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Urban & Renewables

Solar Photovoltaic Glint and Glare Study

Belvoir

December 2021

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Issue	Date	Detail of Changes
1	May 2021	Initial issue
2	September 2021	Second issue – revised panel area
3	November 2021	Third issue – update following screening plans
4	December 2021	Fourth issue – administrative revisions

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EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to assess the possible effects of glint and glare from a solar photovoltaic (PV) development known as Belvoir located in Leicestershire, UK. The assessment pertains to the possible impact upon surrounding road users and dwellings in accordance with industry best practice. In addition, impacts towards surrounding aviation activity and railway infrastructure have been considered at a high level.

Pager Power

Pager Power has undertaken over 750 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.

Guidance and Studies

Pager Power's approach to assessing glint and glare is based on its published guidance document. This was published following a literature review, stakeholder consultation and engagement with solar developers. Broadly, the process 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. 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 reflections produced are of intensity similar to or less than those produced from still water and significantly less than reflections from glass and steel[1].

Conclusions

Significant impacts are not predicted for the proposed development subject to enhanced/maintained screening at relevant sections of the site perimeter. The development team has confirmed[2] that the updated Site Layout and Planting Proposals Version F incorporates all of the necessary mitigation screening recommended in Section 7 of this report. On this basis, no significant glint and glare impacts are predicted following the provision of this mitigation.

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

[2] Email confirmation from Pegasus to Pager Power was given on 23 November 2021.

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 51 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 solar photovoltaic (PV) development known as Belvoir in Leicestershire, UK. The assessment pertains to the possible impact upon surrounding road users and dwellings in accordance with industry best practice. In addition, impacts towards surrounding aviation activity and railway infrastructure have been considered at a high level.

This report 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 ground-based receptors.
- Glint and glare assessment for identified receptors.
- High-level assessment of aviation activity and railway infrastructure.
- Results discussion.

1.2 Pager Power's Experience

Pager Power has undertaken over 750 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 can vary however, the definition used by Pager Power is as follows[3]:

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

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

[3] These definitions are aligned with those of the Federal Aviation Administration (FAA) in the United States of America.

2 SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Proposed Development

Figure 1 below[4] shows the site location plan.

Figure 1 *Proposed development layout*

[4] Provided to Pager Power by JBM Solar, cropped.

2.2 Proposed Development Location – Aerial Image

Figure 2 below[5] shows the solar panel areas in white overlaid on aerial imagery.

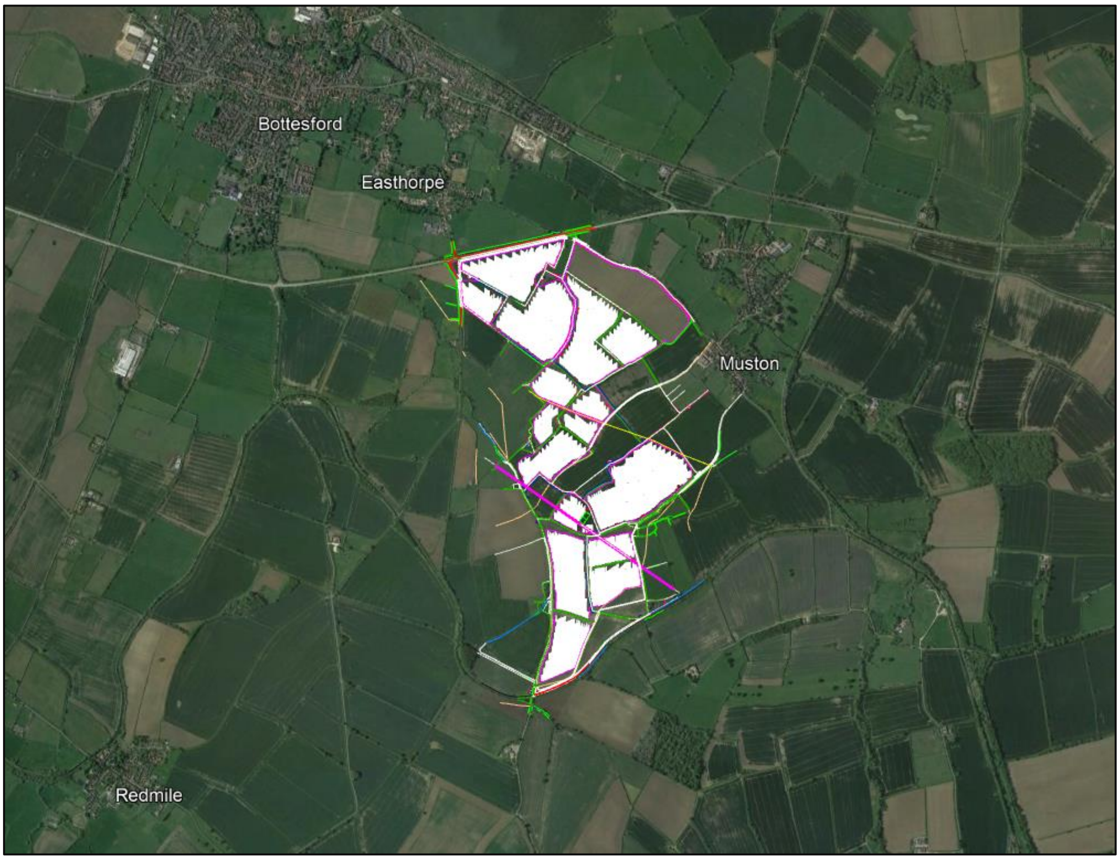

Figure 2 *Proposed development location*

[5] Data provided to Pager Power by JBM Solar. Copyright © 2021 Google.

2.3 Photovoltaic Panel Mounting Arrangements and Orientation

The solar panels will be mounted to the ground and fitted to a single-axis tracking system that tilts the panels from east to west throughout the day. A single-axis tracking system has been modelled in this report. It is understood that:

- The tracking axis has a height of 1.8 metres above ground level.
- The azimuth angle of the tracking system will be 180° meaning the panels track from 90° to 270° throughout the day. The panels will face 90° from north in the morning (east facing) and 270° from north in the evening (west facing). During solar noon, when the Sun is directly overhead, the panels will be flat, directed immediately upwards.
- There will be no tilt of the tracking axis itself.
- The tilt of the panels throughout the day is programmed, based on the known path of the Sun and shading considerations i.e. the tilt angle is optimised to avoid having one row of panels cast a shadow on another row.
- The range of elevation angles will be ±60°.

2.4 Solar Panel Backtracking

Shading considerations that dictate the panel tilt. This is affected by:

- The elevation angle of the Sun.
- The vertical tilt of the panels.
- The spacing between the panel rows.

This means that early in the morning and late in the evening, the panels will not be directed exactly towards the Sun, as the loss from shading of the panels (caused by facing the sun directly when the Sun is low in the horizon), would be greater than the loss from lowering the panels to a less direct in order to avoid the shading. Figure 3 on the following page illustrates this. Note the graphics show two lines illustrating the paths of light from the Sun towards the solar panels[6].

[6] In reality the lines from the Sun to each panel would be effectively parallel due to the large separation distance. The figure is for illustrative purposes only.

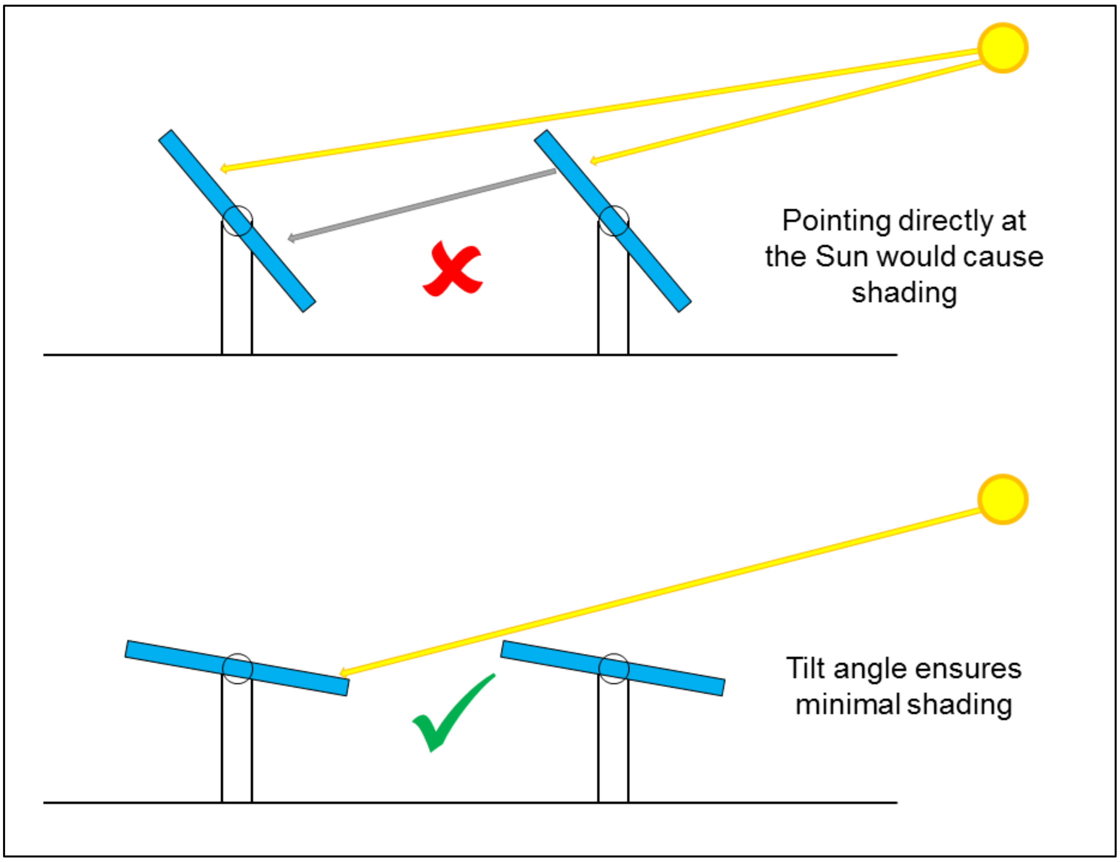

Figure 3 *Shading considerations*

Later in the day, the panels can be directed towards the Sun without any shading issues. This is illustrated in Figure 4 below[7].

