PAGERPOWER
Urban & Renewables

Solar Photovoltaic Glint and Glare Study

Hopkins Solar Farm

Spring Che Ltd.

March, 2020

ADMINISTRATION PAGE

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1	25th October, 2019	Initial issue
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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) installation located south of Capel Hendre, Ammanford, Wales, UK. This assessment pertains to the possible effects upon nearby roads and dwellings.

Pager Power

Pager Power has undertaken over 450 glint and glare assessments in the UK, Europe and internationally. The company's own glint and glare guidance is based on industry experience and extensive consultation with industry stakeholders including airports and aviation regulators.

Findings

Potential solar reflections from the proposed development upon road users and nearby dwellings have been assessed. The assessment has shown that all potential impacts are acceptable based on the associated guidance.

Assessment Results – Roads

A48

The analysis has shown that a solar reflection from the proposed solar development towards road users travelling in both directions on the A48 is geometrically possible for seven locations out of nine. However, screening in form of vegetation has been identified therefore no impact is anticipated for any type of vehicle travelling on A48 at all seven receptor locations, and no mitigation is required.

A483

The analysis has shown that a solar reflection from the proposed solar development towards road users travelling in both directions on the A483 is geometrically possible for eight locations out of ten. In six of the eight locations the impact is categorised as no impact, due to sufficient screening in form of vegetation, and in two of those ten is categorised as "low" impact, due to the fact that:

- The reflection will not originate in front of drivers;
- Sunlight and reflection will originate from the same point in space and sunlight which produces a greater intensity of light.

Therefore, the maximum impact forecasted for any type of vehicle travelling on A483 is "low" and no mitigation is required under such conditions.

Assessment Results – Dwellings

Based on a review of the geometric analysis and available imagery, residents located within 10 of the 20 assessed dwelling receptors could potentially experience a solar reflection from the proposed solar development. In four of those 10 case the impact is categorised as “no impact”, due to sufficient screening in for of vegetation, while for the remaining six is categorised as low because the reflection will last for less than three months per year.

Therefore, the maximum impact forecasted is “low” and no mitigation is required under such conditions.

Recommendation

Overall maximum impact forecasted is categorised as “low” which means no mitigation is required in any case.

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 48 countries within South Africa, Europe, 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) installation located south of Capel Hendre, Ammanford, Wales, UK. This assessment pertains to the possible effects upon nearby roads and dwellings.

This assessment pertains to the possible effects upon aviation activity, nearby roads and dwellings. The analysis contains the following:

- Details of the solar development.
- Explanation of glint and glare.
- Overview of relevant guidance.
- Overview of relevant studies.
- Identification of aviation and ground-based concerns and receptors.
- Assessment methodology.
- Glint and glare assessment for:
    - Roads;
    - Dwellings.
- Results discussion.

1.2 Pager Power's Experience

Pager Power has undertaken over 400 glint and glare assessments 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 can vary however, the definition used by Pager Power 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 Federal Aviation Administration (FAA) in the United States of America. The term 'solar reflection' is used in this report to refer to both reflection types i.e. glint and glare.

2 PROPOSED DEVELOPMENT LOCATION AND DETAILS

2.1 Proposed Development – Location

The location of the proposed development and its approximate red line boundary is shown in the aerial image of Figure 1 on the next page[1]. All solar panels are located within this boundary. Information about the development has been provided by Spring Che.

2.2 Proposed Development – Layout

The arrangement of the solar panels has been provided by Spring Che. Their details are as follows:

- Panel tilt 20 degrees;
- Panel orientation 180 degrees (south facing);
- Mid-height of the panel above ground 2.15m (height bottom 0.8m height top 3.5m).

[1] Source: Copyright © 2019 Google.

Figure 1 – Locations of proposed development

3 GLINT AND GLARE ASSESSMENT METHODOLOGY

3.1 Guidance and Studies

Appendix 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 and glass are possible.
- The measured intensity of a reflection from solar panels can vary from 2% to 30% depending on the angle of incidence.
- Published guidance shows that the intensity of solar reflections from solar panels are equal to or less than those from water and similar to those from glass. It also shows that reflections from solar panels are significantly less intense than many other reflective surfaces, which are common in an outdoor environment.

3.2 Background

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

3.3 Methodology

The assessment methodology is based on guidance, studies, previous discussions with stakeholders and Pager Power's practical experience. Information regarding the methodology of Pager Power's and Sandia National Laboratories' methodology is presented below.

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. The methodology for the glint and glare assessment is as follows:

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

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

3.4 Assessment Methodology and Limitations

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

4 IDENTIFICATION OF RECEPTORS

4.1 Overview

This assessment has been carried out with specific reference to potential impacts upon nearby roads and dwellings.

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.

However, the significance of a solar reflection decreases with distance. This is 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 for ground-based receptors.

4.2 Roads

The analysis has considered through-roads that:

- Are within, or close to one kilometre of the proposed development; and
- Have a potential view of the panels.

The assessed road receptor points are shown as white circular icons and blue lines in Figure 2[2] on the following page. The A48 (1 – 9) is located circa 60 meters (at its closest point) from the proposed solar development (Site 1), the A483 is located circa 130 meters (at its closest point) from the proposed solar development (points 10 – 20). A height above ground level of 1.5 metres has been taken as typical eye level for a road user for all roads. The co-ordinates of the receptor points are presented in Appendix G.

4.2.1 B4297

Road B4297 has not been assessed for the following reasons:

- None of the proposed developments will be in the drivers' field of view;
- The proposed solar development would be sufficiently screened.

[2] Source: Copyright © 2019 Google.

Figure 2 – Road receptors locations

4.3 Dwellings

The analysis has considered dwellings that:

- Are within, or close to one kilometre of the proposed development; and
- Have a potential view of the panels.

The assessed dwellings are shown in Figure 3[3] and in a zoomed in image in Figure 4[4] on the next page. Dwellings are located east and west of the sites 2 and 3. The receptor height used for each dwelling is 1.8m. The height represents the typical eye level for an observer on the relevant ground floor of each dwelling. The co-ordinates of the receptor points are presented in Appendix G. The red lines represent the panel area.

[3] Source: Copyright © 2019 Google.

[4] Source: Copyright © 2019 Google.

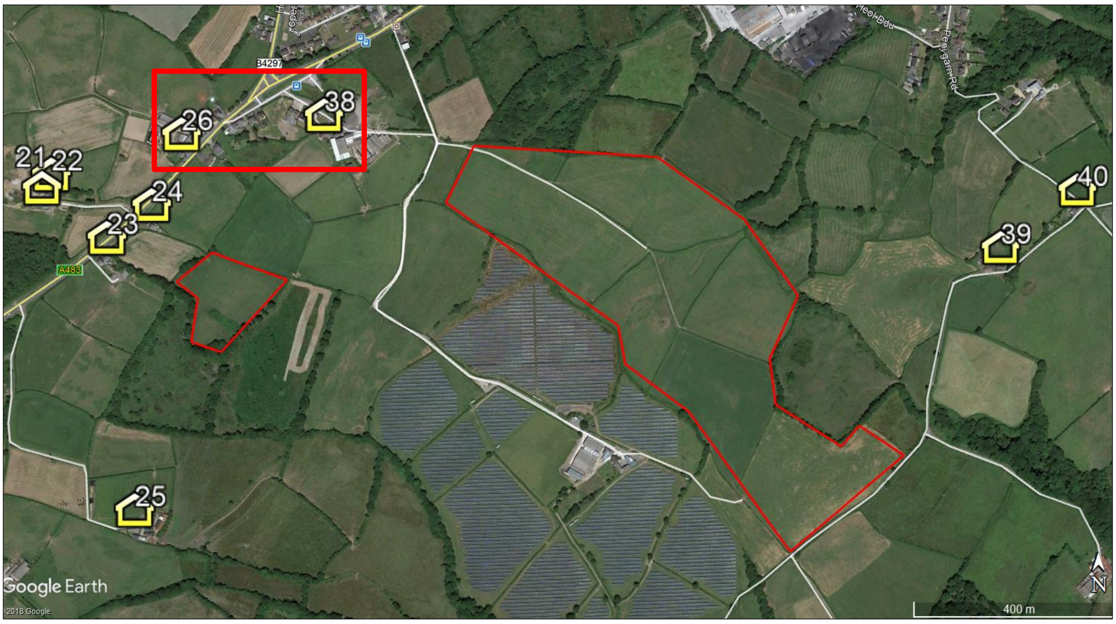

Figure 3 – Dwellings assessed and location relative to the proposed development

Figure 4 – Dwellings between 26 to 38

5 ASSESSED REFLECTOR AREAS

5.1 Reflector Areas

A number of representative panel locations are selected within the proposed reflector area. The number of modelled reflector points being 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 maps. All ground heights are based on OSGB36 terrain data and panel data has been provided by the developer. The data can be found in Appendix G.

A resolution of 20m has been chosen for this assessment. This means that a geometric calculation is undertaken for each identified receptor every 20m from within the defined areas. This resolution is sufficiently high to maximise the accuracy of the results – increasing the resolution further would not significantly change the modelling output.

If a reflection is experienced from an assessed panel location, then it is likely that a reflection will be viewable from similarly located panels within the proposed solar development.

The reflector areas assessed is shown in Figure 5 below[5] (area defined by red lines).

Figure 5 – Assessed reflector area

[5] Source: Copyright © 2019 Google.

6 GLINT AND GLARE ASSESSMENT RESULTS

6.1 Overview

The following section presents an overview of the solar reflection modelling for the identified receptors. The Pager Power model has been used to determine whether reflections are possible.

6.2 Summary of Results

The tables in the following subsections summarise the months and times during which a solar reflection could be experienced by a receptor.

This does not mean that reflections would occur continuously between the times shown.

The range of times at which reflections are geometrically possible is generally greater than the length of time for any particular day. This is because the times of day at which reflections could start and stop vary throughout the days/months.

The results of the analysis are presented in the following sections. Appendix H presents the results charts.

6.3 Geometric Calculation Results Overview – A48

The results of the geometric calculations for car drivers travelling along A48 are presented in Table 1 below.

Receptor	Pager Power Results		Comment
	Predicted reflection times towards drivers travelling along A48 (GMT)		
	am	pm	
Receptor 1	None.	None.	None.
Receptor 2	Between 05:51 and 06:34 from mid-March to mid-September.	None.	Reflection will generate from the northern part of Site 1 and 3. Screening in form of vegetation has been identified. No impact expected.
Receptor 3	Between 05:33 and 06:27 from late March to mid-September.	None.	Reflection will generate from the central part of Site 1 the entire surface of Site 2 and the northern part of Site 3. Screening in form of vegetation has been identified. No impact expected.

Receptor	Pager Power Results		Comment
	Predicted reflection times towards drivers travelling along A48 (GMT)		
	am	pm	
Receptor 4	Between 05:42 and 06:26 from late March mid-September.	None.	Reflection will generate from the southern part of Site 1 the entire surface of Site 2 and Site 3. Screening in form of vegetation has been identified. No impact expected.
Receptor 5	Between 05:46 and 06:11 from early April to early September.	None.	Reflection will generate from the entire surface of Site 2 and Site 3. Screening in form of vegetation has been identified. No impact expected.
Receptor 6	Between 05:51 and 06:08 from mid-April to late August.	None.	Reflection will generate from the southern and central part of Site 3. Screening in form of vegetation has been identified. No impact expected.

Receptor	Pager Power Results Predicted reflection times towards drivers travelling along A48 (GMT)		Comment
	am	pm	
Receptor 7	Between 05:51 and 06:06 from the beginning of May to early August.	None.	Reflection will generate from the southern and central part of Site 3. Screening in form of vegetation has been identified. No impact expected.
Receptor 8	Between 05:52 and 06:02 from late May to mid-July.	None.	Reflection will generate from the southern part of Site 3. Screening in form of vegetation has been identified. No impact expected.
Receptor 9	None.	None.	None.

Table 1 – Geometric analysis results for A48 receptors

6.4 Geometric Calculation Results Overview – A483

The results of the geometric calculations for car drivers travelling along A483 are presented in Table 1 below.

Receptor	Pager Power Results		Comment
	Predicted reflection times towards drivers travelling along A483 (GMT)		
	am	pm	
Receptor 10	None.	None.	None.
Receptor 11	Between 06:16 and 06:37 from early March to mid- April. Between 06:14 and 06:18 from the end of August to late September.	None.	Reflection will generate from the northern part of Site 3. Low impact expected.
Receptor 12	Between 06:04 and 06:37 from mid-March to mid-May. Between 06:11 and 06:18 from the end of July to late September.	Between 18:12 and 18:18 from late March to the beginning of April. Between 17:50 and 18:10 during mid-September.	Reflection will generate from the northern part of all sites. Low impact expected.

Receptor	Pager Power Results		Comment
	Predicted reflection times towards drivers travelling along A483 (GMT)		
	am	pm	
Receptor 13	Between 05:54 and 06:34 from mid-March to the beginning of June. Between 06:02 and 06:15 from early July to late September.	Between 18:10 and 18:18 from late March to late April. Between 17:50 and 18:20 from mid-August to mid-September.	Reflection will generate from the northern part of all sites. Screening in form of vegetation has been identified. No impact expected.
Receptor 14	Between 05:52 and 06:32 from mid-March to mid-September.	Between 18:08 and 18:23 from early March to mid-June. Between 17:48 and 18:32 from the late June to mid-September.	Reflection will generate from the northern and central part of Site 1 and 3 and for the entire surface of Site 2. Screening in form of vegetation has been identified. No impact expected.
Receptor 15	Between 05:51 and 06:27 from mid-March to late September.	Between 17:46 and 18:34 from late March to late September.	Reflection will generate from the northern and central part of Site 1 the entire surface of Site 2 and 3. Screening in form of vegetation has been identified. No impact expected.

Receptor	Pager Power Results Predicted reflection times towards drivers travelling along A483 (GMT)		Comment
	am	pm	
Receptor 16	Between 05:53 and 06:16 from the beginning of April to early September.	Between 17:54 and 18:36 from late March to early of October.	Reflection will generate from the southern and central part of Site 1 and 3. Screening in form of vegetation has been identified. No impact expected.
Receptor 17	Between 05:52 and 06:09 from mid-April to late August.	Between 18:22 and 18:39 from the beginning of May to early August.	Reflection will generate from the southern part of Site 1 and central and southern part of Site 3. Screening in form of vegetation has been identified. No impact expected.
Receptor 18	Between 05:51 and 06:05 from early May to early August.	None.	Reflection will generate from the southern part of Site 3. Screening in form of vegetation has been identified. No impact expected.

Receptor	Pager Power Results		Comment
	Predicted reflection times towards drivers travelling along A483 (GMT)		
	am	pm	
Receptor 19	Between 05:52 and 05:59 from the end of May to mid-July.	None.	Reflection will generate from the southern part of Site 3. Screening in form of vegetation has been identified. No impact expected.
Receptor 20	None.	None.	None.

Table 2 – Geometric analysis results A483 receptors

6.5 Geometric Calculation Results Overview – Dwellings

The results of the geometric calculations for the nearby dwellings are presented in Table 3 below.

