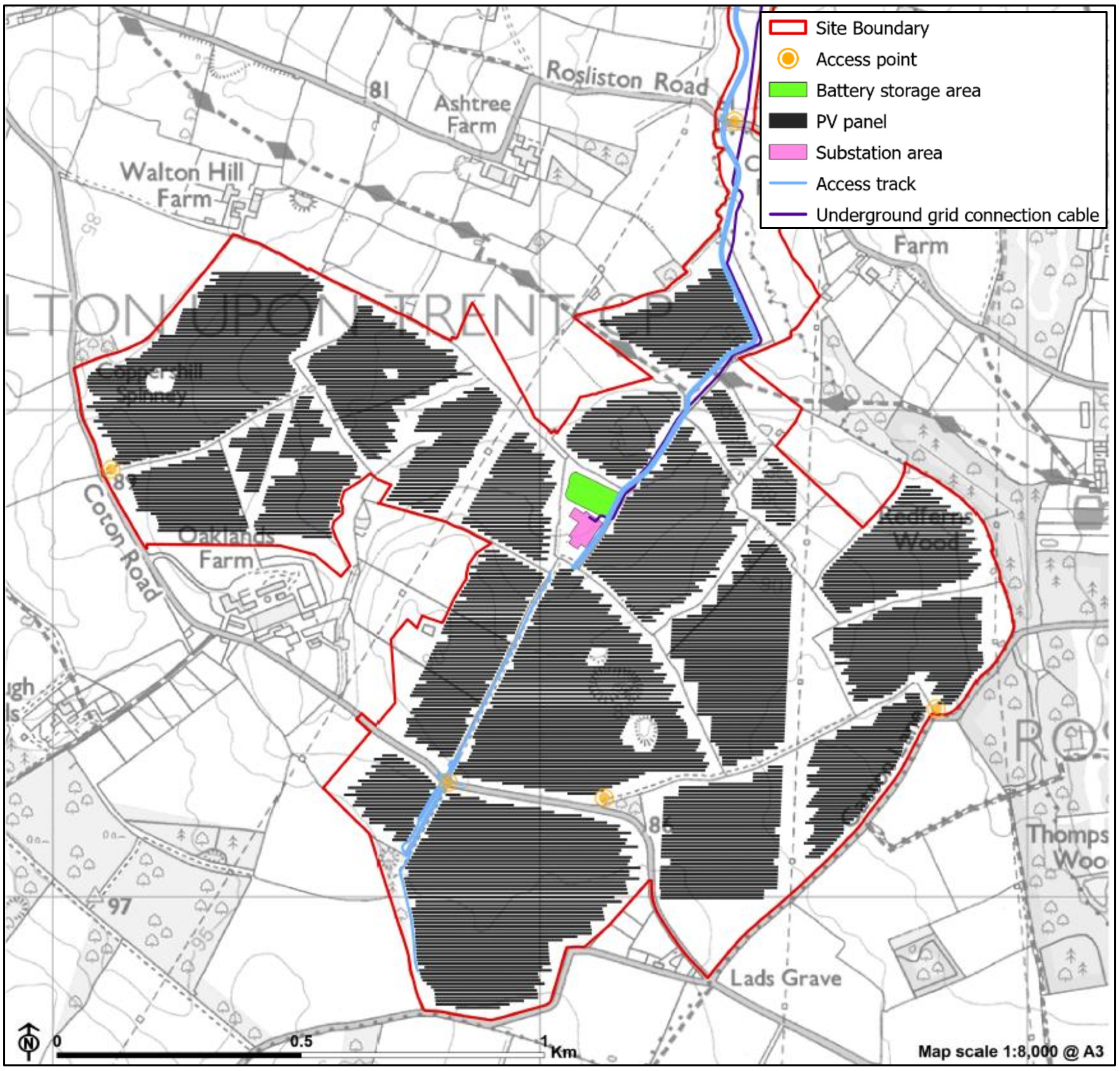

Figure 1 *Illustrative module layout*

[4] 11477_OAK_Fig4_1b_IllustrativeConceptDesign_Sth_A3L (edited).

2.2 Solar Panel Details

The solar panel details used in the assessment are presented in Table 1 below.

Panel Details	
Azimuth angle (°)	180 (south facing)
Elevation angle (°)	20
Assessed centre height (m agl)	1.75

Table 1 *Solar panel details*

The elevation angle of the solar panels will be between 15 and 22 degrees. Any changes in panel angle within this range is predicted to slightly change the time in the day in which reflections occur and is not predicted to change duration of effects or the intensity of any reflections.

The middle of the solar panel has been used as the assessed height in metres above ground level (agl), which has been chosen as it represents the smallest possible variation in height from the bottom and top of the solar panels.

It can be concluded, based on the above and previous assessment experience, that changing the assessed height and/or elevation angle within the defined ranges will not significantly change the results and conclusions of the report.

3 GLINT AND GLARE ASSESSMENT METHODOLOGY

3.1 Guidance and Studies

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

- Specular reflections of the Sun from solar panels 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 water. It also shows that reflections from solar panels are significantly less intense than many other reflective surfaces, which are common in an outdoor environment.

3.2 Background

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

3.3 Methodology

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

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.

Where a solar reflection is identified for an aviation approach path receptor, intensity calculations are completed in line with the Sandia National Laboratories methodology.

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 Aviation Receptors

The aviation receptor details are presented in the following subsection. Terrain elevation heights have been interpolated based on OS Terrain 50 DTM data. Receptor details can be found in Appendix G.

4.2 Grangewood Airfield

4.2.1 Airfield Information

Grangewood Airfield is an unlicensed aerodrome located approximately 4.4km east-southeast of the proposed development. It has one runway and does not appear to have an Air Traffic Control (ATC) Tower. The extrapolated runway details[5] are presented below:

- 12/30 – 440 x 15 metres (Grass).

The location of the aerodrome relative to the proposed development is shown in Figure 3 on the following page.

4.2.2 Identified Receptors

Grangewood Airfield is a general aviation (GA) airfield 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 a 5-degree splayed approach path based on the extended runway centreline, and the final sections of the visual circuits and joins on approach to the corresponding runway thresholds.

Unless otherwise stated in aeronautical publications freely available from the aerodrome, the assessed receptors are based 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 2 on the following page illustrates the splayed approach and final sections of the visual circuits.

[5] As determined by available aerial imagery

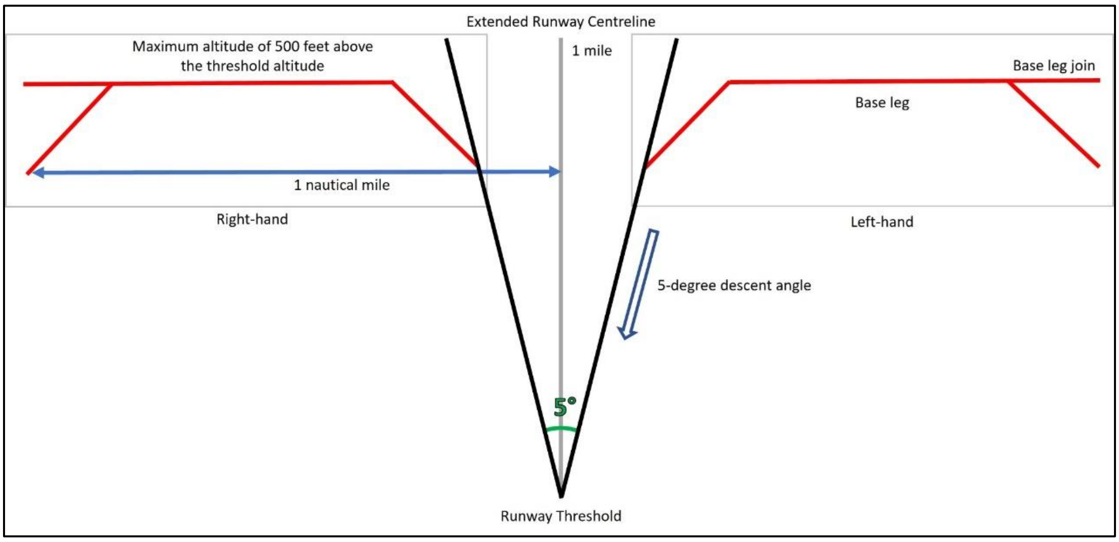

Figure 2 *Splayed approach, base legs, and base leg joins*

Figure 3 below shows the assessed aircraft receptor points for runway 12 (pink lines) and runway 30 (blue lines) at Grangewood Airfield.

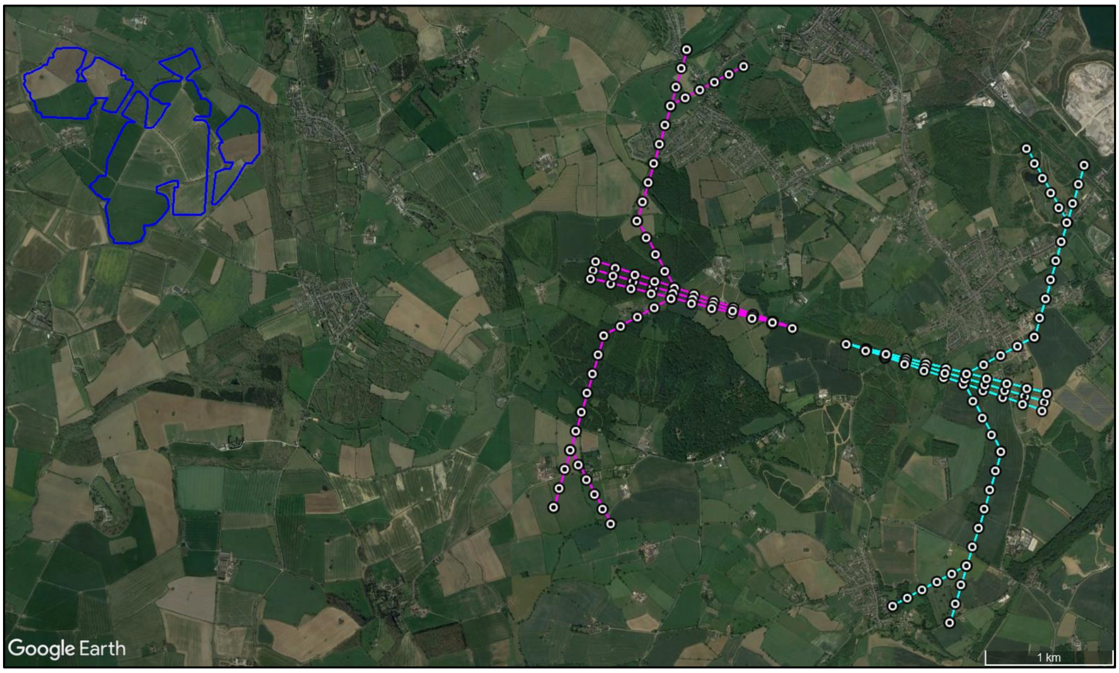

Figure 3 *Assessed aircraft receptors for Grangewood Airfield*

4.3 Ground-Based Receptors

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.

A 1km assessment area is considered appropriate for glint and glare effects on ground-based receptors – shown as the orange outlined areas in the proceeding figures. Receptors are identified based on mapping and aerial photography of the region.

The receptor details are presented in Appendix G and the terrain elevations have been interpolated based on OS Terrain 50 DTM data.

4.3.1 Road Receptors

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 a one or more carriageways with a maximum speed limit 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 therefore considers major national, national, and regional roads that:

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

The assessed receptors along an unnamed regional road (1 – 20), Church Street (21 – 31), Coton Lane (32 – 38), Main Street (39 – 45), Burton Road (46 – 50), and Rosliston Road (51 – 55) are shown in Figure 4 on the following page.

Coton Road is determined to be a local road; however, it has been included in assessment due to its importance to the local road network. The assessed receptors along Coton Road are also shown in Figure 4 on the following page.

A height of 1.5 metres above ground level has been taken as typical eye level of a road user[6].

[6] This height is used for modelling purposes. Small changes to this height are not significant, and views for elevated drivers are also considered in the results discussion, where appropriate.

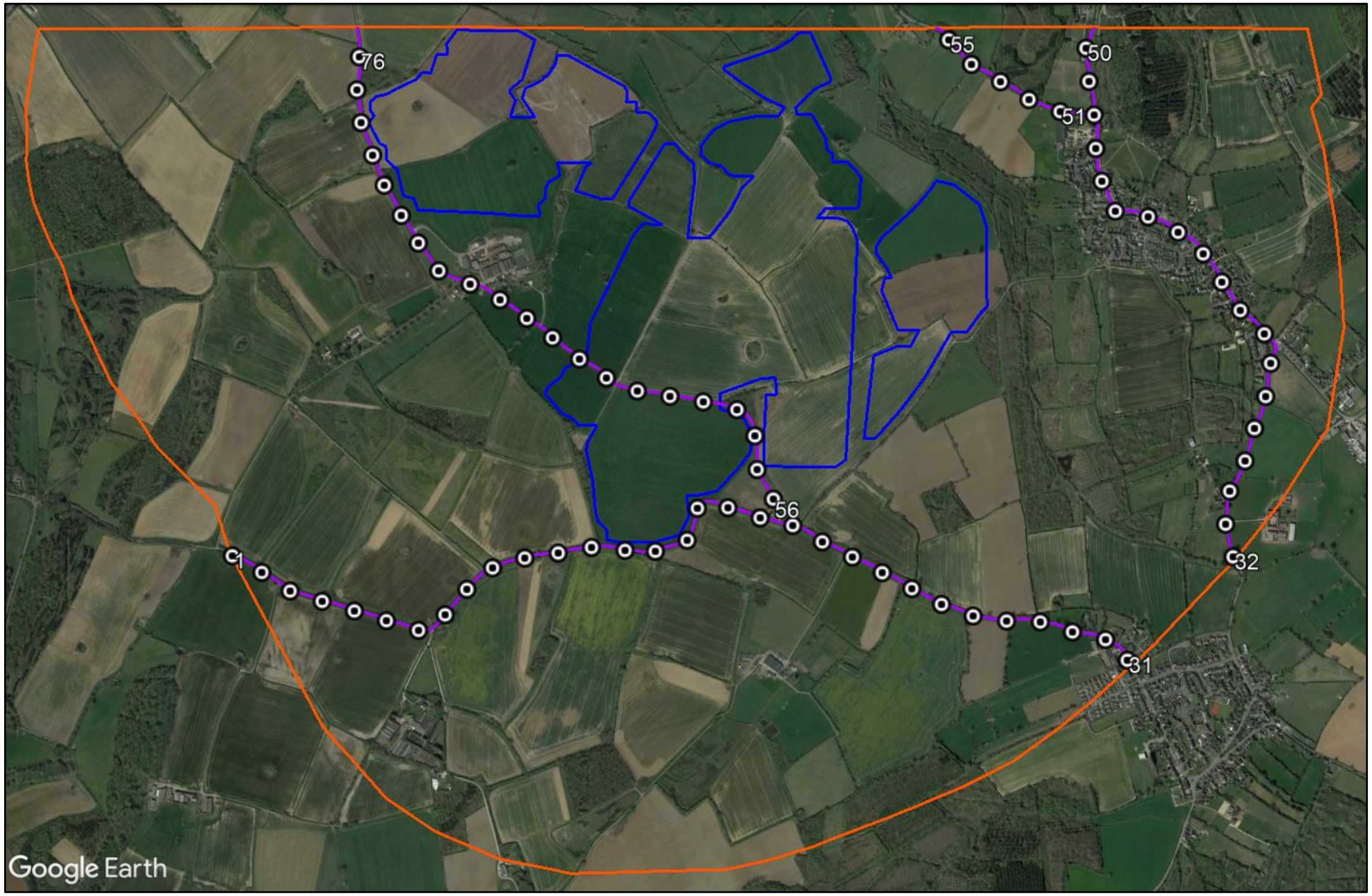

Figure 4 *Assessed road receptors*

4.3.2 Dwelling Receptors

The analysis has considered dwellings that:

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

An overview of the assessed dwelling receptor locations is shown in Figure 5 below. A total of 89 dwelling locations have been assessed and a height of 1.8m above ground level is used in the modelling to simulate the typical viewing height of a ground floor window[7].

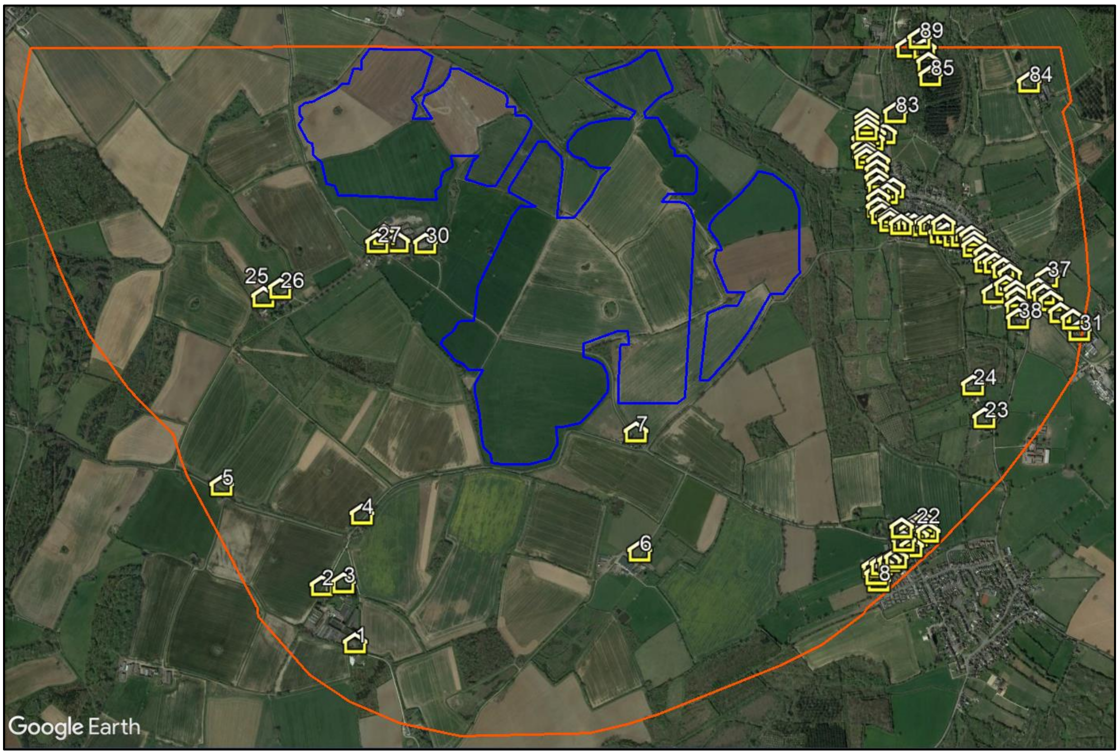

Figure 5 *Assessed dwelling receptor overview*

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.

[7] Consideration of views from upper floors are also considered in the results discussion, where appropriate.

Close-up images of the assessed dwelling receptors are shown in Figures 6 to 13 on the following pages.