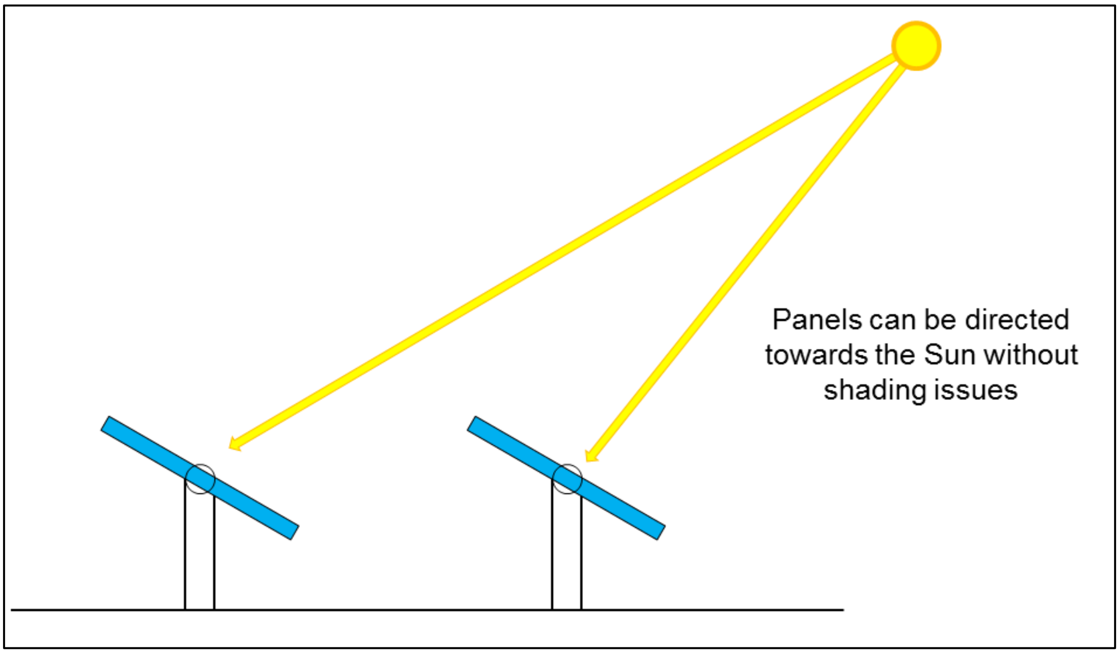

Figure 4 *Panel alignment at high solar angles*

The solar panels backtrack (where the panel angle gradually declines to prevent shading) by reverting to an elevation angle of 0° once the maximum elevation angle of the panels (60°) becomes ineffective due to the low height of the Sun above the horizon and to avoid shading.

2.5 Modelling Backtracking

Back tracking systems are sensitive to panel length, row spacing, topography and the level of shading which varies throughout the year. The Forge Solar model used in this assessment is a widely accepted model within this area. The model approximates a backtracking system by assuming the panels instantaneously revert to its resting angle of 0° whenever the sun is outside the rotation range (60° in this instance). Panels with a maximum tracking angle of 60° and resting angle of 0° would therefore lie horizontally from sunrise until the Sun enters the rotation range, and immediately after the sun leaves the rotation range until sunset daily. It is assumed the panels remain at 0° until the Sun reaches 30° above the horizon – when the Sun is at right angles to the panels at 60°. It is understood that this option was created specifically to account for backtracking to the extent possible.

Whilst this model simplifies the backtracking process to be used by the solar panels within the solar development, panels that revert back to their resting angle immediately in many cases present a worst-case scenario for reflectors. This is because flatter panels can produce solar reflections in a much greater range of azimuth angles at ground level. The results would in most cases be more conservative than modelling a detailed back tracking system.

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[7] In reality the lines from the Sun to each panel would be effectively parallel due to the large separation distance. The two previous figures are for illustrative purposes only.

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 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 and studies. The methodology for a glint and glare assessments is as follows:

- Identify receptors in the area surrounding the solar development.
- Consider direct solar reflections from the solar development towards the identified receptors by undertaking geometric calculations.
- Consider the visibility of the panels from the receptor's location. If the panels 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 both the solar reflection from the solar 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 the process presented in Appendix D.

3.4 Assessment Methodology and Limitations

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

4 GROUND-BASED RECEPTORS

4.1 Ground-Based Receptors – Overview

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

The above parameters and project experience has led to the adoption of a 1km assessment area from the proposed panel area for selection of ground-based receptors.

Potential receptors within the 1km assessment area are identified based on mapping and aerial photography of the region. The initial judgement is made based on high-level consideration of aerial photography and mapping i.e. receptors are excluded if it is clear from the outset that no visibility would be possible. A more detailed assessment is made if the modelling reveals a reflection would be geometrically possible.

Terrain elevation heights have been interpolated based on Shuttle Radar Topography Mission (SRTM) data[8]. Receptor details can be found in Appendix F.

[8] This is understood to be the data source incorporated within the external glare model used for this development. It is an appropriate source of data in this region.

Figure 5 below[9] shows an approximate 1 km assessment area around the panel areas as a green polygon. This zone is based on a combined 1 km around each vertex of the extrapolated panel area, it is therefore an irregular shape.

Figure 5 *Ground-based receptor assessment area (1 km)*

[9] Copyright © 2021 Google.

4.2 Dwelling Receptors

The analysis has considered dwellings that:

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

The assessed dwelling receptors are shown as pink icons in Figure 6 below[10]. A total of 40 dwelling locations have been assessed. In some cases, a concentrated cluster of dwellings / separate addresses have been modelled as a single location, which will be representative of results for the entire cluster.

Figure 6 *Assessed dwelling receptors*

Dwellings to the north of the A52 road in Easthorpe and Bottesford have not been modelled due to the level of screening provided by the hedgerows adjacent to the road. In general, dwelling locations on the edge of populated areas facing the development have been selected because these have the prospect of receiving noticeable reflections.

[10] Copyright © 2021 Google.

A height of 1.8 metres above ground level has been modelled for an observer at each dwelling location. Small variances in this observer height will not meaningfully change the modelling output.

Close-up images to illustrate the dwelling receptors are presented[11] in figures 7-11 below and on the following pages.

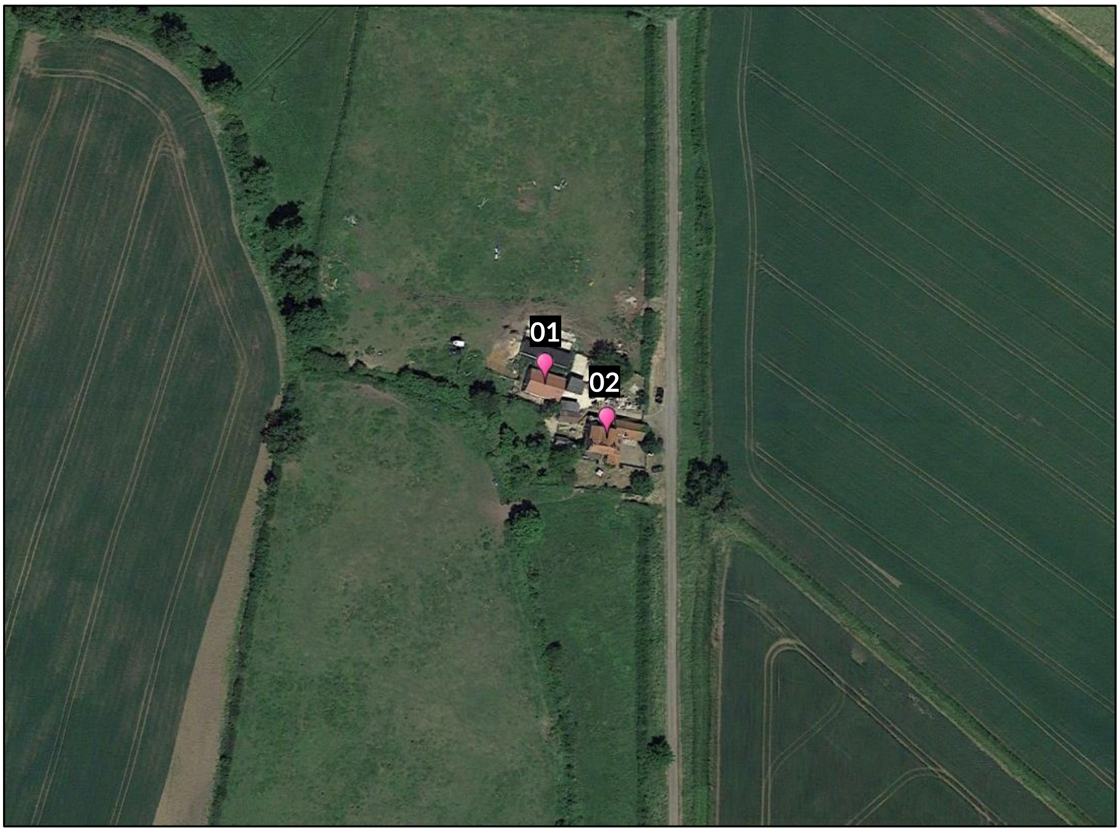

Figure 7 *Dwellings 01-02*

[11] Copyright © 2021 Google.