Dwelling Receptor	Pager Power Results		Comment
	Predicted reflection times towards dwellings (GMT)		
	am	pm	
Receptor 21	Between 06:16 and 06:34 from mid-March to mid-April. Between 06:12 and 06:16 from the end of August to late September.	None.	Reflection will generate from the northern part of Site 3. Screening in form of vegetation has been identified. No impact expected.
Receptor 22	Between 06:19 and 06:35 from mid-March to early April. Between 06:12 and 06:16 from early September to late September.	None.	Reflection will generate from the northern part of Site 3. Screening in form of vegetation has been identified. No impact expected.
Receptor 23	Between 06:07 and 06:38 from mid-March to early May. Between 06:16 and 06:19 from the beginning of August to late September.	None.	Reflection will generate from the northern part of Site 3. Screening in form of vegetation has been identified. No impact expected.

Dwelling Receptor	Pager Power Results		Comment
	Predicted reflection times towards dwellings (GMT)		
	am	pm	
Receptor 24	Between 06:10 and 06:37 from mid-March to the end of April. Between 06:15 and 06:18 from mid-August to late September.	None.	Reflection will generate from the northern part of Site 3. Low impact expected.
Receptor 25	Between 06:02 and 06:34 from mid-March to late September.	Between 18:14 and 18:22 from late March to mid-May. Between 17:55 and 18:31 from late July to mid-September.	Reflection will generate from the northern and central part of Site 1, and central and southern part of Site 3. Screening in form of vegetation has been identified. No impact expected.
Receptor 26	Between 06:28 and 06:36 during late March. Between 06:13 and 06:16 during mid-September.	None.	Reflection will generate from the northern part of Site 3. Low impact expected.
Receptor 27	Between 06:26 and 06:35 during the end of March. Between 06:13 and 06:17 during mid-September.	None.	Reflection will generate from the northern part of Site 3. Low impact expected.

Dwelling Receptor	Pager Power Results		Comment
	Predicted reflection times towards dwellings (GMT)		
	am	pm	
Receptor 28	Between 06:29 and 06:36 during mid-March. Between 06:13 and 06:16 during late September.	None.	Reflection will generate from the northern part of Site 3. Low impact expected.
Receptor 29	None.	None.	None.
Receptor 30	None.	None.	None.
Receptor 31	None.	None.	None.
Receptor 32	None.	None.	None.
Receptor 33	None.	None.	None.
Receptor 34	None.	None.	None.
Receptor 35	None.	None.	None.
Receptor 36	None.	None.	None.

Dwelling Receptor	Pager Power Results		Comment
	Predicted reflection times towards dwellings (GMT)		
	am	pm	
Receptor 37	None.	None.	None.
Receptor 38	None.	None.	None.
Receptor 39	None.	Between 18:23 and 18:33 from late March to the beginning of May. Between 18:07 and 18:41 from early August to mid-September.	Reflection will generate from the northern part of Site 3. Low impact expected.
Receptor 40	None.	Between 18:23 and 18:30 from late March to early April. Between 18:07 and 18:25 during early September.	Reflection will generate from the northern part of Site 3. Low impact expected.

Table 3 – Geometric analysis results for nearby dwellings

7 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

7.1 Road Results

7.1.1 A48

The analysis has shown that a solar reflection from the proposed solar development towards road users travelling in both directions on the A48 is geometrically possible for seven locations out of nine.

However, screening in form of vegetation (Figure 6 below) has been identified therefore no impact is anticipated for any type of vehicle travelling on A48 at all seven receptor locations, and no mitigation is required.

Figure 6 – Screening location 4

7.1.2 A483

The analysis has shown that a solar reflection from the proposed solar development towards road users travelling in both directions on the A483 is geometrically possible for eight locations out of ten.

Screening in the form of vegetation will block the view of the reflective surfaces for all types of vehicle for locations 13 to 20 (Figure 7 on the next page). For locations 11 and 12 no screening has been identified, however, the reflection will not originate in front of drivers[6], also sunlight and reflection will originate from the same point in space and sunlight is a much higher source of light.

Therefore, no impact is anticipated for locations 13 to 20 and "low" impact is anticipated for locations 11 and 12, no mitigation is required.

Figure 7 – Screening location 13

7.2 Dwellings Results

Based on a review of the geometric analysis and available imagery, residents located within 10 of the 20 assessed dwelling receptors could potentially experience a solar reflection from the proposed solar development. In six of those 10 cases, the impact is categorised as "low" and the remaining four cases the impact is categorised as no impact.

For all cases with impact categorised as "low", the reflection will last less than 3 months.

Dwelling 25 will experience reflection for more than 3 months, however, screening in form of vegetation (Figure 8 on the next page) located near the existing solar farm will block any view of the reflective surface area.

Therefore, the maximum impact forecasted is "low" and no mitigation is required for any of the affected dwellings.

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[6] drivers of any type of vehicle.

Figure 8 – Screening dwelling 25

8 OVERALL CONCLUSIONS

8.1 Overall Conclusion

Potential solar reflections from the proposed development upon road users and nearby dwellings have been assessed. The assessment has shown that all potential impacts are acceptable based on the associated guidance.

8.2 Assessment Results – Roads

8.2.1 A48

The analysis has shown that a solar reflection from the proposed solar development towards road users travelling in both directions on the A48 is geometrically possible for seven locations out of nine. However, screening in form of vegetation has been identified therefore no impact is anticipated for any type of vehicle travelling on A48 at all seven receptor locations, and no mitigation is required.

8.2.2 A483

The analysis has shown that a solar reflection from the proposed solar development towards road users travelling in both directions on the A483 is geometrically possible for eight locations out of ten. In six of the eight locations the impact is categorised as no impact, due to sufficient screening in form of vegetation, and in two of those ten is categorised as “low” impact, due to the fact that:

- The reflection will not originate in front of drivers;
- Sunlight and reflection will originate from the same point in space and sunlight which produces a greater intensity of light.

Therefore, the maximum impact forecasted for any type of vehicle travelling on A483 is “low” and no mitigation is required under such conditions.

8.3 Assessment Results – Dwellings

Based on a review of the geometric analysis and available imagery, residents located within 10 of the 20 assessed dwelling receptors could potentially experience a solar reflection from the proposed solar development. In four of those 10 case the impact is categorised as “no impact”, due to sufficient screening in for of vegetation, while for the remaining six is categorised as low because the reflection will last for less than three months per year.

Therefore, the maximum impact forecasted is “low” and no mitigation is required under such conditions.

8.4 Recommendation

Overall maximum impact forecasted is categorised as “low” which means no mitigation is required in any case.

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.

Welsh Government Planning Policy

Aecom on behalf of the Welsh Government produced the document titled 'Renewable and Low Carbon Energy - A Toolkit for Planners'[7] in 2015. The document provides a very brief comment on glint and glare for solar development, the extract is presented below.

'Project Sheet K: Assessing Solar Photovoltaic (PV) Farm Resource

Introduction

…

Alternatively, local authorities may wish to commission work to understand landscape and cumulative impacts to support their assessments, if these are likely to be persistent issues.

Examples of items that may be more difficult to include might be:

- *Where formal consultations are held, for example with the MoD and Civil Aviation Authority to identify any potential objections to certain sites in relation to glare and glint disruption'*

Pager Power has produced its own guidance document based on assessment experience, stakeholder consultation and expertise in the area. Where an aviation receptor is identified and an assessment is required, the typical approach is to assess the ATC Tower and runway approach paths. In some instance an aerodrome operator may request more detailed analysis.

Planning Policy Wales

Planning Policy Wales produced a document in 2016 titled 'Permitted Development Rights and Non-Domestic Solar PV and Thermal Panels[8]'. The document sets out the approaches across various administration and general assessment requirements for solar developments under permitted development. The proposed solar development does not fall under permitted development and is therefore not applicable in this instance.

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[7] Renewable and Low Carbon Energy - A Toolkit for Planners', September 2015. Aecom on behalf of the Welsh Government. Last accessed 01/02/2019.

[8] Permitted Development Rights and Non-Domestic Solar PV and Thermal Panels, September 2016. Planning Policy Wales. Last accessed 01/02/2019.

UK Planning Policy

UK National Planning Practice Guidance dictates that in some instances a glint and glare assessment is required however, there is no specific guidance with respect to the methodology for assessing the impact of glint and glare.

The planning policy from the Department for Communities and Local Government (paragraph 27[9]) states:

'Particular factors a local planning authority will need to consider include… the effect on landscape of glint and glare and on ***neighbouring uses and aircraft safety**.'*

The National Planning Policy Framework for Renewable and Low Carbon Energy[10] (specifically regarding the consideration of solar farms, paragraph 26 and 27) 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.'

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[11] however the advice is still applicable[12] until a formal policy is developed. The relevant aviation guidance from the CAA is presented in the section below.

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[9] Source: Planning practice guidance for renewable and low carbon energy, Department for Communities and Local Government, date: 06/2013, accessed on: 20/03/2019

[10] Source: Planning practice guidance for renewable and low carbon energy, Department for Communities and Local Government, date: 06/2013, accessed on: 20/03/2019

[11] Archived at Pager Power

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

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[13], 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.

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

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[13] Aerodrome Licence Holder.

FAA Guidance

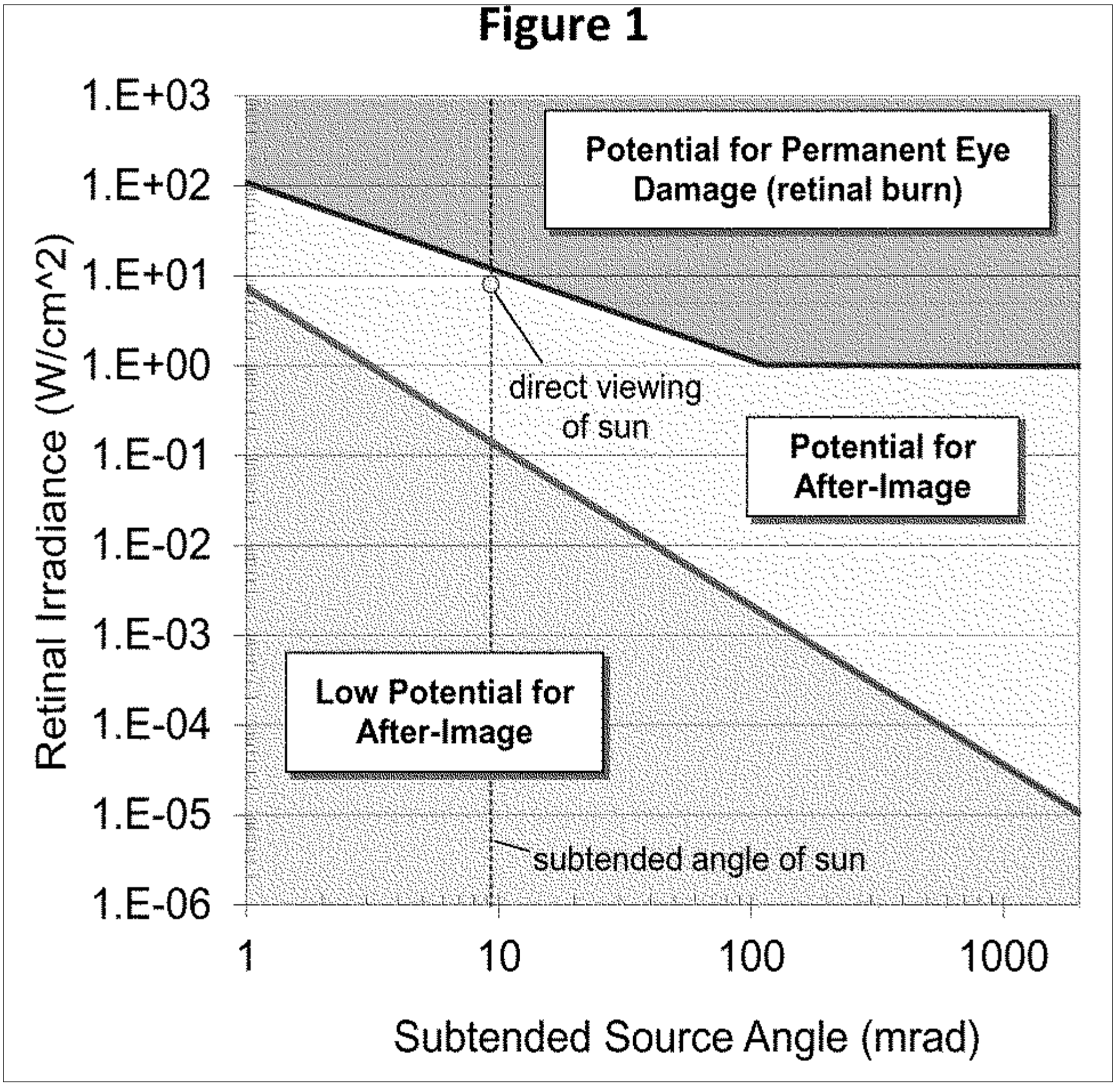
The most comprehensive guidelines available for the assessment of solar developments near aerodromes were produced initially in November 2010 by the United States Federal Aviation Administration (FAA) and updated in 2013.

The 2010 document is entitled '*Technical Guidance for Evaluating Selected Solar Technologies on Airports'*[14] and the 2013 update is entitled '*Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports'*[15]. In April 2018 the FAA released a new version (Version 1.1) of the '*Technical Guidance for Evaluating Selected Solar Technologies on Airports'*[16].

An overview of the methodology presented within the 2013 interim guidance and adopted by the FAA is presented below. This methodology is not presented within the 2018 guidance.

- *Solar energy systems located on an airport that is not federally-obligated or located outside the property of a federally-obligated airport are not subject to this policy.*
- *Proponents of solar energy systems located off-airport property or on non-federally-obligated airports are strongly encouraged to consider the requirements of this policy when siting such system.*
- *FAA adopts the Solar Glare Hazard Analysis Plot…. as the standard for measuring the ocular impact of any proposed solar energy system on a federally-obligated airport. This is shown in the figure below.*

[14] Archived at Pager Power
[15] Source: 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: 20/03/2019
[8] Source: Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019



Solar Glare Hazard Analysis Plot (FAA)

- *To obtain FAA approval to revise an airport layout plan to depict a solar installation and/or a "no objection" … the airport sponsor will be required to demonstrate that the proposed solar energy system meets the following standards:*
- *No potential for glint or glare in the existing or planned Airport Traffic Control Tower (ATC) cab, and*
- *No potential for glare or "low potential for after-image" … along the final approach path for any existing landing threshold or future landing thresholds (including any planned interim phases of the landing thresholds) as shown on the current FAA-approved Airport Layout Plan (ALP). The final approach path is defined as two (2) miles from fifty (50) feet above the landing threshold using a standard three (3) degree glidepath.*
- *Ocular impact must be analysed over the entire calendar year in one (1) minute intervals from when the sun rises above the horizon until the sun sets below the horizon.*

The bullets highlighted above state there should be 'no potential for glare' at that ATC Tower and 'no' or 'low potential for glare' on the approach paths.

Key points from the 2018 FAA guidance are presented below.

- *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*[17].
- *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*[18]*, flat, smooth surfaces reflect a more concentrated amount of sunlight back to the receiver, which is referred to as specular reflection. The more a surface is polished, the more it shines. Rough or uneven surfaces reflect light in a diffused or scattered manner and, therefore, the light will not be received as bright.*
- *Because the FAA has no specific standards for airport solar facilities and potential glare, the type of glare analysis may vary. Depending on site specifics (e.g., existing land uses, location and size of the project) an acceptable evaluation could involve one or more of the following levels of assessment:*
    - *A qualitative analysis of potential impact in consultation with the Control Tower, pilots and airport officials;*
    - *A demonstration field test with solar panels at the proposed site in coordination with FAA Tower personnel;*
    - *A geometric analysis to determine days and times when an impact is predicted.*
- *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.*

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[17] 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.