Figure 6 *Assessed dwelling receptors 1 to 5*

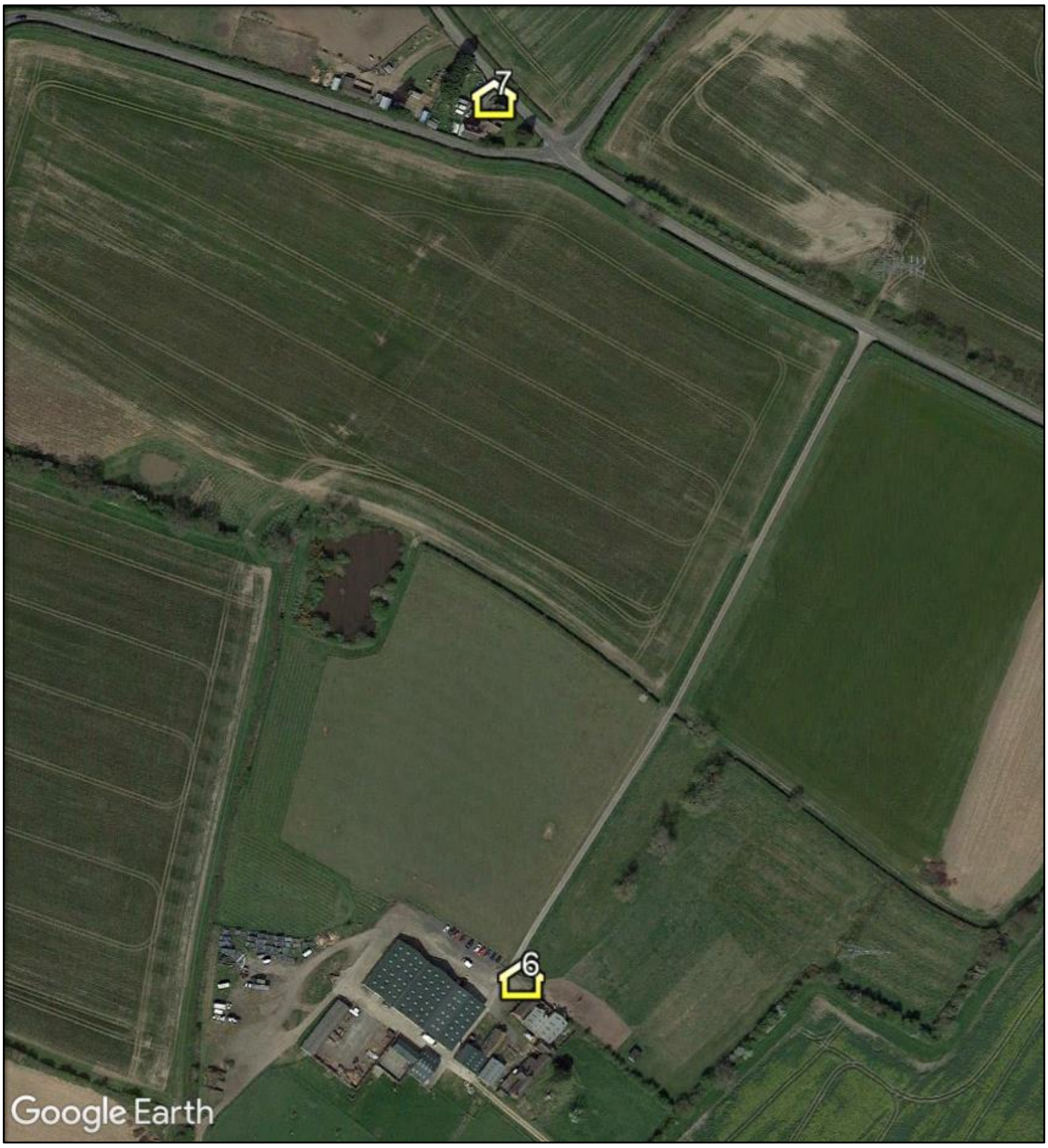

Figure 7 *Assessed dwelling receptors 6 and 7*

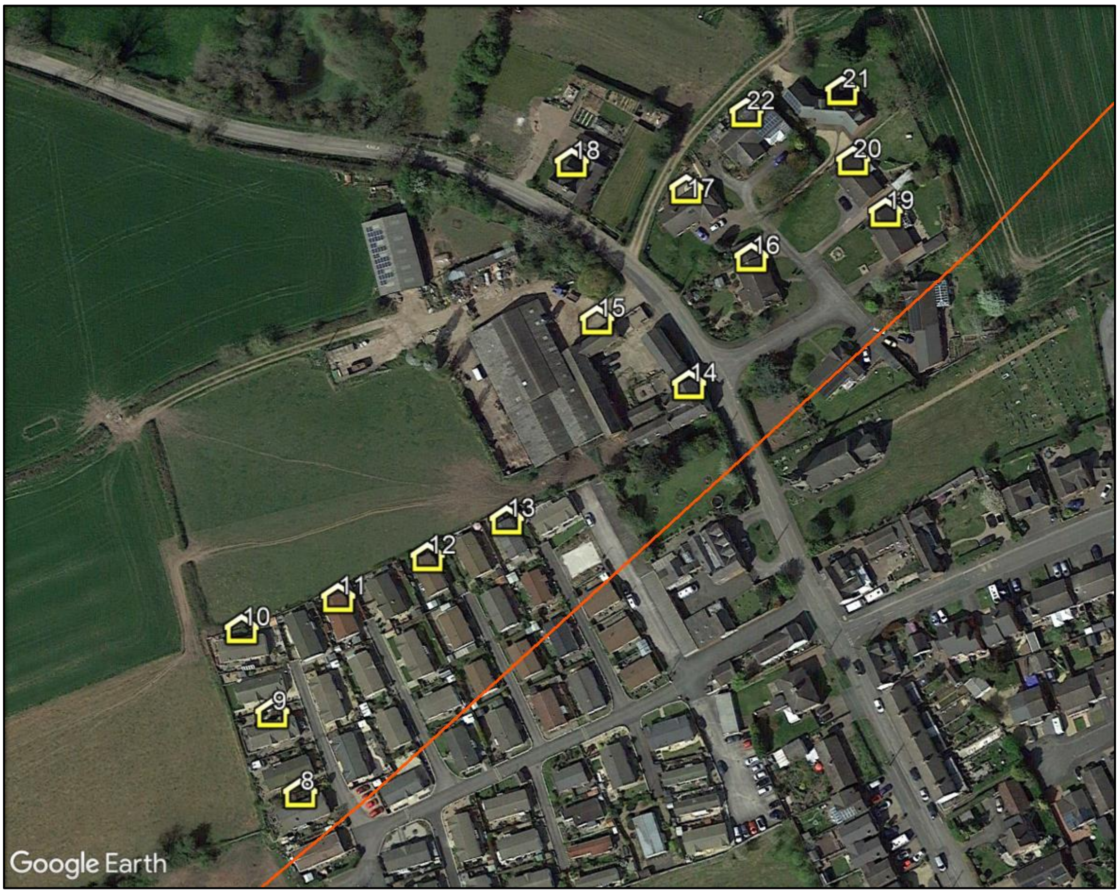

Figure 8 *Assessed dwelling receptors 8 to 22*

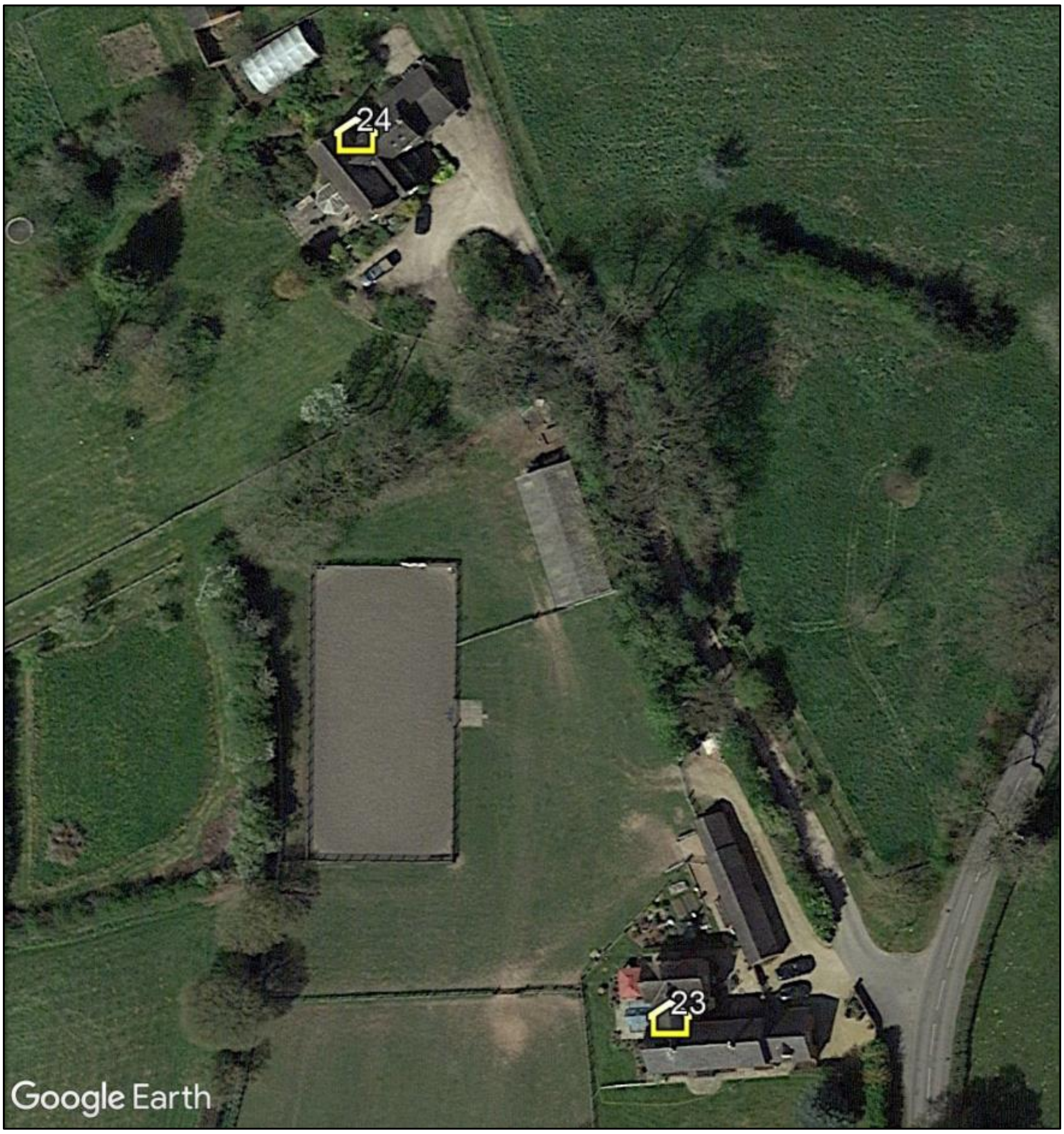

Figure 9 *Assessed dwelling receptors 23 and 24*

Figure 10 *Assessed dwelling receptors 25 to 30*

Figure 11 *Assessed dwelling receptors 31 to 55*

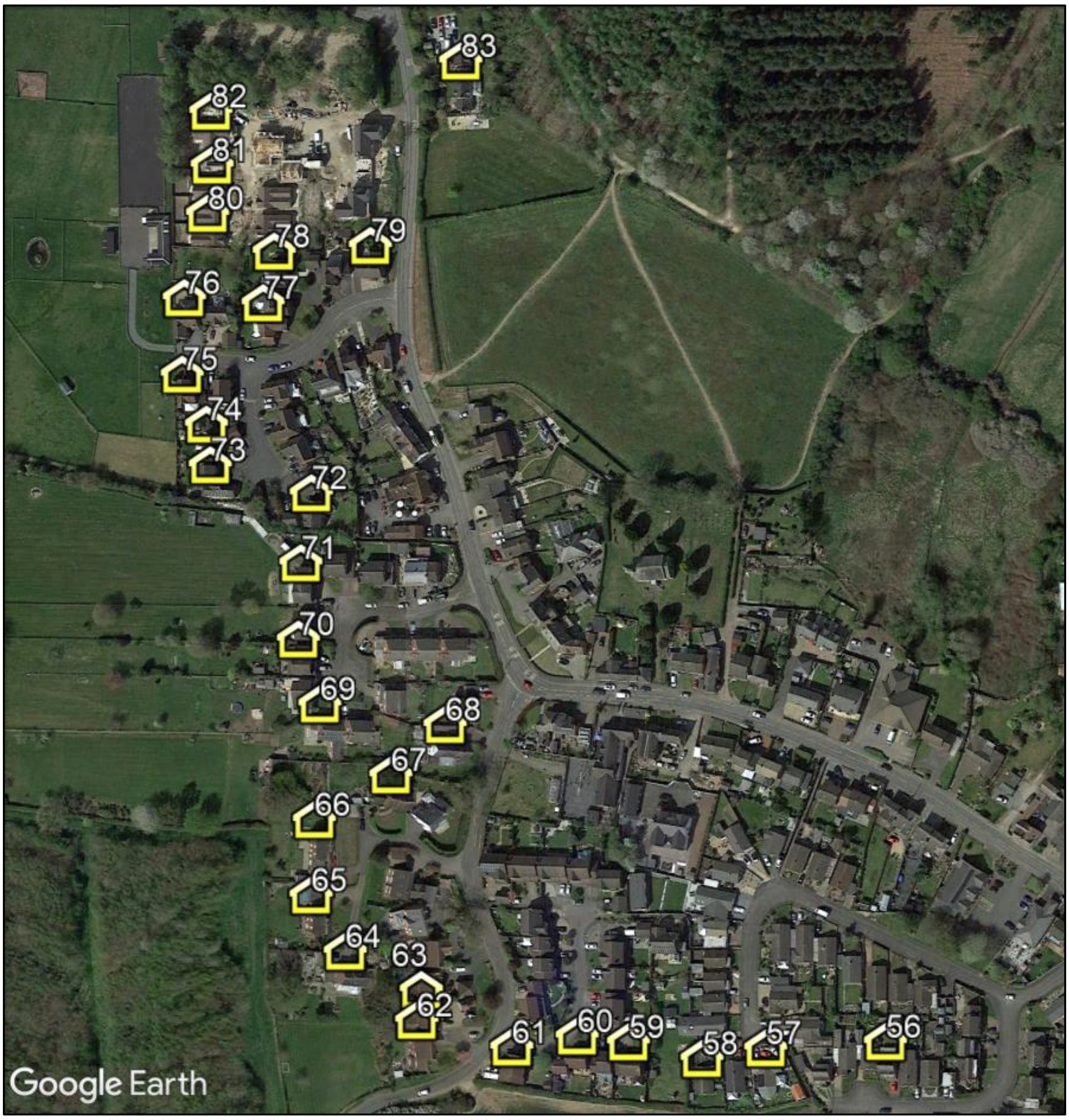

Figure 12 *Assessed dwelling receptors 56 to 83*

Figure 13 *Assessed dwelling receptors 84 to 89*

4.3.3 Drakelow Park

Further to the existing dwellings surrounding the proposed development, dwellings within the proposed Drakelow Park housing development have been considered as part of this assessment. The location of Drakelow Park relative to the proposed development is shown in Figure 14 on the following page.

The figure shows that the housing development is located significantly north of the proposed development, which means solar reflections would not be geometrically possible towards any of the dwellings. No dwellings within Drakelow Park have therefore been taken forward for geometric modelling, and no impacts are predicted.

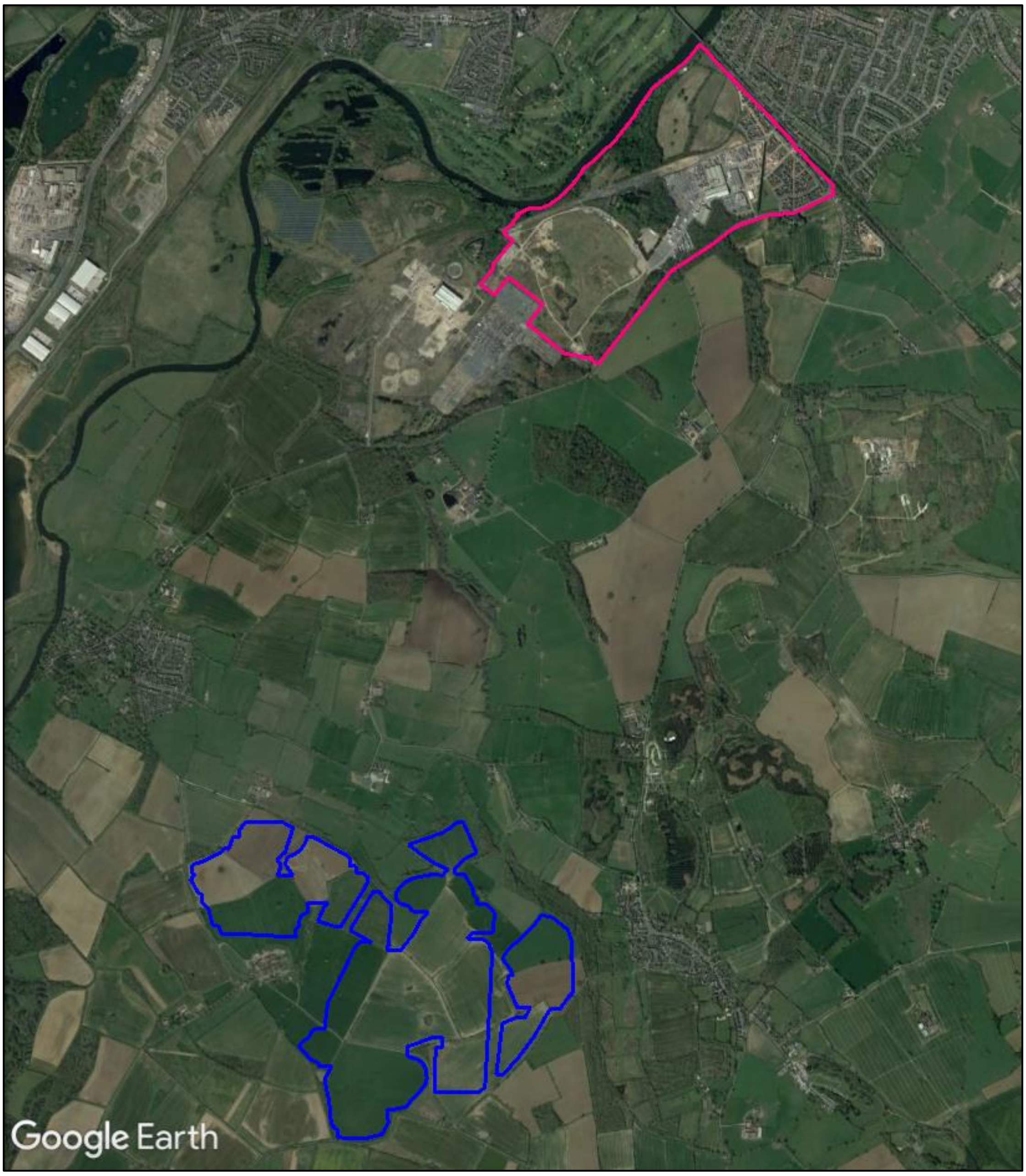

Figure 14 *Drakelow Park relative to the proposed development*

4.4 Public Rights of Way and Bridleways

Public Rights of Way (PRoW) and bridleways are located in the surrounding area. Reflections towards observers on these PRoW and Bridleways could therefore be experienced under certain conditions (typically when the Sun is low in the sky beyond the panels).

Significant impacts on pedestrians/observers along Public Rights of Way (PRoW) due to glint and glare effects from the proposed development are not predicted. The reasoning is due to the sensitivity of the receptors (in terms of amenity and safety) being concluded to be of low significance. This is because:

- The typical density of pedestrians on a PRoW and horse riders on a bridleway is low in a rural environment;
- 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;
- Glint and glare effects towards receptors on a PRoW and a bridleway 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;
- Any observable solar reflection to users of the PRoW and bridleways would be of similar intensity to those experienced whilst navigating the natural and built environment on a regular basis.
- There is no safety hazard associated with reflections towards an observer on a footpath or bridleways.

The overall impact upon pedestrians along the surrounding PRoW and horse riders along the surrounding bridleways is low and no mitigation is required. PRoW and bridleways have not been considered further within this report.

5 ASSESSED REFLECTOR AREAS

5.1 Reflector Areas

A number of representative panel locations are selected within the proposed reflector areas. The number of modelled reflector points is determined by the size of the reflector area and the assessment resolution. The bounding co-ordinates for the proposed solar development have been extrapolated from the site plans and can be found in Appendix G. All ground heights have been based on OS Terrain 50 DTM data.

A geometric calculation is undertaken for each identified receptor every 25m 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.

The assessed reflector areas are shown in Figure 15 below.

Figure 15 *Assessed reflector areas*

6 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

6.1 Overview

The following section presents the geometric modelling results and summarises the results of the assessment. Each sub-section includes:

- 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, 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, and site photography is undertaken. The desk-based imagery is presented in Appendix I and the site photography is presented in Appendix J.
- The impact significance for each receptor.
- The desk-based review of the available imagery.

6.2 Aviation

6.2.1 Glare Intensity Categorisation

Intensity calculations in line with the Sandia National Laboratories methodology have been undertaken for aviation receptors. 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 2 below along with the associated colour coding.

Coding Used	Intensity Key
Glare beyond 50°	Glare beyond 50 deg from pilot line-of-sight Low potential for temporary after-image Potential for temporary after-image Potential for permanent eye damage
Low potential for temporary after-image	
Potential for temporary after-image	
Potential for permanent eye damage	

Table 2 *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.

In addition, the intensity model allows for assessment of a variety of solar panel surface materials. In the first instance, a surface material of 'smooth glass with an anti-reflective coating' is assessed because it is the panel surface most used for modern solar panels. 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.
- Deeply textured glass.

6.2.2 Key Considerations

The key considerations for quantifying the impact significance for the assessed aviation receptors are:

- Whether a reflection is predicted to be experienced in practice.
- The location of glare relative to a pilot's primary horizontal 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.

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 main field of view (50 degrees either side of 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[8] for on-airfield solar. Whilst this guidance was never formally applicable outside of the USA, it has been a common point of reference internationally. Pager Power recommends a pragmatic approach whereby instances of 'yellow' glare are evaluated in a technical and operational context. As per Pager Power's glint and glare guidance document, where solar reflections are of an intensity no

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

greater than 'low potential for temporary after-image' expert assessment of the following relevant factors is required to determine the impact significance[9]:

- 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 factors, where the solar reflections are not considered 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 reflections are considered 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.

6.2.3 Geometric Modelling Results

The modelling indicates that solar reflections are geometrically possible towards the entire splayed 1-mile approach paths towards the runway thresholds, and towards most of the final sections of the base legs and base leg joins.

The sections of the runway 12 flight paths (pink lines) and runway 30 flight paths (blue lines), where solar reflections are geometrically possible, are shown in Figure 16 on the following page.

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[9] 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.

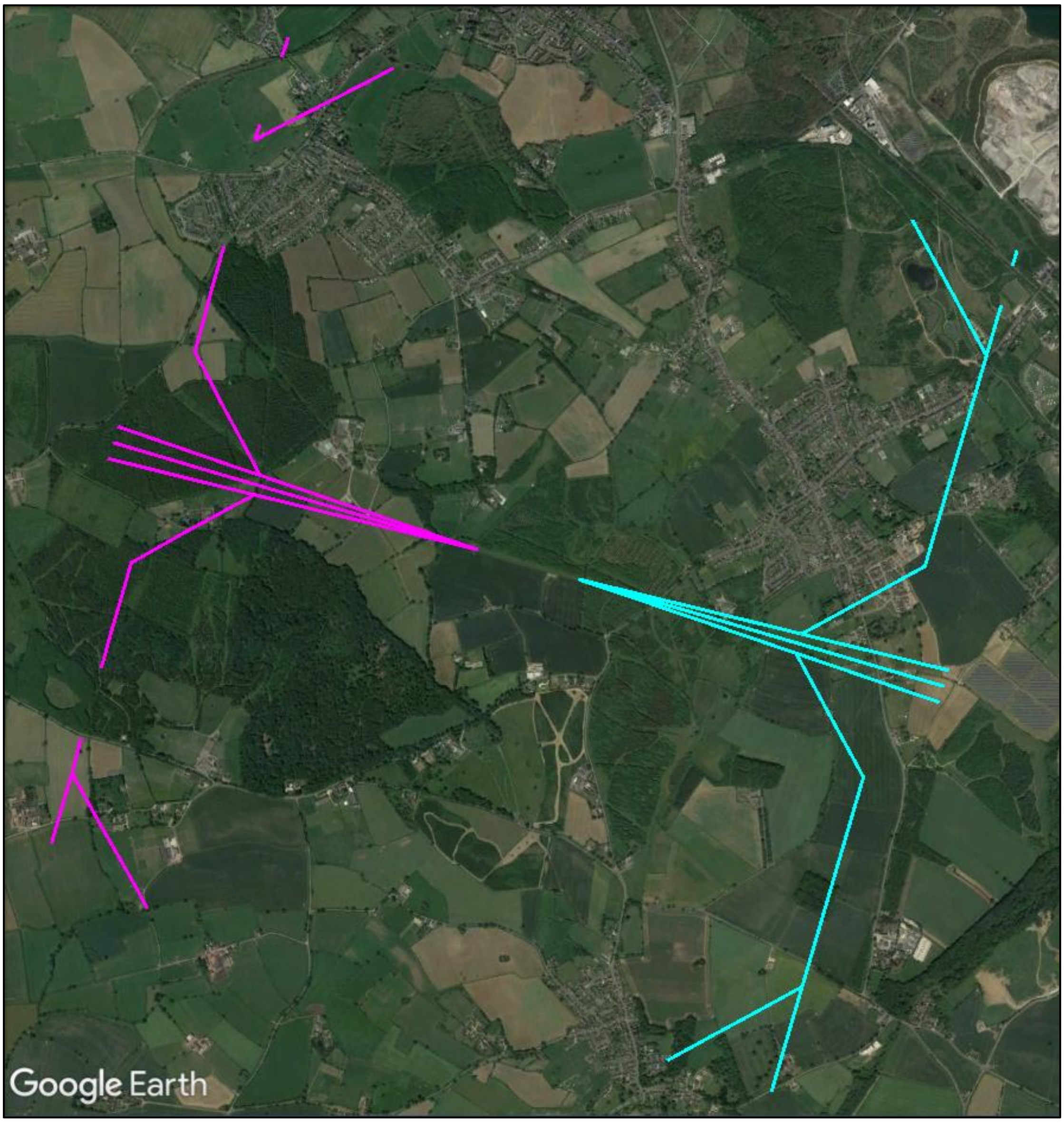

Figure 16 *Sections of flight paths where solar reflections are geometrically possible*

6.2.4 Impact Classification

Table 3 on the following page presents the following:

- Geometric modelling results (without consideration of screening).
- Glare type considering the direction of travel and Forge modelling.
- Consideration of relevant factors (where appropriate).
- Predicted impact significance.

Runway	Flight Path	Geometric Modelling Results (without consideration of screening)	Glare Type (Forge)	Relevant Factors	Predicted Impact Classification
12	Splayed Approach Path	Solar reflections outside the pilot's primary horizontal field of view are geometrically possible		N/A	Low
	RH Base Leg	Solar reflections with a maximum of 'low potential for temporary after-image' are predicted			
	RH Base Leg Join				
	LH Base Leg				
	LH Base Leg Join				
30	Splayed Approach Path	Solar reflections with a maximum of 'low potential for temporary after-image' are predicted		N/A	Low
	RH Base Leg				
	RH Base Leg Join				
	LH Base Leg				
	LH Base Leg Join				

Table 3 *Geometric modelling results and assessment of impact significance – Grangewood Airfield*

6.3 Roads

6.3.1 Key Considerations

The key considerations for quantifying the impact significance 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 horizontal field of view (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 primary horizontal 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 mitigating factors, where solar reflections are not considered to be significant, a low impact is predicted, and mitigation is not recommended. Where the solar reflections are considered 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.

6.3.2 Geometric Modelling Results

The results of the modelling indicate that solar reflections are geometrically possible towards all of the assessed sections of the unnamed regional road, Church Street, Coton Lane, Main Street, Burton Road, Rosliston Road, and Church Road.

Solar reflections are geometrically possible towards a total of approximately 5.4km of road.

6.3.3 Impact Classification

Table 4 on the following pages presents the following:

- Geometric modelling results (without consideration of screening).
- Desk-based review of identified existing and proposed screening (presented in more detail in the following sub-section).
- Consideration of any mitigating factors (where appropriate).
- Predicted impact significance.

<table>
<tr><th>Road Receptor</th><th>Geometric Modelling Results (without consideration of screening)</th><th>Identified Screening (desk-based review)</th><th>Mitigating Factors</th><th>Predicted Impact Classification</th></tr>
<tr><td>1–11</td><td rowspan="3">Solar reflections are geometrically possible from <u>inside</u> a road user's primary horizontal field of view</td><td>Reflecting panel areas are predicted to be significantly obstructed by existing vegetation and intervening terrain

See Appendix I – Figures i1 and i2</td><td rowspan="3">N/A</td><td>No impact</td></tr>
<tr><td>12-14</td><td>Reflecting panel areas are predicted to be significantly obstructed by existing screening which will be allowed to grow to sufficient height

See Appendix I – Figure i3</td><td>High impact prior to the establishment of mitigation

No impact following establishment of mitigation</td></tr>
<tr><td>15</td><td>Reflecting panel areas are predicted to be significantly obstructed by existing screening

See Appendix I – Figure i4</td><td>No impact</td></tr>
</table>

Road Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening (desk-based review)	Mitigating Factors	Predicted Impact Classification
16-17	Solar reflections are geometrically possible from **outside** a road user's primary horizontal field of view	Reflecting panel areas are predicted to be significantly obstructed by proposed screening once established		Low impact prior to the establishment of mitigation No impact following establishment of mitigation
18-19	Solar reflections are geometrically possible from **inside** a road user's primary horizontal field of view	Reflecting panel areas are predicted to be significantly obstructed by proposed screening once established See Appendix I – Figure i5	None	High impact prior to the establishment of mitigation No impact following establishment of mitigation
20-31	Solar reflections are geometrically possible from **inside** a road user's primary horizontal field of view	Reflecting panel areas are predicted to be significantly obstructed by existing screening See Appendix I – Figures i6 to i8	N/A	No impact

<table>
<tr><th>Road Receptor</th><th>Geometric Modelling Results (without consideration of screening)</th><th>Identified Screening (desk-based review)</th><th>Mitigating Factors</th><th>Predicted Impact Classification</th></tr>
<tr><td>32-38</td><td>Solar reflections are geometrically possible from outside a road user's primary horizontal field of view</td><td rowspan="2">Reflecting panel areas are predicted to be significantly obstructed by existing vegetation and/or surrounding buildings

See Appendix I – Figures i9 to i12</td><td rowspan="3">N/A</td><td rowspan="3">No impact</td></tr>
<tr><td>39-45</td><td>Solar reflections are geometrically possible from inside a road user's primary horizontal field of view</td></tr>
<tr><td>46-50</td><td>Solar reflections are geometrically possible from outside a road user's primary horizontal field of view</td><td>Reflecting panel areas are predicted to be significantly obstructed by existing vegetation and surrounding buildings

See Appendix I – Figures i13 and i14</td></tr>
<tr><td>51</td><td>Solar reflections are geometrically possible from inside a road user's primary horizontal field of view</td><td>Reflecting panel areas are predicted to be significantly obstructed by existing vegetation

See Appendix I – Figure i15</td><td>N/A</td><td>No impact</td></tr>
</table>

<table>
<tr><th>Road Receptor</th><th>Geometric Modelling Results (without consideration of screening)</th><th>Identified Screening (desk-based review)</th><th>Mitigating Factors</th><th>Predicted Impact Classification</th></tr>
<tr><td>52-54</td><td>Solar reflections are geometrically possible from <u>inside</u> a road user's primary horizontal field of view</td><td>Partial views of the reflecting panel areas cannot be ruled out through the existing vegetation when the vegetation is not in leaf</td><td>Effects will coincide with direct sunlight

The nearest reflecting area is approximately 420 metres from a road user at its closest point

Effects will not originate from panels directly in front of a road user</td><td>Low impact</td></tr>
<tr><td>55</td><td>Solar reflections are geometrically possible from <u>inside</u> a road user's primary horizontal field of view</td><td>Reflecting panel areas are predicted to be significantly obstructed by existing vegetation

See Appendix I – Figure i16</td><td rowspan="2">N/A</td><td>No impact</td></tr>
<tr><td>56</td><td>Solar reflections are geometrically possible from <u>inside</u> a road user's primary horizontal field of view</td><td>Reflecting panel areas are predicted to be significantly obstructed by existing vegetation

See Appendix I – Figure i17</td><td>No impact</td></tr>
</table>

Road Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening (desk-based review)	Mitigating Factors	Predicted Impact Classification
57 – 58	Solar reflections are geometrically possible from **outside** a road user's primary horizontal field of view	Reflecting panel areas are predicted to be significantly obstructed by existing vegetation See Appendix I – Figure i17	N/A	No impact
59 – 69	Solar reflections are geometrically possible from **inside** a road user's primary horizontal field of view	Reflecting panel areas are predicted to be significantly obstructed by existing vegetation and proposed screening See Appendix I – Figures i18 to i21		
70 – 71	Solar reflections are geometrically possible from **outside** a road user's primary horizontal field of view	Views of the reflecting panels cannot be ruled out based on the available imagery and landscaping plans		Low impact
72 – 76		Reflecting panel areas are predicted to be significantly obstructed by existing vegetation See Appendix I – Figures i22 and i23		No impact

Table 4 *Geometric modelling results and assessment of impact significance – road receptors*

6.3.4 Required Mitigation Locations

The locations where mitigation is required for the identified impacts upon road users are shown by the green lines in Figure 17 below – this can involve proposed planting or ensuring existing hedgerows are allowed to grow to sufficient height.

Screening at these locations has been secured by the Outline Landscape and Ecological Management Plan, including temporary screening to mitigate any impacts prior to the proposed planting reaching maturity.

Figure 17 *Required mitigation for locations for road users*

6.4 Dwellings

6.4.1 Key Considerations

The key considerations for quantifying the impact significance for dwelling receptors are:

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

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 effects are predicted to be experienced for less than 3 months per year and less than 60 minutes on any given day, 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 effects are predicted to be experienced for more than 3 months per year and/or for more than 60 minutes on any given day expert assessment of the following mitigating factors is required to determine the impact significance:

- 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. The Sun is a far more significant source of light.
- Whether solar reflections will be experienced from all storeys. The ground floor is typically considered the main living space and therefore has a greater significance with respect to residential amenity.
- Whether the dwelling appears to have windows facing the reflecting areas. An observer may need to look from a wide angle to observe the reflecting areas.

Following consideration of these mitigating factors, where the solar reflections are not considered to be significant, a low impact is predicted, and mitigation is not recommended. Where the solar reflections are considered significant, the impact significance is moderate, and mitigation is recommended.

Where effects are predicted to be experienced for more than 3 months per year and more than 60 minutes on any given day and there are no mitigating factors, the impact significance is high, and mitigation is required.

6.4.2 Geometric Modelling Results

The results of the modelling indicate that solar reflections are geometrically possible towards dwelling receptors 4, 5, and 7-80, totalling 85 of the 89 assessed dwelling receptors. The dwellings where solar reflections are geometrically possible are shown in Figure 18 on the following page.

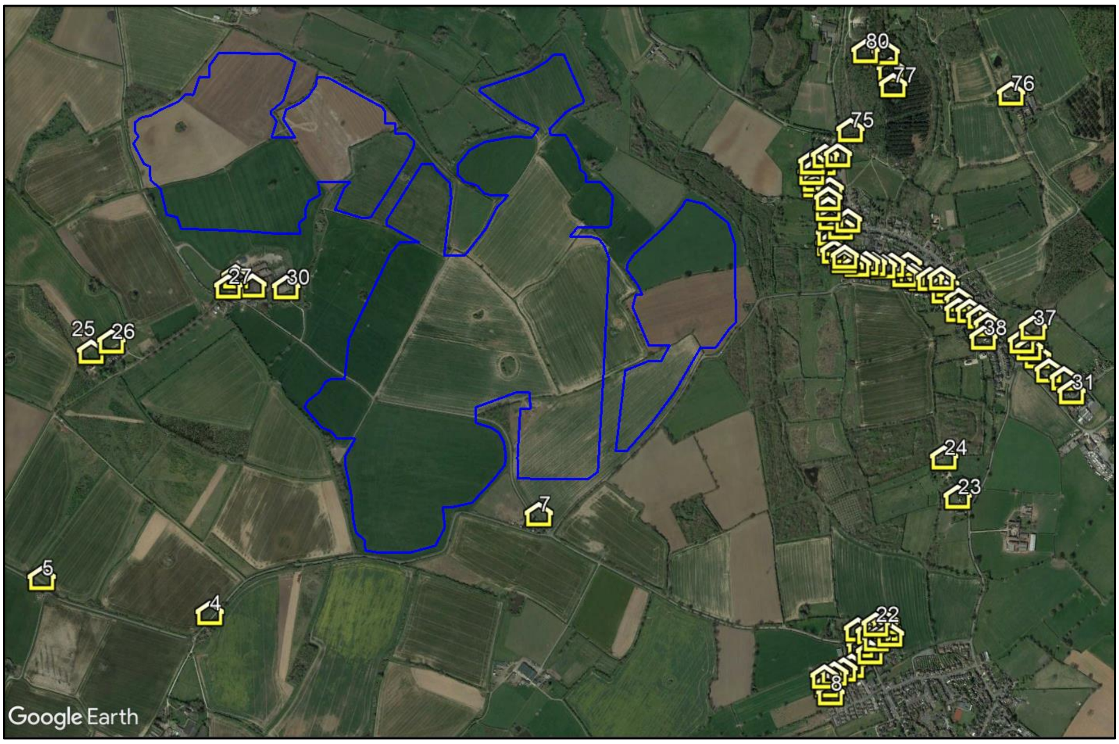

Figure 18 *Dwellings where solar reflections are geometrically possible*

6.4.3 Impact Classification

Table 5 on the following pages presents the following:

- Geometric modelling results (without consideration of screening).
- Desk-based review of identified existing and proposed screening (presented in more detail in the following sub-section).
- Consideration of relevant mitigating factors (where appropriate).
- Predicted impact significance.