Figure 8 *Dwellings 03-04*

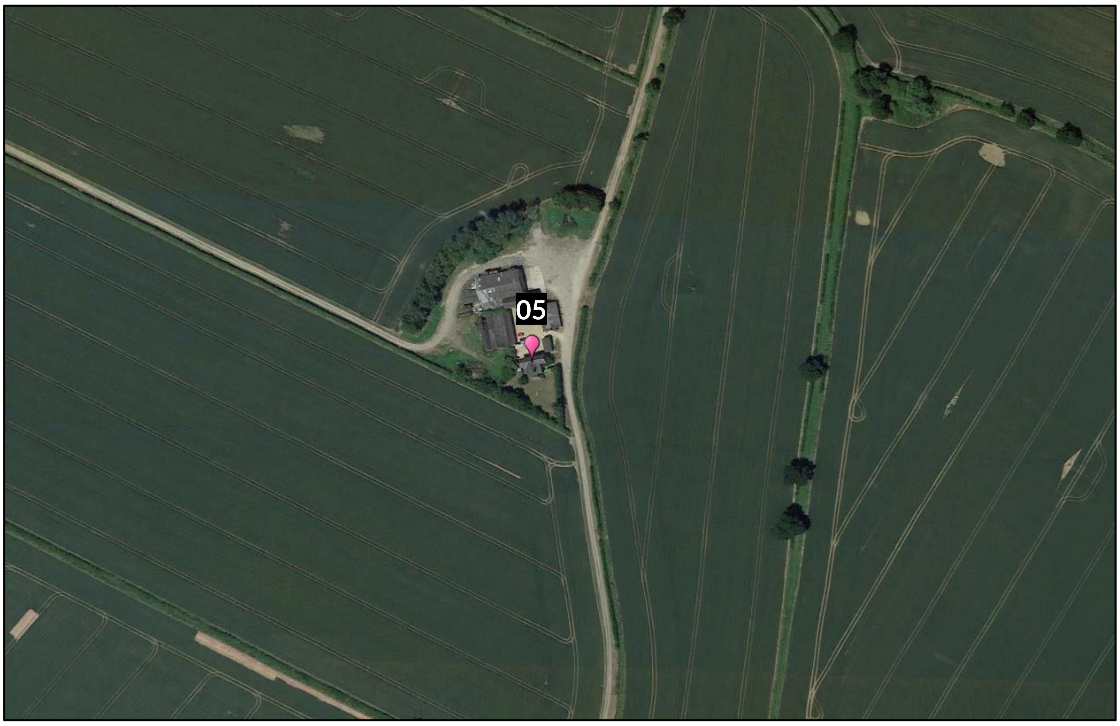

Figure 9 *Dwelling 05*

Figure 10 *Dwellings 06-25*

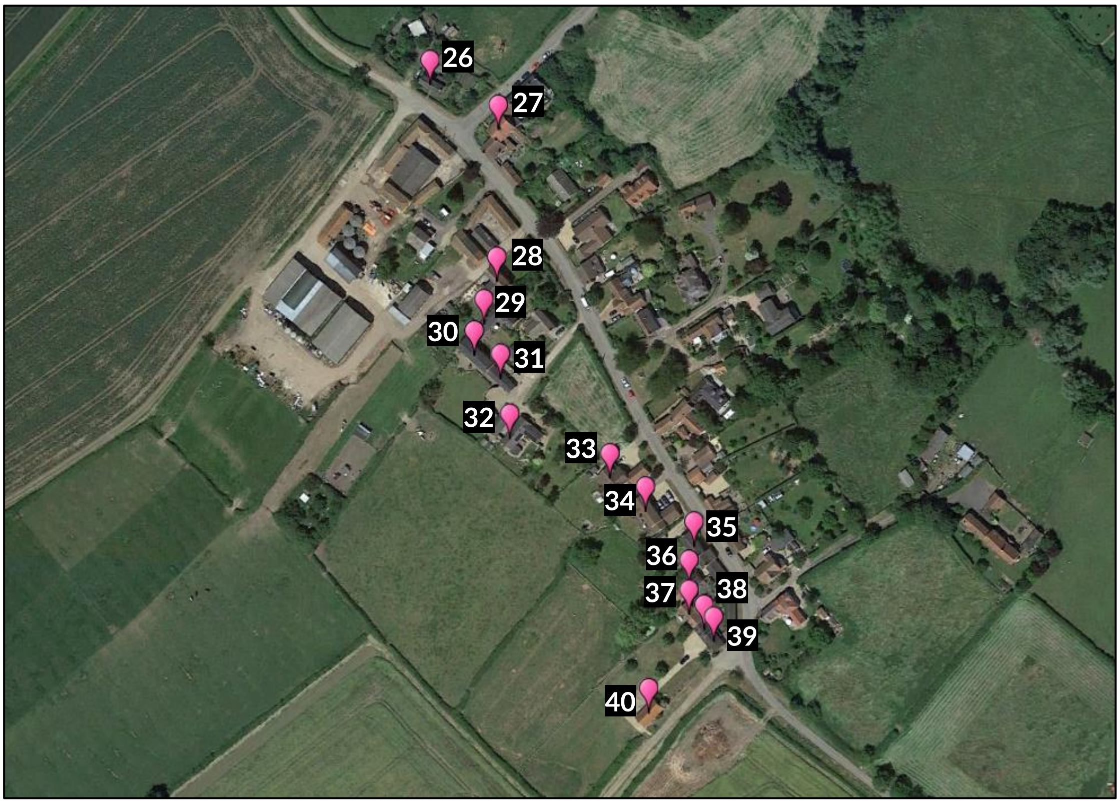

Figure 11 *Dwellings 26-40*

4.3 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 of up to 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; and
- Local – Typically roads and lanes with the lowest traffic densities. Speed limits vary.

Assessment is not recommended for local roads, where traffic volumes and/or speeds are likely to be relatively low, as any solar reflections from the proposed development that are experienced by a road user would be considered low impact in the worst case.

Regional roads surrounding the panel area are shown in the aerial image in Figure 12 on the following page[12]. The white zones show the panel areas, the green zone shows the combined 1 km assessment area and the blue icons show the assessed road locations. A height of 1.5 metres above ground level has been modelled, this is a typical eye level for a road user.

[12] Copyright © 2021 Google.

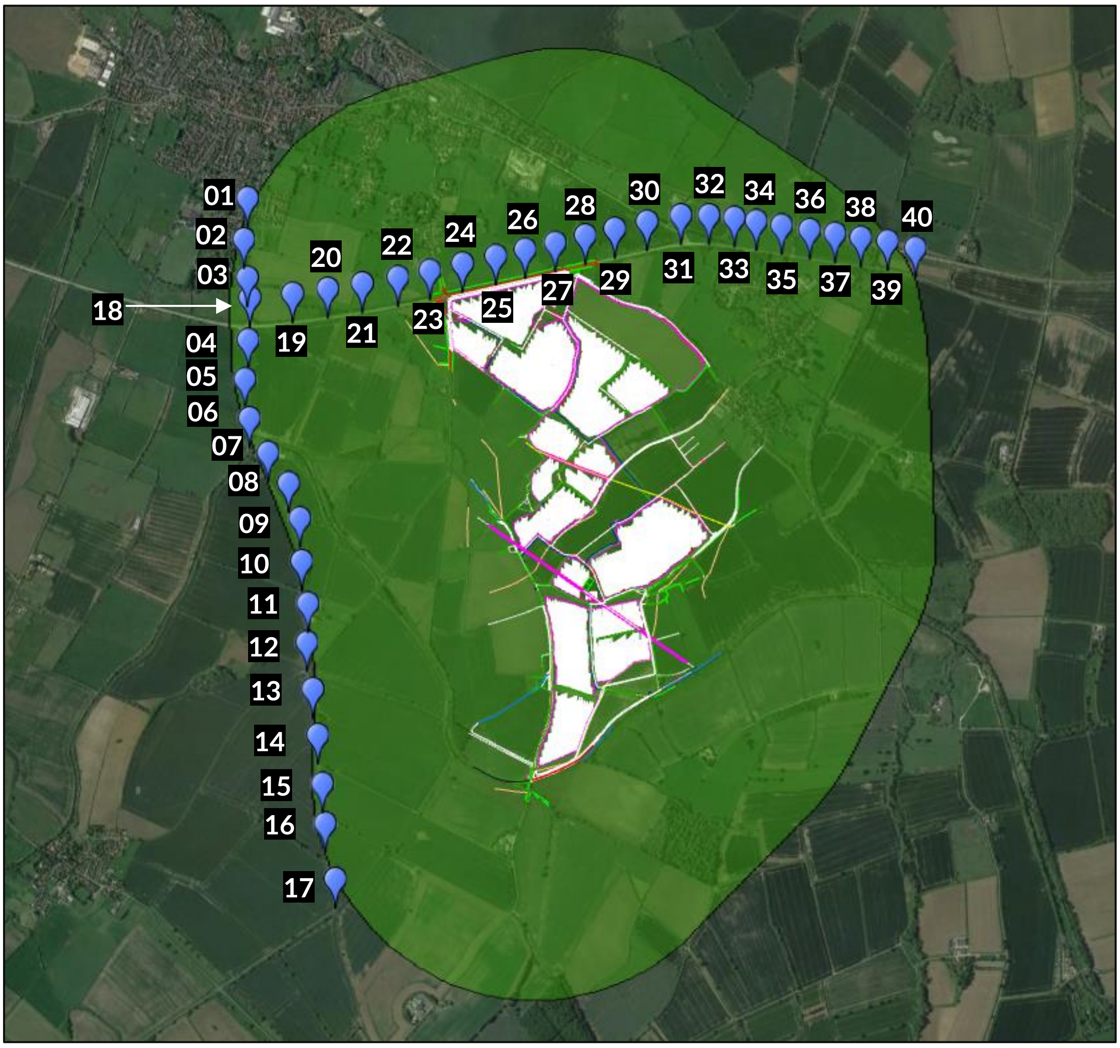

Figure 12 *Main roads surrounding panel area*

Other roads within the 1 km assessment area have not been modelled because they meet one or more of the following criteria:

- They are local roads where traffic volumes/speeds are generally low.
- They are significantly screened such that effects would not be noticeable.

5 ASSESSED REFLECTORS

5.1 Reflector Area

The extrapolated coordinate data can be found in Appendix F. The assessed panel areas are shown in Section 2 of this report.

Figure 13 below shows an image of the modelled panel area overlaid on aerial photography[13].

Figure 13 *Modelled site footprint*

[13] The connecting sections have been incorporated between the panel areas to ensure that the modelling output is presented cumulatively, considering the effects of all panels at once.

6 GLINT AND GLARE ASSESSMENT – TECHNICAL RESULTS

6.1 Evaluation of Effects

The tables in the following subsections present the results of the technical analysis. The final column summarises the predicted impact considering the level of identified screening based primarily on a desk-based review of the available imagery.

The significance of the predicted effects has been evaluated in accordance with Pager Power's published guidance document[14].

The flowcharts setting out the impact characterisation and presented in Appendix D. The list of assumptions and limitations are presented in Appendix E. The modelling output for key receptors can be found in Appendix F.

When evaluating visibility in the context of glint and glare, it is only the *reflecting* panel area that must be considered. For example, if the western half of the development is visible, but reflections would only be possible from the eastern half, it can be concluded that the reflecting area is not visible and no impacts are predicted. This is why there can be instances where visibility of the development is predicted, but glint and glare issues are screened.

Receptors are included within the assessment based on the potential visibility of the development as a whole, among other factors. Once the modelling output has been generated, the assessment can be refined to evaluate the visibility of the reflecting area specifically.

[14] Solar Photovoltaic Development – Glint and Glare Guidance Issue 3.1, April 2021.

6.2 Dwellings

Dwelling(s)	Approximate predicted reflection times (GMT)		Comment
	am	pm	
01-02	Between 03:45 and 09:00 throughout the year for up to 25 minutes per day.	None.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.1).
03	Between 03:45 and 09:00 throughout the year for up to 25 minutes per day.	None.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. Examination of the available imagery shows that significant screening is likely to be provided by a building and a tree belt to the east of the property. Impacts are not predicted in practice.
04	Between 03:45 and 08:30 for parts of January to November for up to 25 minutes per day.	None.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.1).
05-25	None.	None.	No glare predicted.
26-27	None.	Between 15:00 and 20:00 throughout most of the year for up to 20 minutes per day.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.1).
28-40	None.	Between 15:00 and 20:30 throughout the year for up to 25 minutes per day.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. The worst-case impact is moderate, which requires further consideration (see Section 7.1).

Table 1 *Results – dwelling receptors*

6.3 Roads

Road Receptor(s)	Approximate predicted reflection times (GMT)		Comment
	am	pm	
01	Between 06:00 and 09:00 for parts of September to March.	None.	Visibility of the development is not predicted to be available due to existing screening. No impact predicted.
02	Between 05:30 and 09:00 for parts of September to March.	None.	Visibility of the development is not predicted to be available due to existing screening. No impact predicted.
03	Between 05:30 and 09:00 for parts of September to April.	None.	Visibility of the development is not predicted to be available due to existing screening. No impact predicted.
04	Between 04:45 and 09:00 for parts of August to April.	None.	Significant visibility of the development is not predicted to be available due to existing screening. Furthermore, reflections would occur from outside a driver's primary field of view relative to the direction of travel. The worst-case impact is low, which is acceptable without further mitigation.
05	Between 04:00 and 09:00 for parts of July to May.	None.	Significant visibility of the development is not predicted to be available due to existing screening. Furthermore, reflections would occur from outside a driver's primary field of view relative to the direction of travel. The worst-case impact is low, which is acceptable without further mitigation.
06-09	Between 03:45 and 09:00 throughout the year.	None.	Significant visibility of the development is not predicted to be available due to existing screening. Furthermore, reflections would occur from outside a driver's primary field of view relative to the direction of travel. The worst-case impact is low, which is acceptable without further mitigation.

Road Receptor(s)	Approximate predicted reflection times (GMT)		Comment
	am	pm	
10-11	Between 03:45 and 08:30 for parts of January to November.	None.	Significant visibility of the development is not predicted to be available due to existing screening. Furthermore, reflections would occur from outside a driver's primary field of view relative to the direction of travel. The worst-case impact is low, which is acceptable without further mitigation.
12	Between 03:45 and 08:00 for parts of February to October.	None.	Significant visibility of the development is not predicted to be available due to existing screening. Furthermore, reflections would occur from outside a driver's primary field of view relative to the direction of travel. The worst-case impact is low, which is acceptable without further mitigation.
13	Between 03:45 and 07:30 for parts of March to October.	None.	Significant visibility of the development is not predicted to be available due to existing screening. Furthermore, reflections would occur from outside a driver's primary field of view relative to the direction of travel. The worst-case impact is low, which is acceptable without further mitigation.
14	Between 03:45 and 06:30 for parts of March to September.	None.	Significant visibility of the development is not predicted to be available due to existing screening. Furthermore, reflections would occur from outside a driver's primary field of view relative to the direction of travel. The worst-case impact is low, which is acceptable without further mitigation.
15	Between 03:45 and 06:00 for parts of April to September.	None.	Significant visibility of the development is not predicted to be available due to existing screening. Furthermore, reflections would occur from outside a driver's primary field of view relative to the direction of travel. The worst-case impact is low, which is acceptable without further mitigation.