[18] First figure in Appendix B.

- ***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*19 *but still requires further research to definitively answer.*
- ***Experiences of Existing Airport Solar Projects*** *– Solar installations are presently operating at a number of airports, including megawatt-sized solar facilities covering multiple acres. Air traffic control towers have expressed concern about glint and glare from a small number of solar installations. These were often instances when solar installations were sited between the tower and airfield, or for installations with inadequate or no reflectivity analysis. Adequate reflectivity analysis and alternative siting addressed initial issues at those installations.*

[19] Source: 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.

Air Navigation Order (ANO) 2009

In some instances, an aviation stakeholder can refer to the ANO 2009 with regard to safeguarding. Key points from the document are presented below.

Endangering safety of an aircraft

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

Lights liable to endanger

221.

(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

222. 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.

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

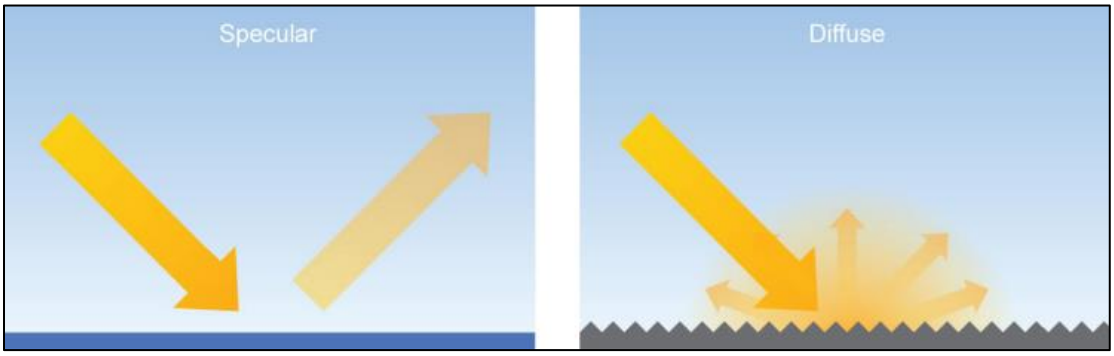
Overview

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[20], 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

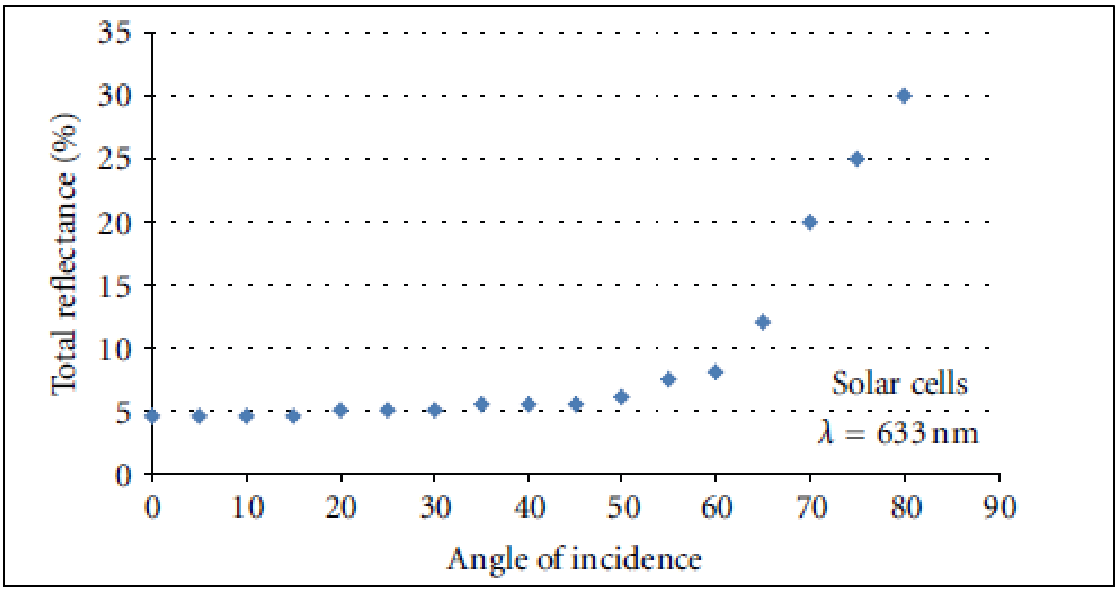
[20] Source: Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

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*[21]". 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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[21] Source: 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"[22]

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[23]
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).

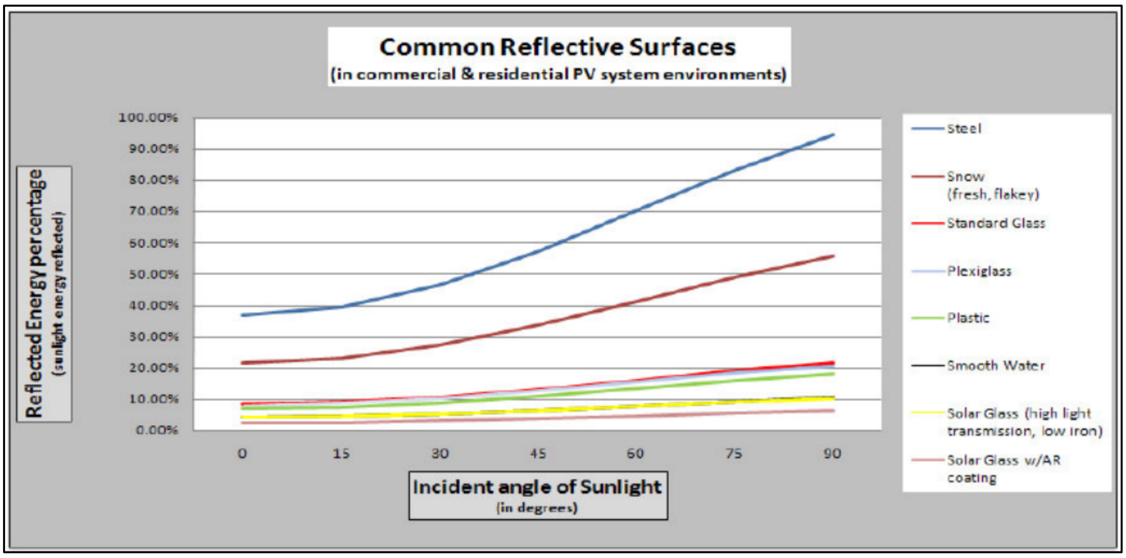
[22] Source: Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.
[23] Extrapolated data, baseline of 1,000 W/m^2 for incoming sunlight.

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.

SunPower Technical Notification (2009)

SunPower published a technical notification[24] 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.

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

APPENDIX C – OVERVIEW OF SUN MOVEMENTS AND RELATIVE REFLECTIONS

Overview

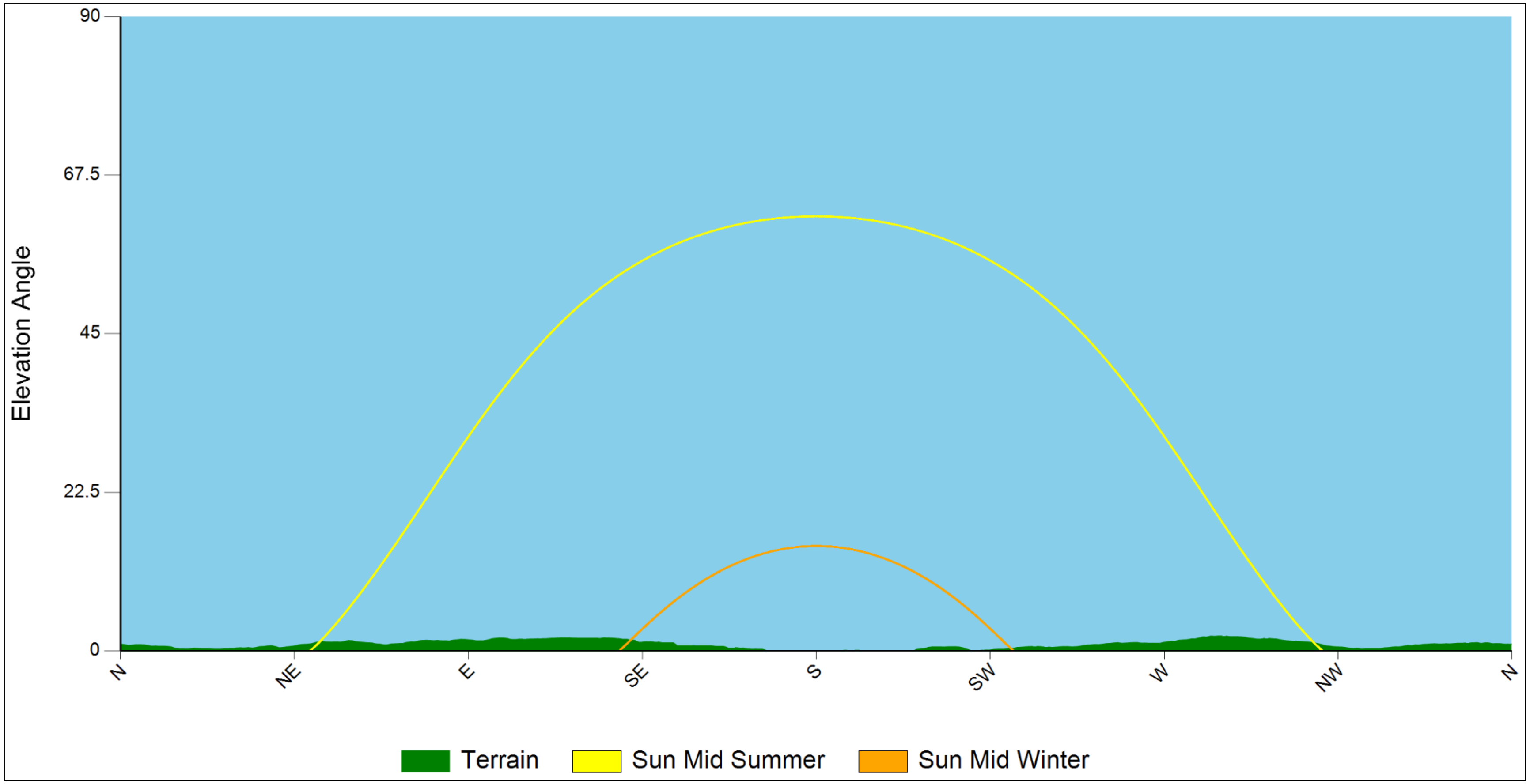
The Sun's position in the sky can be accurately described by its azimuth and elevation. Azimuth is a direction relative to true north (horizontal angle i.e. from left to right) and elevation describes the Sun's angle relative to the horizon (vertical angle i.e. up and down).

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 combination of the Sun's azimuth angle and vertical elevation will affect the direction and angle of the reflection from a reflector.

Terrain Sun Curve - From lon:-4.052156 lat: 51.765141



Terrain profile at horizon and sunrise/sunset curve at proposed development location

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.

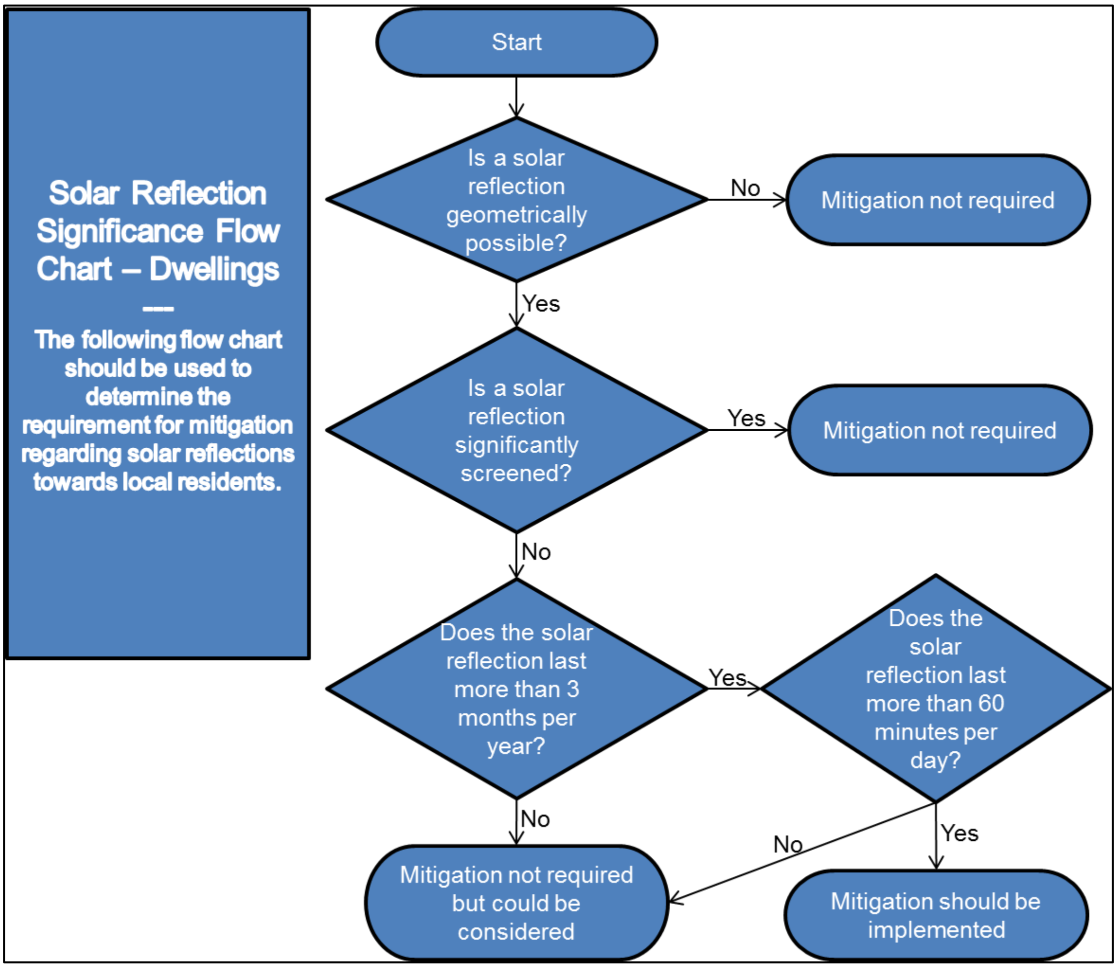
Impact Significance	Definition	Mitigation Requirement
No Impact	A solar reflection is not geometrically possible or will not be visible from the assessed receptor.	No mitigation required.
Low	A solar reflection is geometrically possible however any impact is considered to be small such that mitigation is not required e.g. intervening screening will limit the view of the reflecting solar panels.	No mitigation required.
Moderate	A solar reflection is geometrically possible and visible however it occurs under conditions that do not represent a worst-case.	Whilst the impact may be acceptable, consultation and/or further analysis should be undertaken to determine the requirement for mitigation.
Major	A solar reflection is geometrically possible and visible under conditions that will produce a significant impact. Mitigation and consultation is recommended.	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 relevant receptors.