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening (desk-based review)	Mitigating Factors	Predicted Impact Classification
1-3	No solar reflections geometrically possible	N/A	N/A	No impact
4	Solar reflections predicted for **less** than three months of the year and **less** than 60 minutes on any given day	Reflecting panel areas are predicted to be significantly obstructed from view by existing vegetation and intervening terrain See Appendix I – Figure i24		
5	Solar reflections predicted for **more** than three months of the year but **less** than 60 minutes on any given day			
6	No solar reflections geometrically possible	N/A		
7	Solar reflections predicted for **more** than three months of the year but **less** than 60 minutes on any given day	Reflecting panel areas are predicted to be significantly obstructed from view at the ground-floor by existing vegetation Views from above the ground-floor cannot be ruled out	Effects will be limited to above the ground-floor only Effects will coincide with direct sunlight	Low impact

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening (desk-based review)	Mitigating Factors	Predicted Impact Classification
8	Solar reflections predicted for **less** than three months of the year and **less** than 60 minutes on any given day	Reflecting panel areas are predicted to be significantly obstructed from view by existing vegetation and intervening terrain See Appendix I – Figure i25	N/A	No impact
9-26	Solar reflections predicted for **more** than three months of the year but **less** than 60 minutes on any given day	Reflecting panel areas are predicted to be significantly obstructed from view by existing vegetation, surrounding buildings and/or intervening terrain See Appendix I – Figures i26 and i27		
27-30		Reflecting panel areas are predicted to be significantly obstructed from view by surrounding buildings and intervening terrain See Appendix I – Figure i28		
31-37		Reflecting panel areas are predicted to be significantly obstructed from view by existing vegetation, surrounding buildings, and intervening terrain See Appendix I – Figure i29		

Dwelling Receptor	Geometric Modelling Results (without consideration of screening)	Identified Screening (desk-based review)	Mitigating Factors	Predicted Impact Classification
38-55	Solar reflections predicted for **more** than three months of the year but **less** than 60 minutes on any given day	Reflecting panel areas are predicted to be significantly obstructed from view at the ground-floor by existing vegetation and intervening terrain Views from above the ground-floor cannot be ruled out	Effects will be limited to above the ground-floor only The closest visible reflecting panel will be beyond 500 metres from the dwellings Effects will coincide with direct sunlight	Low impact
56-60		Reflecting panel areas are predicted to be significantly obstructed from view by surrounding dwellings See Appendix I – Figure i30	N/A	No impact
61-78		The closest reflecting panel areas are predicted to be partially obstructed by existing vegetation, intervening terrain, and/or surrounding buildings Additional reflecting panel areas will be obstructed by intervening terrain Visibility of the remaining reflecting panel areas cannot be ruled out	It is possible effects will be reduced to less than 3 months per year The closest visible reflecting panel will be beyond 300 metres from the dwellings Effects will coincide with direct sunlight	Low impact

<table>
<tr><th>Dwelling Receptor</th><th>Geometric Modelling Results (without consideration of screening)</th><th>Identified Screening (desk-based review)</th><th>Mitigating Factors</th><th>Predicted Impact Classification</th></tr>
<tr><td>79</td><td rowspan="2">Solar reflections predicted for more than three months of the year but less than 60 minutes on any given day</td><td>Reflecting panel areas are predicted to be significantly obstructed from view by existing vegetation and surrounding buildings

See Appendix I – Figure i31</td><td>N/A</td><td>No impact</td></tr>
<tr><td>80-83</td><td>The closest reflecting panel areas are predicted to be partially obstructed by existing vegetation, intervening terrain, and/or surrounding buildings

Additional reflecting panel areas will be obstructed by intervening terrain

Visibility of the remaining reflecting panel areas cannot be ruled out</td><td>The closest visible reflecting panel will be beyond 700 metres from the dwellings

Effects will coincide with direct sunlight</td><td>Low impact</td></tr>
<tr><td>84-88</td><td>Solar reflections predicted for less than three months of the year and less than 60 minutes on any given day.</td><td>Reflecting panel areas are predicted to be significantly obstructed from view by existing vegetation and intervening terrain

See Appendix I – Figure i32</td><td rowspan="2">N/A</td><td rowspan="2">No impact</td></tr>
<tr><td>89</td><td>No solar reflections geometrically possible.</td><td>N/A</td></tr>
</table>

Table 5 *Geometric modelling results and assessment of impact significance - dwelling receptors*

7 HIGH-LEVEL AVIATION CONSIDERATIONS

7.1 Overview

Glint and glare assessment for aviation receptors are typically undertaken for aerodromes within 10km of a proposed solar development, with most concerns being raised when within 6km of an aerodrome. At ranges of 10-20km, the requirement for assessment is much less common, with assessment only typically being undertaken for licensed aerodromes at these ranges. Assessment of any aviation effects for developments over 20km is not a usual requirement.

The locations of the aerodromes relative to the proposed development are shown in Figure 19 below.

Figure 19 *Aerodromes relative to the proposed development*

7.2 Aerodrome Details

Sittles Farm Airstrip is an unlicensed aerodrome located approximately 6.8km southwest of the proposed development. It has two runways and is understood to have an ATC Tower. The extrapolated runway details are presented below:

- 08/26 – 530 x 10 metres (Grass).
- 16/34 – 430 x 10 metres (Grass).

Fisherwick Airfield is an unlicensed aerodrome located approximately 8.2km south-southwest of the proposed development. It has one runway and is understood to have an ATC Tower. The extrapolated runway details are presented below:

- 18/36 – 520 x 20 metres (Grass).

Streethay Farm Airstrip is an unlicensed aerodrome located approximately 9.7km southwest of the proposed development. It has one runway and does not appear to have an ATC Tower. The extrapolated runway details are presented below:

- 04/22 – 360 x 20 metres (Grass).

Tatenhill Airfield is CAA licensed aerodrome located approximately 9.4km northwest of the proposed development. It has two runways and is understood to have an ATC Tower. The runway details are presented below:

- 08/26 – 1,190 x 28 metres (Asphalt).
- 04/22 – 535 x 18 metres (Asphalt).

7.3 High-Level Assessment Conclusions

Considering the distance between the aerodromes and the proposed development, Pager Power's extensive project experience, and the results of the assessment for Grangewood Airfield, the following conclusions can be made:

- Any solar reflections experienced by pilot's using the final approaches, base legs, or base leg joins at these aerodromes 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.
- Personnel within any of the surrounding ATC Towers are not predicted to have visibility of the proposed development due to screening that will significantly obstruct views of the proposed development.

Overall, no significant impacts upon aviation activity associated with Sittles Farm Airstrip, Fisherwick Airfield, Streethay Farm Airstrip, or Tatenhill Airfield are predicted. No further assessment is recommended.

8 OVERALL CONCLUSIONS

8.1 Conclusions – Aviation

The modelling has shown that solar reflections with a maximum intensity of 'low potential for temporary after-image' are predicted towards pilots using the final approaches, base legs, or base leg joins at Grangewood Airfield. This level of glare is acceptable in accordance with the associated guidance and industry best practice.

Considering the distance between the aerodromes and the proposed development, Pager Power's extensive project experience, and the results of the assessment for Grangewood Airfield, no significant impacts upon aviation activity associated with Sittles Farm Airstrip, Fisherwick Airfield, Streethay Farm Airstrip, or Tatenhill Airfield are predicted.

No significant impacts upon aviation activity are predicted.

8.2 Conclusions – Roads

The results of the modelling indicate that solar reflections are geometrically possible towards a total of 5.4km of road, including an unnamed regional road, Church Street, Coton Lane, Main Street, Burton Road, and Rosliston Road.

For road users along approximately 4.7km of the assessed roads, views of the reflecting panels are predicted to be significantly obstructed due to screening in the form of existing vegetation, proposed screening, surrounding buildings, and/or intervening terrain.

Solar reflections are predicted to be experienced from within a road user's primary horizontal field of view along approximately 300m of Rosliston Road. A low impact is predicted upon this section of road following expert assessment of the glare scenario, and mitigation is therefore not recommended.

A low impact upon approximately 100m of the unnamed regional road is predicted prior to the implementation of mitigation measures. This reduces to no impact once the proposed screening has reached maturity.

A high impact upon two sections of the unnamed regional road and a section of Coton Road is predicted prior to the implementation of mitigation measures and reduces to no impact following the implementation of screening. Temporary screening will be utilised where necessary to mitigate impacts prior to the proposed planting reaching maturity.

8.3 Conclusions – Dwellings

The results of the modelling indicate that solar reflections are geometrically possible towards 85 of the 89 assessed dwelling receptors.

Views of the reflecting panels are predicted to be significantly obstructed at 44 of these dwellings due to screening in the form of existing vegetation, surrounding buildings, surrounding dwellings and/or intervening terrain.

For the final 41 dwellings, solar reflections are predicted to be experienced for more than three months per year but less than 60 minutes on any given day. A low impact is predicted upon these dwellings following expert assessment of the glare scenario, and mitigation is therefore not recommended.

No significant impacts upon residential amenity are predicted.

8.4 Conclusions – Community Uses, PRoW, and Bridleways

Public Rights of Way (PRoW) and bridleways are located in the surrounding area. Reflections towards observers on these PRoW and Bridleways could therefore be experienced under certain conditions (typically when the Sun is low in the sky beyond the panels).

Significant impacts on pedestrians/observers along Public Rights of Way (PRoW) due to glint and glare effects from the proposed development are not predicted. The reasoning is due to the sensitivity of the receptors (in terms of amenity and safety) being concluded to be of low significance.

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

Renewable and Low Carbon Energy

The National Planning Policy Framework under the planning practice guidance for Renewable and Low Carbon Energy[10] (specifically regarding the consideration of solar farms, paragraph 013) states:

'What are the particular planning considerations that relate to large scale ground-mounted solar photovoltaic Farms?

The deployment of large-scale solar farms can have a negative impact on the rural environment, particularly in undulating landscapes. However, the visual impact of a well-planned and well-screened solar farm can be properly addressed within the landscape if planned sensitively.

Particular factors a local planning authority will need to consider include:

…

- *the proposal's visual impact, the effect on landscape of glint and glare (see guidance on landscape assessment) and on **neighbouring uses and aircraft safety**;*
- *the extent to which there may be additional impacts if solar arrays follow the daily movement of the sun;*

…

The approach to assessing cumulative landscape and visual impact of large scale solar farms is likely to be the same as assessing the impact of wind turbines. However, in the case of ground-mounted solar panels it should be noted that with effective screening and appropriate land topography the area of a zone of visual influence could be zero.'

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[10] Renewable and low carbon energy, Ministry of Housing, Communities & Local Government, date: 18 June 2015, accessed on: 01/11/2021

National Policy Statement for Renewable Energy Infrastructure

The draft National Policy Statement for Renewable Energy Infrastructure (EN-3)[11] 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.[12] 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.'

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.

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[11] Draft National Policy Statement for Renewable Energy Infrastructure (EN-3) to be designated, Department for Energy Security & Net Zero, date: November 2023, accessed on: 21/12/2023.

[12] *'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.'*

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[13] which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

[13] Solar Photovoltaic Development Glint and Glare Guidance, Fourth Edition, September 2022. Pager Power.

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[14] however the advice is still applicable[15] 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[16]*, 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.*

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.

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[14] Archived at Pager Power

[15] Reference email from the CAA dated 19/05/2014.

[16] Aerodrome Licence Holder.

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*'[17], the 2013 update is entitled '*Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports*'[18], and the 2021 final policy is entitled '*Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports*'[19].

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

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[17] Archived at Pager Power

[18] 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.

[19] 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.

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 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'*[20]. 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*[21].
- *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*[22]*, 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;*

[20] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 08/12/2021.
[21] 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.
[22] First figure in Appendix B.

- *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.*

- *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[23] but still requires further research to definitively answer.*

[23] 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.

- ***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. 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[24] 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.

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

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.

Civil Aviation Authority consolidation of UK Regulation 139/2014

The Civil Aviation Authority (CAA) published a consolidating document[25] 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. the dazzling caused by large and highly reflective surfaces;
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.

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

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

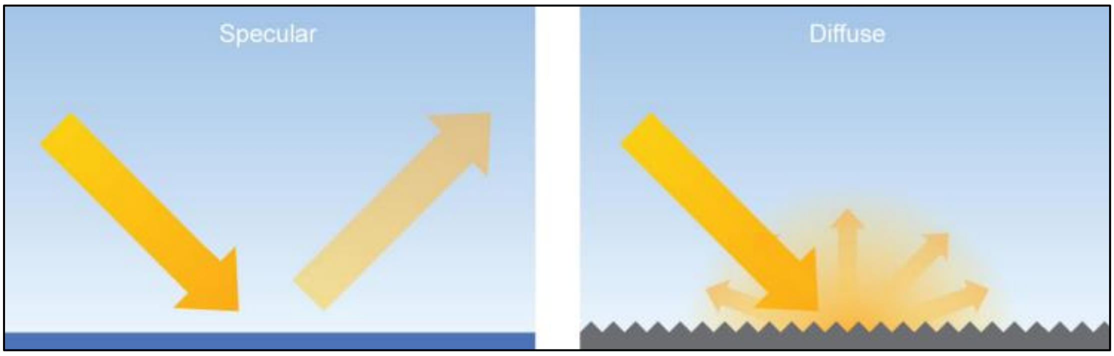
Overview

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[26], 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

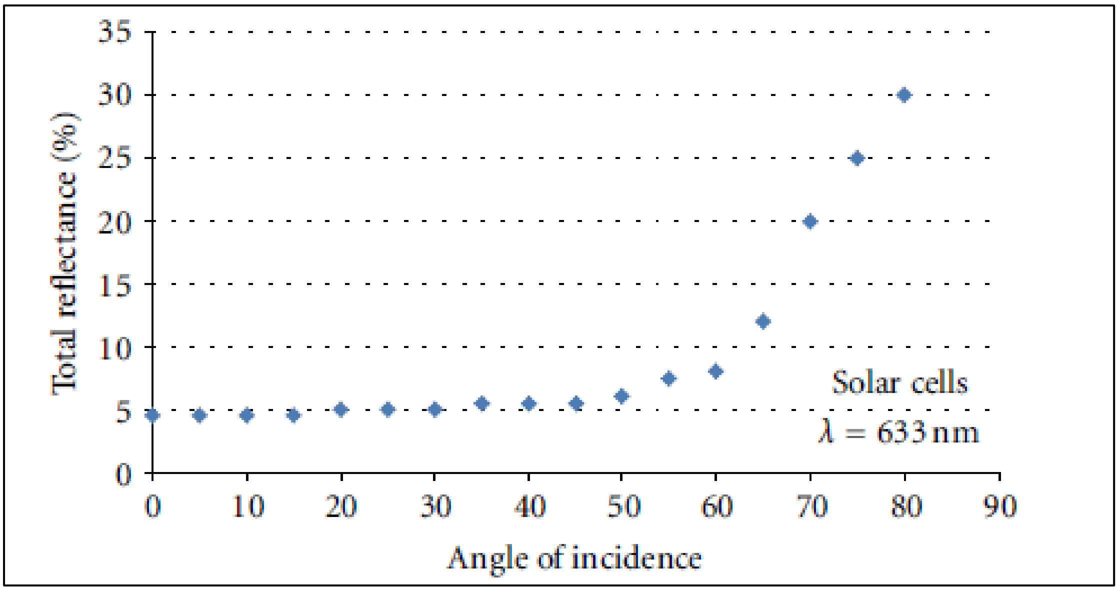
[26] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

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*[27]". 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.

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[27] 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"[28]

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[29]
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).

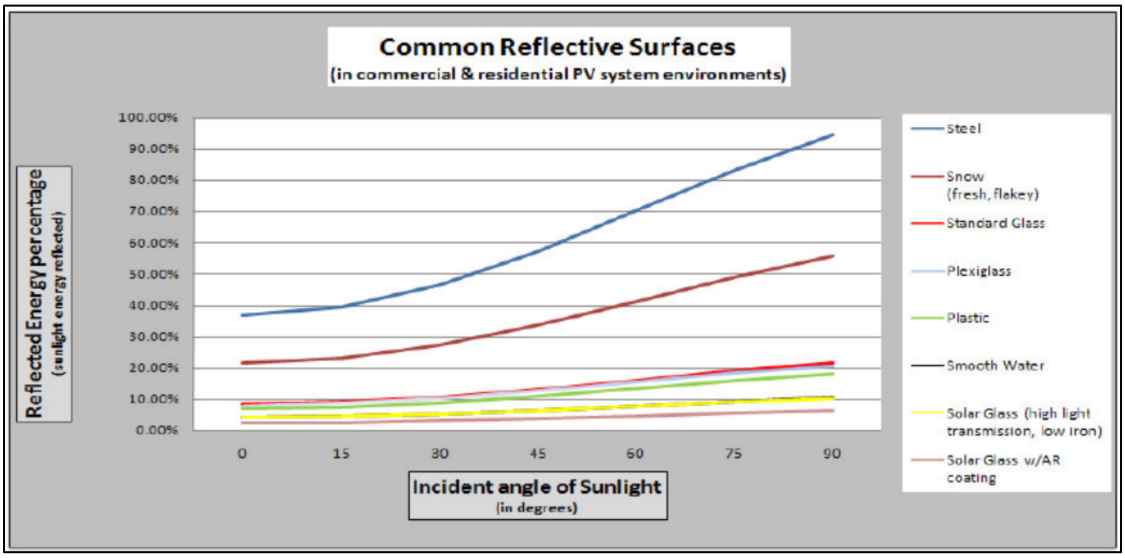
An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel. The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

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

SunPower Technical Notification (2009)

SunPower published a technical notification[30] 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.

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[30] 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).

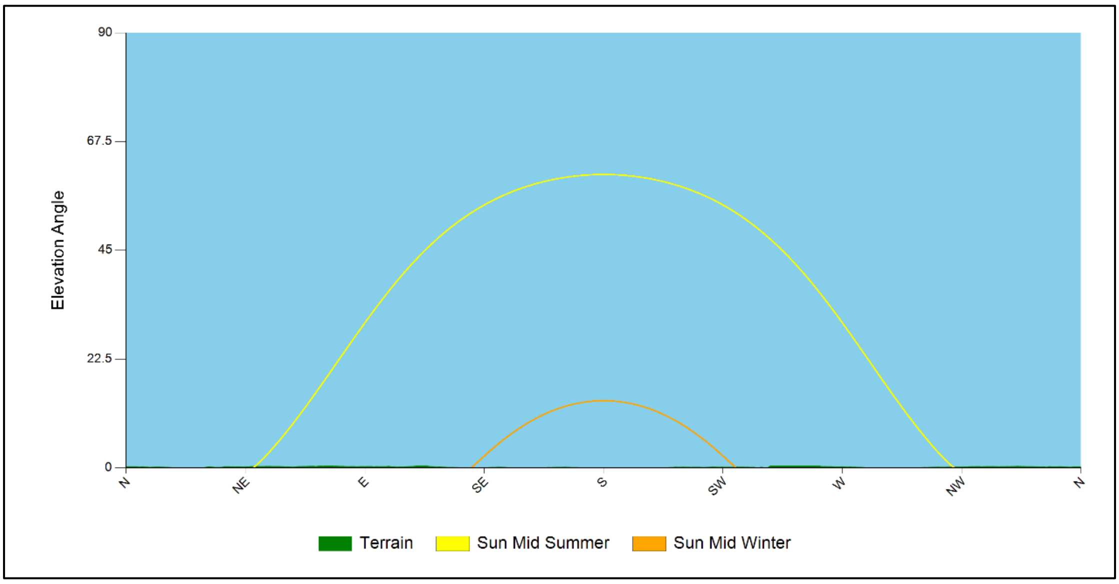
The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

- 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 reaching a maximum elevation of approximately 60-65 degrees (longest day);
- On 21 December, the maximum elevation reached by the Sun is approximately 10-15 degrees (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 as well as the sunrise and sunset curves throughout the year.



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.

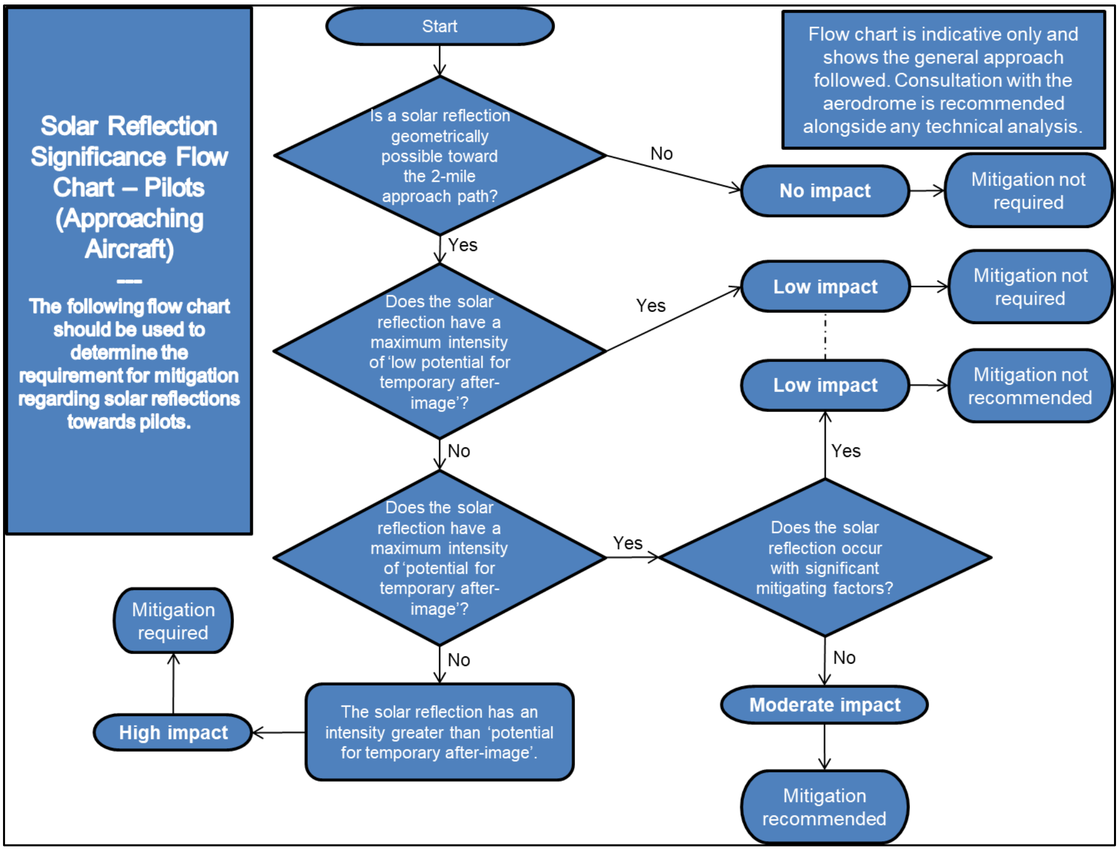
Impact Significance	Definition	Mitigation Requirement
No Impact	A solar reflection is not geometrically possible or will not be visible from the assessed receptor.	No mitigation required.
Low	A solar reflection is geometrically possible however any impact is considered to be small such that mitigation 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

The flow charts presented in the following sub-sections have been followed when determining the mitigation requirement for the assessed receptors.

Impact Significance Determination for Airborne Aircraft Receptors

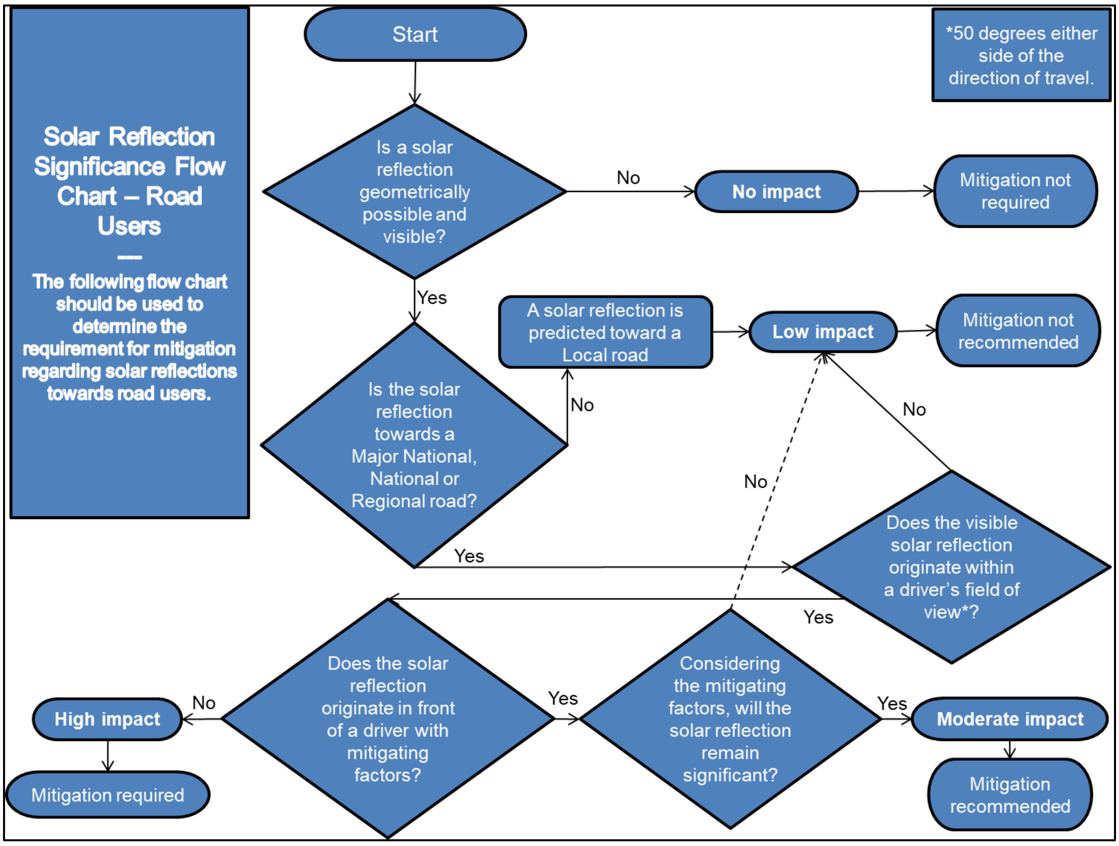
The flow chart presented below has been followed when determining the impact significance for approaching aircraft.



Airborne aircraft receptors impact significance flow chart

Impact Significance Determination for Road Receptors

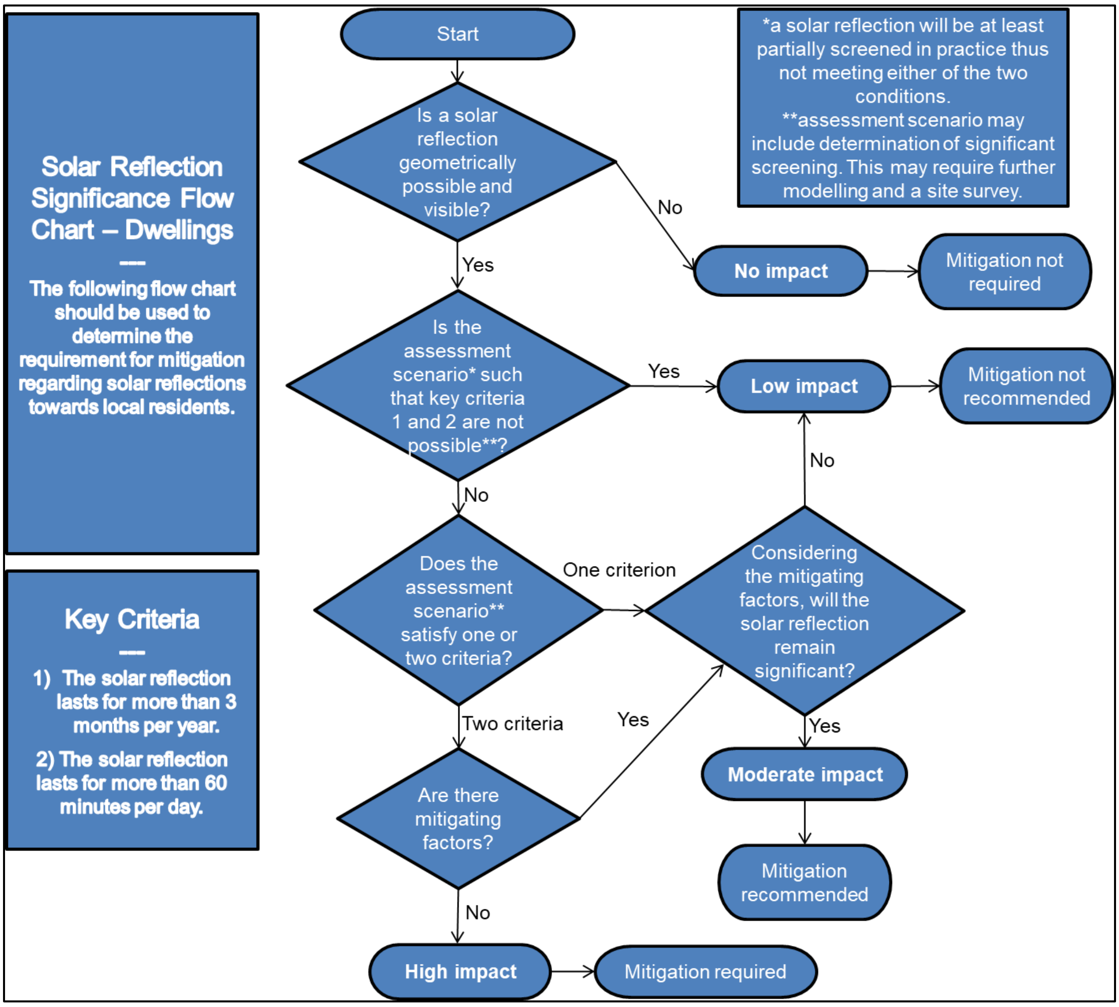
The flow chart presented below has been followed when determining the impact significance for road receptors.