Road Receptor(s)	Approximate predicted reflection times (GMT)		Comment
	am	pm	
16	Between 03:45 and 05:30 for parts of April to August.	None.	Significant visibility of the development is not predicted to be available due to existing screening. Furthermore, reflections would occur from outside a driver's primary field of view relative to the direction of travel. The worst-case impact is low, which is acceptable without further mitigation.
17	Between 03:45 and 04:45 for parts of May to July.	None.	Significant visibility of the development is not predicted to be available due to existing screening. Furthermore, reflections would occur from outside a driver's primary field of view relative to the direction of travel. The worst-case impact is low, which is acceptable without further mitigation.
18-23	Between 05:00 and 09:00 for parts of August to April.	None.	Significant visibility of the development is not predicted to be available due to existing screening. The worst-case impact is low, which is acceptable without further mitigation.
24	Between 05:00 and 09:30 for parts of August to April.	Between 14:30 and 16:30 for parts of October to March.	Visibility of the panel area is predicted based on the available imagery. Discussed in Section 7.2.
25	Between 04:30 and 09:00 for parts of September to April.	Between 15:00 and 17:30 for parts of October to March.	Visibility of the panel area is predicted based on the available imagery. Discussed in Section 7.2.
26	Between 05:30 and 09:00 for parts of September to April.	Between 15:00 and 17:30 for parts of October to March.	Visibility of the panel area is predicted based on the available imagery. Discussed in Section 7.2.
27	Between 06:00 and 09:00 for parts of October to March.	Between 15:00 and 17:30 for parts of October to March.	Visibility of the panel area is predicted based on the available imagery. Discussed in Section 7.2.
28-32	None.	None.	No glare predicted.

Road Receptor(s)	Approximate predicted reflection times (GMT)		Comment
	am	pm	
33-34	None.	Between 15:00 and 18:30 for parts of September to March.	Visibility of the development is not predicted to be available due to existing screening. No impact predicted.
35-40	None.	None.	No glare predicted.

Table 2 *Results – road receptors*

7 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

7.1 Dwelling Results

The process for quantifying impact significance is defined in the report appendices. For dwelling receptors, the key considerations are:

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

Where effects occur for less than 3 months per year and less than 60 minutes per day, the worst-case impact significance is low and mitigation is not required.

Where effects last for more than 3 months per year and less than 60 minutes per day[15], the worst-case impact significance is moderate and expert assessment of any mitigating factors is required to determine the mitigation requirement (if any). Of particular relevance is the level of likely screening, the separation distance between the reflecting panels and the receptor location[16] and the extent to which effects coincide with direct sunlight.

Where effects last for more than 3 months per year and more than 60 minutes per day, the worst-case impact is high, and mitigation is required. In this case, there are no instances of high impact, even under worst-case conditions.

A conservative review of the available imagery has been undertaken within the desk-based assessment, whereby it is assumed views of the panels are possible if it cannot be reliably determined that existing screening will remove effects.

Moderate impacts have been predicted for 24 dwellings. In all cases, this is due to worst-case effects potentially lasting for more than 3 months per year and less than 60 minutes on any one day. The maximum duration on any one day would be approximately 30 minutes, which is comfortably below the threshold of 60 minutes that would lead to a high impact.

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[15] Or if effects last for less than 3 months per year but more than 60 minutes per day, which is a scenario that is almost never seen in practice but could occur in theory.

[16] Which is often greater than the nearest panel boundary, because not all areas of the site cause specular reflections towards particular receptor locations.

The dwellings that could experience moderate impacts based on the modelling output and the initial review of existing screening are shown in Figure 14 below[17]. Further examination of these dwellings is required to determine the mitigation requirement in each individual case.

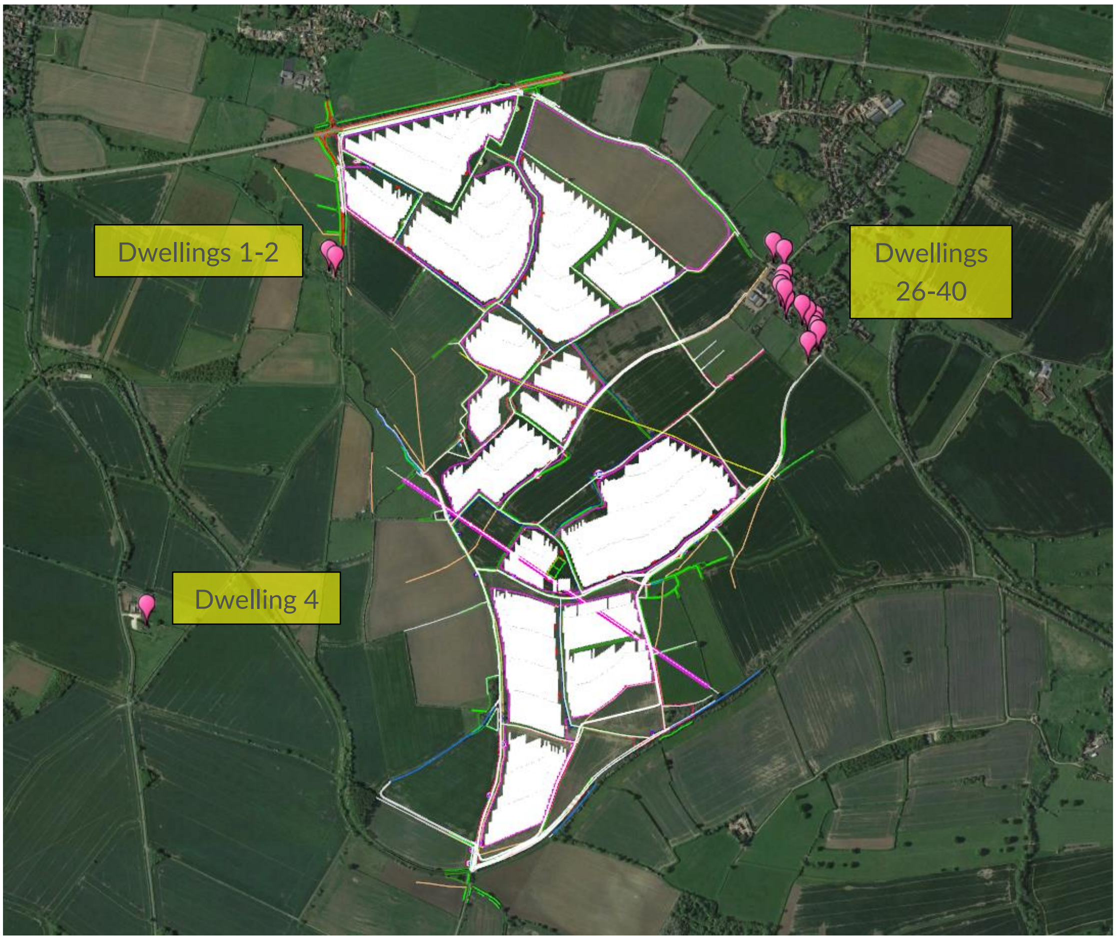


Figure 14 *Dwellings to be examined for potential mitigation requirements*

[17] Copyright © 2021 Google.

7.1.1 Dwellings 1 and 2

Figure 15 below shows the area of the panel footprint that could reflect towards dwellings 1 and 2[18].

Figure 15 *Reflective panel area for dwellings 1 and 2*

Examination of the available imagery suggests that visibility of the reflecting area may be available from dwellings 1 and 2. This is shown in Figure 16 on the following page[19], which shows a street level image from immediately outside dwellings 1 and 2 facing northeast. Panels would be located in the second field as marked in the image.

[18] Taken from the Forge modelling output for Dwelling 1, the area for Dwelling 2 looks almost identical.

[19] Copyright © 2021 Google.

Figure 16 *Baseline visibility for dwelling receptors 1 and 2*

It is recommended that the intervening hedgerow at the site boundary is managed and maintained to a height that is sufficient to significantly obscure the panels from view of the dwellings. The portion of the site boundary for which this screening is recommended is illustrated by the blue line in Figure 17 on the following page[20].

[20] Copyright © 2021 Google.

Figure 17 *Screening recommendation for dwellings 1-2*

7.1.2 Dwelling 4

The nearest proposed panels are approximately 970 metres from dwelling 4, such that the vast majority of reflecting panels will be outside the 1 km distance within which effects are generally considered.

Furthermore, it is likely that the development as a whole will be significantly screened by intervening hedgerows – although marginal visibility of some areas cannot be ruled out.

Any effects would coincide with direct sunlight at times when the Sun is low in the sky. Direct sunlight is a significantly more intense source of glare than a reflection from a solar panel.

Overall, no mitigation requirement is judged to be necessary for dwelling 4.

7.1.3 Dwellings 26-40

Dwellings 25-40 are located in Muston and form the western 'edge' of the village facing the proposed development. The location of these dwellings relative to the nearest panel areas is shown in Figure 18 below[21].

Figure 18 *Dwellings in Muston*

The shortest distance between a panel area and a dwelling in this region is approximately 150 metres.

[21] Copyright © 2021 Google.

The reflecting footprint for Dwelling 30, approximately central to this cluster of dwellings, is shown in Figure 19 below.

Figure 19 *Reflecting footprint for Dwelling 30*

It is not possible to definitively conclude the level of visibility from each dwelling in this cluster from the available imagery. The majority of the reflecting area is located to the southwest, west and northwest of this cluster of dwellings.

Figure 20 on the following page[22] shows a street level image from immediately outside dwelling 26 facing northwest. Panels would be located in the second field as marked in the image.

[22] Copyright © 2021 Google.

Figure 20 *Baseline visibility for dwelling receptors*

It is recommended that the intervening hedgerow at the site boundary to the southwest, west and northwest of this location is managed and maintained to a height that is sufficient to significantly obscure the panels from view of the dwellings.

7.2 Road Results

For road users, the key considerations are:

- Whether a reflection is predicted in practice.
- The type of road (and associated likely traffic levels/speeds).
- The location of the reflecting panels relative to a road user's direction of travel (a reflection directly in front of a driver is more hazardous than a reflection from a location off to one side).

Reflections towards Belvoir Road are not significant because they would occur from a bearing that is outside a driver's primary field of focus when facing the direction of travel. Furthermore, the reflecting area is likely to be partially or entirely screened by intervening terrain at locations where reflections would be geometrically possible.

Effects have been predicted towards drivers for a stretch of the A52 road to the north of the panel area. This stretch is illustrated by the orange line in Figure 21 below[23]. The individual receptor points are numbered in accordance with the table in Section 6.3 and Appendix G for reference.

[23] Copyright © 2021 Google.

Figure 21 *Potentially affected stretch of road*

The reflecting footprint for Receptor 24 is shown in Figure 22 below for reference.