Assessment Process for Dwelling Receptors

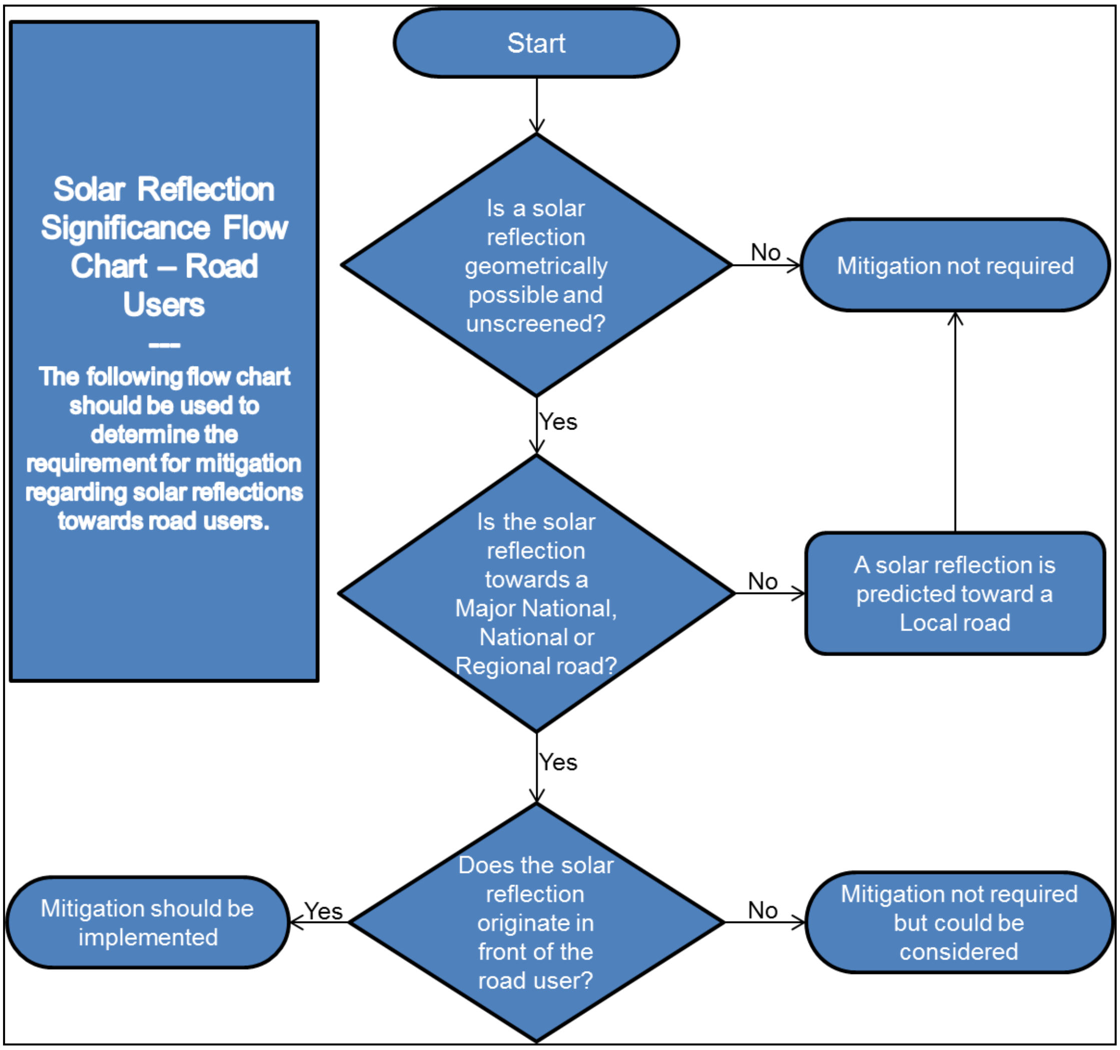
The flow chart presented below has been followed when determining the mitigation requirement for dwelling receptors.



Dwelling receptor mitigation requirement flow chart

Assessment Process for Road Receptors

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



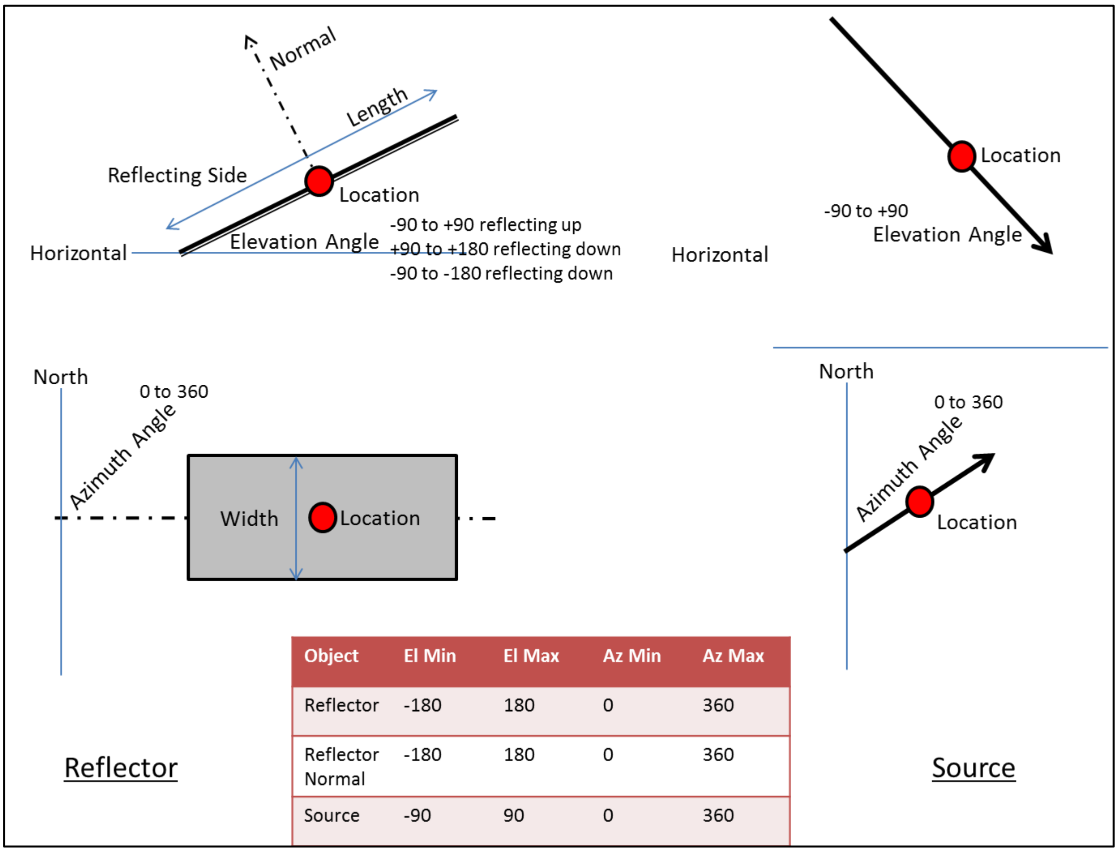
Road receptor mitigation requirement flow chart

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

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 the solar development.

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

Only a reflection from the face of the panel has been considered. The frame or the reverse 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 reflection from the face of a solar panel that is not visible to a receptor will not occur.

A finite number of points within the proposed development are chosen based on an assessment resolution so we can build a comprehensive understanding of the entire development. This will determine whether a reflection could ever occur at a chosen receptor. The calculations do not incorporate all of the possible panel locations within the development outline.

A single reflection point on the panel has been chosen for the geometric calculations. This will suitably determine whether a reflection can be experienced at a location and the general time of year and duration of this 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.

Whilst line of sight to the development from receptors has been considered, only available street view imagery and satellite mapping has been used. 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 considered unless stated.

Sandia National Laboratories' (SGHAT) Model

The following text is taken from the Solar Glare Hazard Analysis Tool (SGHAT) Technical Reference Manual[25] which was previously freely available. The following is presented for reference.

3. Assumptions and Limitations

Below is a list of assumptions and limitations of the models and methods used in SGHAT:

- The software currently only applies to flat reflective surfaces. For curved surfaces (e.g., focused mirrors such as parabolic troughs or dishes used in concentrating solar power systems), methods and models derived by Ho et al. (2011) [1] can be used and are currently being evaluated for implementation into future versions SGHAT.
- When enabled, PV array single- or dual-axis tracking does not account for backtracking or the effects of panel shading and blocking.
- SGHAT 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.
- SGHAT 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.
- SGHAT 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.
- 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 [2] 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.
- 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.

[25] https://share.sandia.gov/phlux/static/references/glint-glare/SGHAT_Technical_Reference-v5.pdf

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

A48

ID	Latitude (°)	Longitude (°)	Observer height (agl)	Overall height (m) (amsl)
1	51.768326	-4.071355	1.5m	99.62
2	51.766109	-4.070831		90.50
3	51.763888	-4.070358		80.25
4	51.761650	-4.069875		76.52
5	51.759483	-4.068877		74.72
6	51.757552	-4.067111		75.93
7	51.755581	-4.065406		66.50
8	51.753497	-4.064005		66.92
9	51.751327	-4.063150		55.84

Assessed receptor (road) locations for A48

A483

ID	Latitude (°)	Longitude (°)	Observer height (agl)	Overall height (m) (amsl)
10	51.769701	-4.040655	1.5m	130.11
11	51.768087	-4.043156		136.73
12	51.766688	-4.045916		141.09
13	51.765406	-4.048918		136.12
14	51.764136	-4.051889		129.95
15	51.762703	-4.054630		120.10
16	51.760878	-4.056698		105.04
17	51.758805	-4.058107		81.15
18	51.756601	-4.058662		68.50

ID	Latitude (°)	Longitude (°)	Observer height (agl)	Overall height (m) (amsl)
19	51.754369	-4.058445		65.69
20	51.752119	-4.058091		57.81

Assessed receptor (road) locations for A483

Dwelling Receptors

ID	Longitude (°)	Latitude (°)	Observer height (agl)	Overall height (m) (amsl)
21	51.767995	-4.045828	1.8m	137.02
22	51.768204	-4.045588		137.68
23	51.767218	-4.044151		141.80
24	51.767727	-4.043058		137.45
25	51.762991	-4.043529		130.33
26	51.768826	-4.042322		133.83
27	51.768741	-4.041624		132.85
28	51.768916	-4.041412		132.47
29	51.769263	-4.041622		132.80
30	51.769387	-4.041558		132.80
31	51.769469	-4.041429		132.80
32	51.769292	-4.040963		131.99
33	51.769362	-4.040586		130.80
34	51.769431	-4.040364		130.80
35	51.769498	-4.039562		125.48
36	51.769407	-4.039332		123.90
37	51.769301	-4.039069		124.74
38	51.769137	-4.038799		124.52
39	51.76708	-4.021518		90.80

ID	Longitude (°)	Latitude (°)	Observer height (agl)	Overall height (m) (amsl)
40	51.767989	-4.019616		92.80

Assessed receptor locations for dwellings

Modelled Reflector Area

Site 1

ID	Latitude (°)	Longitude (°)	ID	Latitude (°)	Longitude (°)
1	51.767846	-4.067888	11	51.763234	-4.068560
2	51.767772	-4.065687	12	51.763099	-4.069335
3	51.767008	-4.064823	13	51.763731	-4.069659
4	51.764612	-4.065462	14	51.764056	-4.069236
5	51.762220	-4.065381	15	51.764490	-4.069313
6	51.762322	-4.065956	16	51.764926	-4.069670
7	51.760470	-4.067519	17	51.766010	-4.069524
8	51.760967	-4.068752	18	51.766117	-4.069088
9	51.761981	-4.069042	19	51.766540	-4.068913
10	51.762109	-4.068515	20	51.766809	-4.069065

Site 1: modelled reflector area details

Site 2

ID	Latitude (°)	Longitude (°)	ID	Latitude (°)	Longitude (°)
1	51.767310	-4.041561	4	51.765920	-4.042100
2	51.766878	-4.039718	5	51.766601	-4.041929
3	51.765768	-4.041383	6	51.766849	-4.042442

Site 2: modelled reflector area details

Site 2

ID	Latitude (°)	Longitude (°)	ID	Longitude (°)	Latitude (°)
1	51.768096	-4.035735	7	51.764553	-4.025118
2	51.768979	-4.035036	8	51.764084	-4.023973
3	51.768812	-4.030337	9	51.762559	-4.026908
4	51.766632	-4.026739	10	51.765551	-4.031176
5	51.764890	-4.027275	11	51.766150	-4.031356
6	51.764225	-4.025583			

Site 2: modelled reflector area details

APPENDIX H – GEOMETRIC CALCULATION RESULTS – PAGER POWER RESULTS

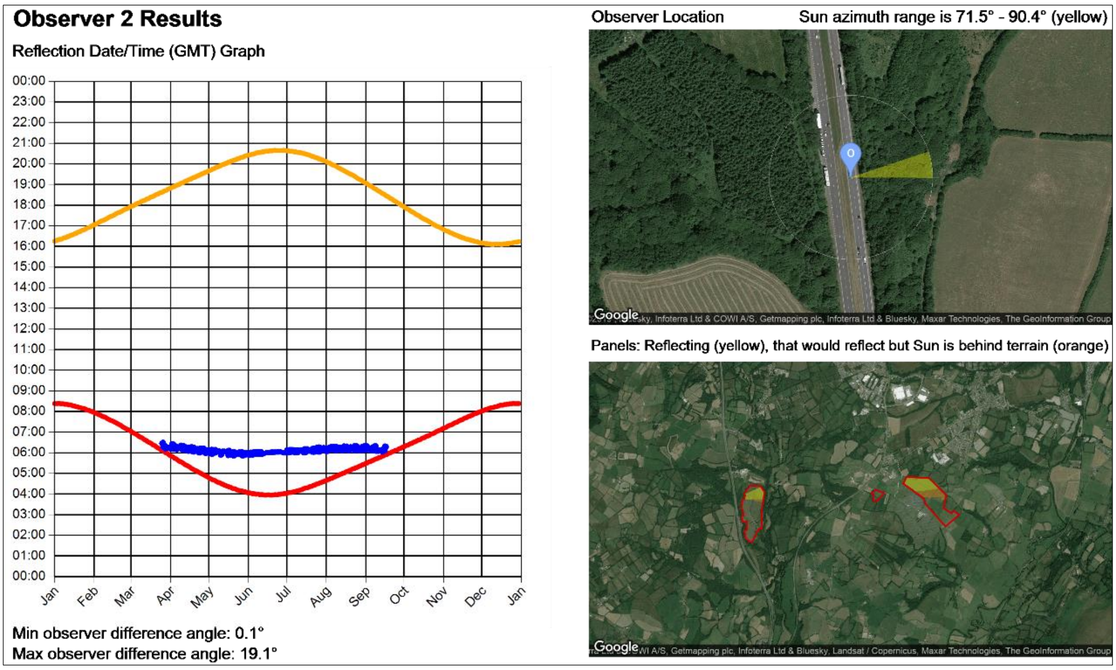
The charts for the receptors are shown on the following pages. Each chart shows:

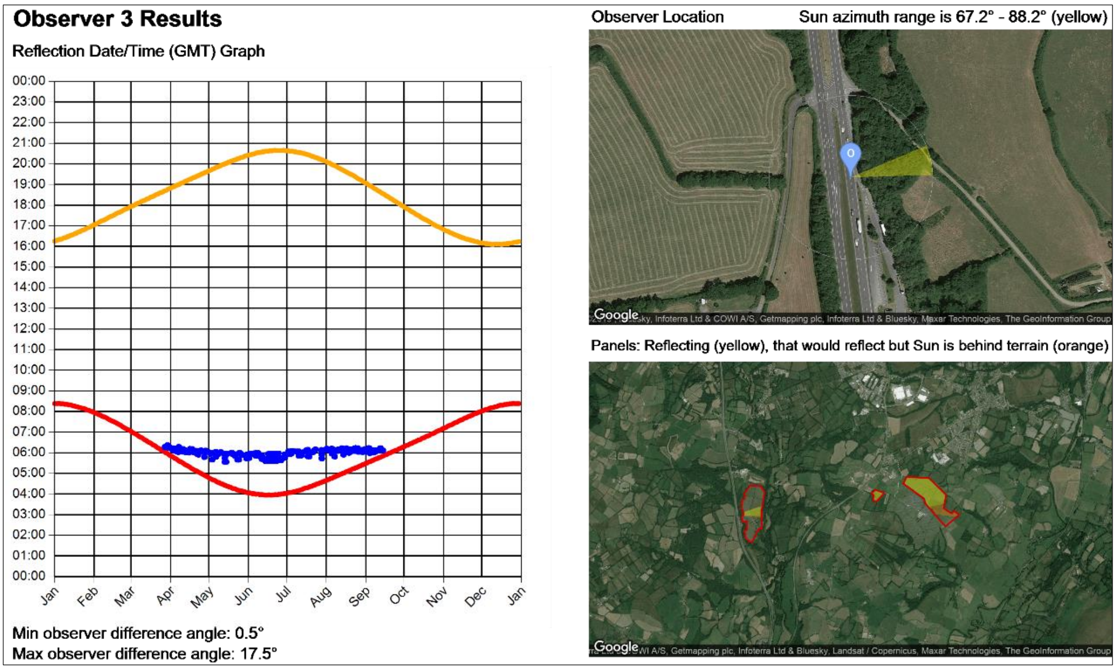
- The receptor (observer) location – top right image. This also shows the azimuth range of the Sun itself at times when reflections are possible. If sunlight is experienced from the same direction as the reflecting panels, the overall impact of the reflection is reduced as discussed within the body of the report;
- The reflecting areas – bottom right image. The reflecting area is shown in red. If the red 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. This relates to reflections from the red areas only;
- In the same graph the red line shows the time at which the sun is rising while the red line shows when the sun is setting for each specific month.