Road user impact significance flow chart

Impact Significance Determination for Dwelling Receptors

The flow chart presented below has been followed when determining the impact significance for dwelling receptors.



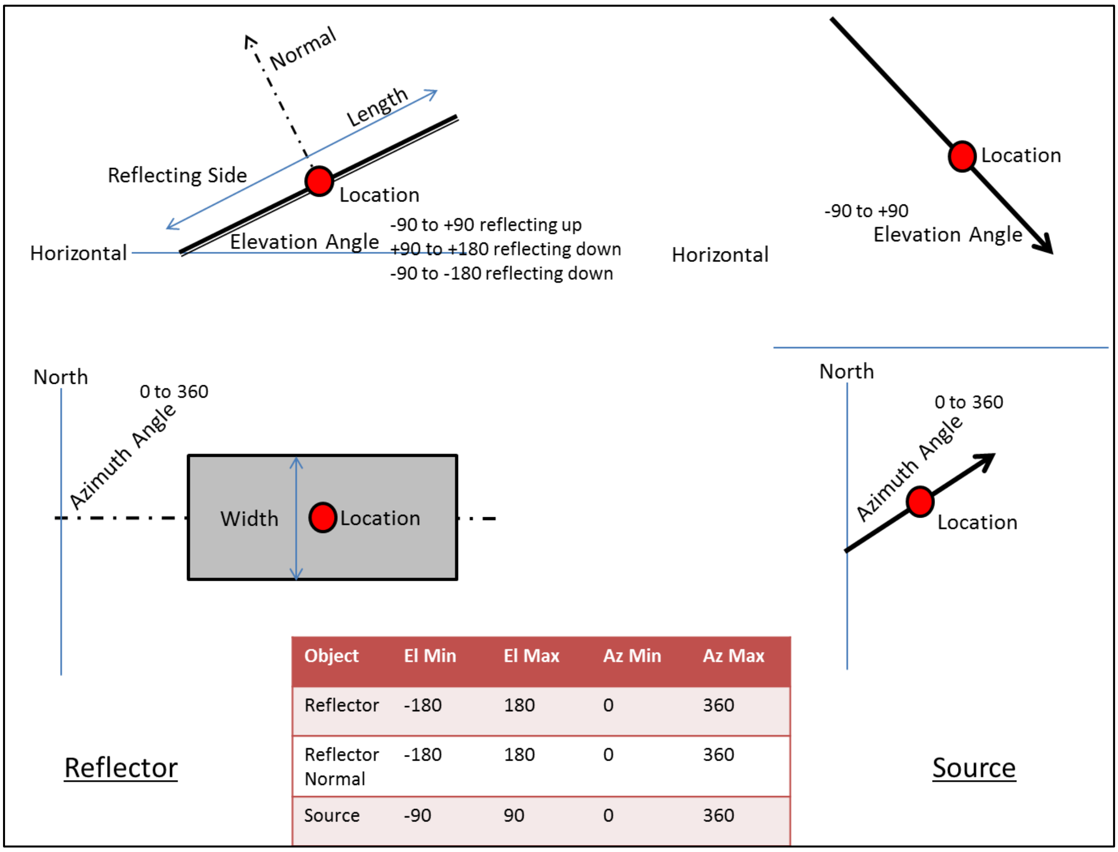
Dwelling impact significance flow chart

APPENDIX E – PAGER POWER'S REFLECTION CALCULATIONS 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.

APPENDIX F – ASSESSMENT LIMITATIONS AND ASSUMPTIONS

Pager Power's Model

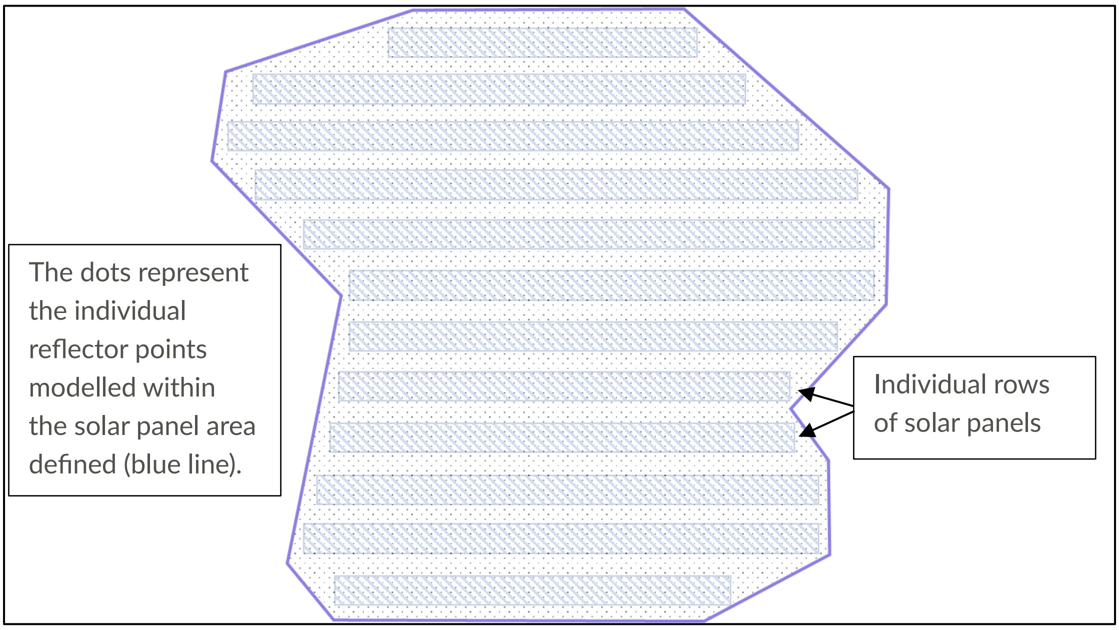
It is assumed that the panel elevation angle provided by the developer represents the elevation angle for all of the panels within each solar panel area defined.

It is assumed that the panel azimuth angle provided by the developer represents the azimuth angle for all of the panels within each solar panel area defined.

Only a reflection from the face of the panel has been considered. The frame or the reverse or frame of the solar panel has not been considered.

The model assumes that a receptor can view the face of every panel within the proposed development area whilst in reality this, in the majority of cases, will not occur. Therefore any predicted solar reflection from the face of a solar panel that is not visible to a receptor will not occur in practice.

A finite number of points within each solar panel area defined is chosen based on an assessment resolution so that a comprehensive understanding of the entire development can be formed. This determines whether a solar reflection could ever occur at a chosen receptor. The model does not consider the specific panel rows or the entire face of the solar panel within the development outline, rather a single point is defined every 'x' metres (based on the resolution) with the geometric characteristics of the panel. A panel area is however defined to encapsulate all possible panel locations. See the figure below which illustrates this process.



Solar panel area modelling overview

A single reflection point is chosen for the geometric calculations. This suitably determines whether a solar reflection can be experienced at a receptor location and the time of year and duration of the solar reflection. Increased accuracy could be achieved by increasing the number of heights assessed however this would only marginally change the results and is not considered significant.

The available street view imagery, satellite mapping, terrain and any site imagery provided by the developer has been used to assess line of sight from the assessed receptors to the modelled solar panel area, unless stated otherwise. In some cases, this imagery may not be up to date and may not give the full perspective of the installation from the location of the assessed receptor.

Any screening in the form of trees, buildings etc. that may obstruct the Sun from view of the solar panels is not within the modelling unless stated otherwise. The terrain profile at the horizon is considered if stated.

Forge's Sandia National Laboratories' (SGHAT) Model[31]

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.

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

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Receptor Data – Roads

The table below presents the data for the assessed road receptors.

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.680455	52.738783	28	-1.643498	52.736757
2	-1.679168	52.738339	29	-1.642054	52.736556
3	-1.677931	52.737842	30	-1.641104	52.736009
4	-1.676519	52.737567	31	-1.636407	52.738754
5	-1.675099	52.737311	32	-1.636740	52.739625
6	-1.673676	52.737055	33	-1.636570	52.740508
7	-1.672253	52.736801	34	-1.635904	52.741313
8	-1.671076	52.737219	35	-1.635490	52.742178
9	-1.670113	52.737899	36	-1.634991	52.743029
10	-1.668982	52.738470	37	-1.634768	52.743915
11	-1.667564	52.738733	38	-1.635040	52.744700
12	-1.666096	52.738867	39	-1.636093	52.745328
13	-1.664635	52.739015	40	-1.636889	52.746085
14	-1.663168	52.738935	41	-1.637706	52.746840
15	-1.661837	52.738910	42	-1.638817	52.747416
16	-1.660440	52.739205	43	-1.640135	52.747827
17	-1.659989	52.740055	44	-1.641593	52.747975
18	-1.658648	52.740071	45	-1.642184	52.748772
19	-1.657232	52.739800	46	-1.642455	52.749645

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
20	-1.655802	52.739597	47	-1.642534	52.750536
21	-1.654500	52.739161	48	-1.642768	52.751423
22	-1.653180	52.738755	49	-1.642885	52.752320
23	-1.651867	52.738339	50	-1.644023	52.750627
24	-1.650562	52.737911	51	-1.645402	52.750945
25	-1.649253	52.737491	52	-1.646654	52.751424
26	-1.647863	52.737182	53	-1.647927	52.751890
27	-1.646396	52.737048	54	-1.648927	52.752545
28	-1.644916	52.737025			

Road receptor data

Receptor Data – Dwellings

The table below presents the data for the assessed dwelling receptors.

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.671434	52.732796	46	-1.636712	52.745291
2	-1.673233	52.734682	47	-1.637213	52.745317
3	-1.672056	52.734774	48	-1.637205	52.745596
4	-1.671022	52.737044	49	-1.637862	52.745824
5	-1.678664	52.737983	50	-1.637811	52.746004
6	-1.655977	52.735834	51	-1.637976	52.746183
7	-1.656177	52.739743	52	-1.638496	52.746166
8	-1.643024	52.734844	53	-1.638893	52.746175
9	-1.643152	52.735066	54	-1.639303	52.746269
10	-1.643291	52.735299	55	-1.639641	52.746274

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
11	-1.642850	52.735385	56	-1.639493	52.746572
12	-1.642441	52.735498	57	-1.640231	52.746551
13	-1.642079	52.735600	58	-1.640625	52.746511
14	-1.641244	52.735974	59	-1.641078	52.746574
15	-1.641665	52.736153	60	-1.641394	52.746597
16	-1.640958	52.736327	61	-1.641798	52.746554
17	-1.641256	52.736515	62	-1.642381	52.746657
18	-1.641781	52.736589	63	-1.642354	52.746771
19	-1.640344	52.736451	64	-1.642829	52.746911
20	-1.640493	52.736594	65	-1.643039	52.747122
21	-1.640543	52.736788	66	-1.643022	52.747403
22	-1.640981	52.736727	67	-1.642543	52.747572
23	-1.637257	52.740207	68	-1.642209	52.747760
24	-1.637889	52.741283	69	-1.642984	52.747836
25	-1.676341	52.744174	70	-1.643116	52.748079
26	-1.675433	52.744453	71	-1.643101	52.748363
27	-1.670184	52.745954	72	-1.643032	52.748625
28	-1.669862	52.746230	73	-1.643665	52.748730
29	-1.669106	52.745981	74	-1.643685	52.748882
30	-1.667604	52.745939	75	-1.643843	52.749070
31	-1.632155	52.743067	76	-1.643819	52.749354
32	-1.632488	52.743442	77	-1.643322	52.749332

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
33	-1.633167	52.743656	78	-1.643251	52.749524
34	-1.633685	52.744048	79	-1.642668	52.749548
35	-1.634049	52.744267	80	-1.643656	52.749663
36	-1.634360	52.744455	81	-1.643639	52.749846
37	-1.633859	52.744825	82	-1.643640	52.750044
38	-1.635446	52.743468	83	-1.642104	52.750232
39	-1.635511	52.743878	84	-1.634836	52.751234
40	-1.635505	52.744172	85	-1.640182	52.751455
41	-1.635569	52.744384	86	-1.640285	52.751892
42	-1.636773	52.744300	87	-1.640509	52.752351
43	-1.636094	52.744554	88	-1.641420	52.752391
44	-1.635901	52.744924	89	-1.640779	52.752681
45	-1.636240	52.745128			

Dwelling receptor data

Receptor Data – Aviation

Aviation receptor can be provided upon request.

Modelled Reflector Areas

Area A

The table below presents the data for the modelled reflector area A.

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-1.673709	52.751048	32	-1.662724	52.750602
2	-1.674151	52.751000	33	-1.662729	52.750872
3	-1.674428	52.750874	34	-1.663190	52.750879
4	-1.674449	52.750634	35	-1.663163	52.751181

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
5	-1.674278	52.750483	36	-1.663300	52.751312
6	-1.674499	52.750284	37	-1.665754	52.752119
7	-1.674001	52.749730	38	-1.666238	52.752122
8	-1.673738	52.749655	39	-1.666311	52.751902
9	-1.673692	52.749287	40	-1.666642	52.751605
10	-1.673239	52.749037	41	-1.667011	52.751423
11	-1.672962	52.748337	42	-1.667648	52.751239
12	-1.672504	52.748268	43	-1.667781	52.750975
13	-1.672324	52.747961	44	-1.667238	52.750473
14	-1.669285	52.747891	45	-1.668300	52.750473
15	-1.667964	52.747830	46	-1.668080	52.750907
16	-1.666997	52.747829	47	-1.668178	52.751014
17	-1.667069	52.748115	48	-1.668319	52.751114
18	-1.666758	52.748300	49	-1.668320	52.751196
19	-1.666785	52.748496	50	-1.667778	52.751473
20	-1.666627	52.748735	51	-1.667218	52.752527
21	-1.666115	52.748910	52	-1.667935	52.752760
22	-1.666231	52.749258	53	-1.670632	52.752762
23	-1.664740	52.749260	54	-1.671076	52.752397
24	-1.665010	52.749106	55	-1.671061	52.752107
25	-1.665432	52.748495	56	-1.671515	52.752110
26	-1.664246	52.748272	57	-1.671789	52.751619

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
27	-1.663802	52.748273	58	-1.672159	52.751621
28	-1.662147	52.749895	59	-1.672454	52.751433
29	-1.661888	52.750218	60	-1.673282	52.751194
30	-1.661851	52.750385	61	-1.673709	52.751048
31	-1.662213	52.750590			

Modelled reflector area A

Area B

The table below presents the data for the modelled reflector area B.

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-1.662865	52.747291	52	-1.652932	52.748080
2	-1.664098	52.745739	53	-1.652845	52.748854
3	-1.664745	52.744953	54	-1.653047	52.749020
4	-1.664958	52.743845	55	-1.653431	52.749257
5	-1.665594	52.743846	56	-1.654076	52.749256
6	-1.665823	52.743773	57	-1.654079	52.749479
7	-1.666102	52.743488	58	-1.654322	52.749592
8	-1.666612	52.743247	59	-1.654408	52.749928
9	-1.666745	52.743082	60	-1.654994	52.750544
10	-1.665972	52.742539	61	-1.655662	52.750546
11	-1.665527	52.742418	62	-1.655717	52.750723
12	-1.665260	52.742224	63	-1.654979	52.751180
13	-1.664464	52.742224	64	-1.654600	52.751317
14	-1.664892	52.741756	65	-1.654191	52.751431

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
15	-1.664921	52.741544	66	-1.654178	52.751543
16	-1.664637	52.740752	67	-1.655065	52.752765
17	-1.664520	52.739968	68	-1.655534	52.752763
18	-1.664408	52.739671	69	-1.655857	52.752579
19	-1.664031	52.739456	70	-1.656569	52.752313
20	-1.663992	52.739177	71	-1.658857	52.751839
21	-1.663363	52.739120	72	-1.658900	52.751769
22	-1.662003	52.739116	73	-1.658125	52.751411
23	-1.660843	52.739308	74	-1.657093	52.750993
24	-1.660413	52.739805	75	-1.656202	52.750744
25	-1.660507	52.740354	76	-1.656507	52.750494
26	-1.660084	52.740360	77	-1.657399	52.750503
27	-1.659187	52.740482	78	-1.658664	52.750355
28	-1.658262	52.741081	79	-1.659141	52.750199
29	-1.657727	52.741497	80	-1.659342	52.750132
30	-1.657665	52.741729	81	-1.659889	52.749716
31	-1.657756	52.742125	82	-1.659885	52.749467
32	-1.657984	52.742390	83	-1.659567	52.749263
33	-1.658331	52.742525	84	-1.658989	52.749159
34	-1.659028	52.742657	85	-1.658692	52.748948
35	-1.659038	52.743079	86	-1.658364	52.748889
36	-1.657213	52.743488	87	-1.657580	52.748887

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
37	-1.656612	52.743491	88	-1.658088	52.748561
38	-1.656555	52.743050	89	-1.658583	52.747979
39	-1.657016	52.743047	90	-1.659538	52.747234
40	-1.657139	52.741728	91	-1.660473	52.747231
41	-1.657132	52.741140	92	-1.660347	52.747951
42	-1.653963	52.741123	93	-1.660167	52.748823
43	-1.653520	52.741316	94	-1.660233	52.749237
44	-1.653262	52.743996	95	-1.660806	52.749566
45	-1.653010	52.747142	96	-1.661003	52.749756
46	-1.653222	52.747479	97	-1.661506	52.749761
47	-1.653461	52.747670	98	-1.663073	52.748203
48	-1.653857	52.747742	99	-1.663064	52.748070
49	-1.654777	52.747742	100	-1.661596	52.747589
50	-1.654421	52.748003	101	-1.662448	52.747602
51	-1.653050	52.747996	102	-1.662865	52.747291

Modelled reflector area B

Area C

The table below presents the data for the modelled reflector area C.

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-1.652711	52.741885	16	-1.650011	52.748351
2	-1.652222	52.741881	17	-1.650589	52.747966
3	-1.651090	52.742648	18	-1.651877	52.747269
4	-1.650046	52.743493	19	-1.652169	52.747013

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
5	-1.648865	52.744719	20	-1.652213	52.746836
6	-1.648175	52.744718	21	-1.651709	52.746417
7	-1.647576	52.745218	22	-1.651515	52.746157
8	-1.647271	52.745403	23	-1.651799	52.746162
9	-1.647298	52.747546	24	-1.651947	52.745815
10	-1.647620	52.748140	25	-1.651214	52.744773
11	-1.648723	52.748663	26	-1.650279	52.744772
12	-1.649426	52.748760	27	-1.650659	52.744337
13	-1.649523	52.748760	28	-1.651259	52.744341
14	-1.649578	52.748723	29	-1.652278	52.744087
15	-1.649645	52.748635	30	-1.652711	52.741885

Modelled reflector area C

APPENDIX H – GEOMETRIC CALCULATION RESULTS

Overview

The charts for the receptors are shown on the following pages. In detail each chart shows:

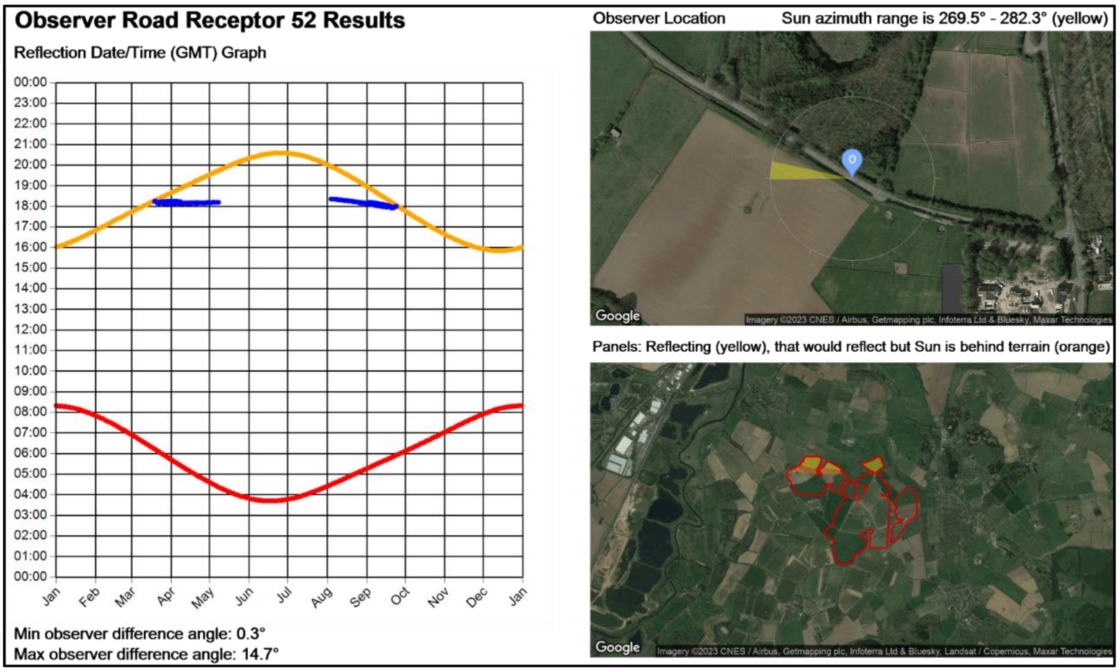
- The receptor (observer) location – top right image. This also shows the azimuth range of the Sun itself at times when reflections are possible. If sunlight is experienced from the same direction as the reflecting panels, the overall impact of the reflection is reduced as discussed within the body of the report;
- The modelled reflectors/ reflection areas – 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 reflector area 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.

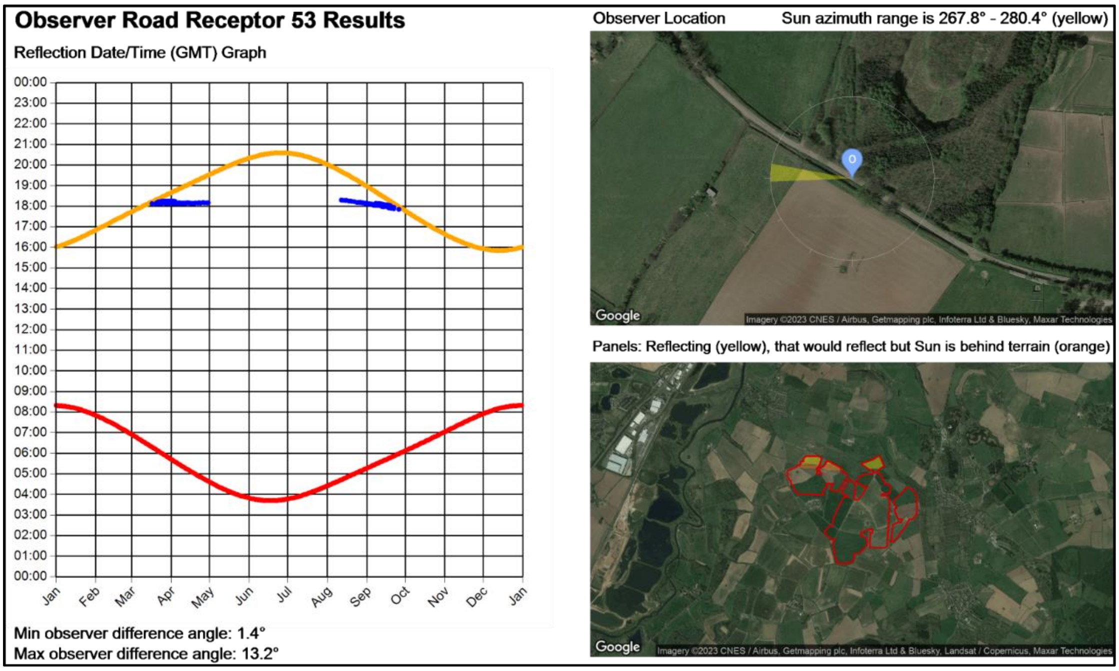
The modelling output has only been provided for receptors where effects are predicted to be experienced in practice.

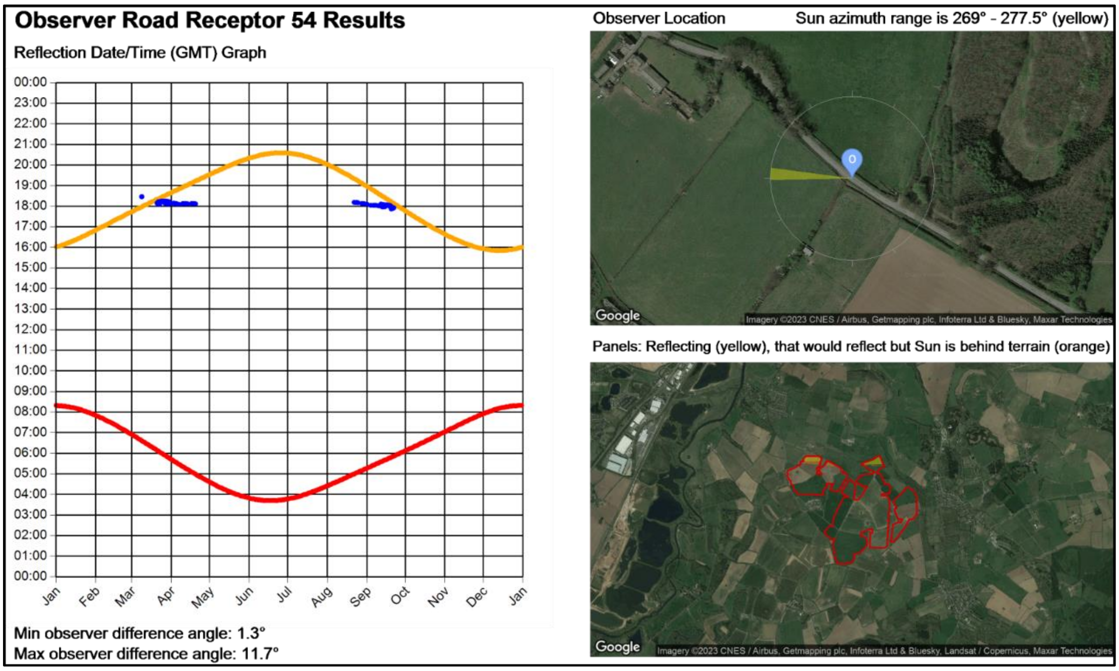
Aviation Receptors

The aviation receptor modelling output can be provided upon request.