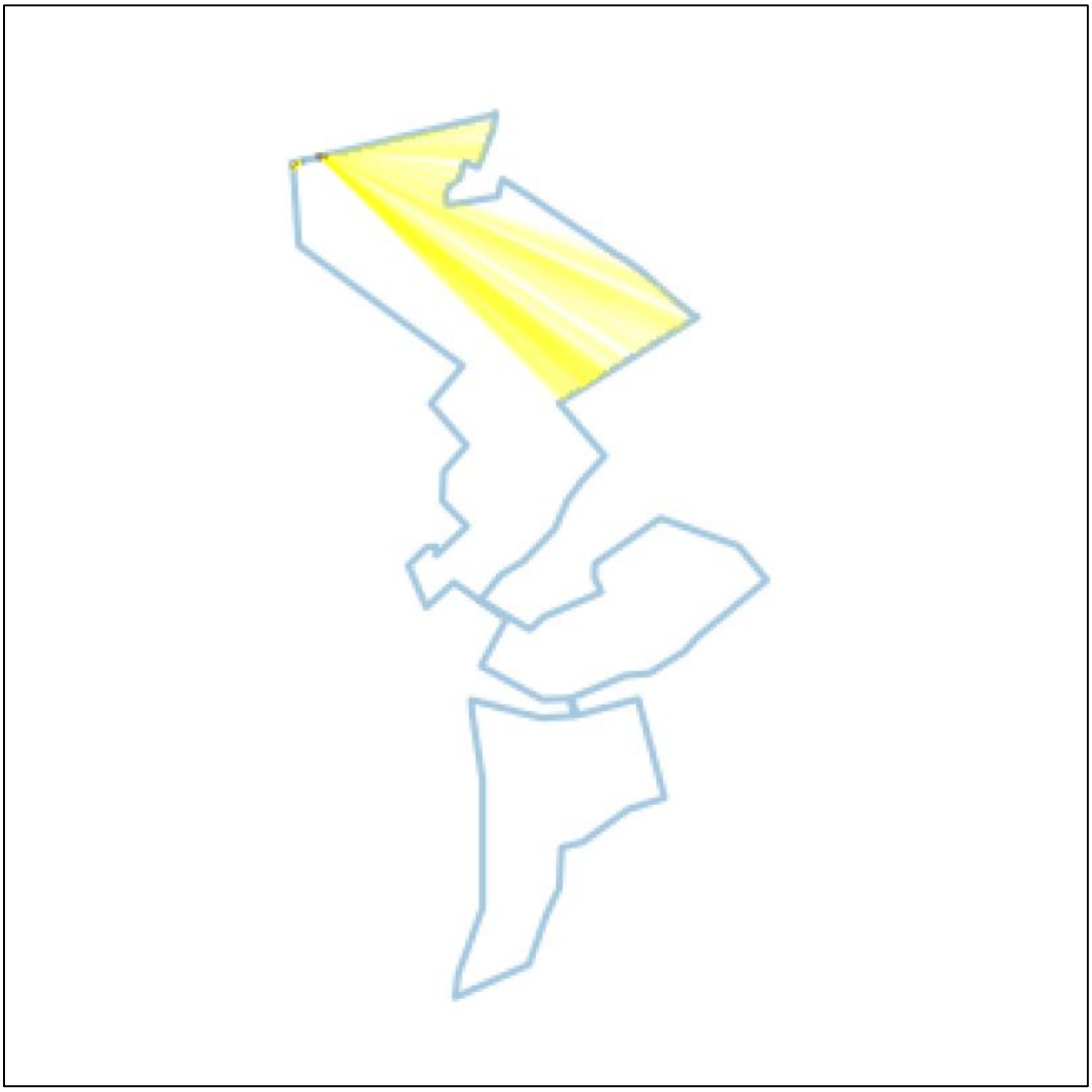


Figure 22 *Reflective footprint for road receptor 24*

Figure 23 below[24] shows a street level image of the road facing east from Receptor 24. The field to the right will contain solar panels.

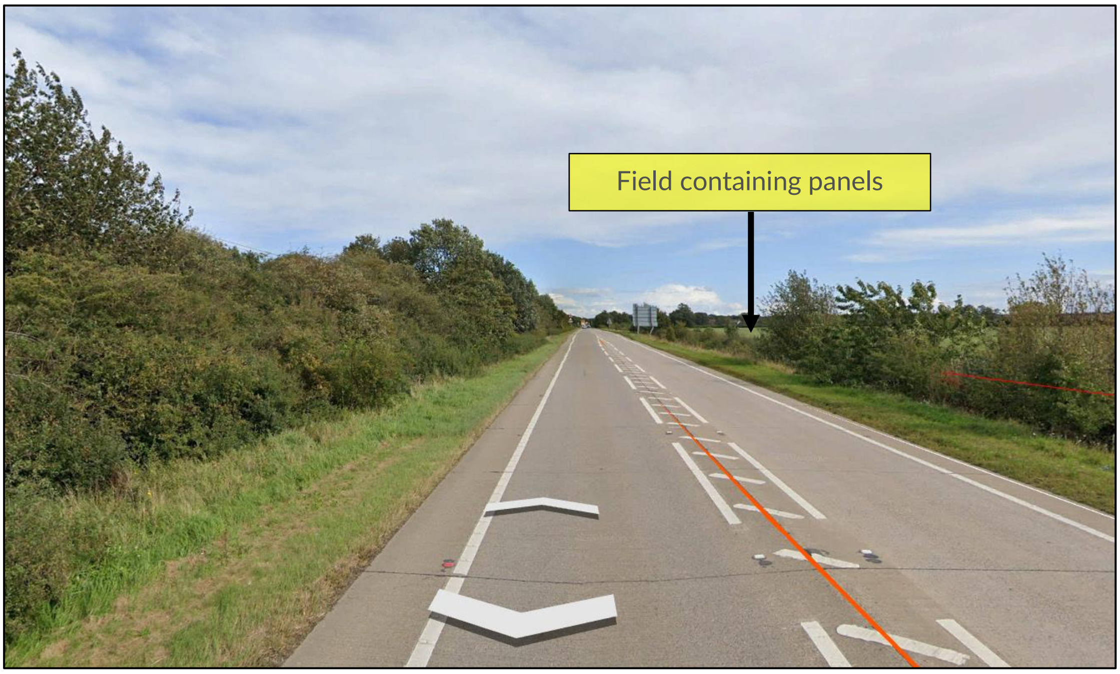


Figure 23 *Baseline visibility for road receptor 24 (A52)*

Whilst there is some screening between the road and the panel area, there is a reasonable prospect of visibility for panels that are close to a driver's primary field of view. It is therefore recommended that the screening along this boundary is enhanced in order to remove visibility of the adjacent panel are from the road.

7.3 Proposed Mitigation

The identified impacts will be mitigated via landscape screening. Figure 24 on the following page[25].

The development team has confirmed[26] that these Planting Proposals (Version F) incorporate all of the necessary mitigation screening recommended in the preceding sections of this report. On this basis, no significant glint and glare impacts are predicted following the provision of this mitigation.

[24] Copyright © 2021 Google.
[25] Provided to Pager Power by Pegasus.
[26] Email confirmation from Pegasus to Pager Power was given on 23 November 2021.

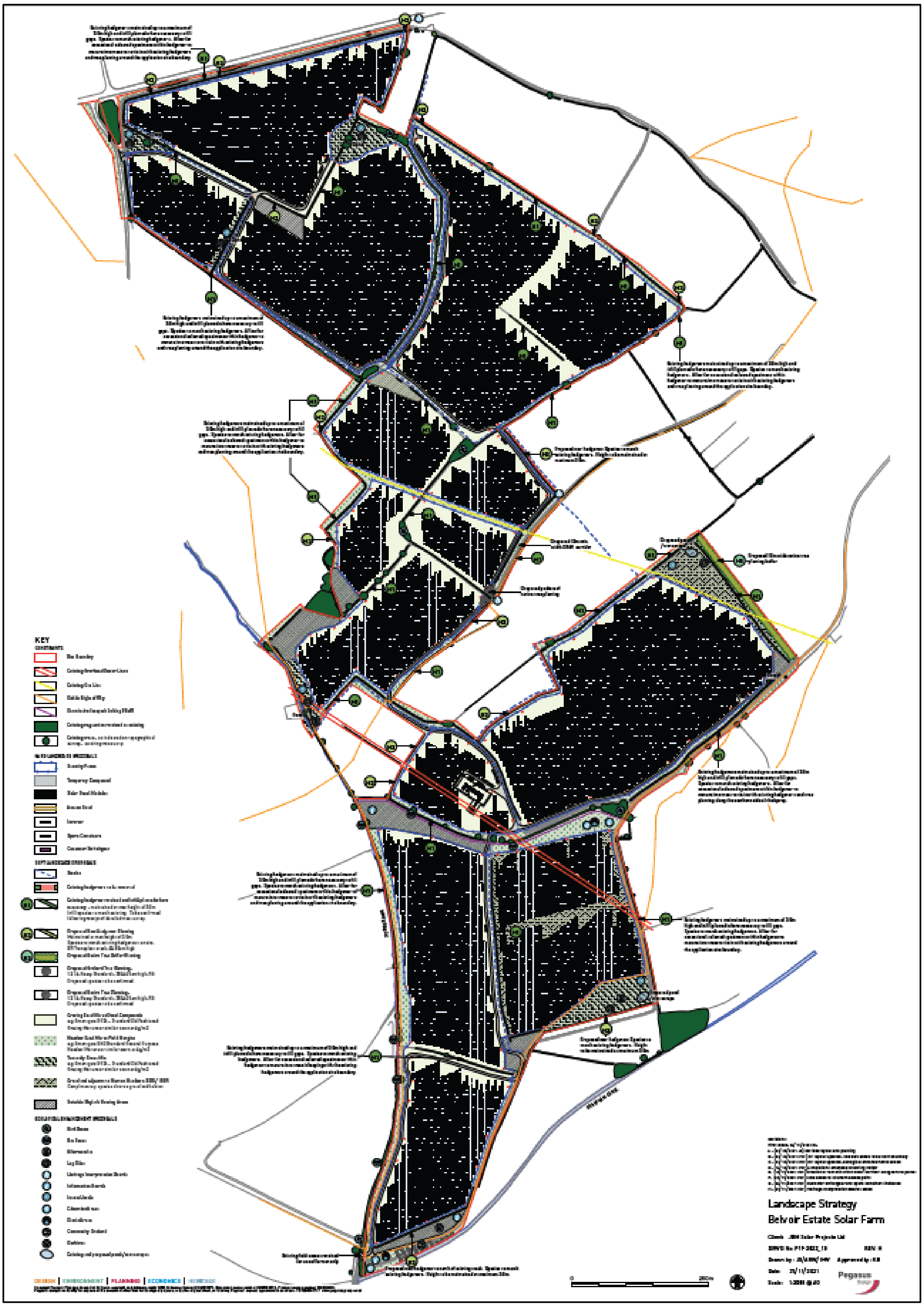


Figure 24 *Proposed screening plan*

7.4 Aviation Considerations – High Level

Impacts of reflections on aviation are a material consideration for solar panels that are in close proximity to major aerodromes (typically within 10 kilometres, although there is no formal safeguarded range).

The receptors of concern are typically the final two miles of the approach to the runway and personnel within Air Traffic Control towers.

The nearest major aerodrome to the development is RAF Barkston Heath which is approximately 15 km to the east-northeast. At this range, significant reflections are not predicted[27].

The nearest unlicensed aerodrome to the development is Langar, approximately 8.7 km to the southwest of the development. The runways that are in the best condition run north-south and southwest-northeast. At this range, significant impacts are not predicted, in particular given that three of the four approaches would not be directed towards the panel area.