A48

Observer 1

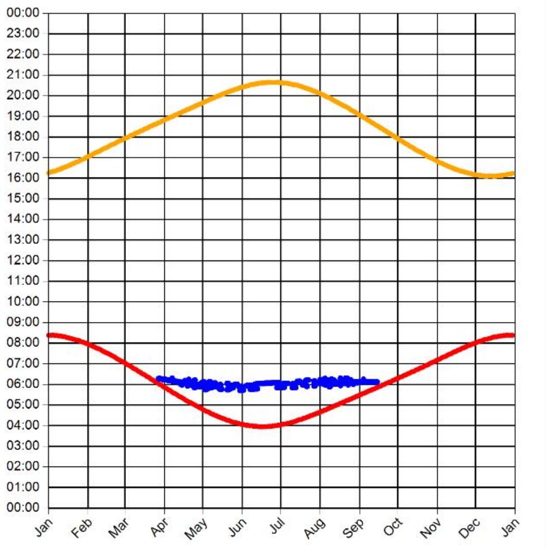
No valid reflections found





Observer 4 Results

Reflection Date/Time (GMT) Graph



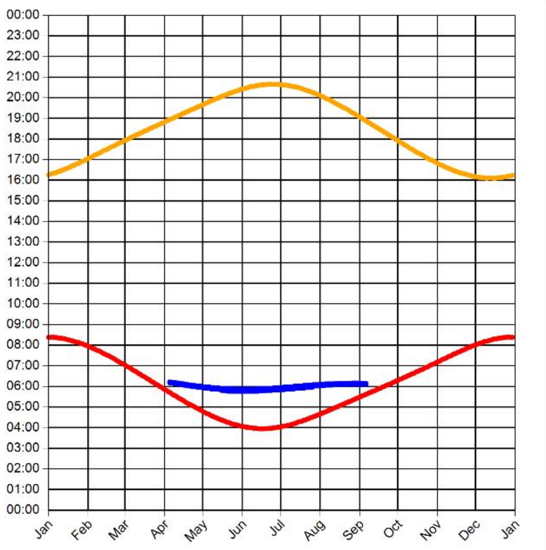
Min observer difference angle: 1.8°
Max observer difference angle: 18.8°

Observer Location — Sun azimuth range is 69.7° - 87.6° (yellow)

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

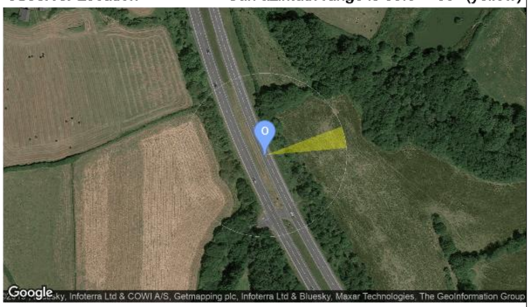
Observer 5 Results

Reflection Date/Time (GMT) Graph

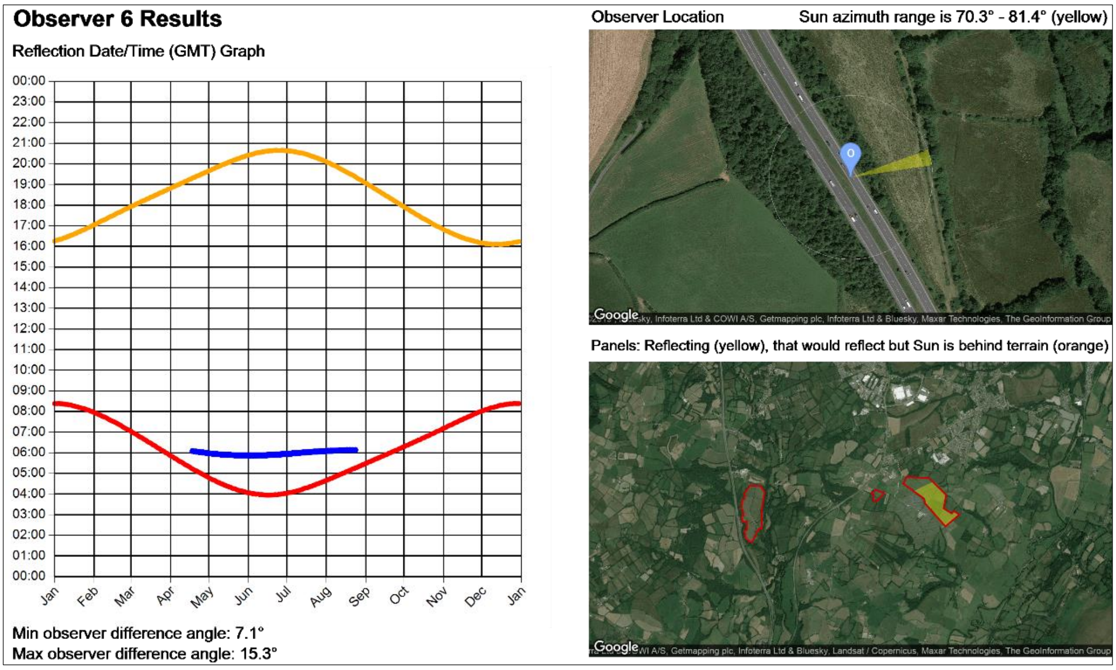


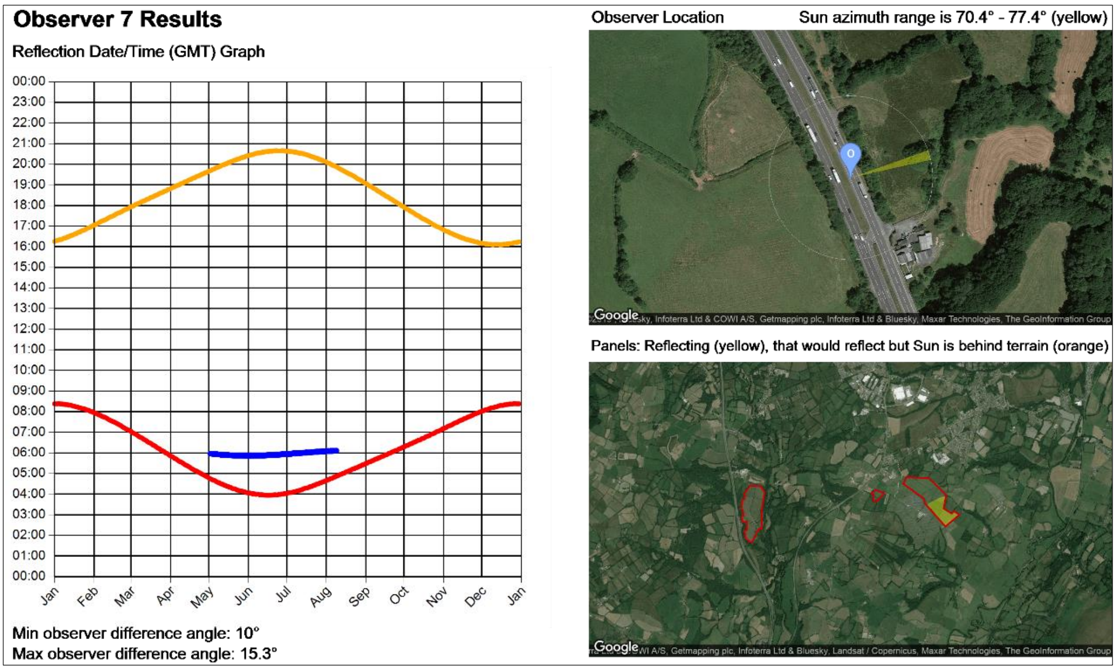
Min observer difference angle: 4°
Max observer difference angle: 14.7°

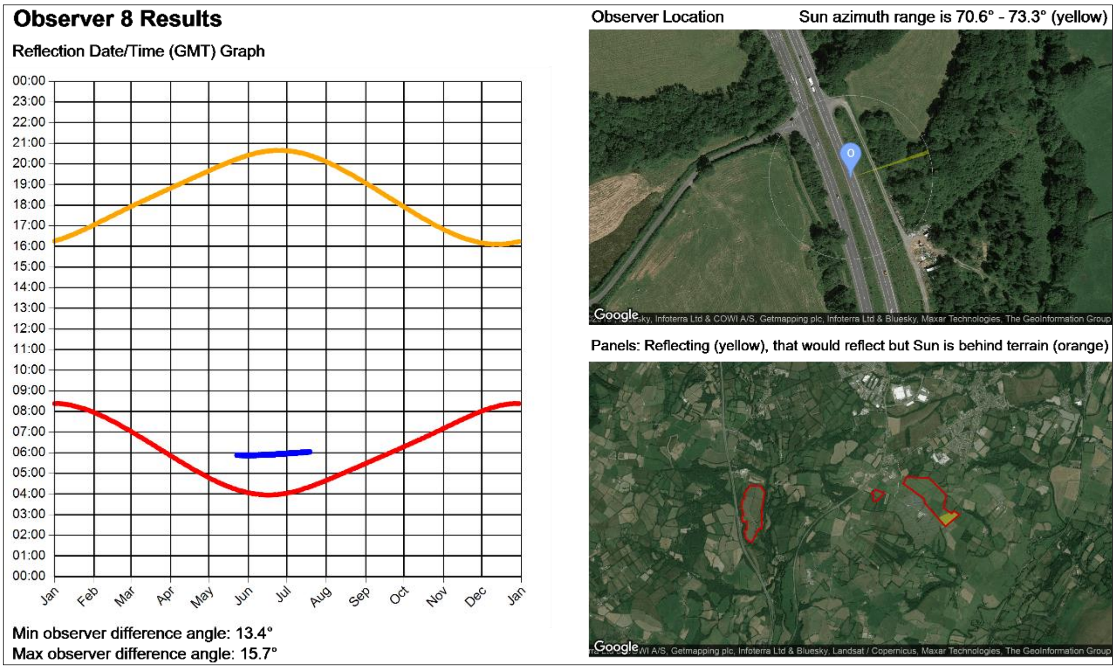
Observer Location — Sun azimuth range is 69.6° - 85° (yellow)



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


Observer 6 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: 7.1°
Max observer difference angle: 15.3°
Observer Location
Sun azimuth range is 70.3° - 81.4° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 7 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: 10°
Max observer difference angle: 15.3°
Observer Location
Sun azimuth range is 70.4° - 77.4° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google