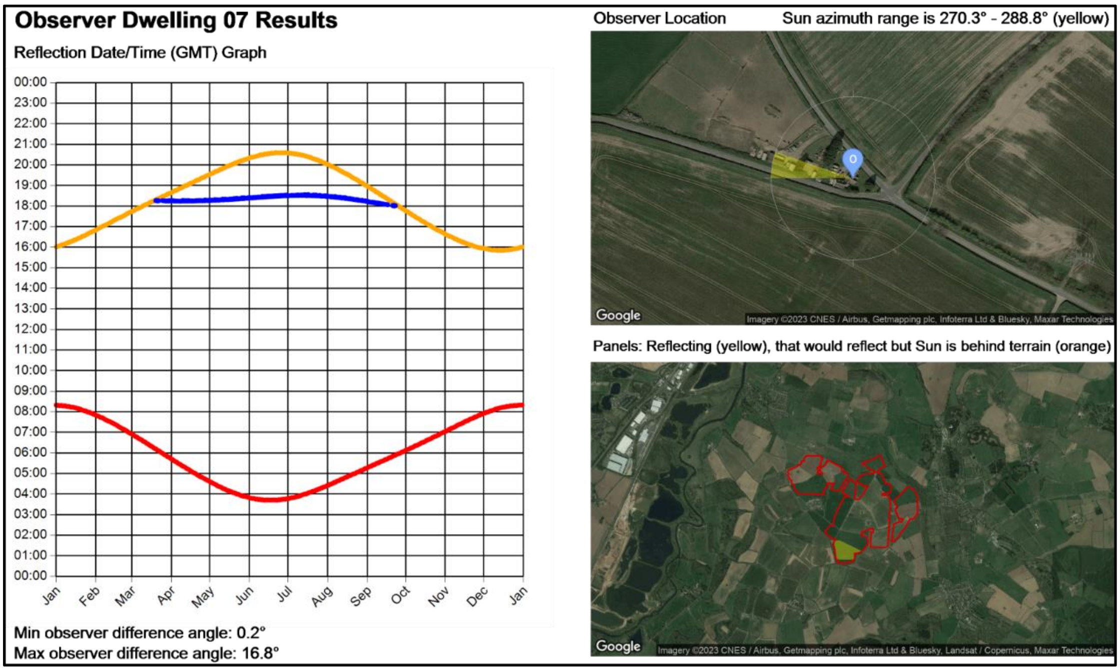
Road Receptors

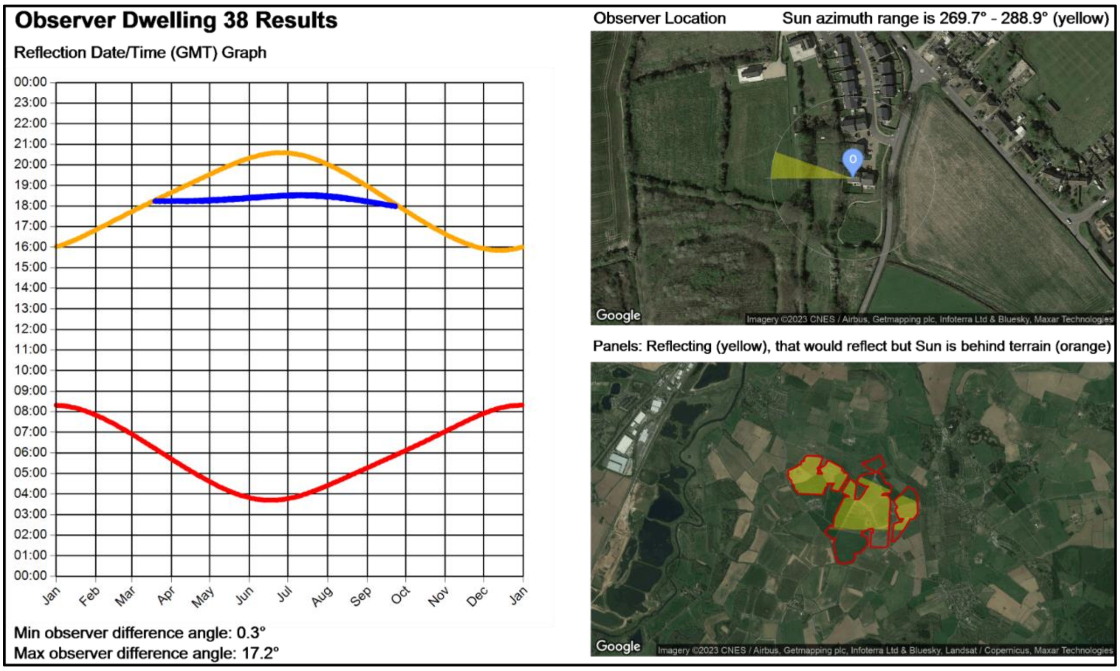


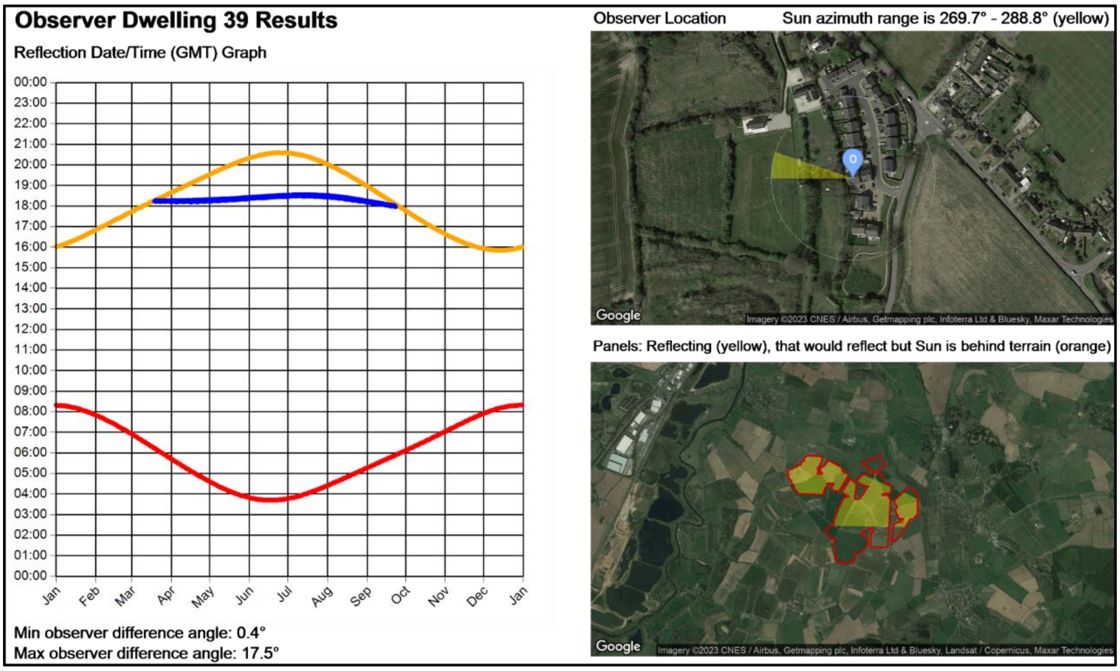

Observer Road Receptor 53 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 1.4°
Max observer difference angle: 13.2°
Observer Location
Sun azimuth range is 267.8° - 280.4° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

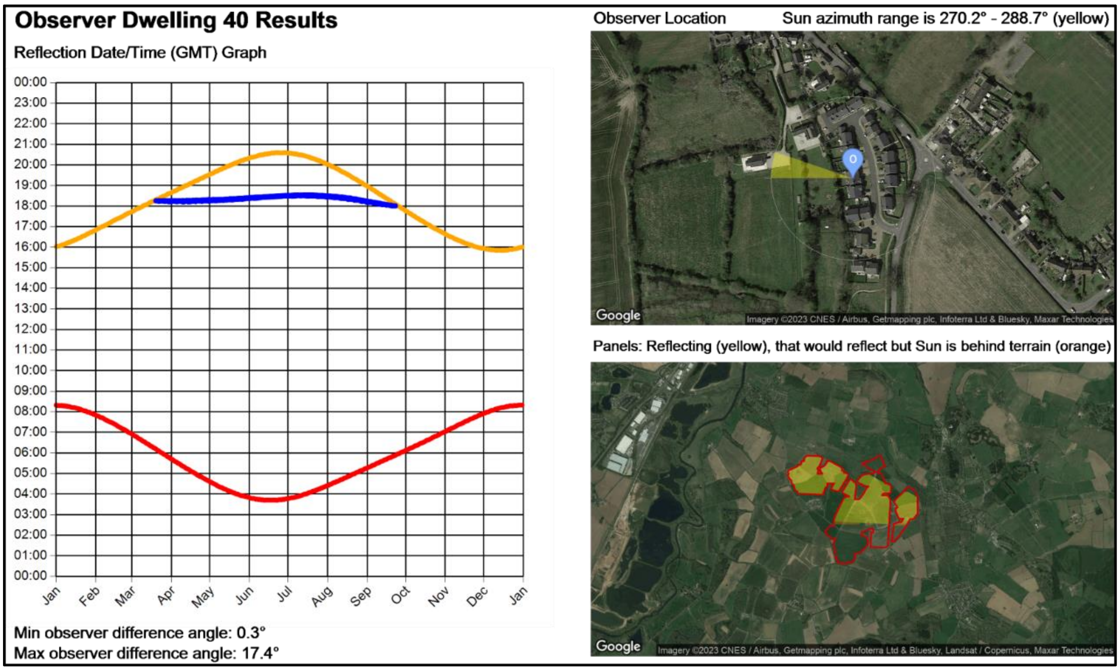

Observer Road Receptor 54 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 1.3°
Max observer difference angle: 11.7°
Observer Location
Sun azimuth range is 269° - 277.5° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

Dwelling Receptors



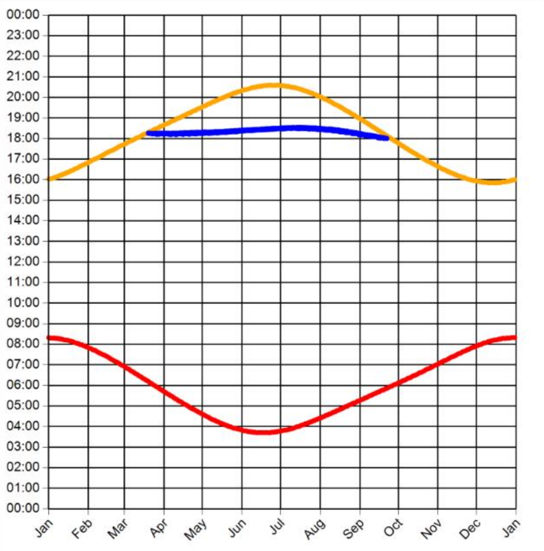



Observer Dwelling 39 Results
Reflection Date/Time (GMT) Graph
00:00 23:00 22:00 21:00 20:00 19:00 18:00 17:00 16:00 15:00 14:00 13:00 12:00 11:00 10:00 09:00 08:00 07:00 06:00 05:00 04:00 03:00 02:00 01:00 00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.4°
Max observer difference angle: 17.5°
Observer Location
Sun azimuth range is 269.7° - 288.8° (yellow)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Landsat / Copernicus, Maxar Technologies


Observer Dwelling 40 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: 0.3°
Max observer difference angle: 17.4°
Observer Location
Sun azimuth range is 270.2° - 288.7° (yellow)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Landsat / Copernicus, Maxar Technologies

Observer Dwelling 41 Results

Reflection Date/Time (GMT) Graph



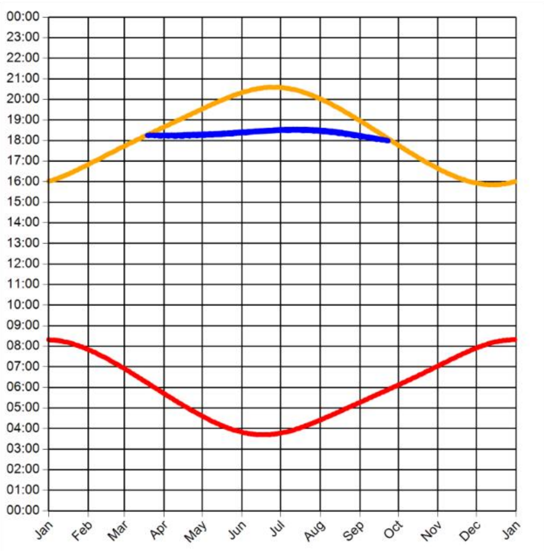
Min observer difference angle: 0.3°
Max observer difference angle: 17.8°

Observer Location | Sun azimuth range is 270.3° - 288.6° (yellow)

Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

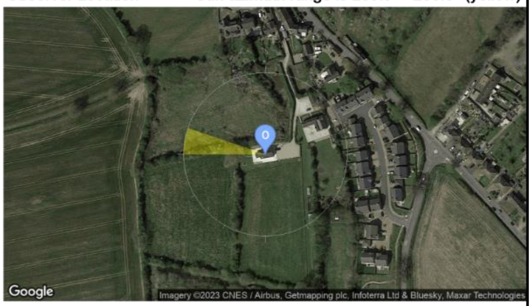
Observer Dwelling 42 Results

Reflection Date/Time (GMT) Graph

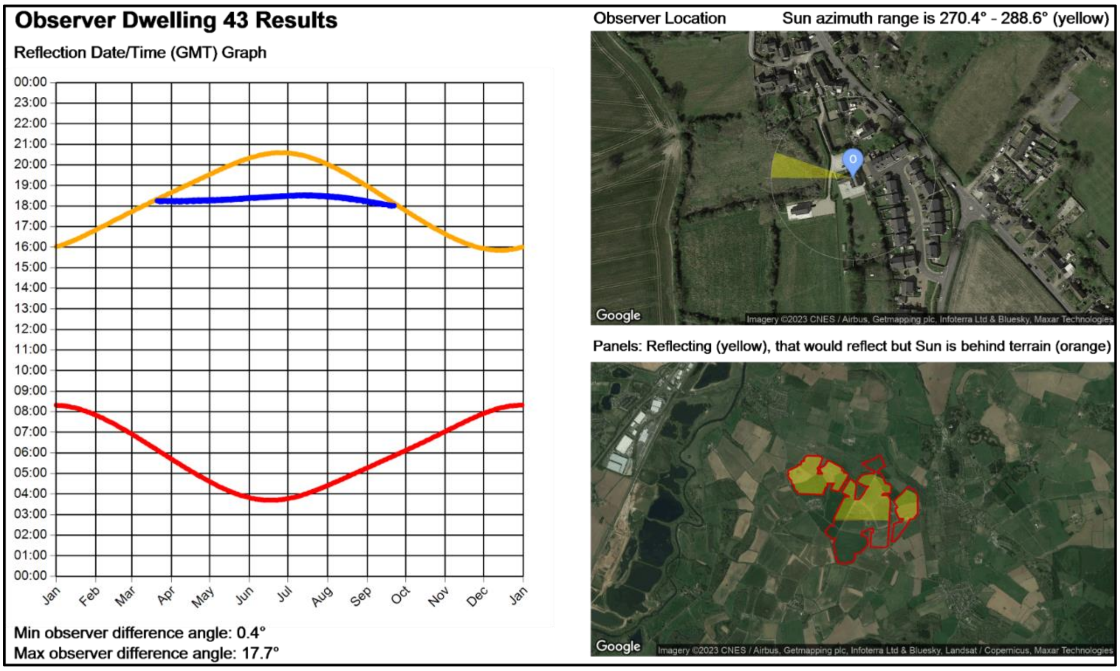


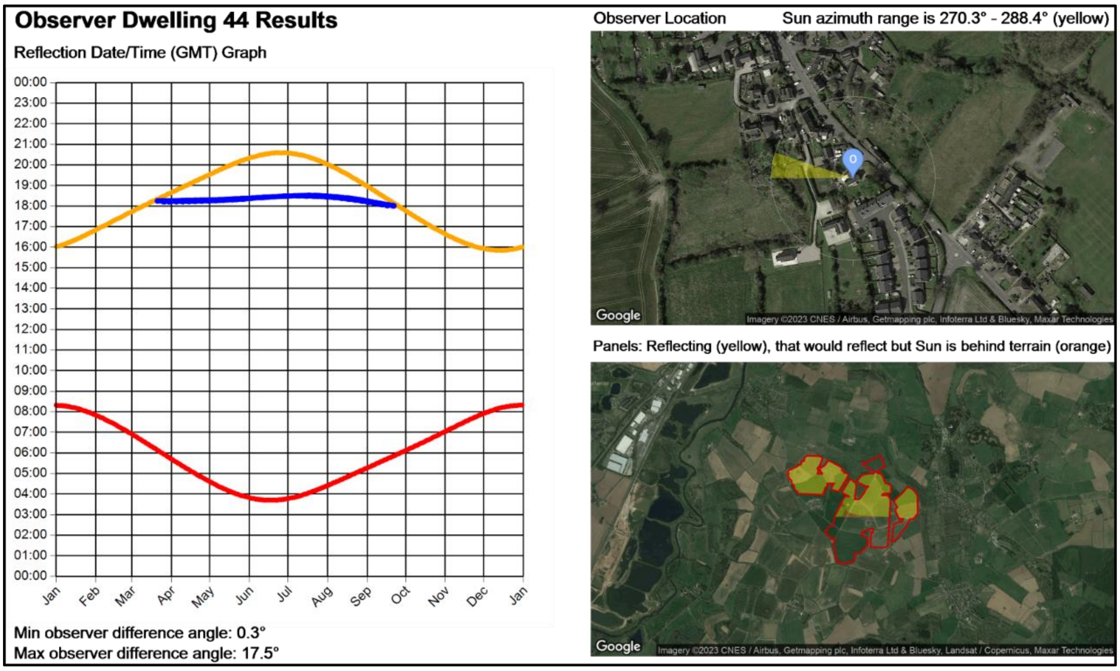
Min observer difference angle: 0.3°
Max observer difference angle: 17.3°

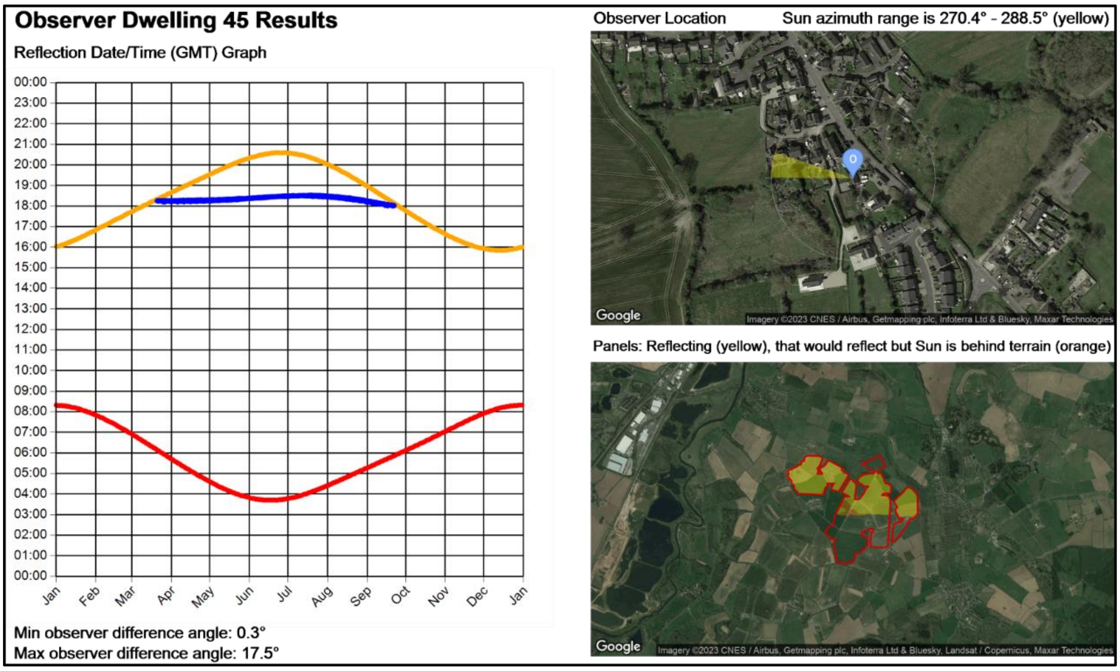
Observer Location | Sun azimuth range is 269.9° - 288.8° (yellow)