Figure 25 below[28] shows the location of the aerodromes relative to the panel area.

Figure 25 *Nearest aerodromes*

Overall, significant impacts on aviation activity are not predicted.

[27] Reflections towards an Air Traffic Control tower are unlikely at this range, and would generally not be visible. Reflections towards approaching pilots, if possible, would be highly likely to present a 'low potential for a temporary after-image', which is acceptable in accordance with the associated guidance.

[28] Copyright © 2021 Google.

7.5 Railway Considerations – High Level

Impacts of reflections on aviation are a material consideration for solar panels that are in close proximity to railway lines (typically within ~100 metres, although there is no formal safeguarded range). Concerns typically relate to the potential to distract drivers and potential illumination of signals along the railway line.

The nearest railway line passes more than 500 metres north of the development at its closest point. There is significant screening between the railway line and the nearest panel area in the form of vegetation.

Figure 26 below[29] shows the location of the railway line (in red) relative to the panel area.

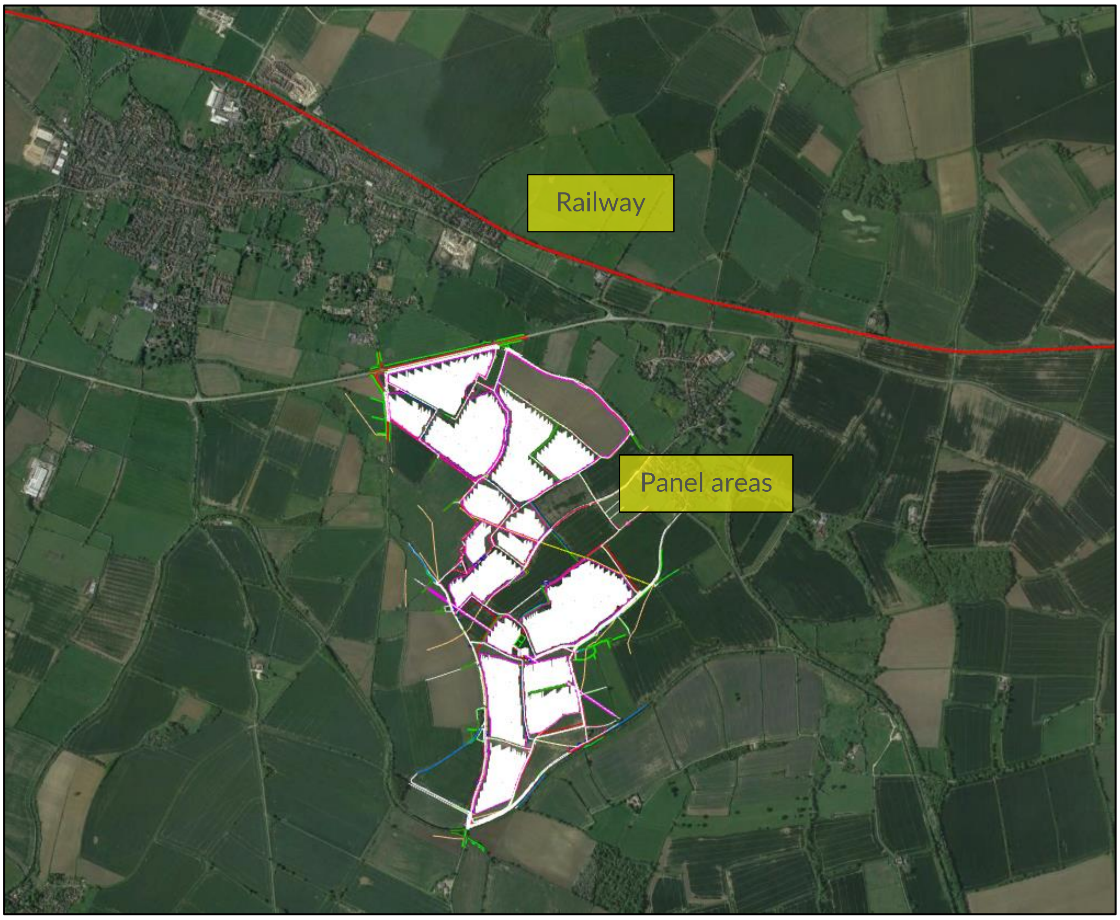


Figure 26 *Nearest railway line*

Based on the range, screening and relative position of the development to the railway line, significant impacts on railway infrastructure are not predicted.

[29] Copyright © 2021 Google.

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

The National Planning Policy Framework under the planning practice guidance for Renewable and Low Carbon Energy[30] (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.'

[30] Renewable and low carbon energy, Ministry of Housing, Communities & Local Government, date: 18 June 2015, accessed on: 17/06/2020

Assessment Process – Ground-Based Receptors

No process for determining and contextualising the effects of glint and glare are, however, provided for 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[31] which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

[31] Solar Photovoltaic Development – Glint and Glare Guidance, Edition 3.1, April 2021. Pager Power.

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

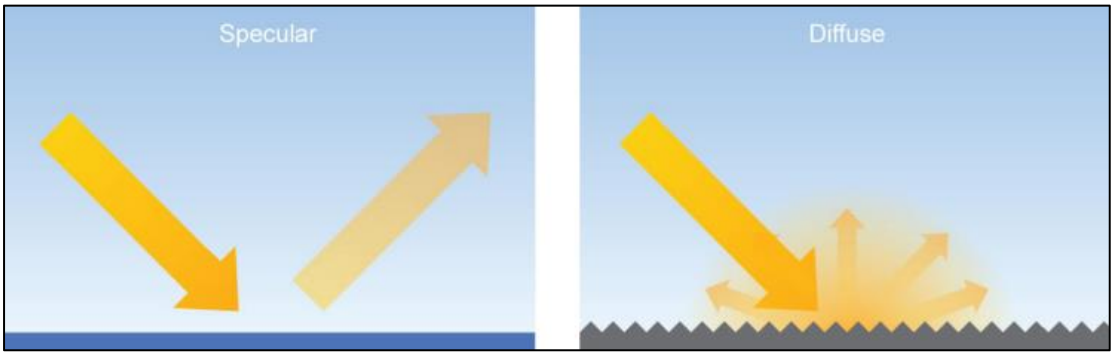
Overview

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[32], 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

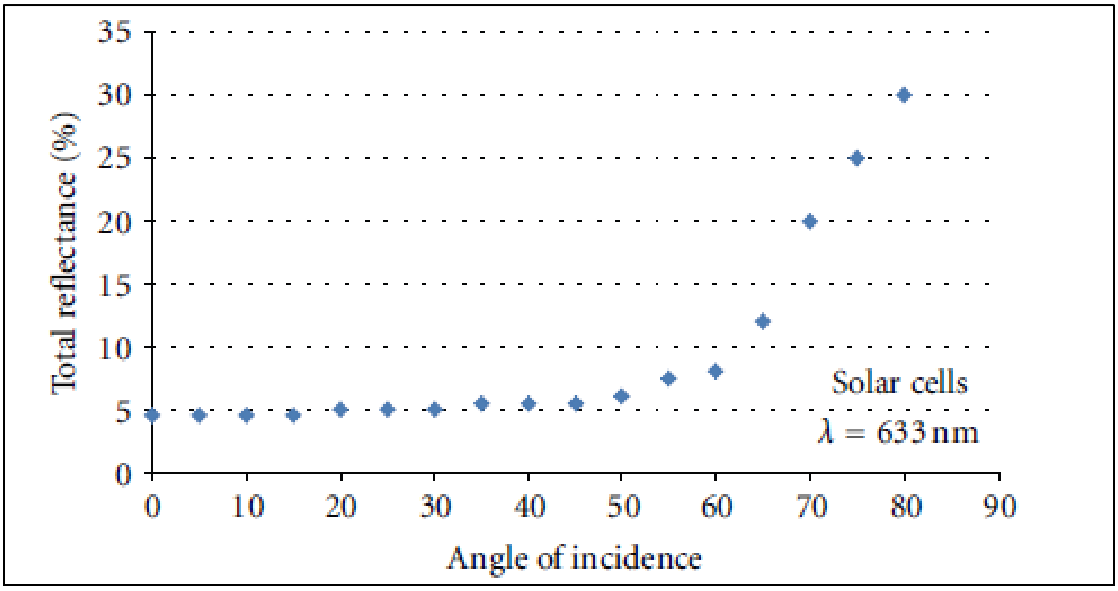
[32] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

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*[33]". 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.

---

[33] 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"[34]

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[35]
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).

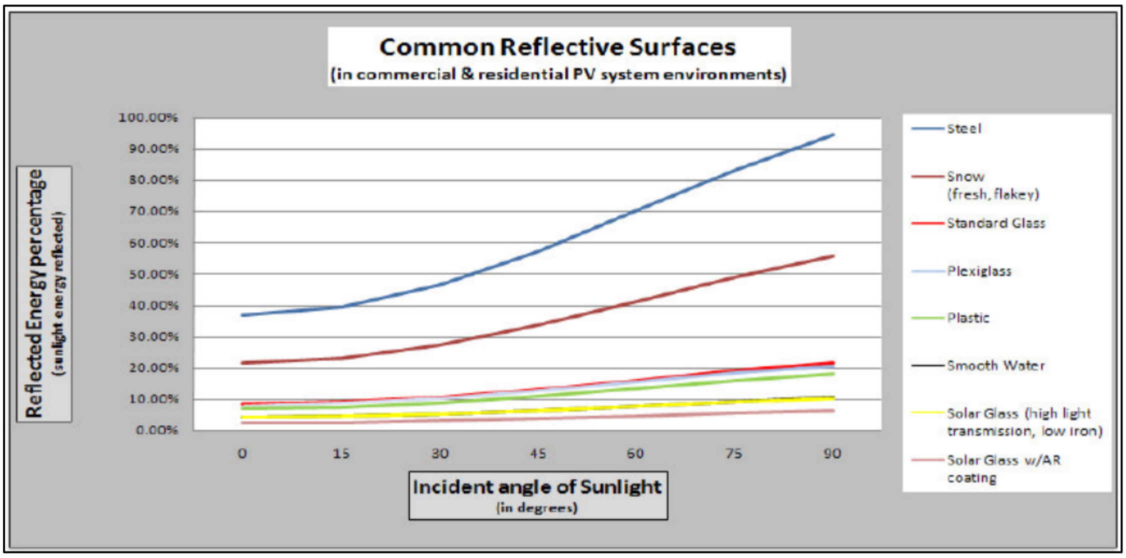
An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel. The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

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

SunPower Technical Notification (2009)

SunPower published a technical notification[36] 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.