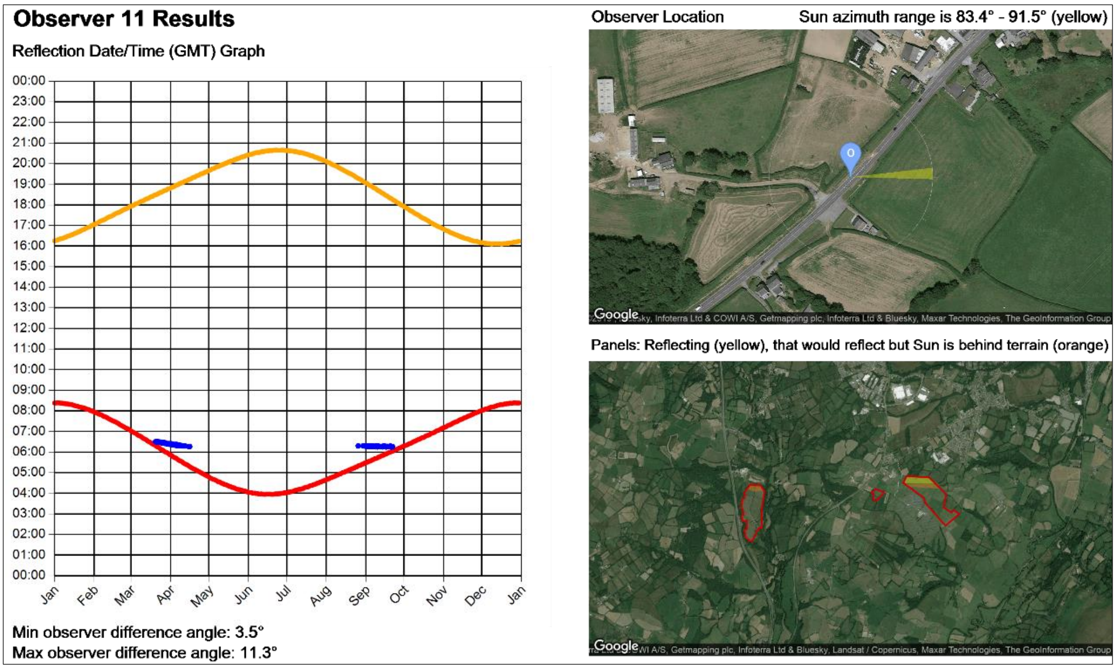
Observer 9

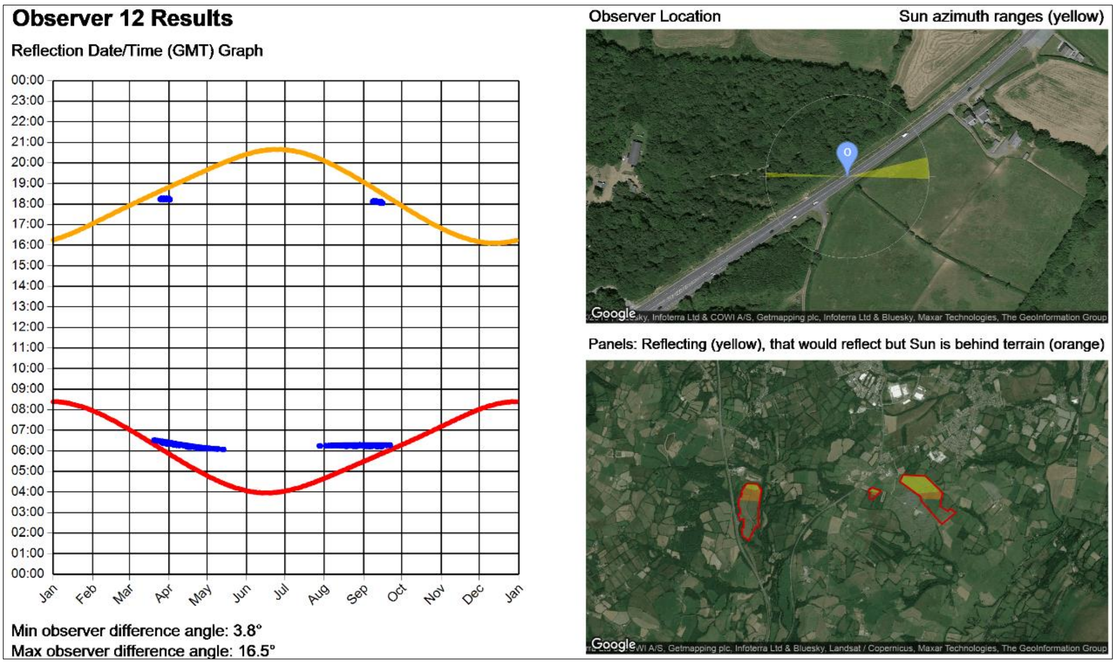
No valid reflections found

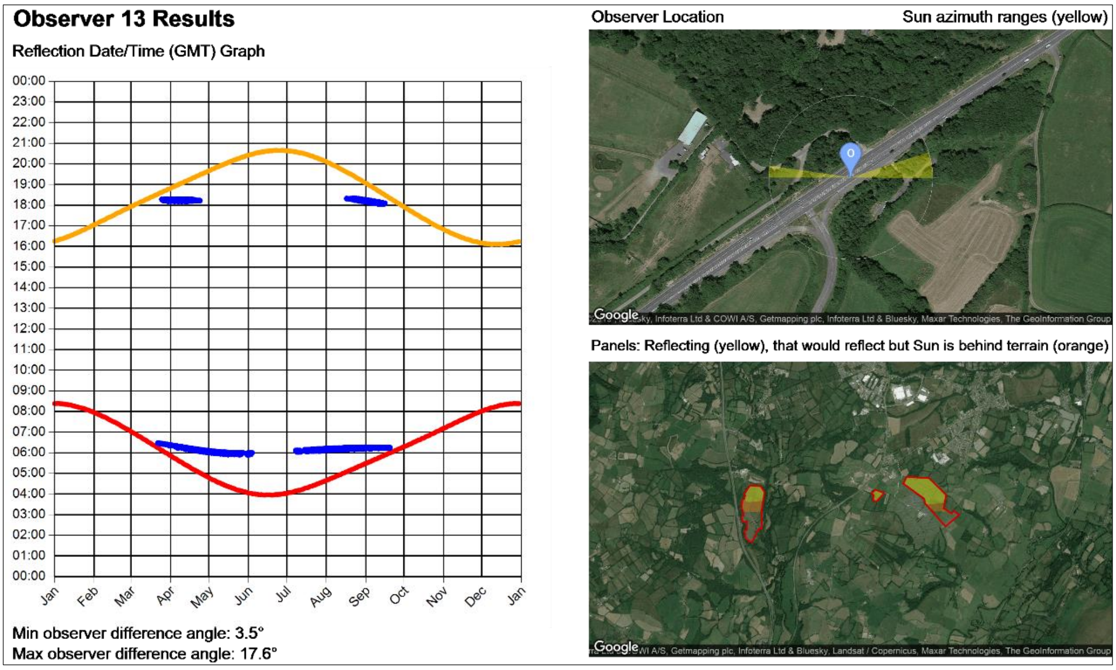
A483

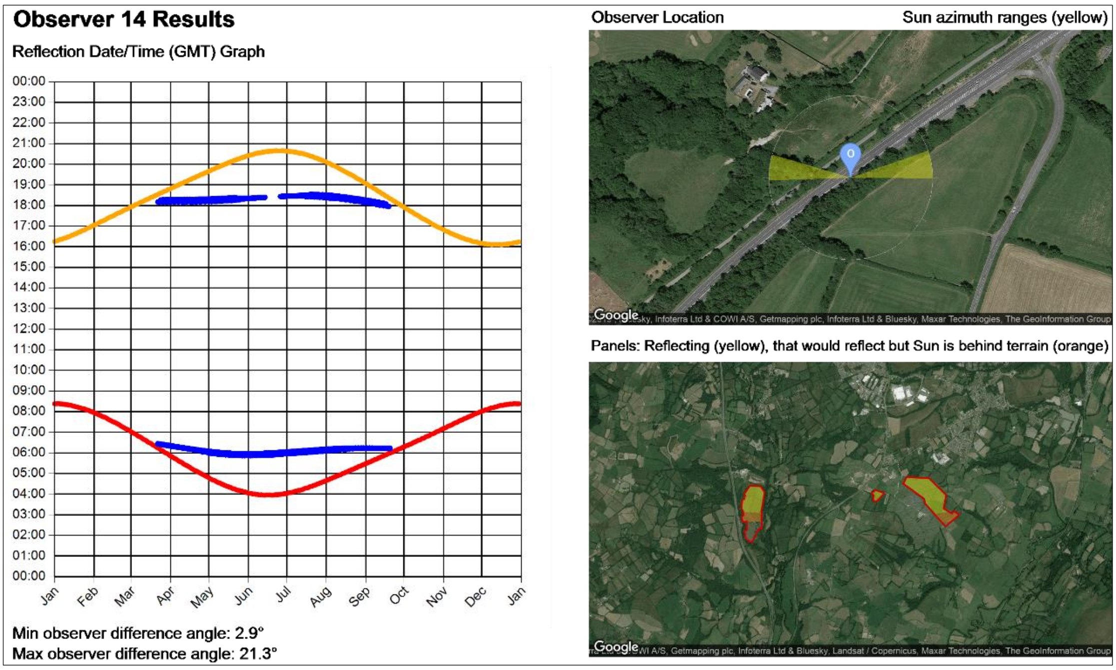
Observer 10

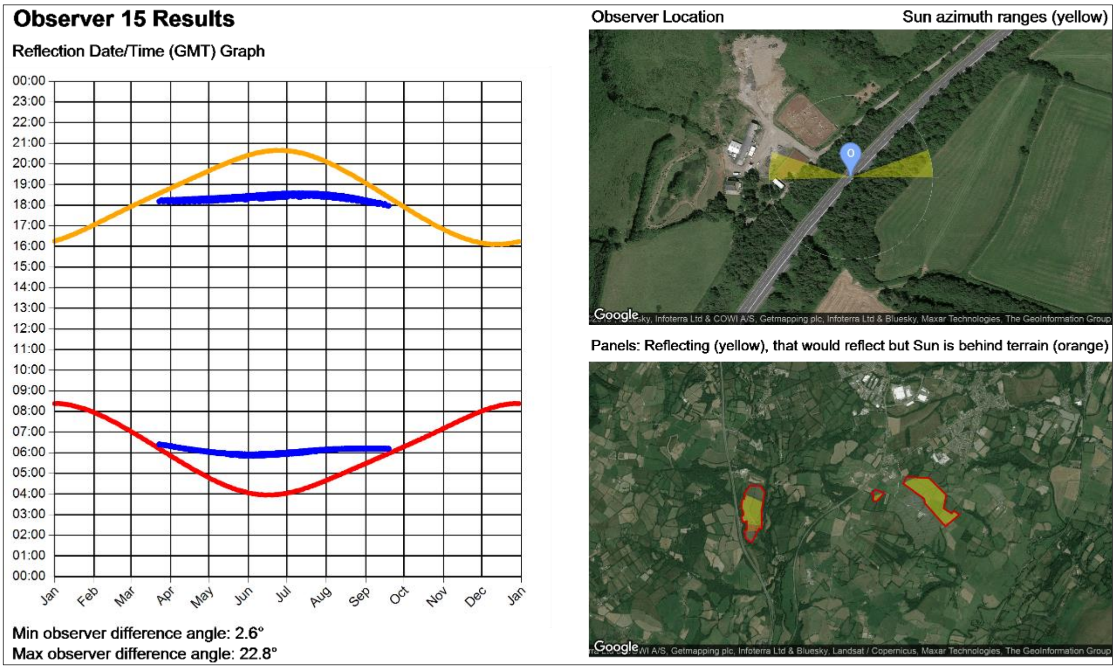
No valid reflections found

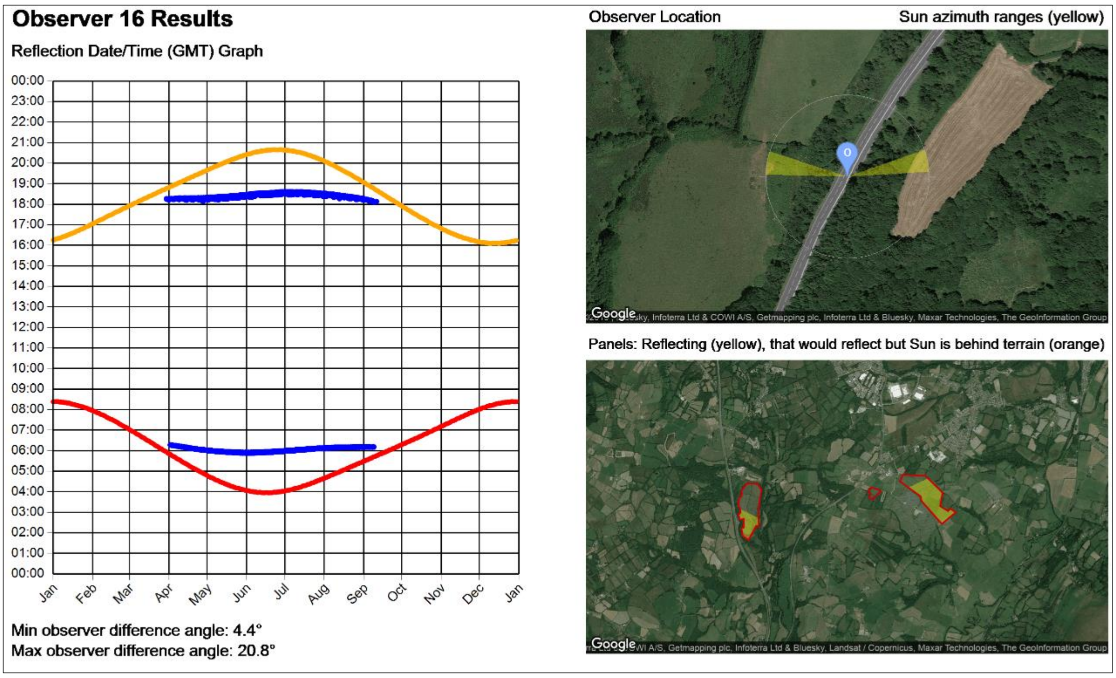


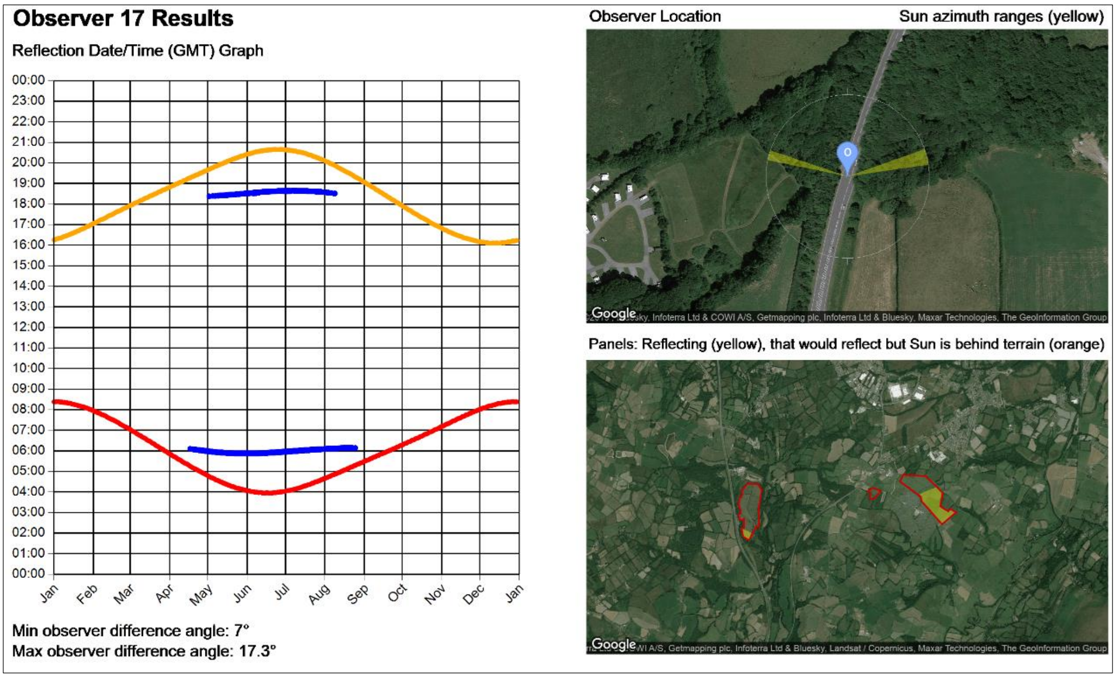


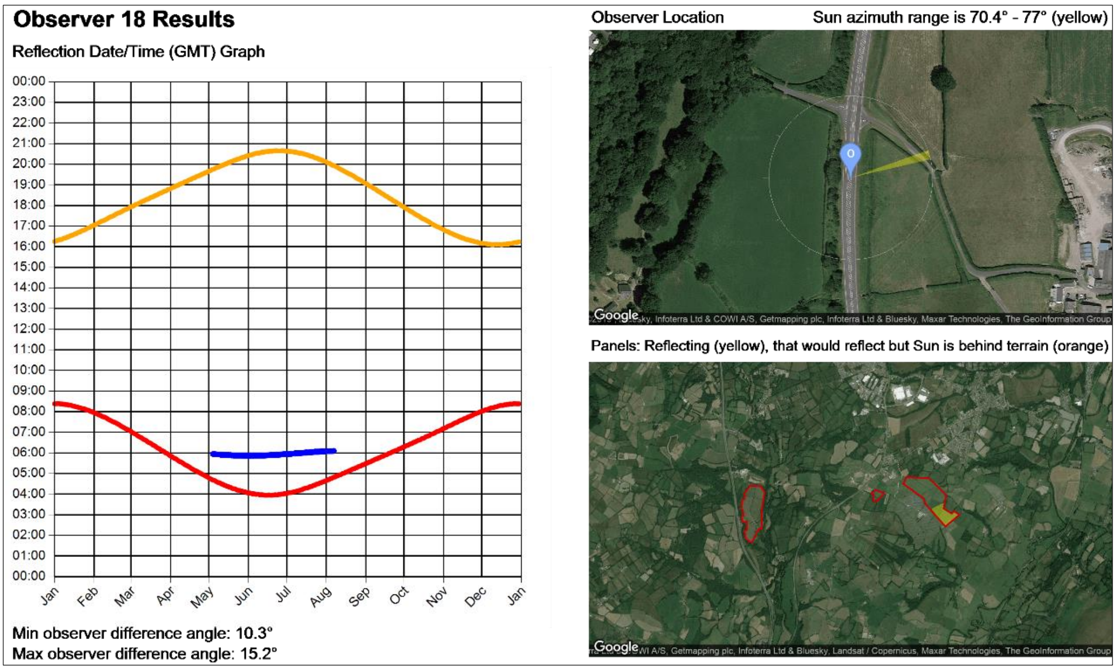

Observer 13 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 3.5°
Max observer difference angle: 17.6°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