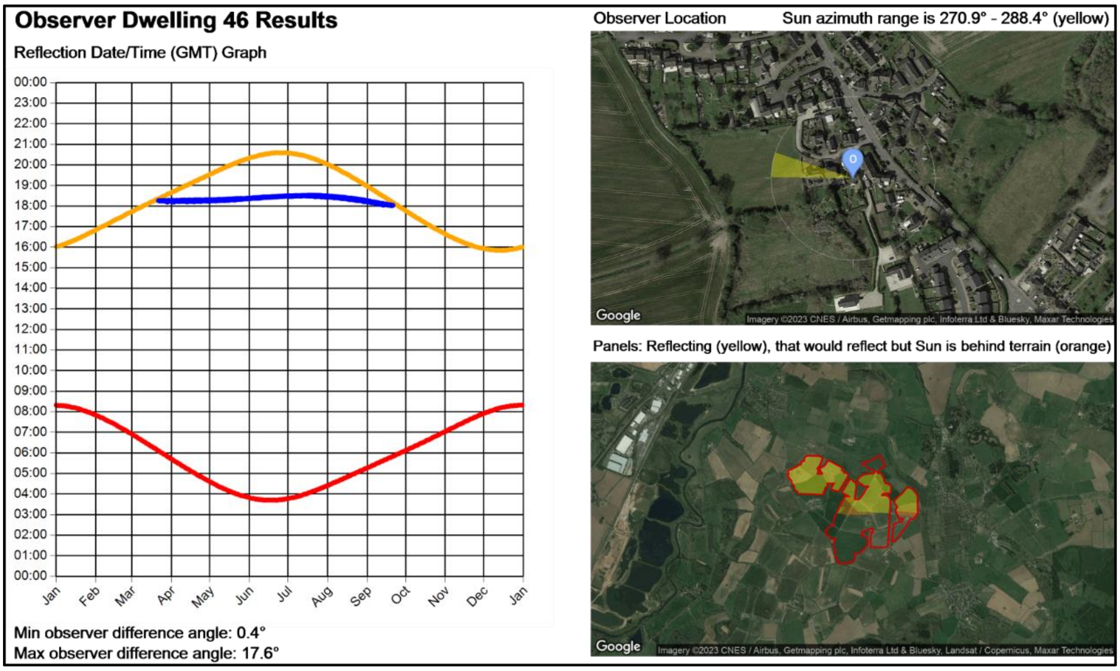


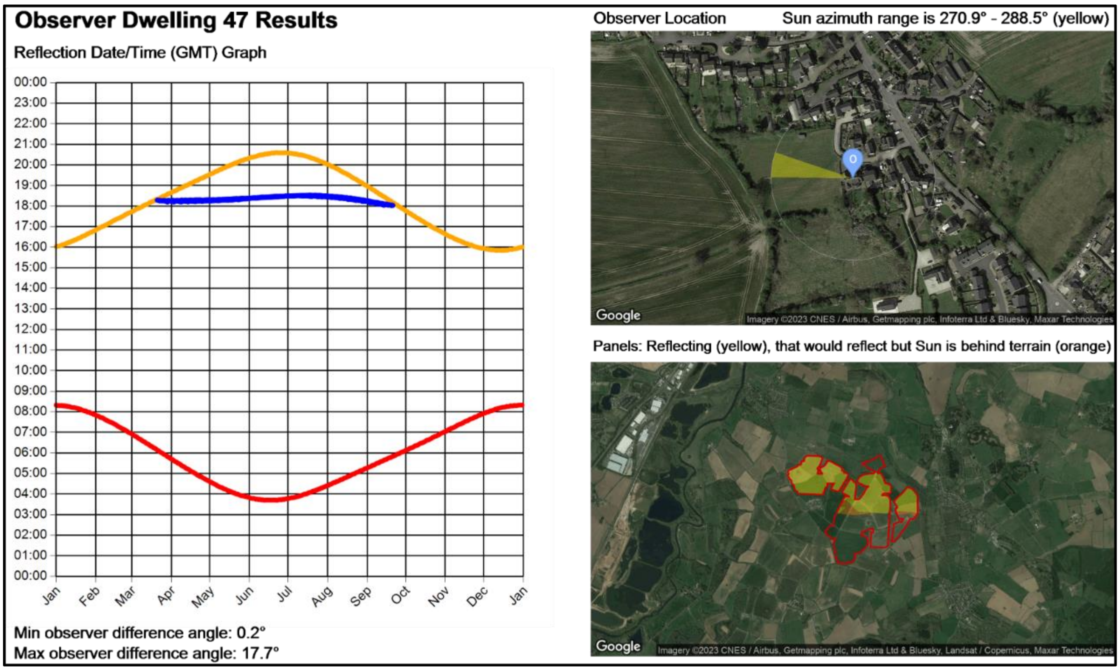
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer Dwelling 43 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: 0.4°
Max observer difference angle: 17.7°
Observer Location
Sun azimuth range is 270.4° - 288.6° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer Dwelling 44 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: 0.3°
Max observer difference angle: 17.5°
Observer Location
Sun azimuth range is 270.3° - 288.4° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer Dwelling 45 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.3°
Max observer difference angle: 17.5°
Observer Location
Sun azimuth range is 270.4° - 288.5° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer Dwelling 46 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.4°
Max observer difference angle: 17.6°
Observer Location
Sun azimuth range is 270.9° - 288.4° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer Dwelling 47 Results
Reflection Date/Time (GMT) Graph
00:00
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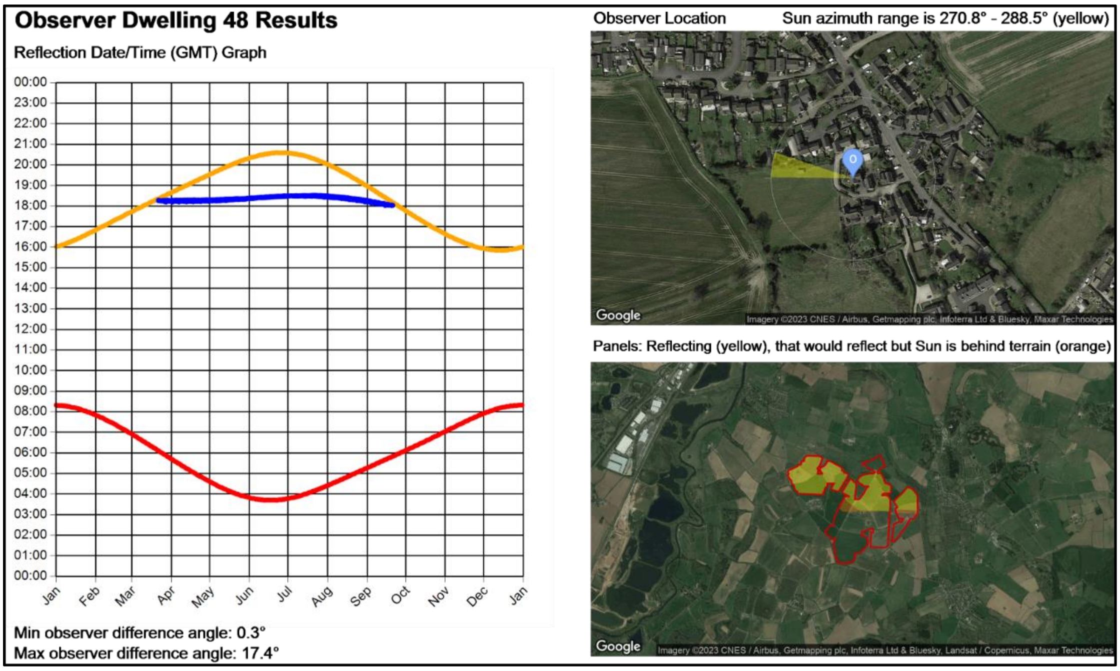
Jan
Min observer difference angle: 0.2°
Max observer difference angle: 17.7°
Observer Location
Sun azimuth range is 270.9° - 288.5° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer Dwelling 48 Results
Reflection Date/Time (GMT) Graph
00:00
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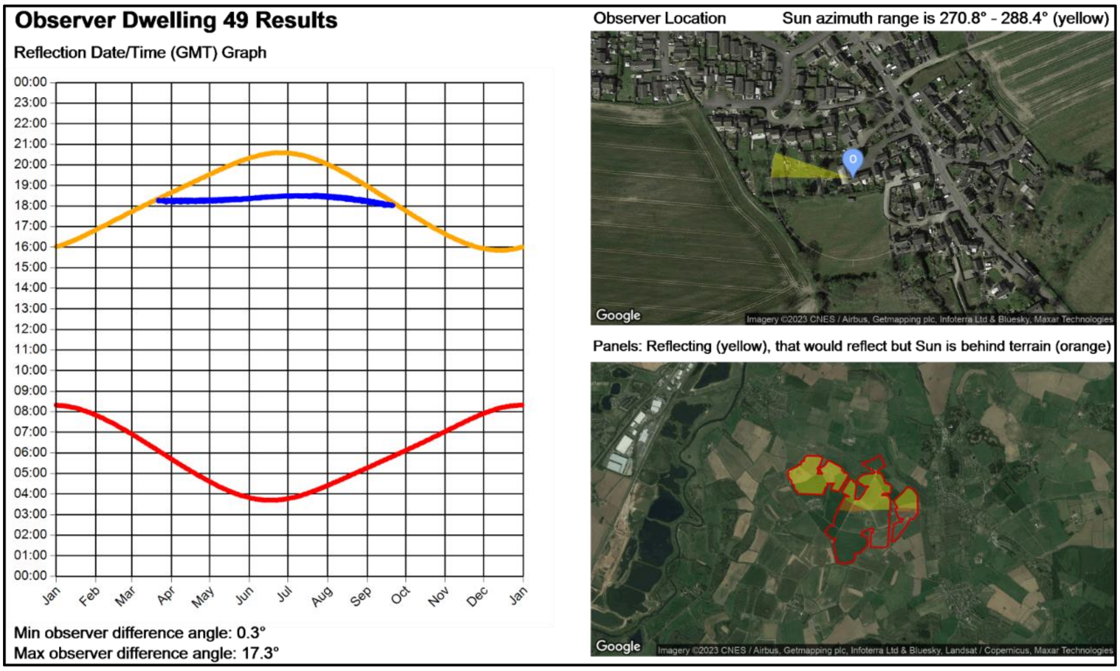
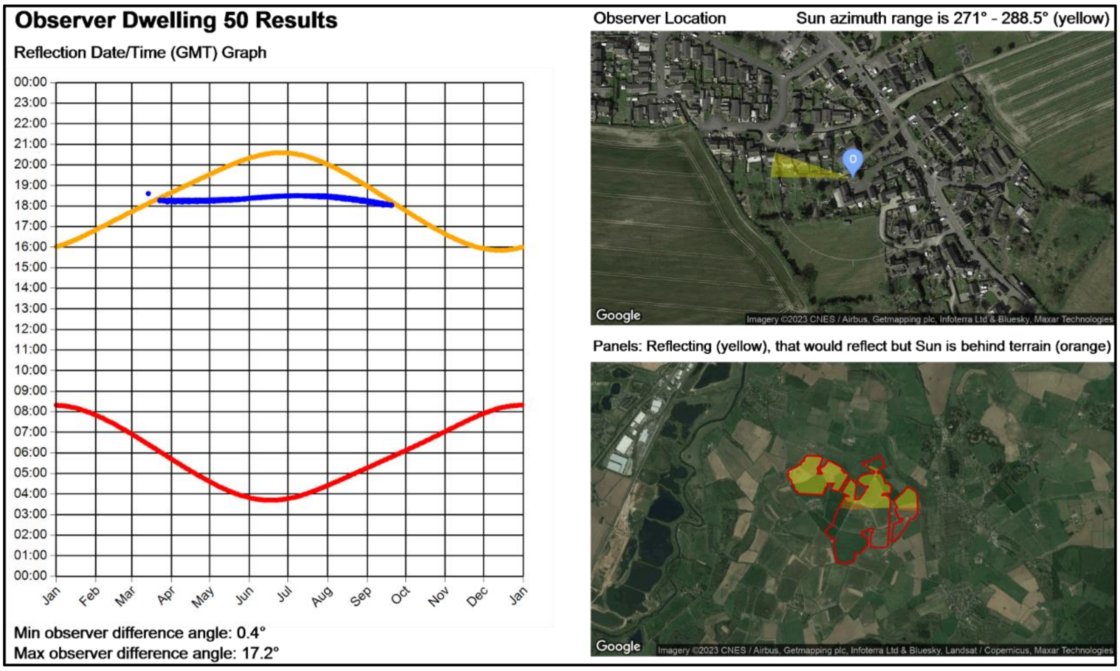
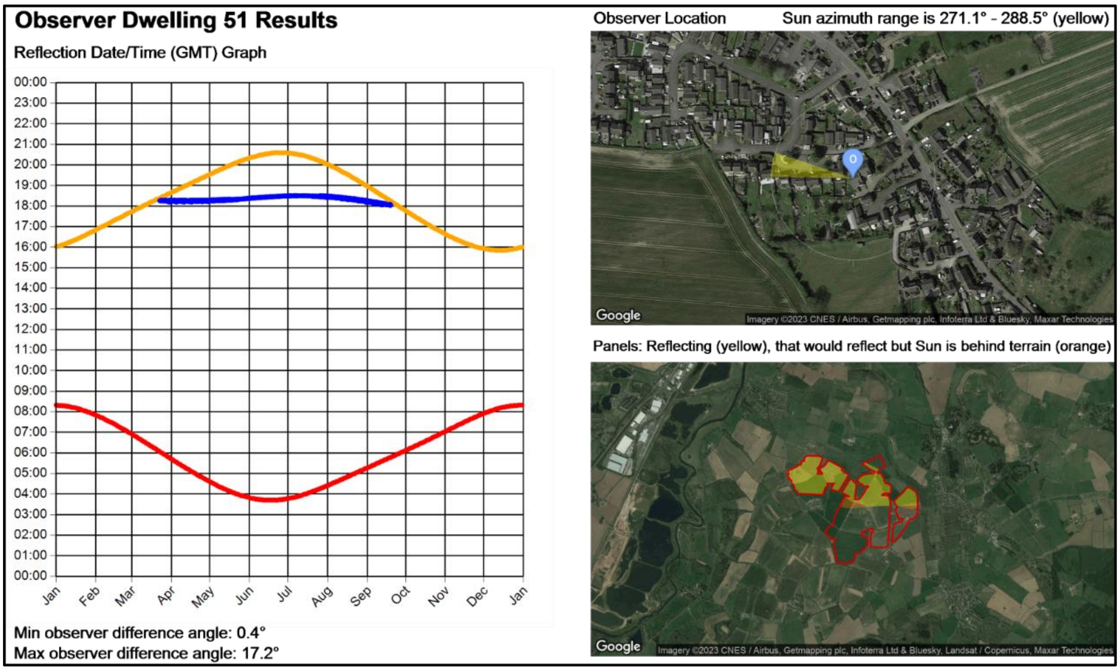
Jan
Min observer difference angle: 0.3°
Max observer difference angle: 17.4°
Observer Location
Sun azimuth range is 270.8° - 288.5° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer Dwelling 49 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: 0.3°
Max observer difference angle: 17.3°
Observer Location
Sun azimuth range is 270.8° - 288.4° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer Dwelling 50 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: 0.4°
Max observer difference angle: 17.2°
Observer Location
Sun azimuth range is 271° - 288.5° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer Dwelling 51 Results
Reflection Date/Time (GMT) Graph
00:00
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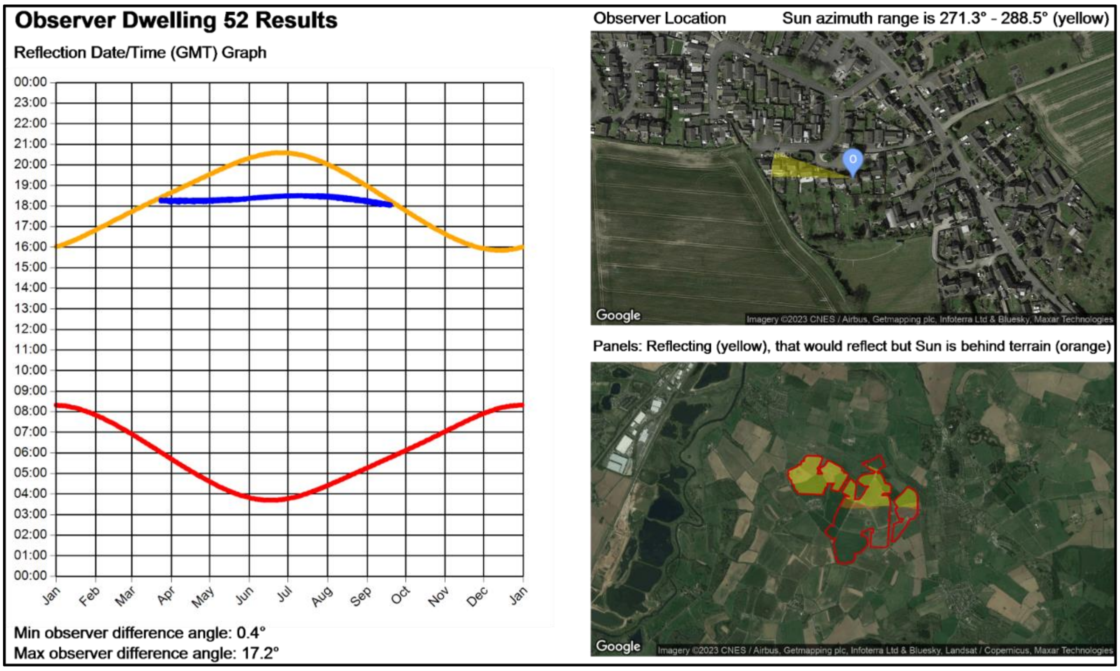
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.4°
Max observer difference angle: 17.2°
Observer Location
Sun azimuth range is 271.1° - 288.5° (yellow)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Landsat / Copernicus, Maxar Technologies


Observer Dwelling 52 Results
Reflection Date/Time (GMT) Graph
00:00
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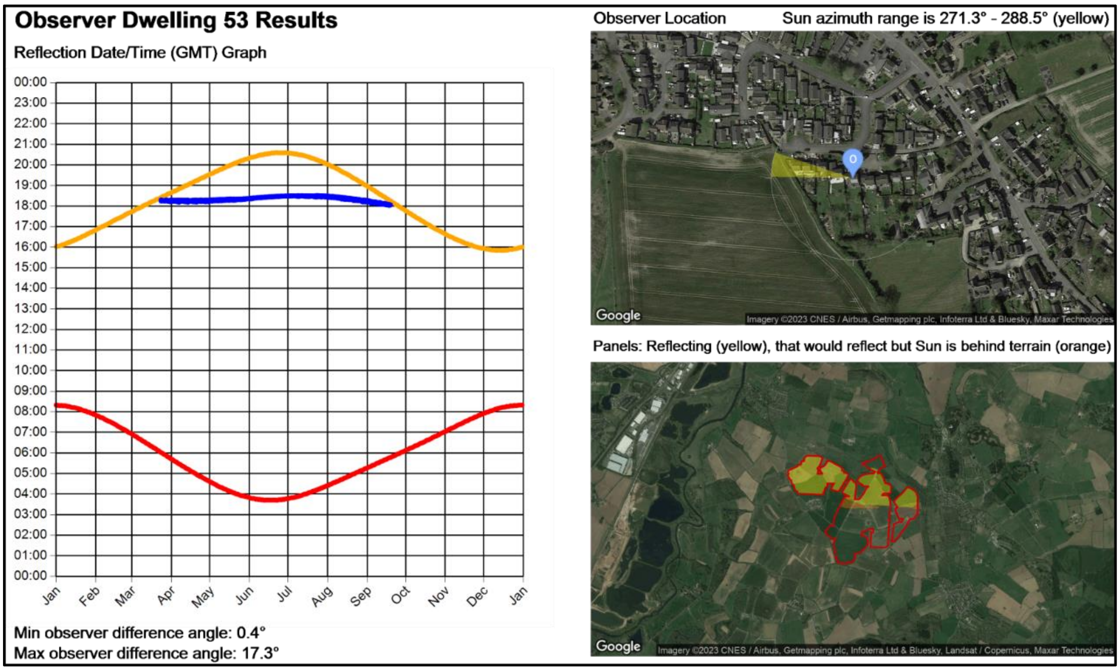
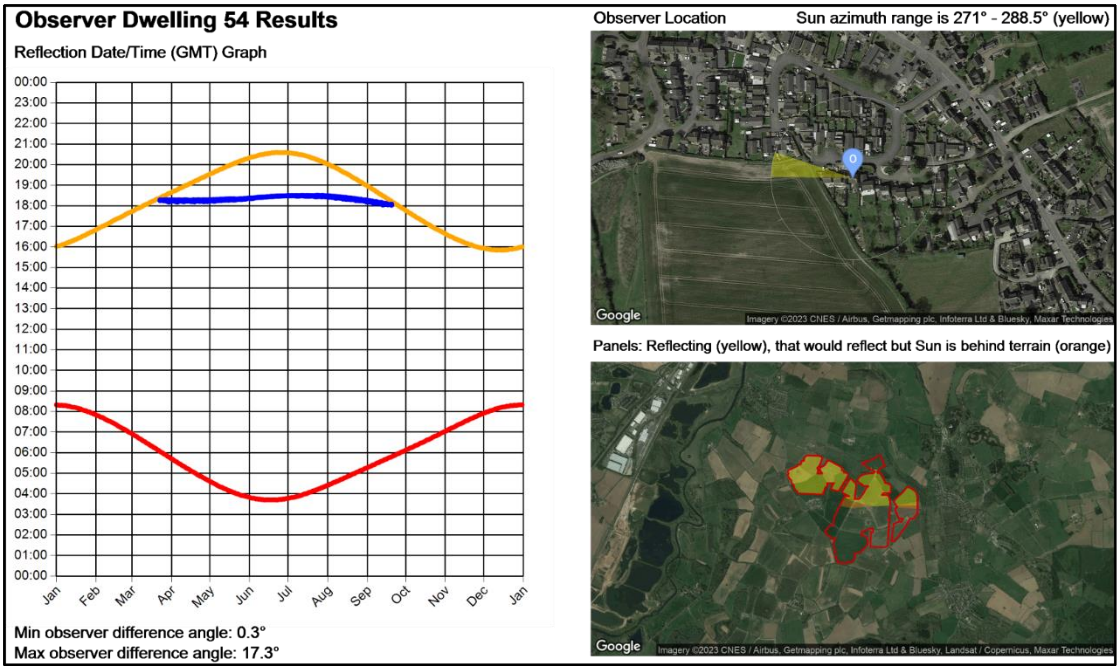
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.4°
Max observer difference angle: 17.2°
Observer Location
Sun azimuth range is 271.3° - 288.5° (yellow)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Landsat / Copernicus, Maxar Technologies


Observer Dwelling 53 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.4°
Max observer difference angle: 17.3°
Observer Location
Sun azimuth range is 271.3° - 288.5° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer Dwelling 54 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.3°
Max observer difference angle: 17.3°
Observer Location
Sun azimuth range is 271° - 288.5° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

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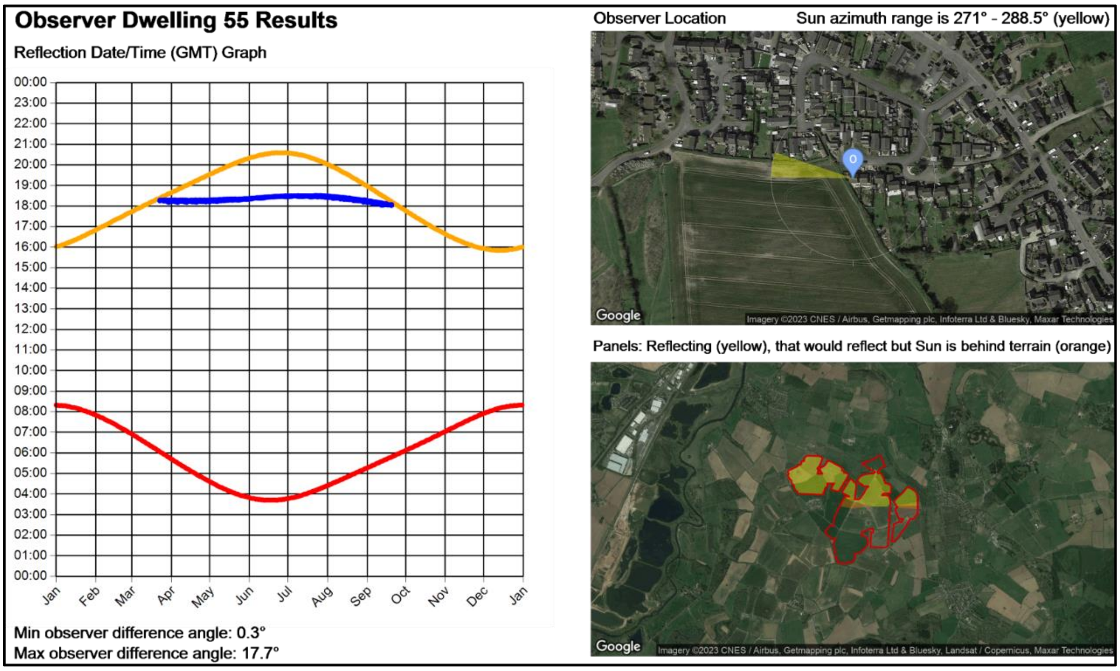
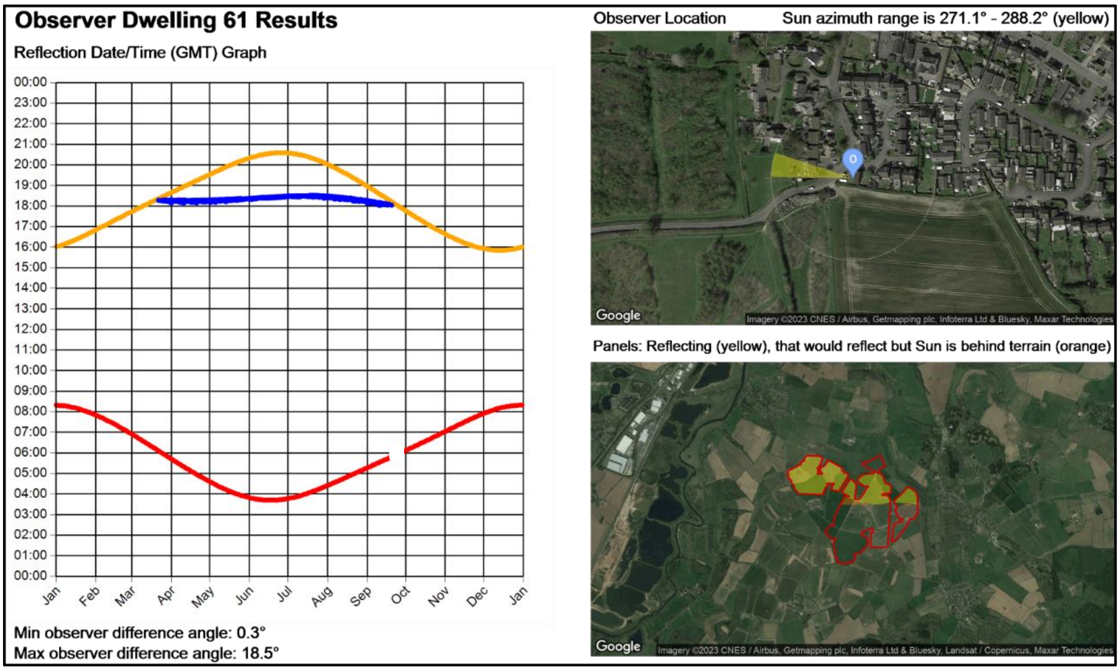
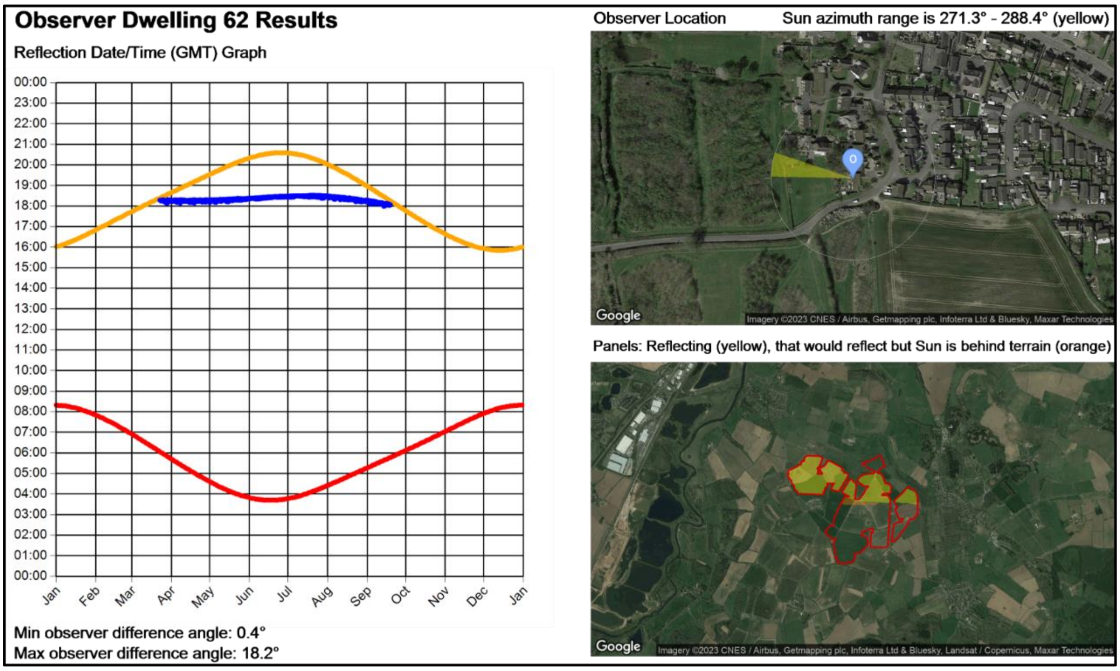
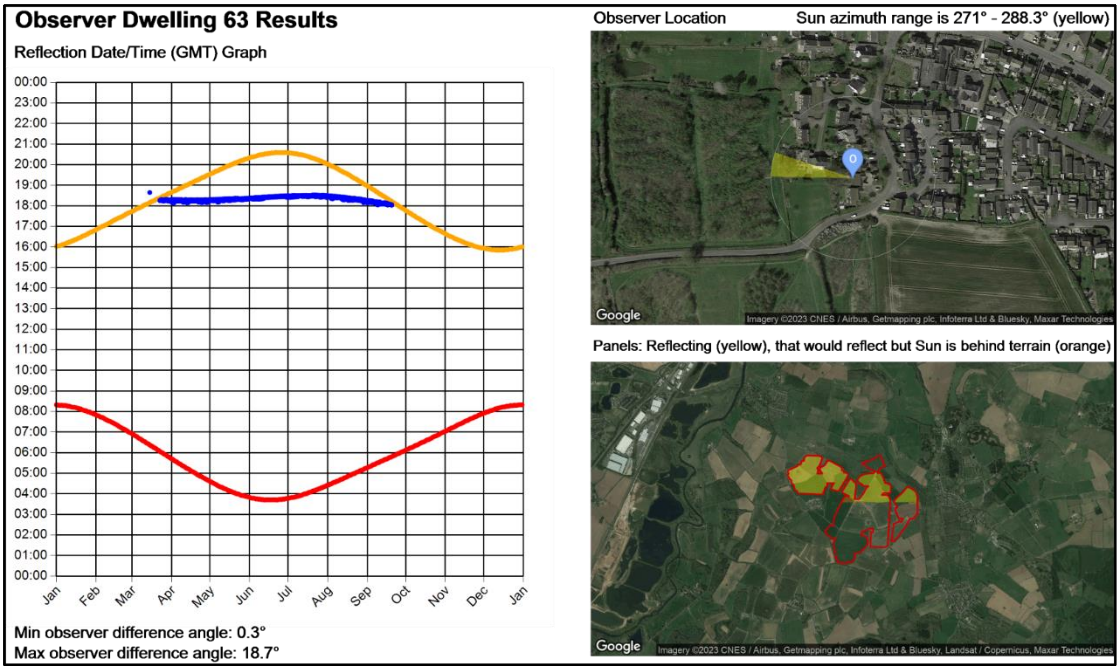
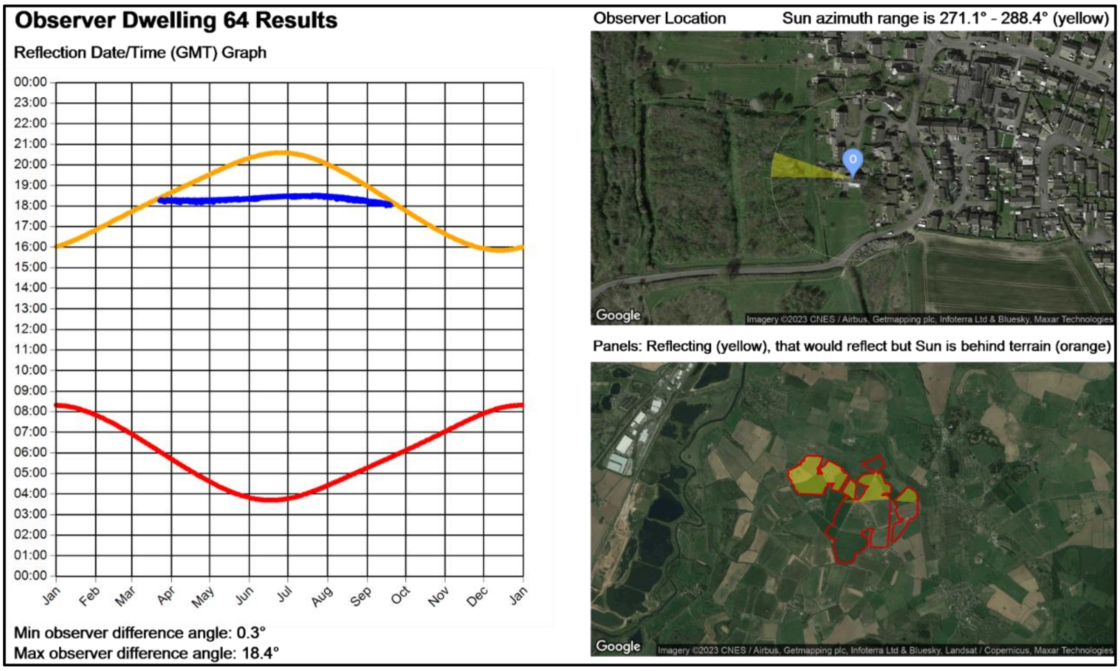
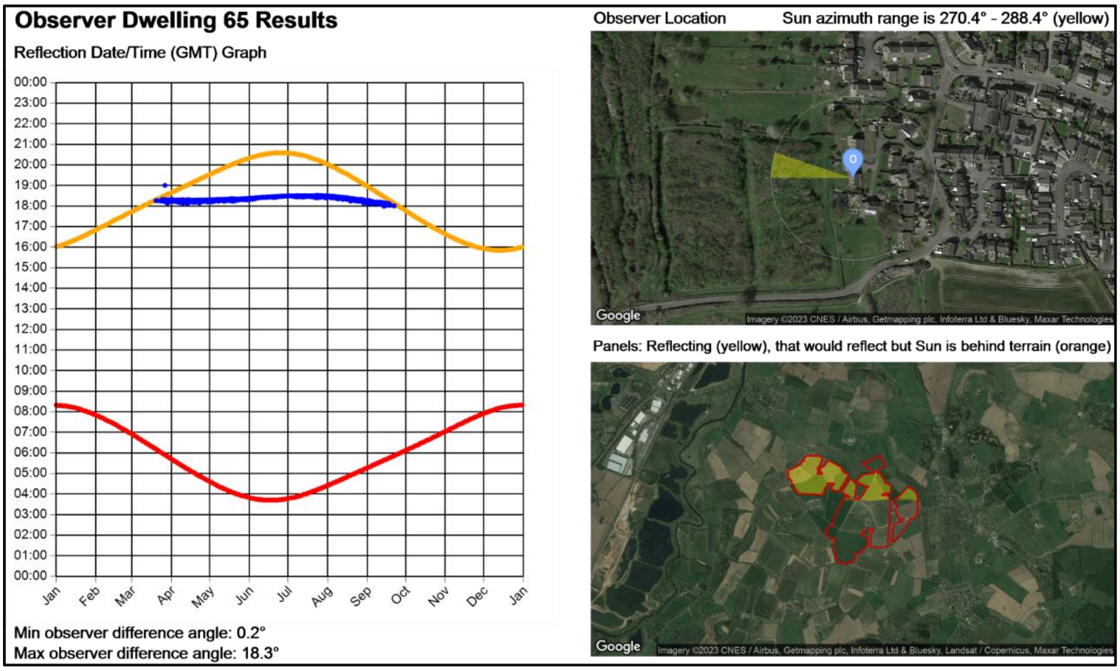