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

APPENDIX C – OVERVIEW OF SUN MOVEMENTS AND RELATIVE REFLECTIONS

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

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

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

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

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

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

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

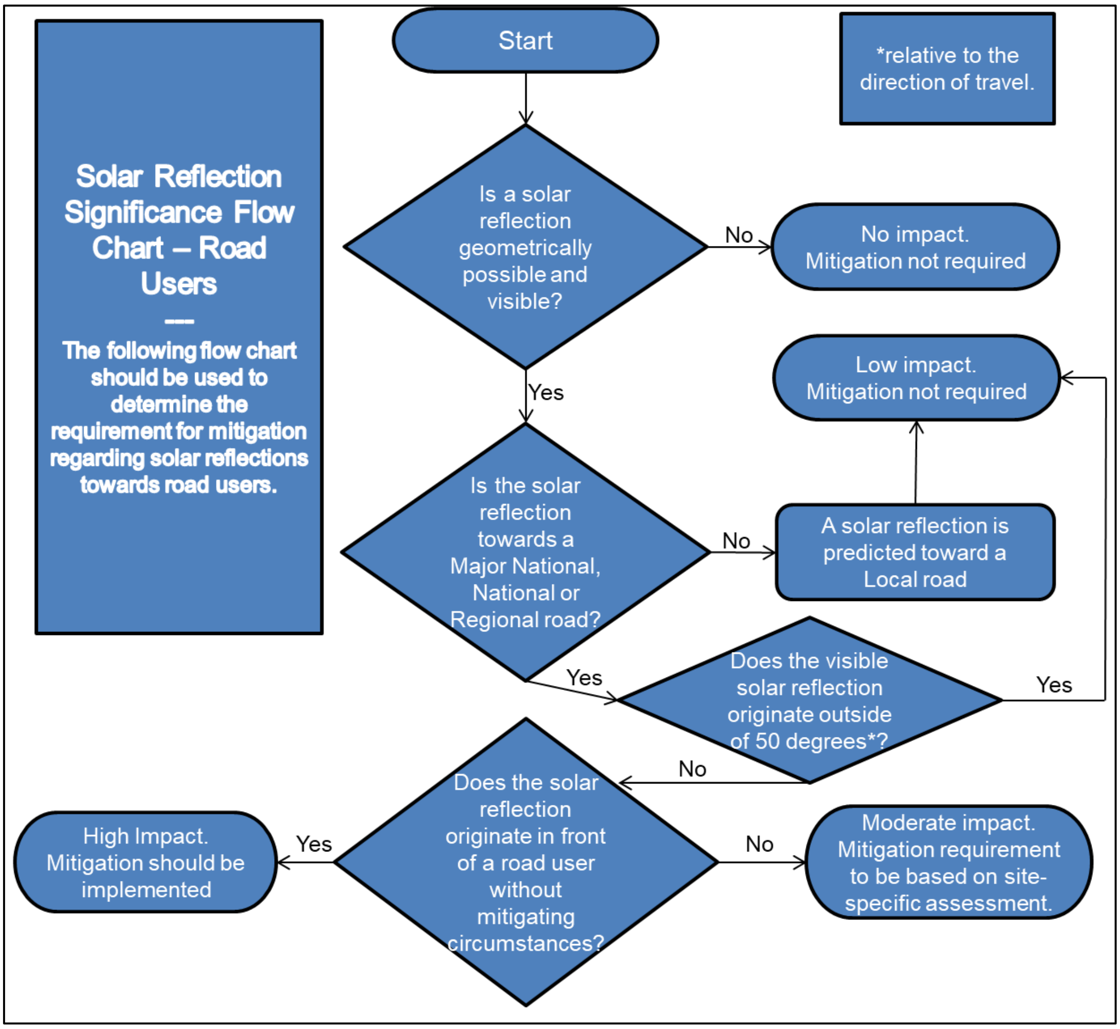
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

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 solar development is to proceed.

Impact significance definition

Assessment Process for Road Receptors

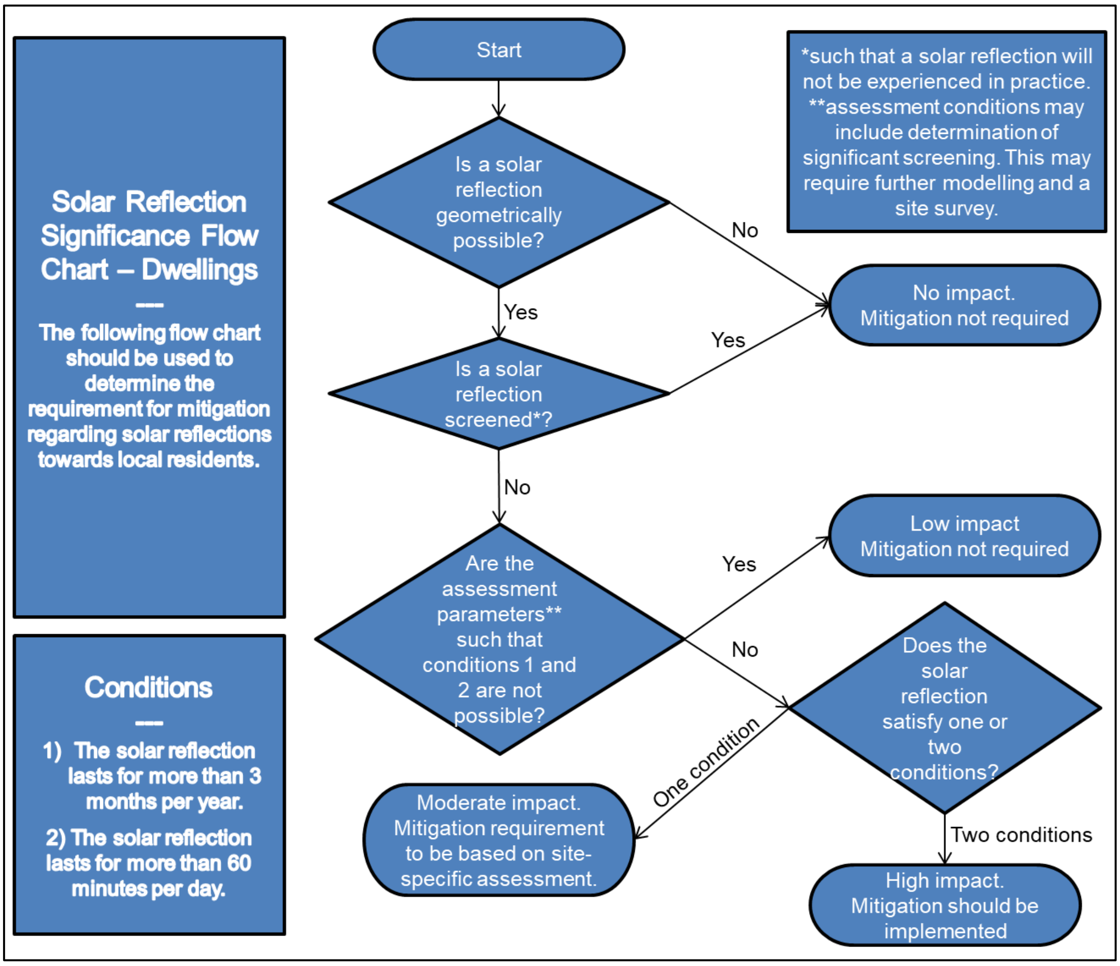
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



Road receptor mitigation requirement flow chart

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

APPENDIX E – ASSESSMENT LIMITATIONS AND ASSUMPTIONS

Forge Solar

Assumptions & Limitations

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.

APPENDIX F – RECEPTOR AND REFLECTOR AREA DETAILS

Terrain Height

All ground heights are interpolated based on OSGB data.

Dwelling Data

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

Dwelling	Longitude (°)	Latitude (°)	Dwelling	Longitude (°)	Latitude (°)
01	-0.791155	52.930475	21	-0.768982	52.932746
02	-0.790868	52.930324	22	-0.769146	52.932313
03	-0.802648	52.927635	23	-0.769510	52.931875
04	-0.799165	52.921058	24	-0.769848	52.931630
05	-0.786389	52.911699	25	-0.770130	52.931078
06	-0.771180	52.935126	26	-0.771569	52.930687
07	-0.771207	52.934923	27	-0.771090	52.930497
08	-0.771113	52.934831	28	-0.771096	52.929855
09	-0.772433	52.934437	29	-0.771184	52.929677
10	-0.772378	52.934344	30	-0.771251	52.929546
11	-0.769194	52.934258	31	-0.771069	52.929449
12	-0.769286	52.934146	32	-0.771005	52.929198
13	-0.769403	52.934062	33	-0.770310	52.929032
14	-0.769369	52.933727	34	-0.770063	52.928893
15	-0.769323	52.933585	35	-0.769725	52.928746
16	-0.769325	52.933479	36	-0.769760	52.928586
17	-0.769191	52.933395	37	-0.769760	52.928461
18	-0.769195	52.933243	38	-0.769655	52.928398
19	-0.769566	52.933104	39	-0.769588	52.928348
20	-0.769082	52.932970	40	-0.770040	52.928048

Dwelling data

Road Data

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

Road	Longitude (°)	Latitude (°)	Road	Longitude (°)	Latitude (°)
01	-0.804303	52.936970	21	-0.796519	52.933547
02	-0.804526	52.935294	22	-0.794124	52.933813
03	-0.804269	52.933742	23	-0.791978	52.934093
04	-0.804169	52.931207	24	-0.789782	52.934390
05	-0.804346	52.929609	25	-0.787547	52.934711
06	-0.803997	52.928017	26	-0.785573	52.934984
07	-0.802704	52.926621	27	-0.783553	52.935267
08	-0.801304	52.925393	28	-0.781531	52.935579
09	-0.800531	52.923976	29	-0.779546	52.935857
10	-0.800371	52.922236	30	-0.777379	52.936161
11	-0.799928	52.920524	31	-0.775104	52.936426
12	-0.799963	52.918944	32	-0.773216	52.936439
13	-0.799523	52.917055	33	-0.771500	52.936342
14	-0.799169	52.915191	34	-0.770030	52.936212
15	-0.798826	52.913218	35	-0.768324	52.936044
16	-0.798620	52.911605	36	-0.766436	52.935870
17	-0.797912	52.909353	37	-0.764730	52.935727
18	-0.804086	52.932932	38	-0.762992	52.935572
19	-0.801208	52.933108	39	-0.761189	52.935436
20	-0.798847	52.933319	40	-0.759312	52.935165

Road data

Modelled Reflector Data

The table below presents the coordinate data for modelled reflector area used in the assessment.