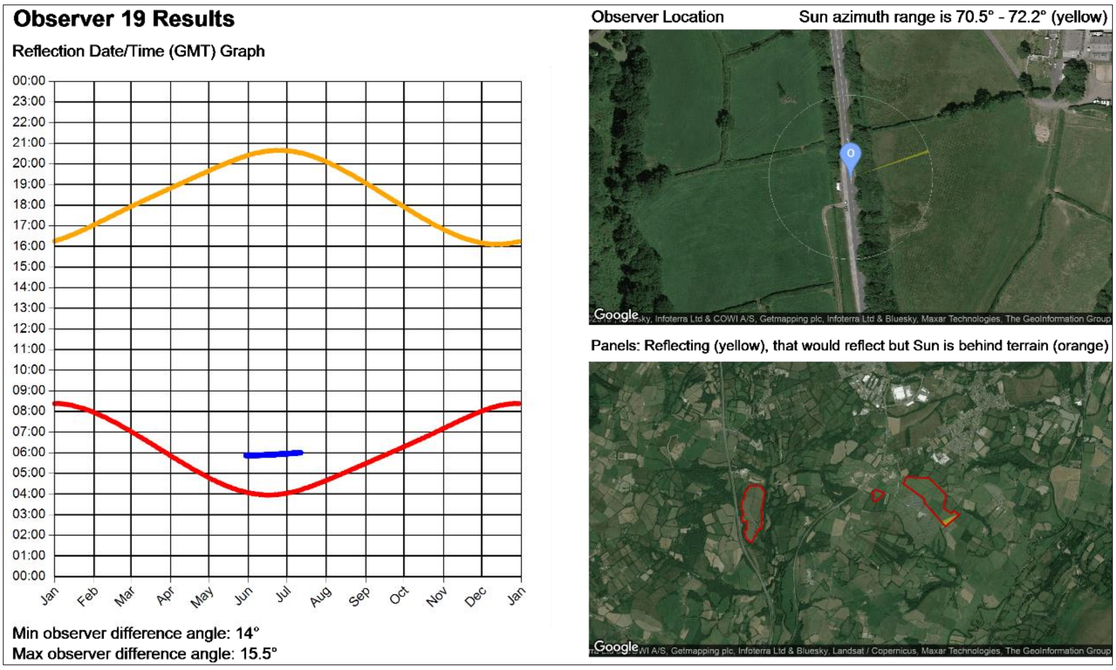

Observer 14 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 2.9°
Max observer difference angle: 21.3°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google


Observer 15 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 2.6°
Max observer difference angle: 22.8°
Observer Location
Sun azimuth ranges (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer 16 Results
Reflection Date/Time (GMT) Graph
Min observer difference angle: 4.4°
Max observer difference angle: 20.8°
Observer Location
Sun azimuth ranges (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)


Observer 17 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: 7°
Max observer difference angle: 17.3°
Observer Location
Sun azimuth ranges (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

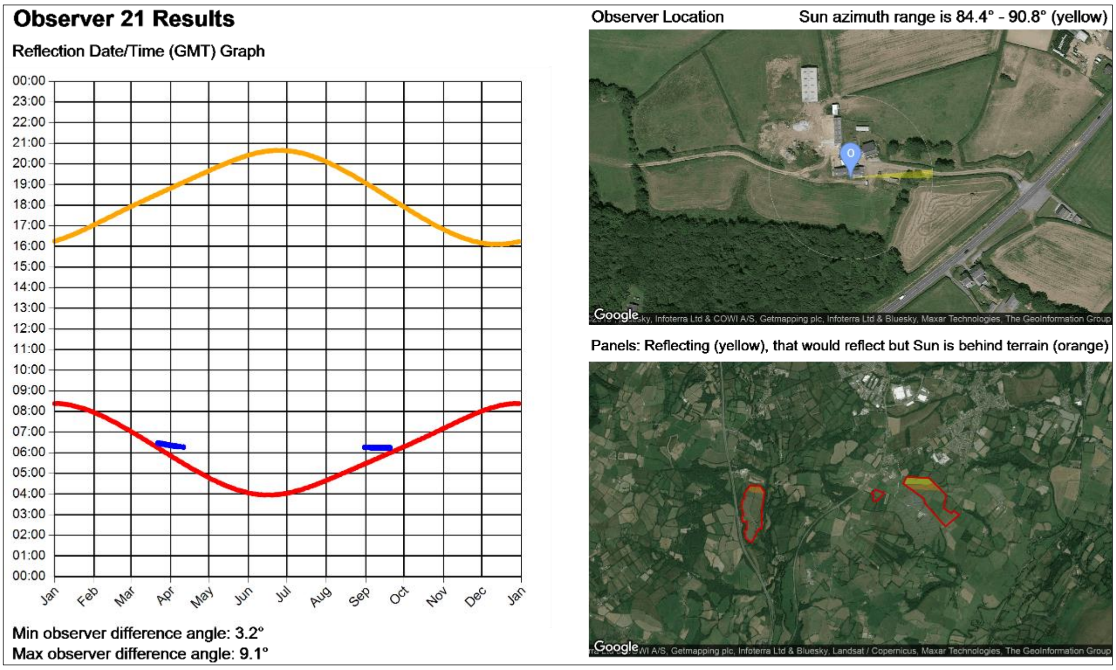

Observer 18 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 10.3°
Max observer difference angle: 15.2°
Observer Location
Sun azimuth range is 70.4° - 77° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