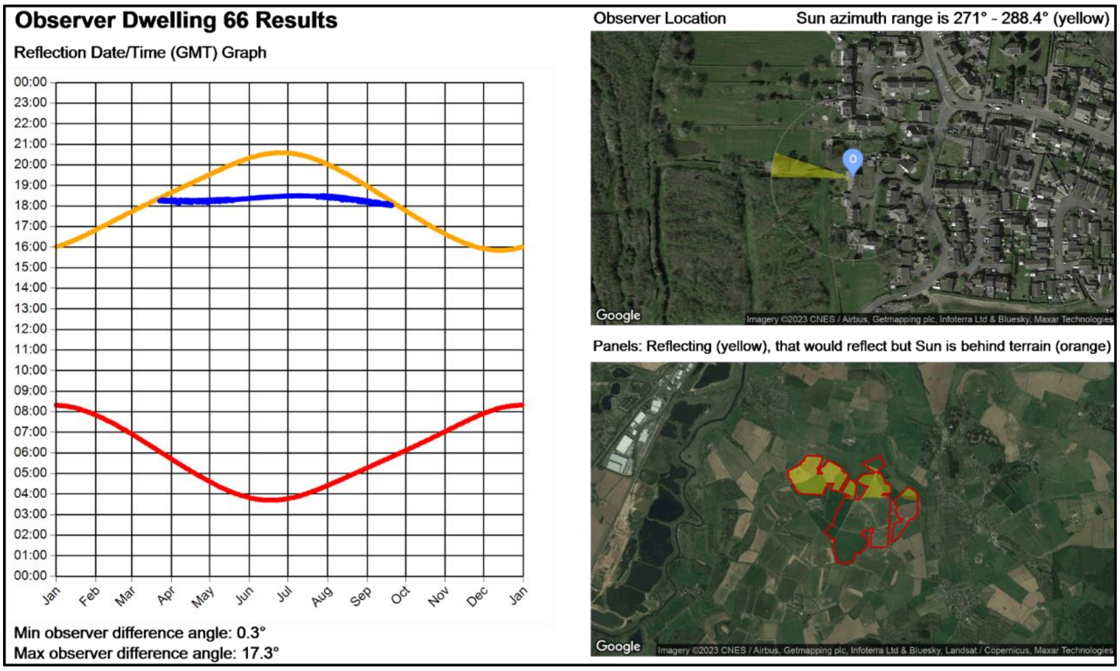



Observer Dwelling 62 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.4°
Max observer difference angle: 18.2°
Observer Location
Sun azimuth range is 271.3° - 288.4° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer Dwelling 63 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.3°
Max observer difference angle: 18.7°
Observer Location
Sun azimuth range is 271° - 288.3° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer Dwelling 64 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 271.1° - 288.4° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 0.3°
Max observer difference angle: 18.4°


Observer Dwelling 65 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 270.4° - 288.4° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 0.2°
Max observer difference angle: 18.3°


Observer Dwelling 66 Results
Reflection Date/Time (GMT) Graph
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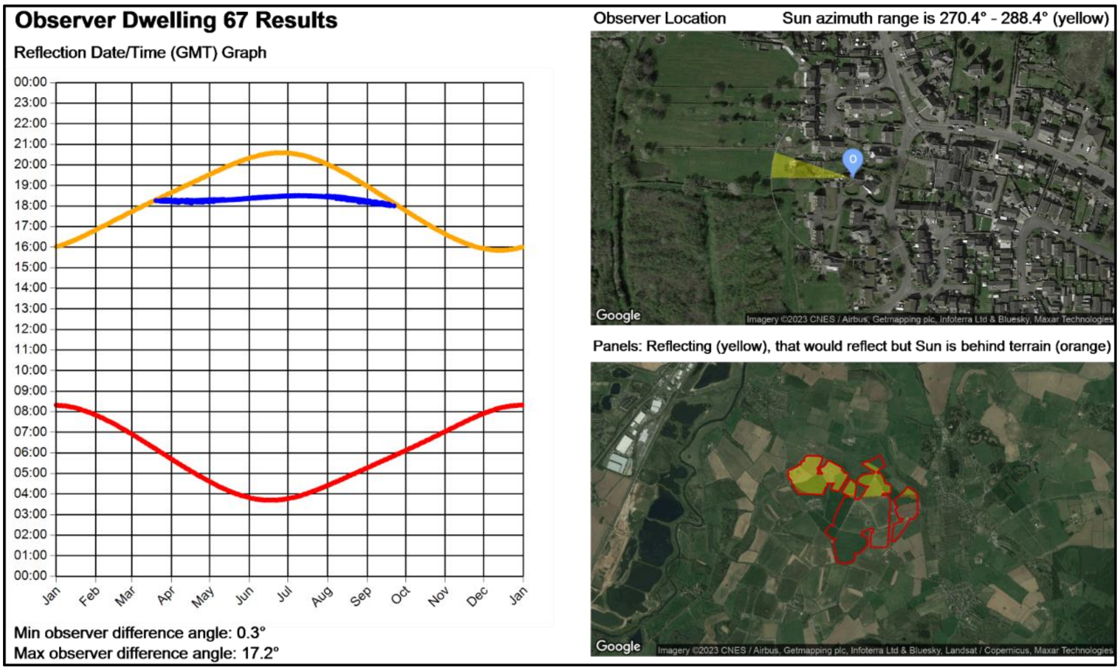
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.3°
Max observer difference angle: 17.3°
Observer Location
Sun azimuth range is 271° - 288.4° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer Dwelling 67 Results
Reflection Date/Time (GMT) Graph
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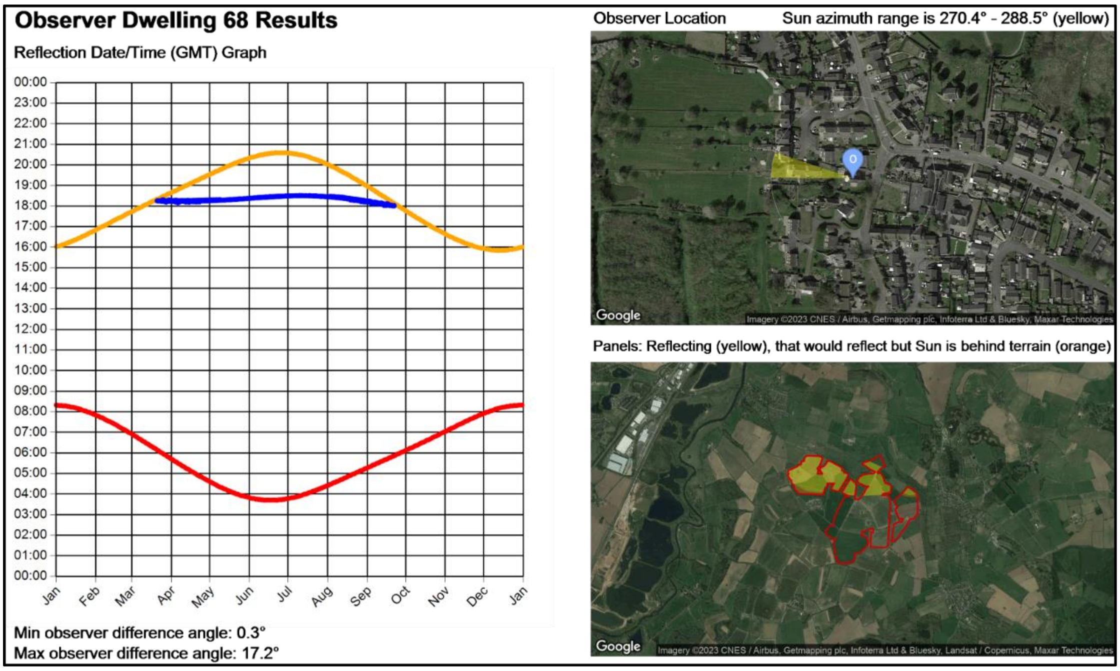
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.3°
Max observer difference angle: 17.2°
Observer Location
Sun azimuth range is 270.4° - 288.4° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer Dwelling 68 Results
Reflection Date/Time (GMT) Graph
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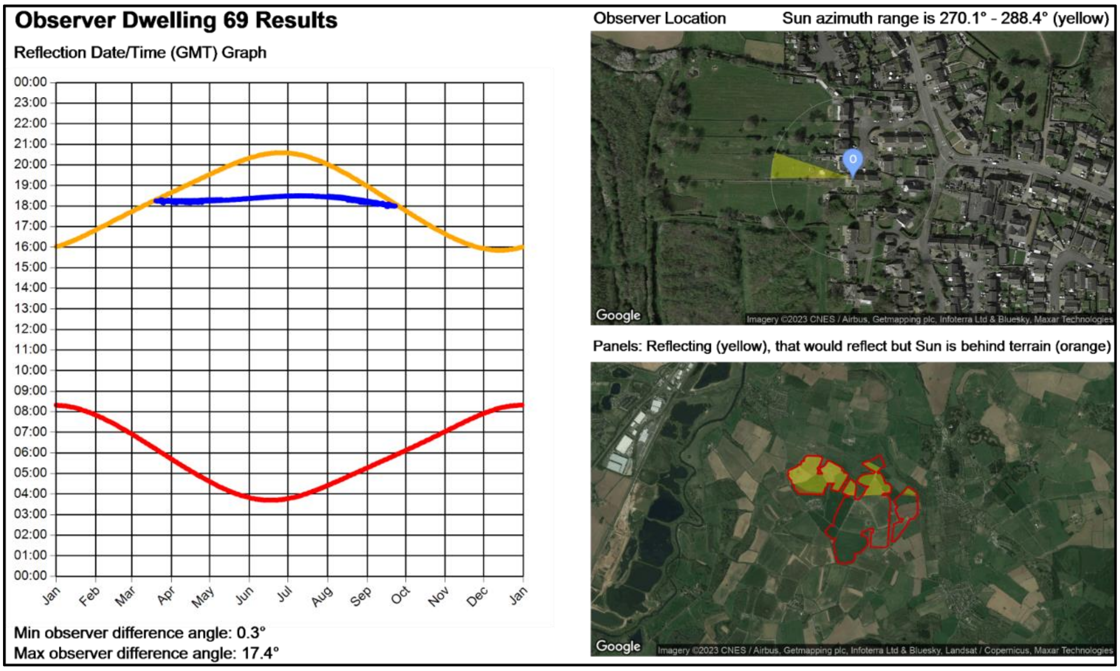
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.3°
Max observer difference angle: 17.2°
Observer Location
Sun azimuth range is 270.4° - 288.5° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer Dwelling 69 Results
Reflection Date/Time (GMT) Graph
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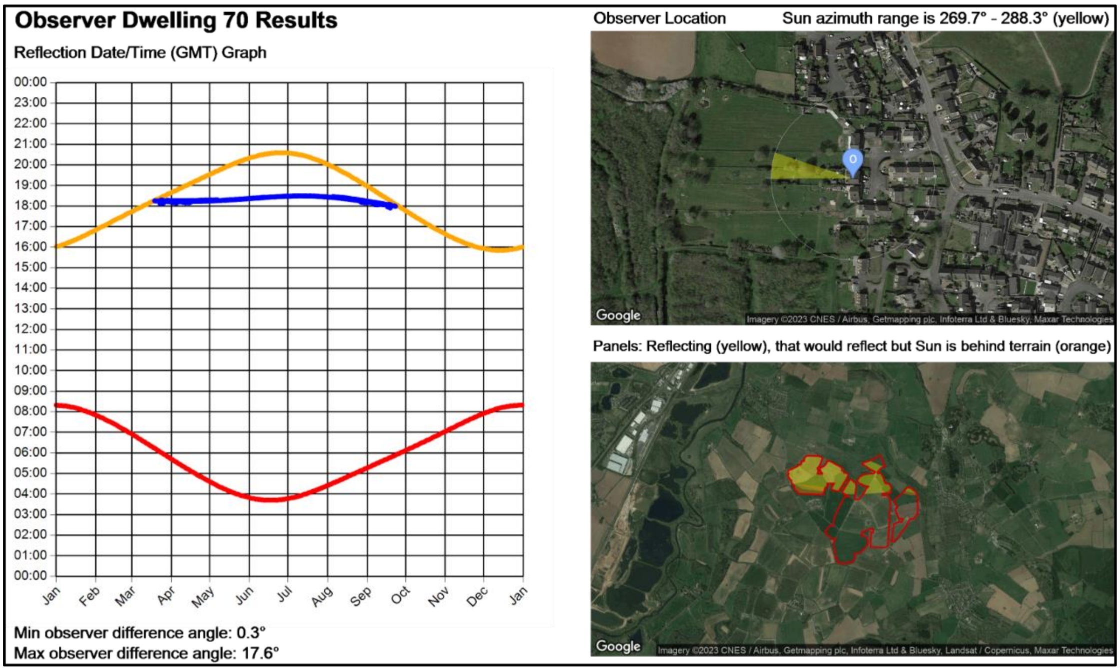
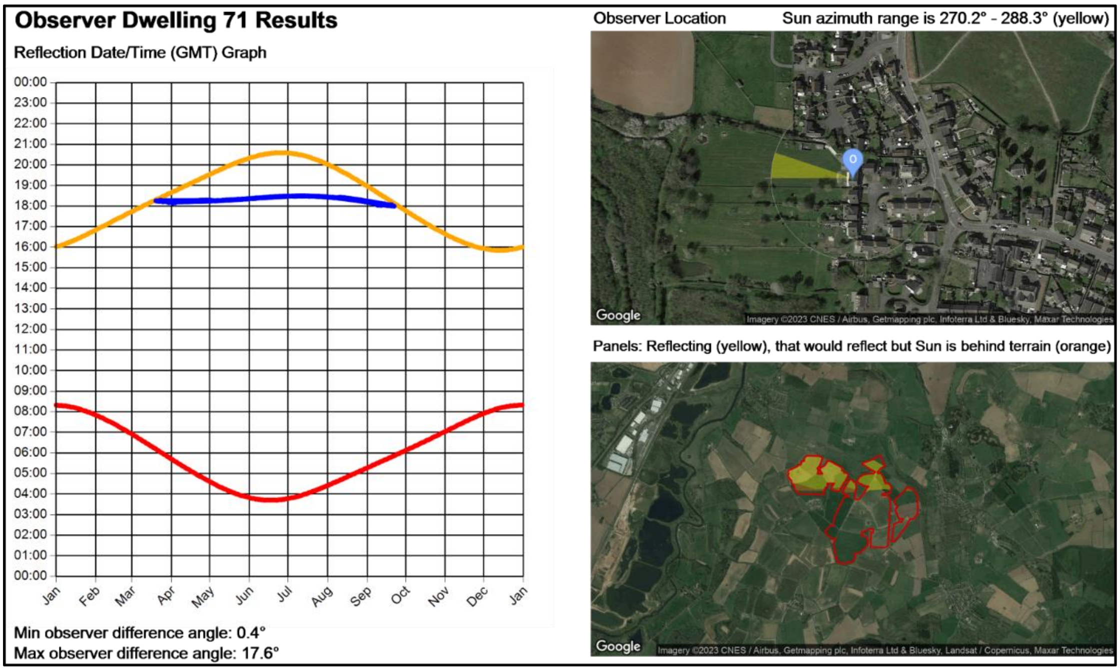
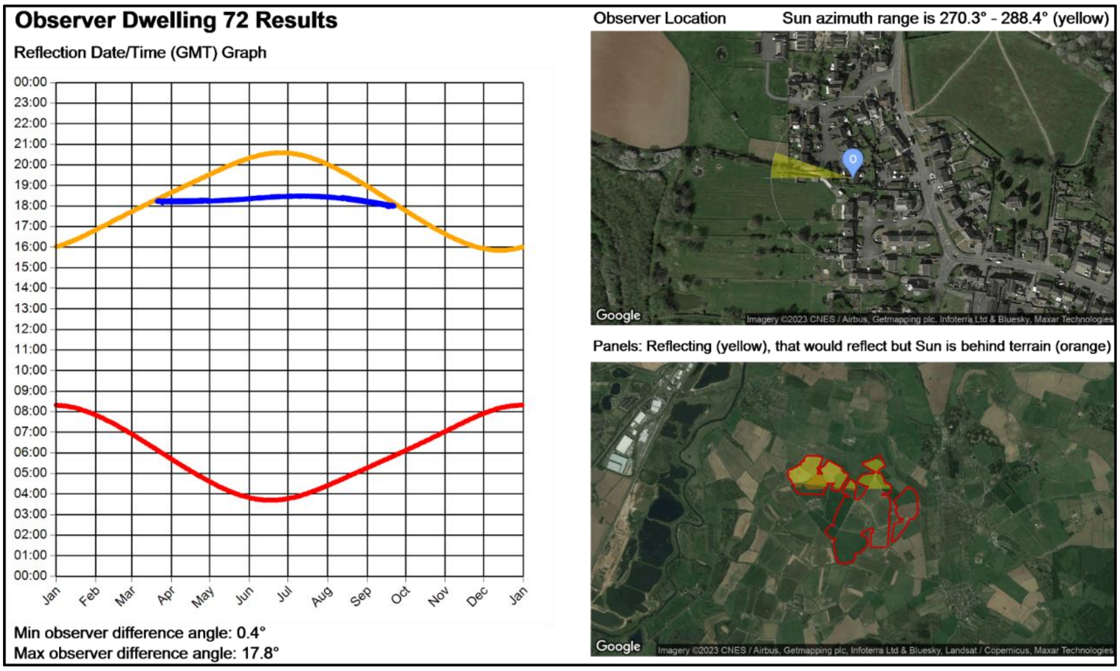
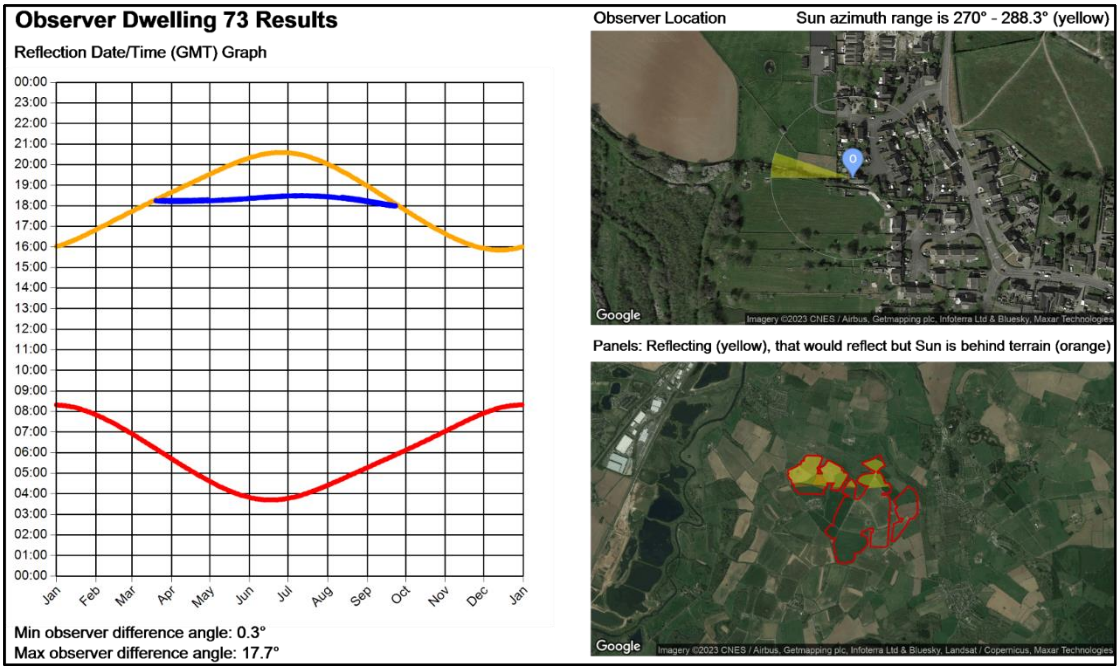
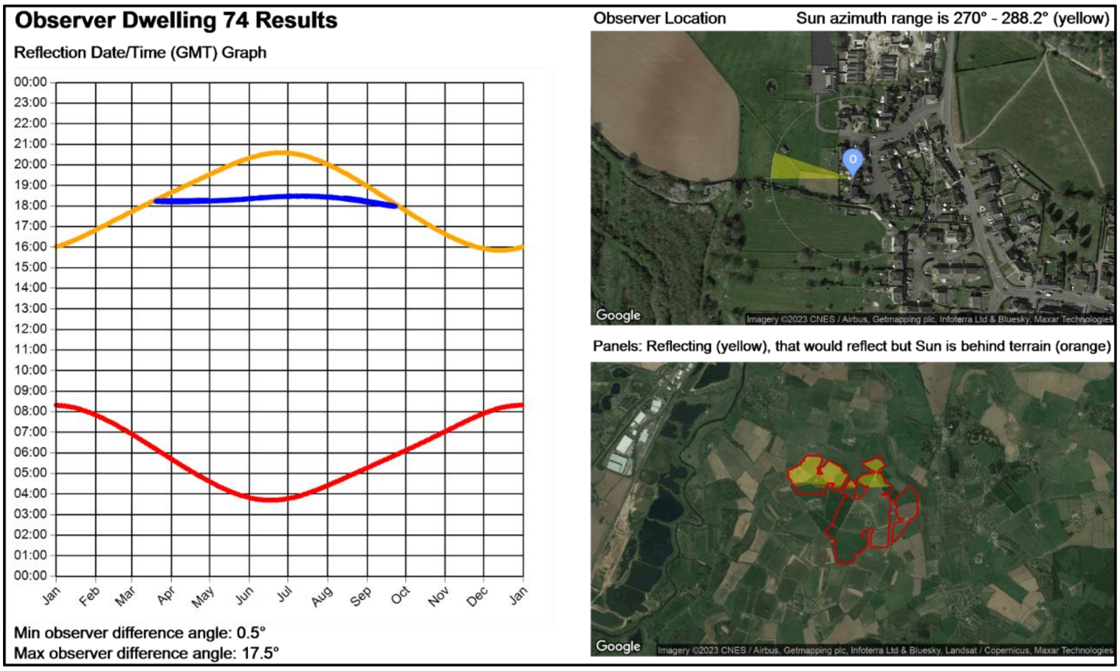
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.3°
Max observer difference angle: 17.4°
Observer Location
Sun azimuth range is 270.1° - 288.4° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

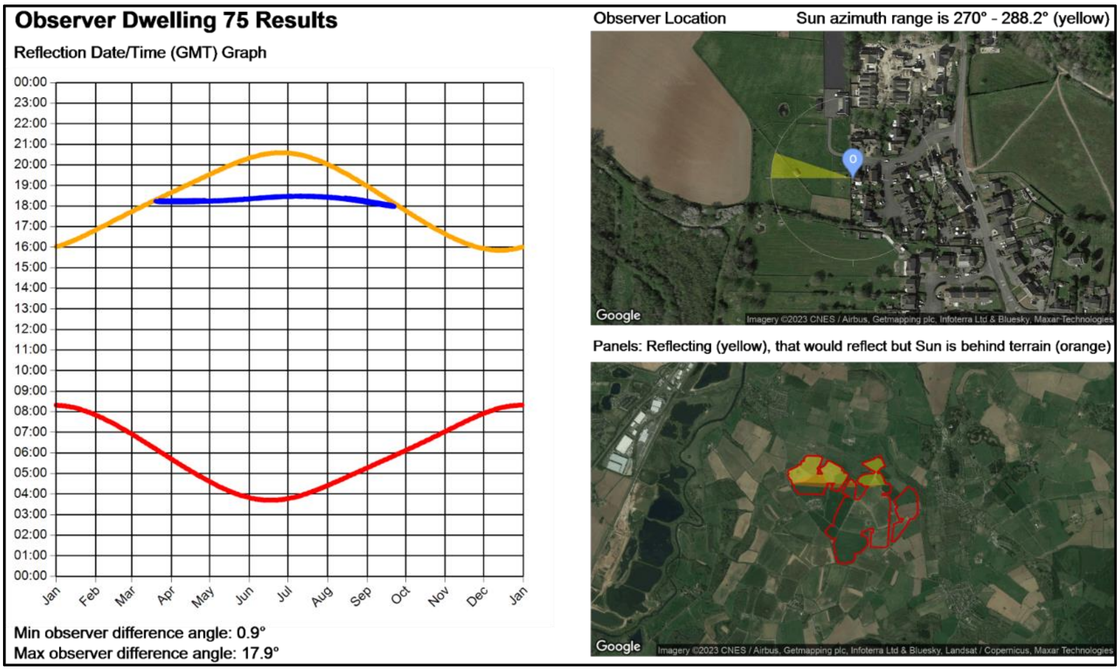

Observer Dwelling 70 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.3°
Max observer difference angle: 17.6°
Observer Location
Sun azimuth range is 269.7° - 288.3° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

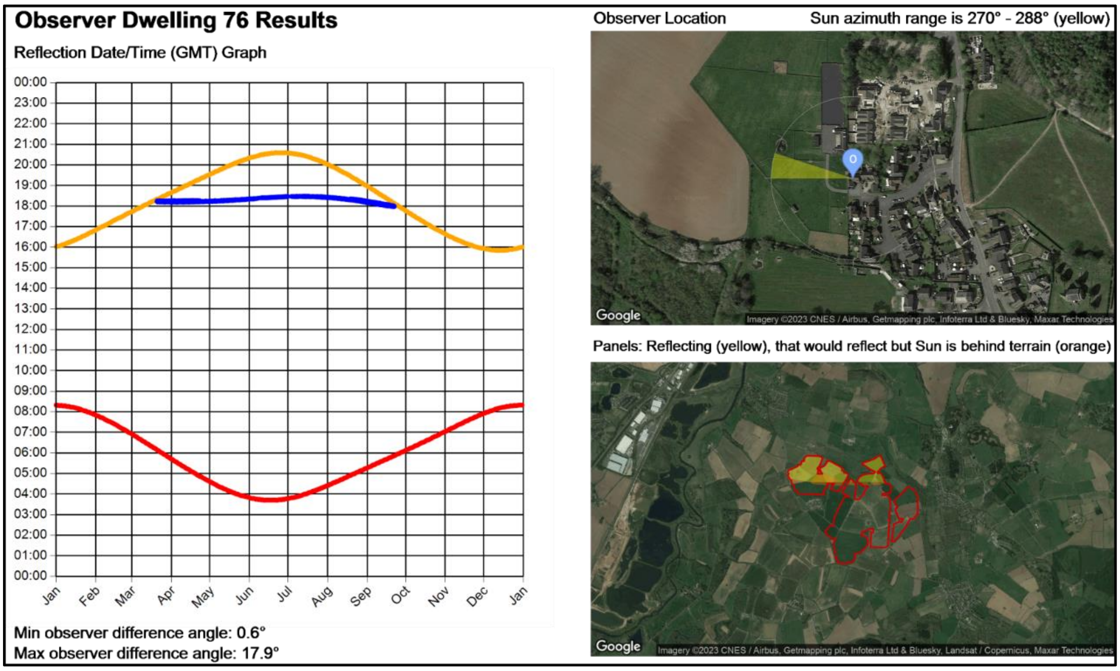

Observer Dwelling 71 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.4°
Max observer difference angle: 17.6°
Observer Location
Sun azimuth range is 270.2° - 288.3° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)

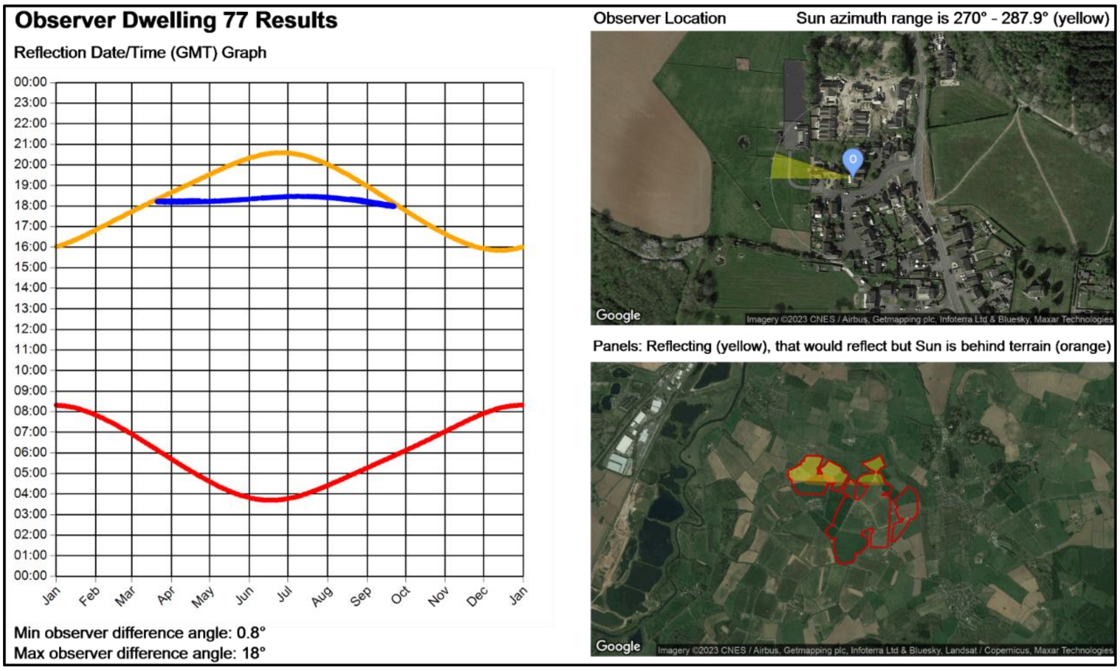

Observer Dwelling 72 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 270.3° - 288.4° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 0.4°
Max observer difference angle: 17.8°