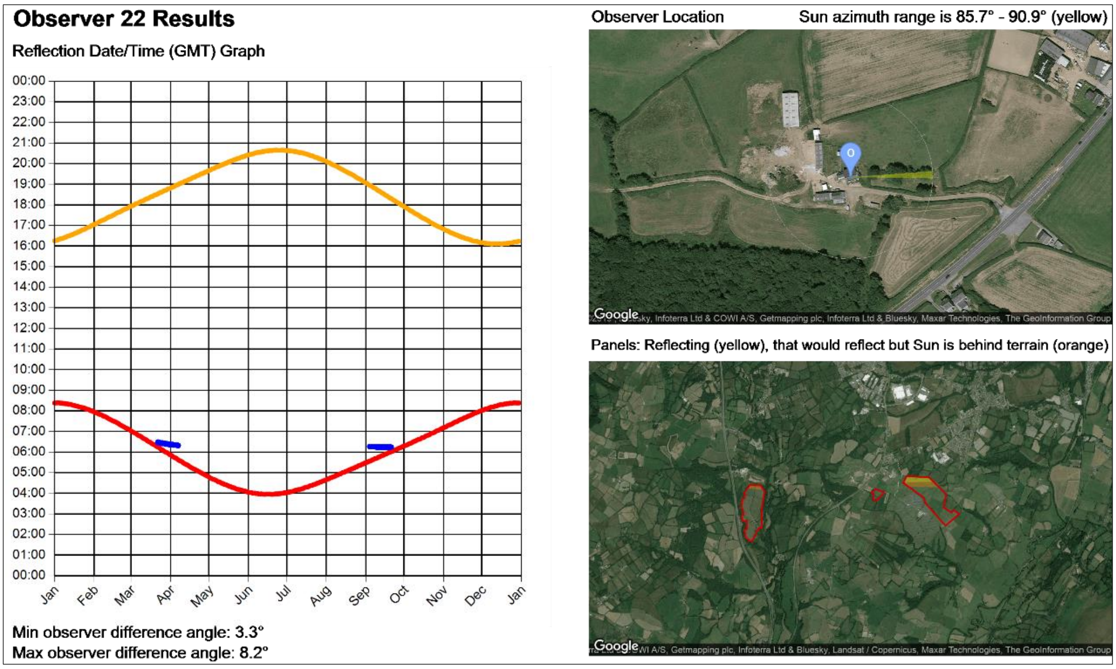


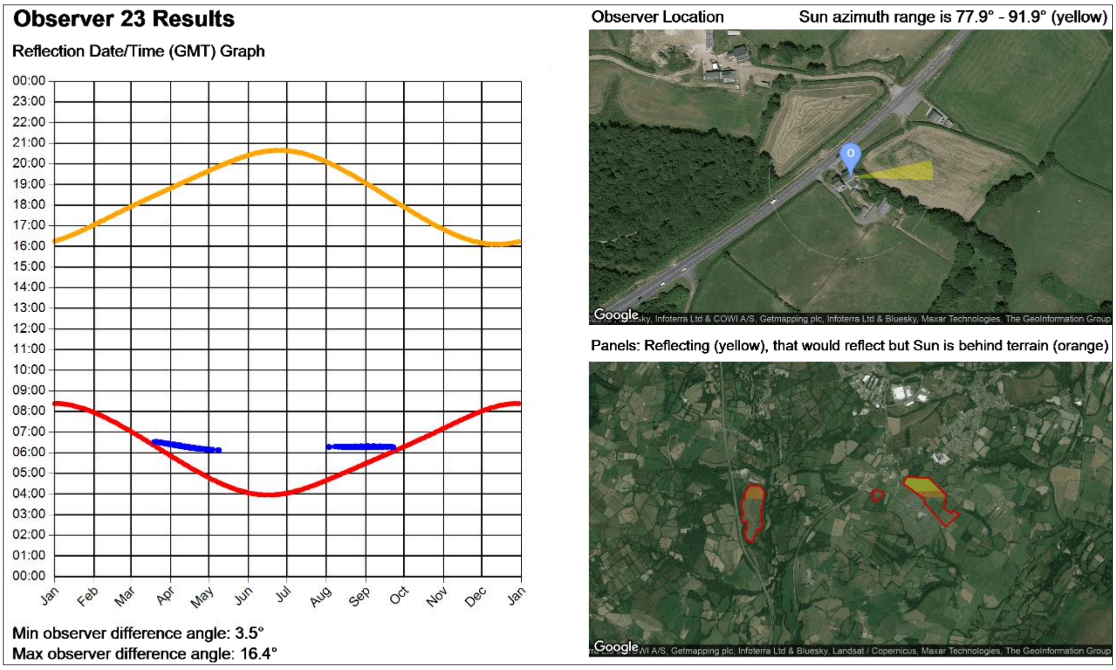
Observer 20

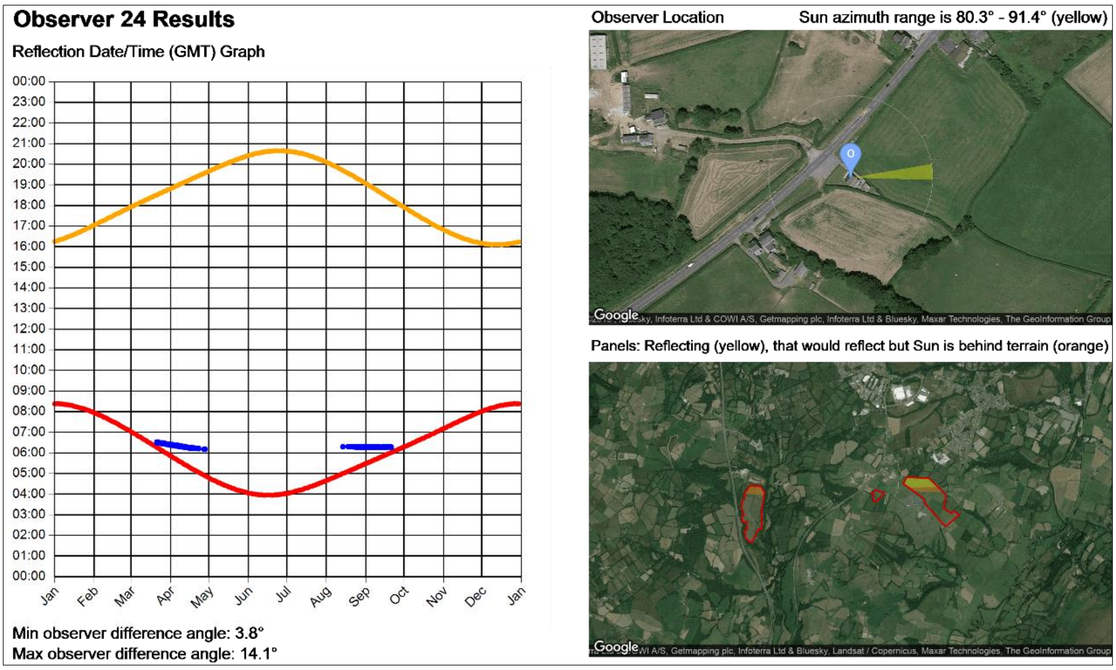
No valid reflections found

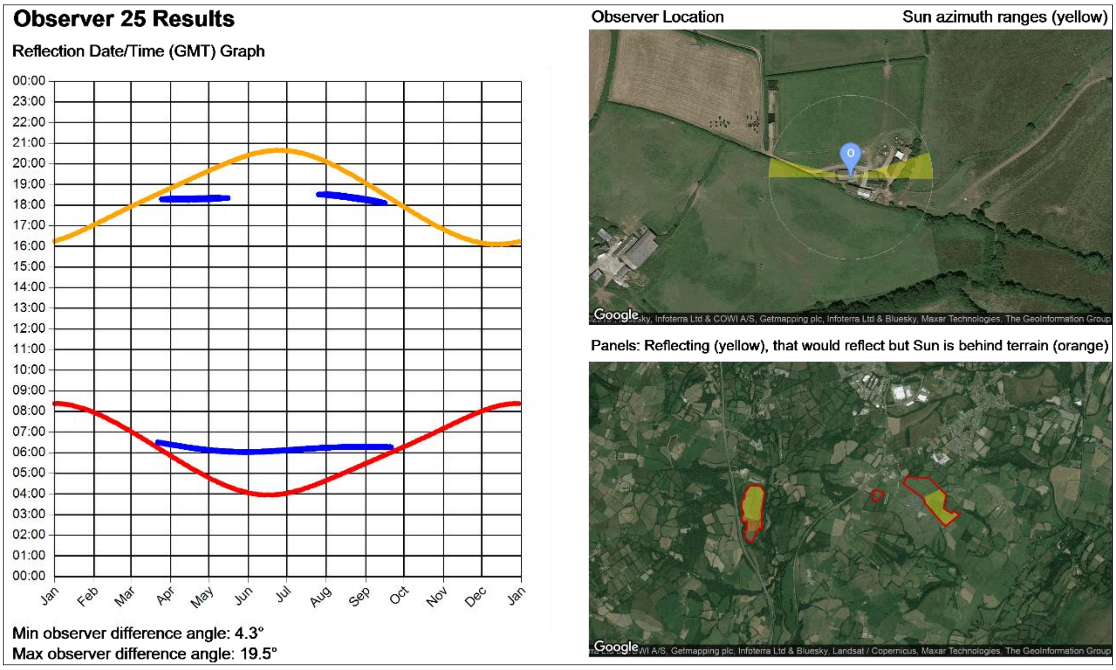
Dwellings

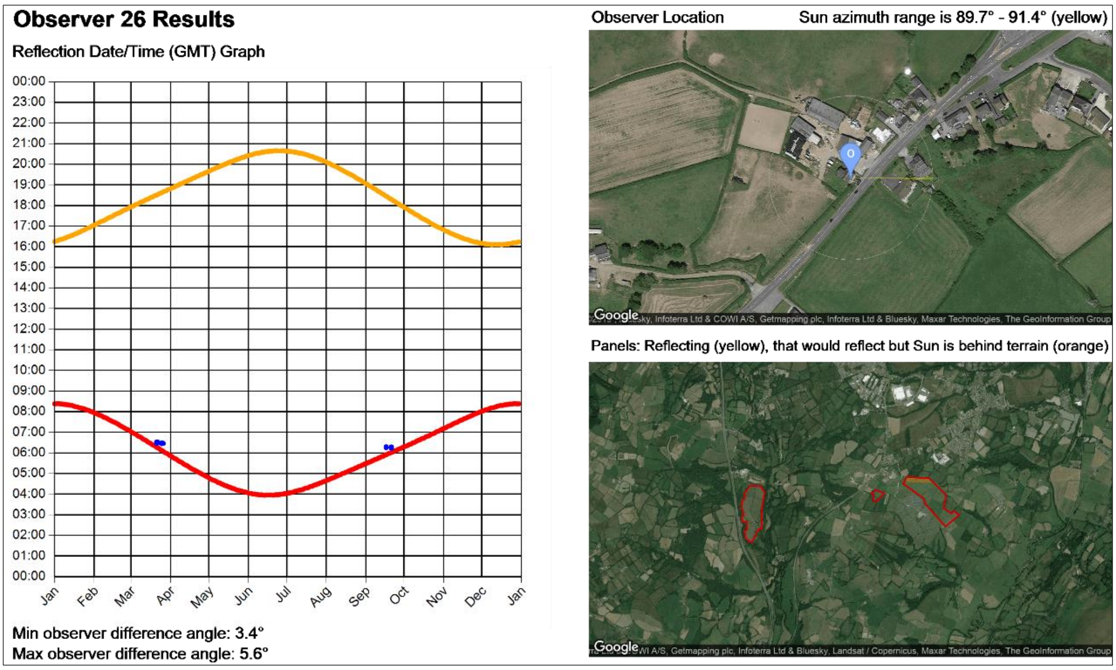

Observer 21 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 3.2°
Max observer difference angle: 9.1°
Observer Location
Sun azimuth range is 84.4° - 90.8° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

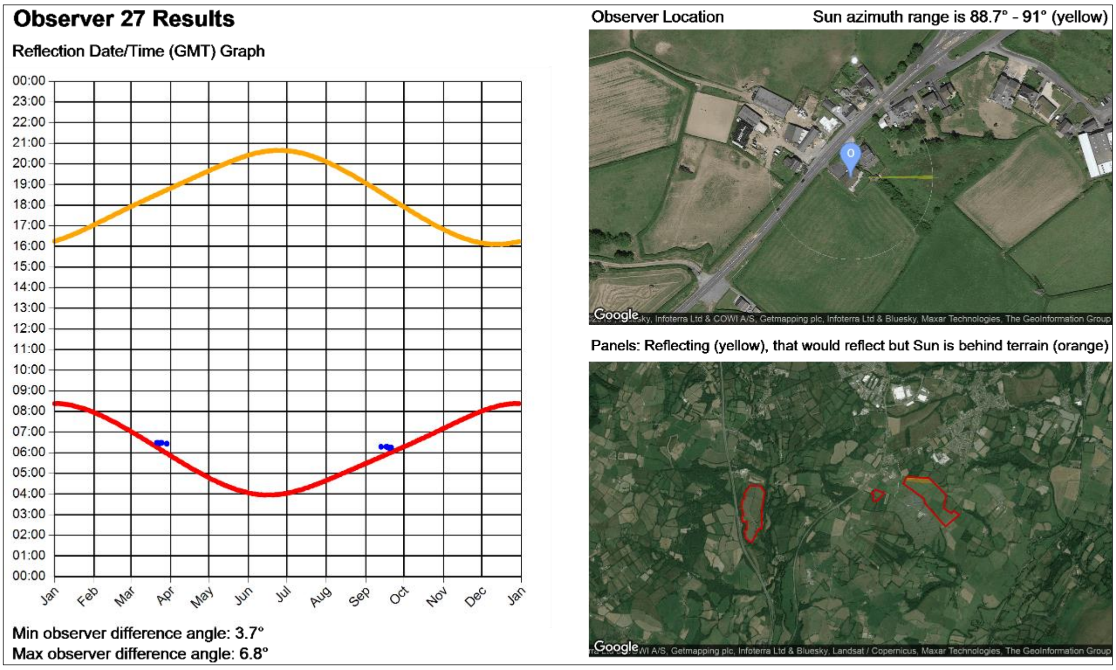

Observer 22 Results
Reflection Date/Time (GMT) Graph
00:00
23:00
22:00
21:00
20:00
19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
06:00
05:00
04:00
03:00
02:00
01:00
00:00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Min observer difference angle: 3.3°
Max observer difference angle: 8.2°
Observer Location
Sun azimuth range is 85.7° - 90.9° (yellow)
Google
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Google

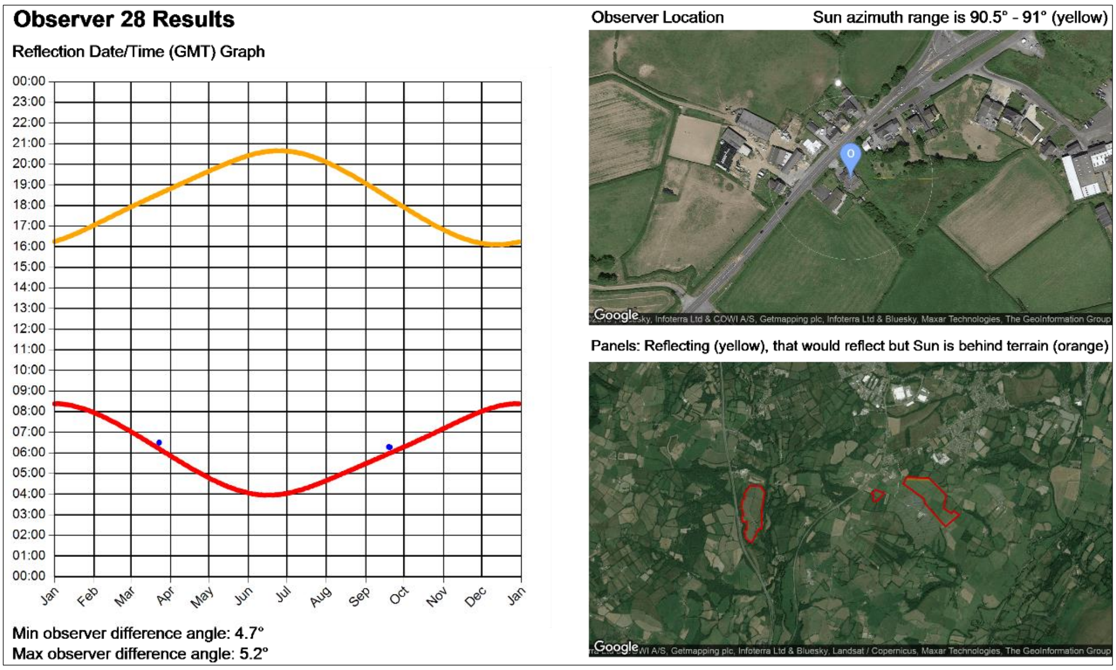

Observer 23 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 77.9° - 91.9° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 3.5°
Max observer difference angle: 16.4°

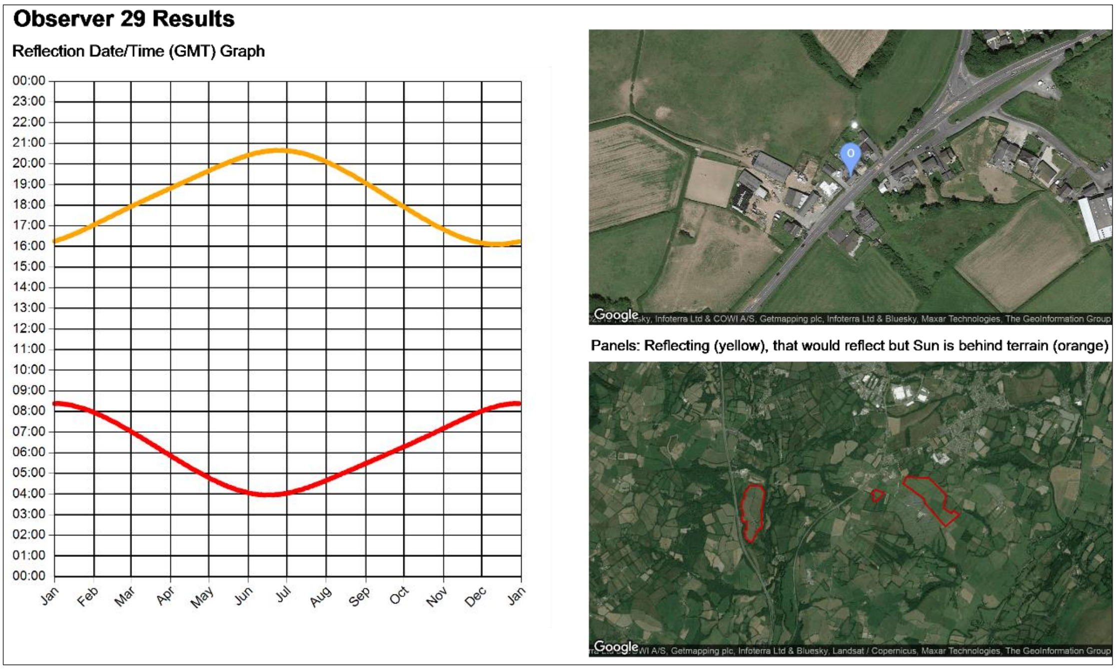

Observer 24 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 80.3° - 91.4° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 3.8°
Max observer difference angle: 14.1°


Observer 25 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth ranges (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 4.3°
Max observer difference angle: 19.5°


Observer 26 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 89.7° - 91.4° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 3.4°
Max observer difference angle: 5.6°


Observer 27 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 88.7° - 91° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 3.7°
Max observer difference angle: 6.8°


Observer 28 Results
Reflection Date/Time (GMT) Graph
Observer Location
Sun azimuth range is 90.5° - 91° (yellow)
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)
Min observer difference angle: 4.7°
Max observer difference angle: 5.2°



Observer 30

No valid reflections found

Observer 31

No valid reflections found

Observer 32

No valid reflections found

Observer 33

No valid reflections found

Observer 34

No valid reflections found

Observer 35

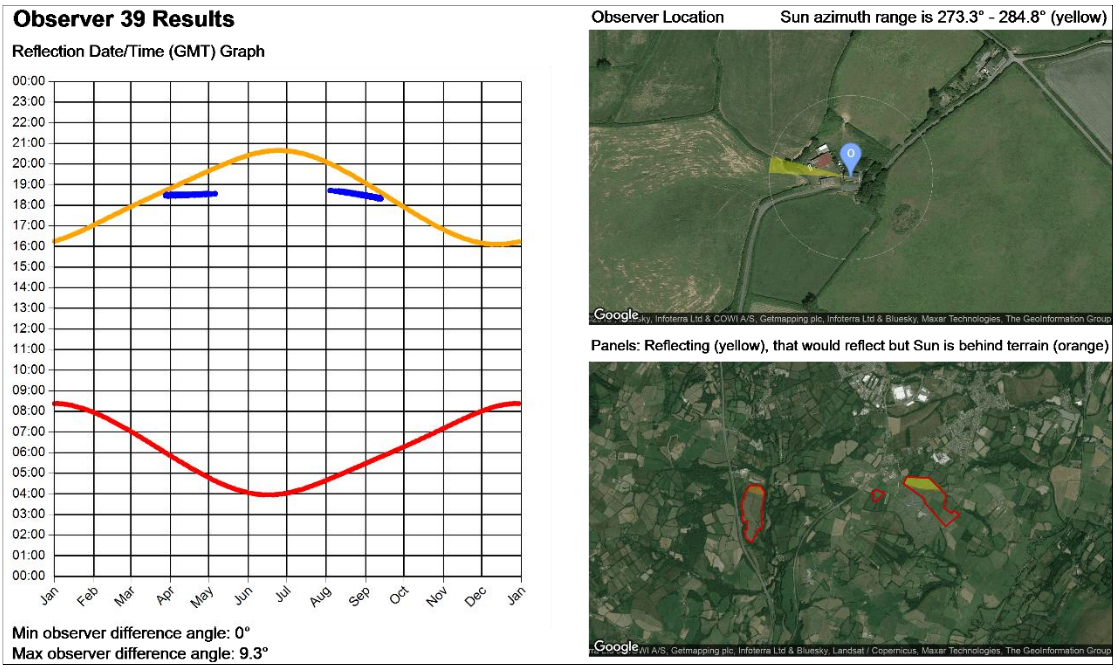
No valid reflections found

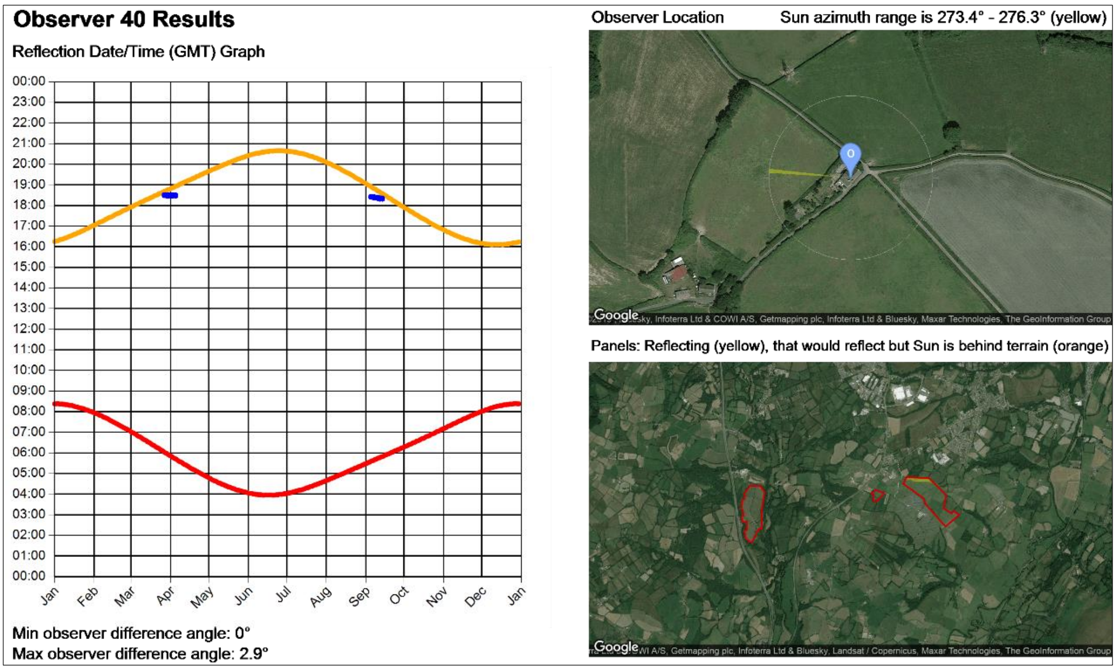
Observer 36

No valid reflections found

Observer 37

No valid reflections found





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