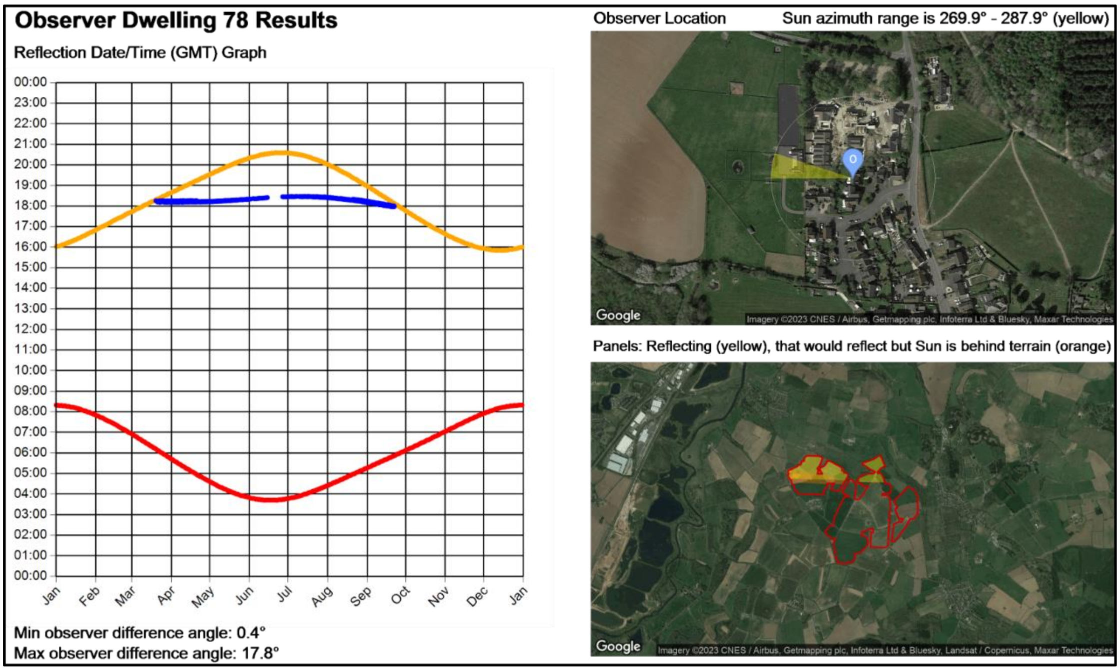

Observer Dwelling 73 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 270° - 288.3° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 0.3°
Max observer difference angle: 17.7°

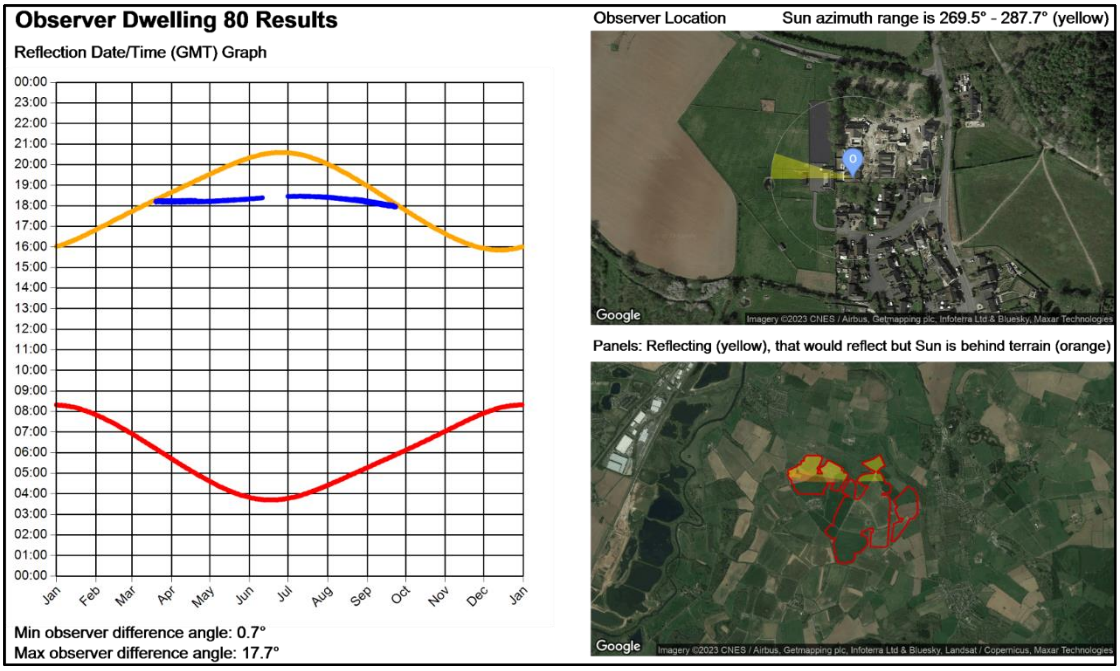

Observer Dwelling 74 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 270° - 288.2° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 0.5°
Max observer difference angle: 17.5°

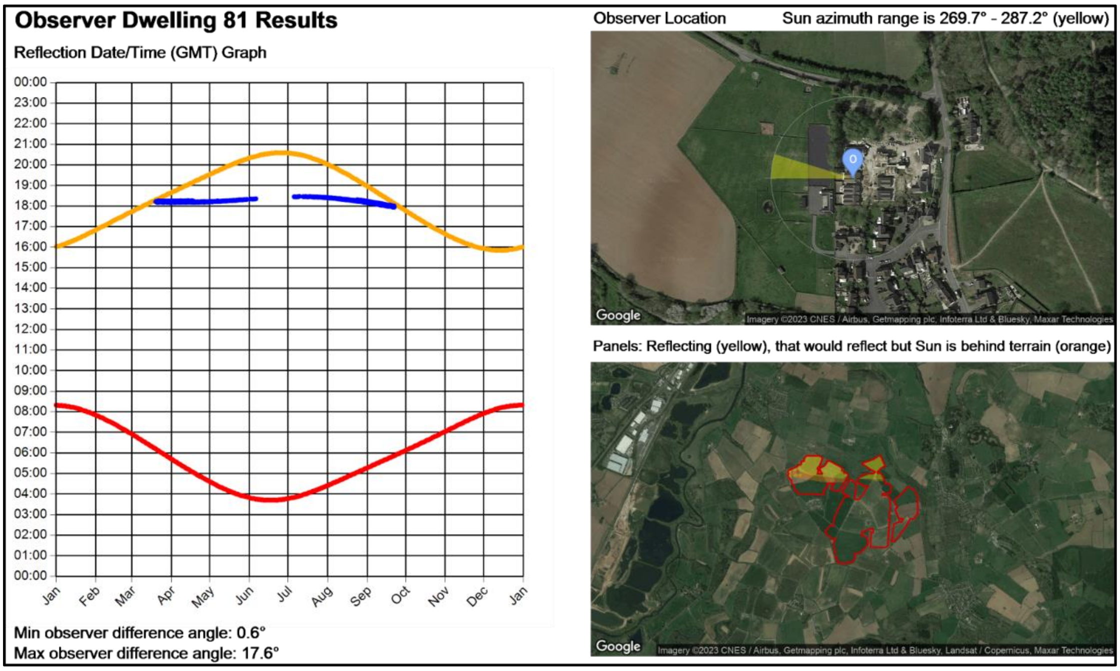

Observer Dwelling 75 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 270° - 288.2° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 0.9°
Max observer difference angle: 17.9°

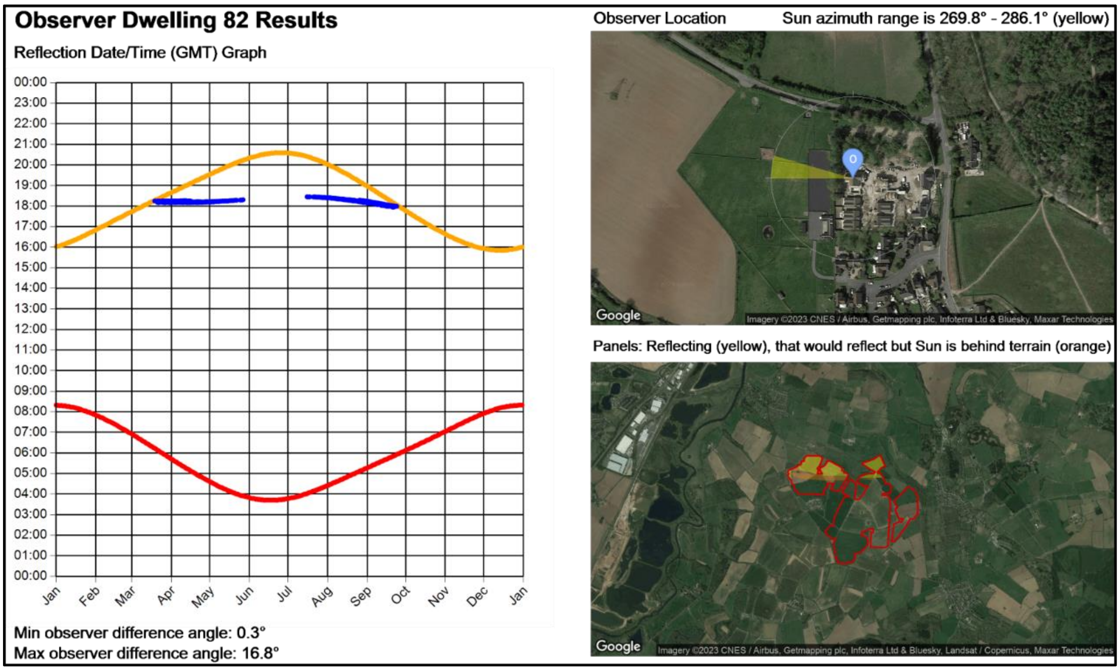

Observer Dwelling 76 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 270° - 288° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.6°
Max observer difference angle: 17.9°
Google

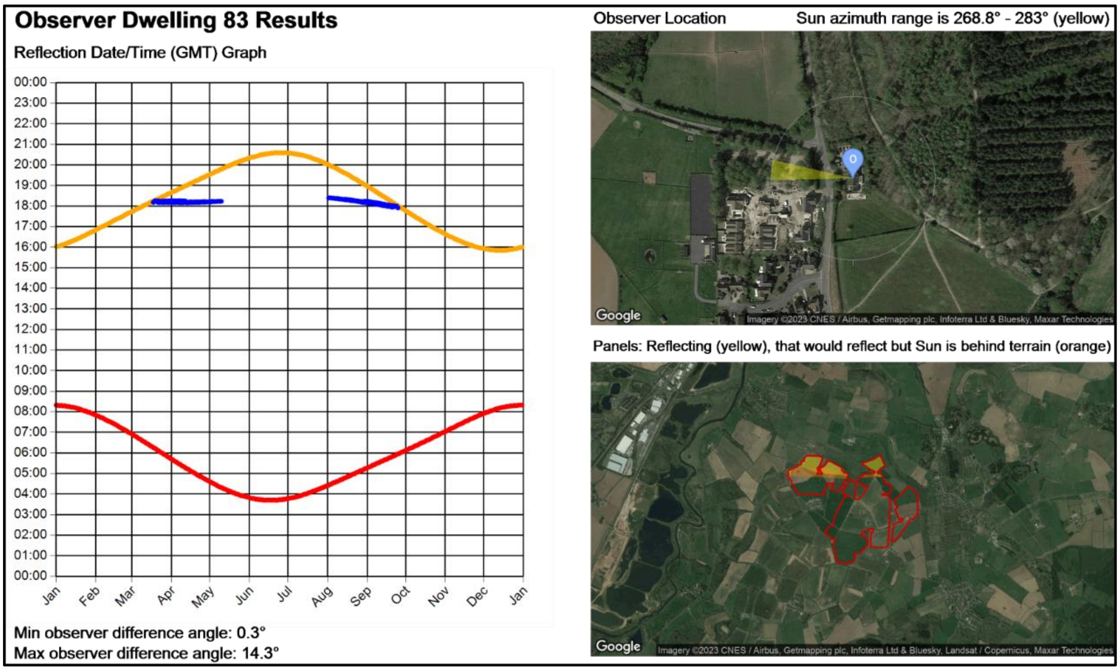

Observer Dwelling 77 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 270° - 287.9° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.8°
Max observer difference angle: 18°
Google


Observer Dwelling 78 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.4°
Max observer difference angle: 17.8°
Observer Location
Sun azimuth range is 269.9° - 287.9° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer Dwelling 80 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 0.7°
Max observer difference angle: 17.7°
Observer Location
Sun azimuth range is 269.5° - 287.7° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer Dwelling 81 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: 0.6°
Max observer difference angle: 17.6°
Observer Location
Sun azimuth range is 269.7° - 287.2° (yellow)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Landsat / Copernicus, Maxar Technologies


Observer Dwelling 82 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: 0.3°
Max observer difference angle: 16.8°
Observer Location
Sun azimuth range is 269.8° - 286.1° (yellow)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Landsat / Copernicus, Maxar Technologies


Observer Dwelling 83 Results
Reflection Date/Time (GMT) Graph
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01:00
00:00
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
Min observer difference angle: 0.3°
Max observer difference angle: 14.3°
Observer Location
Sun azimuth range is 268.8° - 283° (yellow)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google
Imagery ©2023 CNES / Airbus, Getmapping plc, Infoterra Ltd & Bluesky, Landsat / Copernicus, Maxar Technologies

APPENDIX I – DESK-BASED REVIEW OF AVAILABLE IMAGERY

Roads

The street view imagery[32] for the sections of road where the reflecting panels will be significantly obstructed from view are shown in Figures i1 to i13 on the following pages. Specifically, each figure shows:

- Figures i1 to i6: Viewpoint of a road user at road receptors 5, 10, 13, 15, 18, and 20 – representative of road users travelling on the unnamed regional road (receptors 1 to 20).
- Figures i7 and i8: Viewpoint of a road user at road receptors 22 and 28 – representative of road users travelling on Church Street (road receptors 21 to 31).
- Figures i9 and i10: Viewpoint of a road user at road receptors 33 and 36 – representative of road users travelling on Coton Lane (road receptors 32 to 38).
- Figures i11 and i12: Viewpoint of a road user at road receptors 40 and 44 – representative of road users travelling on Main Street (road receptors 39 to 45).
- Figures i13 and i14: Viewpoint of a road user at road receptors 47 and 49 – representative of road users travelling on Burton Road (road receptors 46 to 50).
- Figures i15 and i16: Viewpoint of a road user at road receptors 51 and 55 – representative of road users travelling at these specific locations on Rosliston Road (road receptors 51 and 55).
- Figures i17: Viewpoint of a road user at road receptors 57 – representative of road users travelling along a section of Coton Road (road receptors 56 and 58).
- Figures i18 to i23: Viewpoint of a road user at road receptors 61, 64, 66, 69, 72, and 76 – representative of road users travelling on Coton Road (road receptors 59 to 76).

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[32] The camera used for the street view imagery is higher than the typical eye level of a road user. This should be considered when viewing the imagery as the roadside screening is in fact taller than it appears in the figures.

Figure i1 Viewpoint at road receptor 5 – proposed development straight ahead / to the left

Figure i2 Viewpoint at road receptor 10 – proposed development straight ahead

Figure i3 Viewpoint at road receptor 13 – proposed development to the left

Figure i4 Viewpoint at road receptor 15 – proposed development to the left

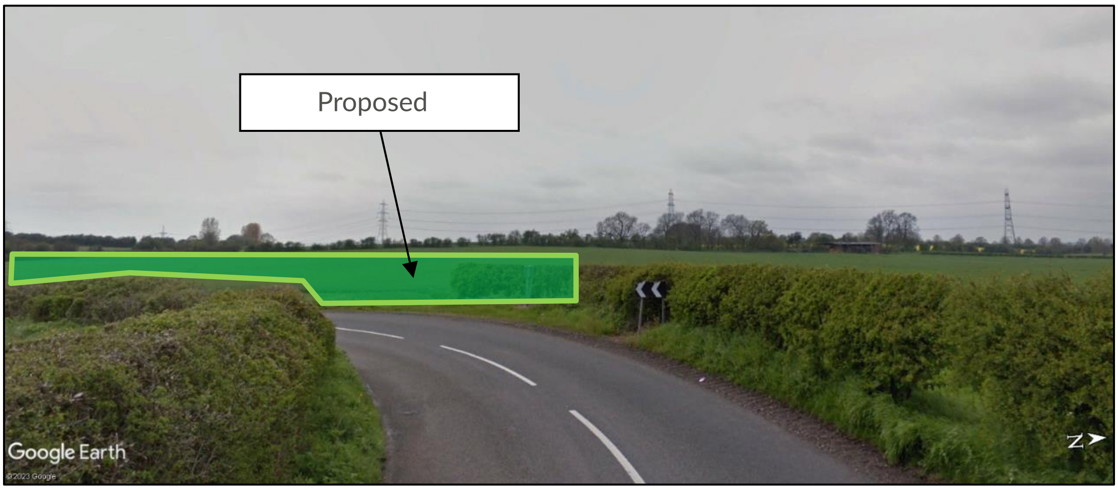

Figure i5 Viewpoint at road receptor 18 – proposed development straight ahead

Figure i6 Viewpoint at road receptor 20 – proposed development straight ahead

Figure i7 Viewpoint at road receptor 22 – proposed development straight ahead (behind terrain)

Figure i8 Viewpoint at road receptor 28 – proposed development straight ahead

Figure i9 Viewpoint at road receptor 33 – proposed development to the left

Figure i10 Viewpoint at road receptor 36 – proposed development to the right

Figure i11 Viewpoint at road receptor 40 – proposed development to the left / straight ahead

Figure i12 Viewpoint at road receptor 44 – proposed development straight ahead / to the left

Figure i13 Viewpoint at road receptor 47 – proposed development to the left

Figure i14 Viewpoint at road receptor 49 – proposed development to the left

Figure i15 Viewpoint at road receptor 51 – proposed development straight ahead

Figure i16 Viewpoint at road receptor 55 – proposed development to the left

Figure i17 Viewpoint at road receptor 57 – proposed development to the left and right

Figure i18 Viewpoint at road receptor 61 – proposed development to the left and right

Figure i19 Viewpoint at road receptor 64 – proposed development to the left and right

Figure i20 Viewpoint at road receptor 66 – proposed development to the left

Figure i21 Viewpoint at road receptor 69 – proposed development to the left

Figure i22 Viewpoint at road receptor 72 – proposed development to the left

Figure i23 Viewpoint at road receptor 76 – proposed development to the right

Dwellings

The reflecting panel areas and relevant areas of screening for these dwelling receptors are shown in Figures i24 to i32 on the following pages. Specifically, each figure shows:

- Yellow icons – Reflecting solar panels based on the geometric modelling.
- Shaded green areas (only relevant to some figures) – Areas of terrain that are potentially visible to the observer based on the typical height of an observer on the first floor of a dwelling, rounded up to the nearest metre (5m agl)[33].
- Green outlined areas – relevant areas of proposed screening set out in the landscaping plans.

[33] High-level zones of theoretical visibility (ZTV Viewshed) generated by Google Earth.

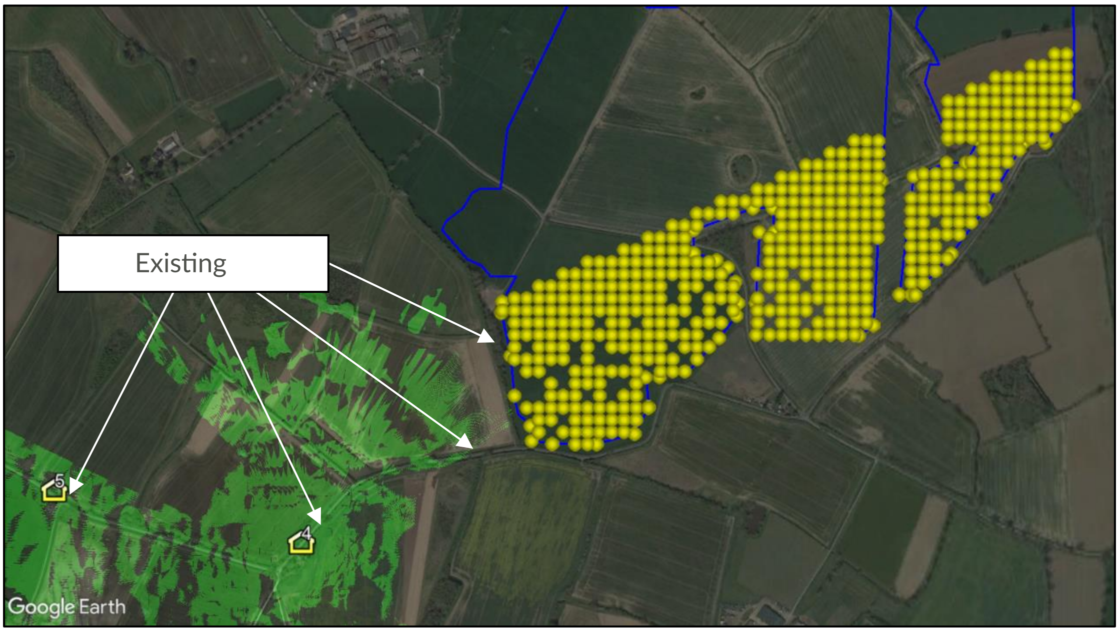

Figure i24 Significant screening for dwelling receptors 4 and 5[34]

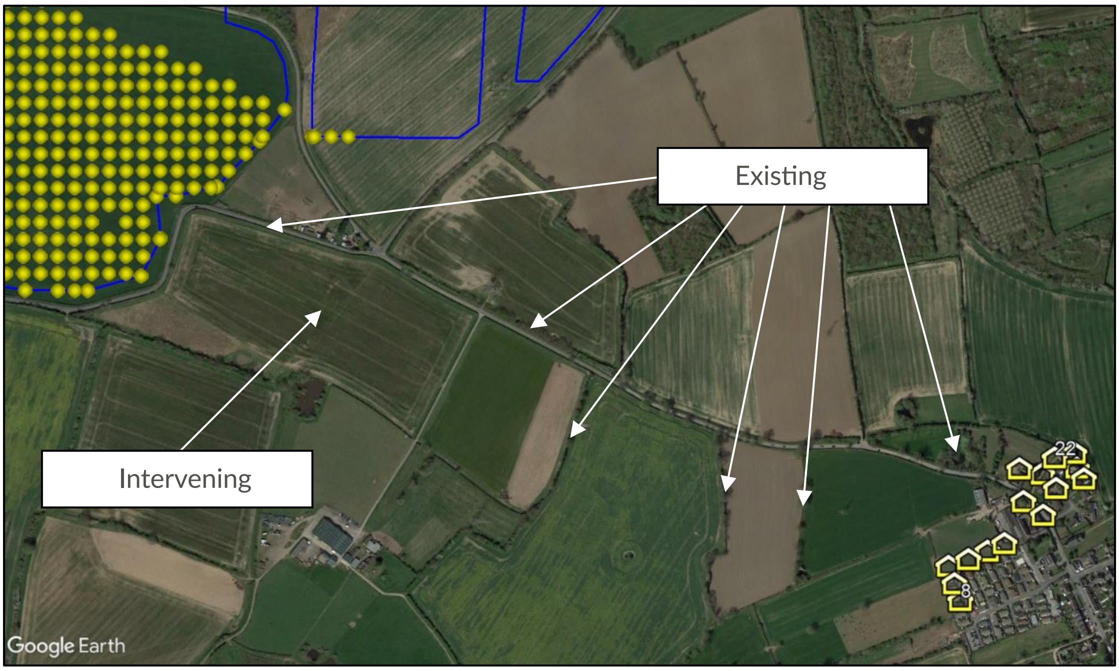

Figure i25 Significant screening for dwelling receptors 8 to 22

[34] ZTV Viewshed for dwelling receptor 4 shown within the figure.

Figure i26 Significant screening for dwelling receptors 23 and 24

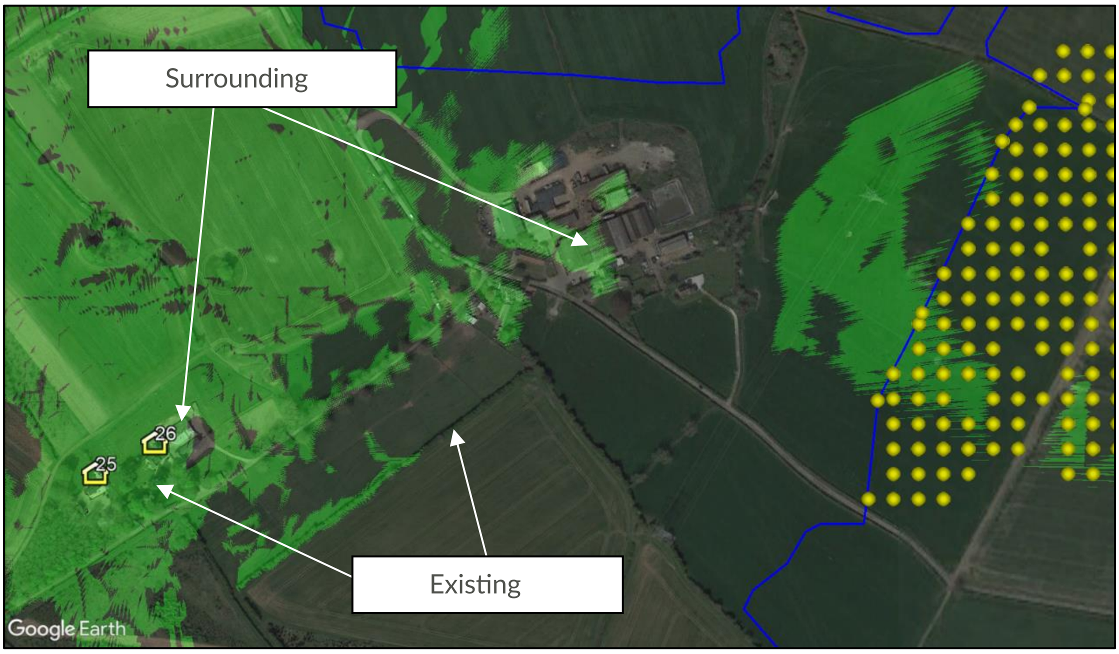

Figure i27 Significant screening for dwelling receptors 25 and 26[35]

[35] ZTV Viewshed for dwelling receptor 26 shown within the figure.

Figure i28 Significant screening for dwelling receptors 27 to 30[36]

Figure i29 Significant screening for dwelling receptors 31 to 37

[36] ZTV Viewshed for dwelling receptor 30 shown within the figure.

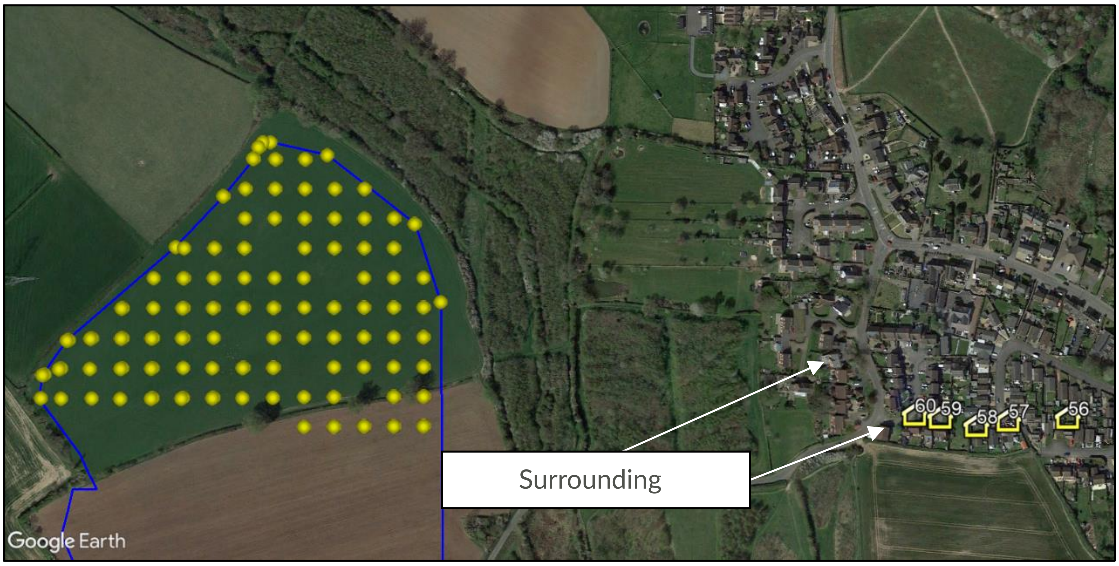

Figure i30 Significant screening for dwelling receptors 56 to 60

Figure i31 Significant screening for dwelling receptor 79

Figure i32 Significant screening for dwelling receptors 84 to 88

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