Vertex number	Longitude (°)	Latitude (°)	Vertex number	Longitude (°)	Latitude (°)
01	-0.782973	52.935177	43	-0.772790	52.924618
02	-0.783038	52.934860	44	-0.775397	52.923325
03	-0.783628	52.933971	45	-0.775869	52.923001
04	-0.784137	52.934107	46	-0.777199	52.922503
05	-0.784298	52.933729	47	-0.778090	52.922451
06	-0.784615	52.933596	48	-0.780102	52.921944
07	-0.784749	52.933496	49	-0.779908	52.921552
08	-0.784840	52.933373	50	-0.777618	52.921921
09	-0.784787	52.933111	51	-0.776624	52.919676
10	-0.782882	52.933318	52	-0.777975	52.919418
11	-0.782710	52.933710	53	-0.779713	52.918667
12	-0.782110	52.933490	54	-0.780486	52.918551
13	-0.781570	52.933280	55	-0.780572	52.917632
14	-0.781010	52.933050	56	-0.781065	52.917011
15	-0.780470	52.932830	57	-0.781709	52.915898
16	-0.779870	52.932590	58	-0.784477	52.915148
17	-0.779180	52.932310	59	-0.784370	52.915666
18	-0.778570	52.932060	60	-0.783447	52.917179
19	-0.778080	52.931880	61	-0.783447	52.920077
20	-0.777550	52.931650	62	-0.783855	52.921643
21	-0.776900	52.931310	63	-0.783876	52.921902
22	-0.776450	52.931060	64	-0.781237	52.921488
23	-0.776040	52.930870	65	-0.780009	52.921539
24	-0.775760	52.930730	66	-0.780207	52.921931

Vertex number	Longitude (°)	Latitude (°)	Vertex number	Longitude (°)	Latitude (°)
25	-0.775550	52.930630	67	-0.781194	52.921902
26	-0.775383	52.930582	68	-0.783508	52.922669
27	-0.780583	52.928630	69	-0.782559	52.923726
28	-0.778864	52.927432	70	-0.784527	52.924564
29	-0.779733	52.926859	71	-0.785557	52.924001
30	-0.780269	52.926419	72	-0.786233	52.924945
31	-0.780741	52.925773	73	-0.785525	52.925366
32	-0.781911	52.925048	74	-0.785193	52.925379
33	-0.782758	52.924738	75	-0.785193	52.925178
34	-0.783531	52.924162	76	-0.784023	52.925838
35	-0.782143	52.923659	77	-0.784957	52.926407
36	-0.781682	52.923497	78	-0.784914	52.927073
37	-0.781135	52.923788	79	-0.784045	52.927675
38	-0.778989	52.924344	80	-0.785396	52.928619
39	-0.779257	52.924681	81	-0.784193	52.929479
40	-0.779236	52.924991	82	-0.790342	52.932207
41	-0.776781	52.926022	83	-0.790568	52.934070
42	-0.773852	52.925388			

Modelled reflector area

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Urban & Renewables

APPENDIX G – DETAILLED MODELLING RESULTS

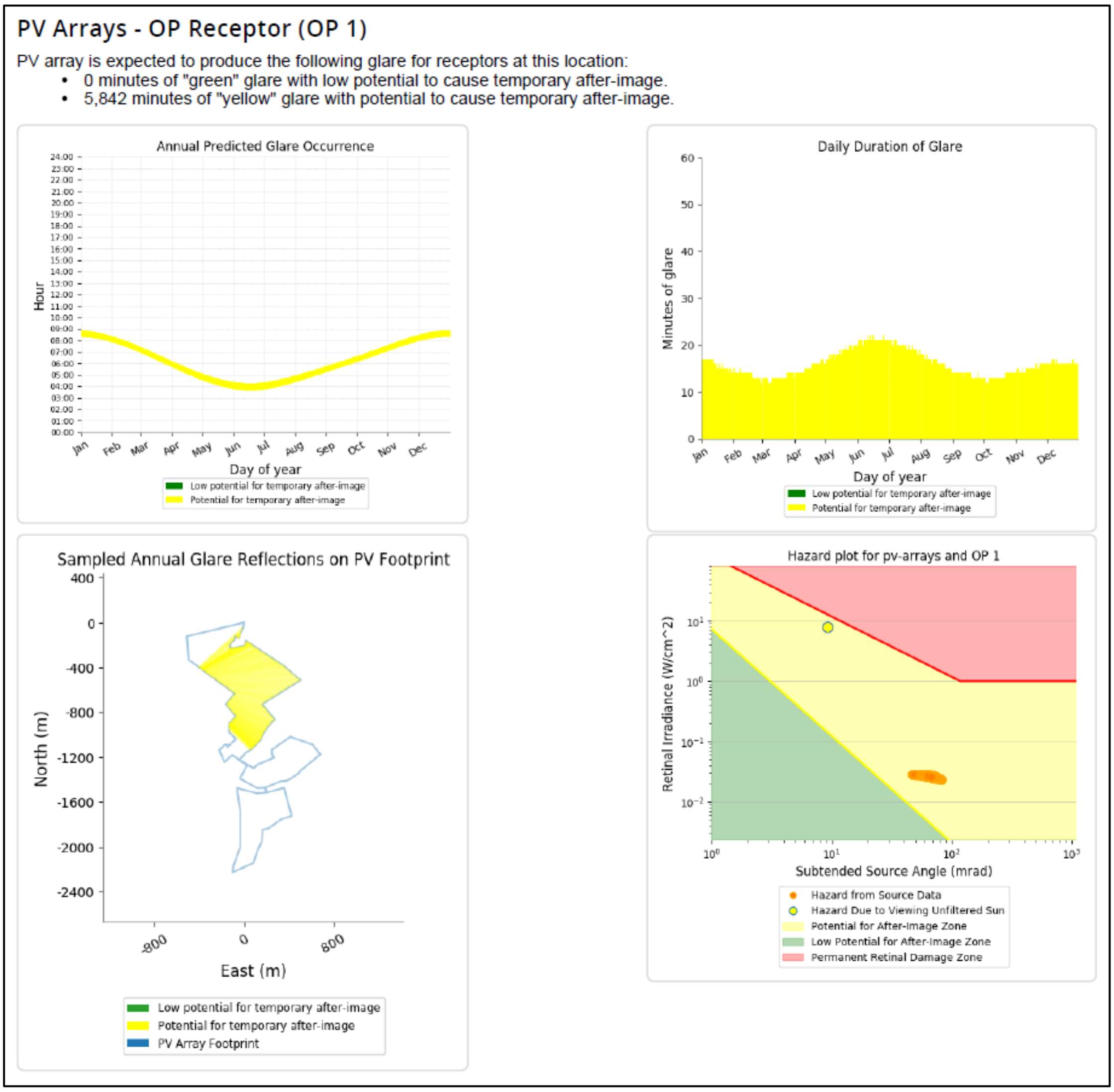
Model Output Charts

The modelling output for the potentially affected receptors are shown on the following pages. This output has been taken from the Forge model. Each image shows:

- The dates/times that glare is predicted (top left panel).
- The glare duration per day at affected times (top right panel).
- The reflecting footprint in yellow for the predicted reflections (bottom left panel).
- The glare intensity plot (bottom right panel). This is not particularly relevant for ground-based receptors, intensity criteria are mostly applicable to approaching aircraft.

Dwelling Receptors

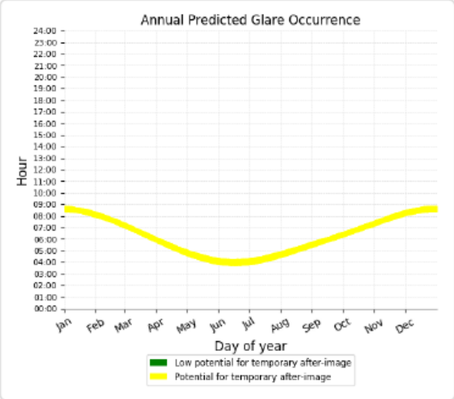
The charts below relate to the dwelling receptors where moderate impacts have been predicted. Modelling output for the remaining receptors can be provided on request.

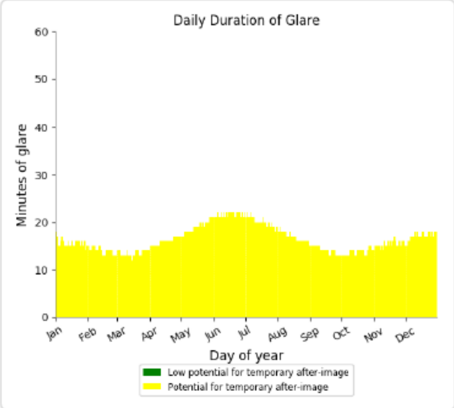


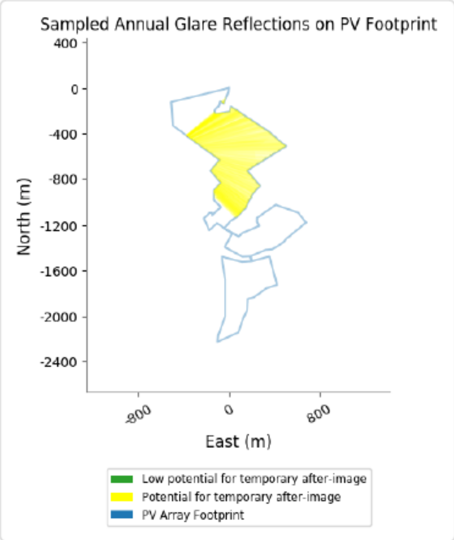
PV Arrays - OP Receptor (OP 2)

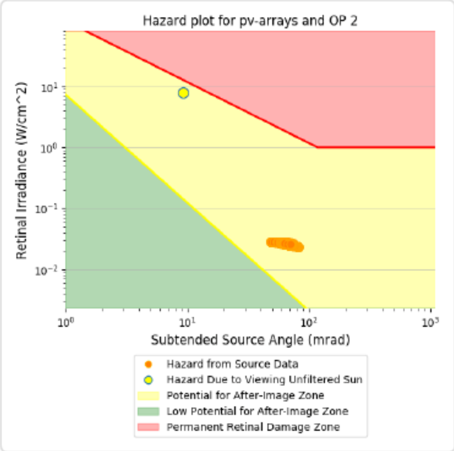
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 5,995 minutes of "yellow" glare with potential to cause temporary after-image.





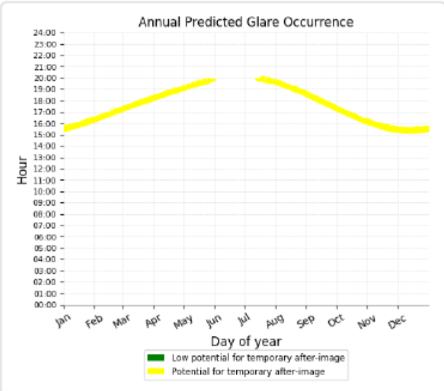


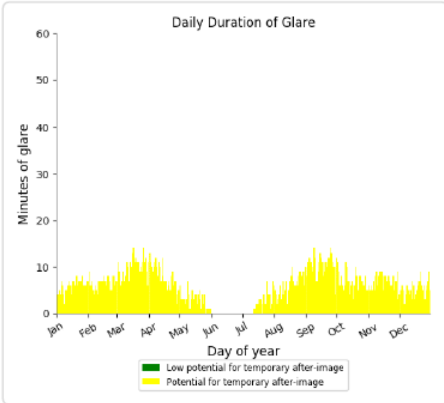


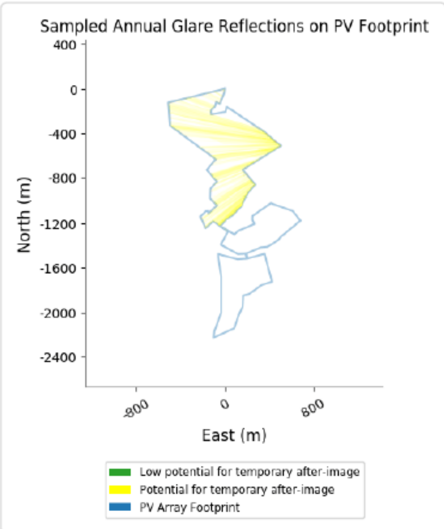
PV Arrays - OP Receptor (OP 26)

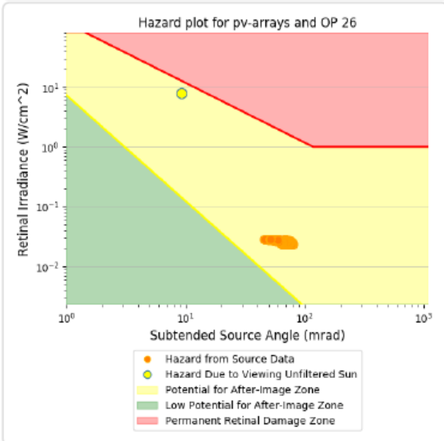
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,170 minutes of "yellow" glare with potential to cause temporary after-image.





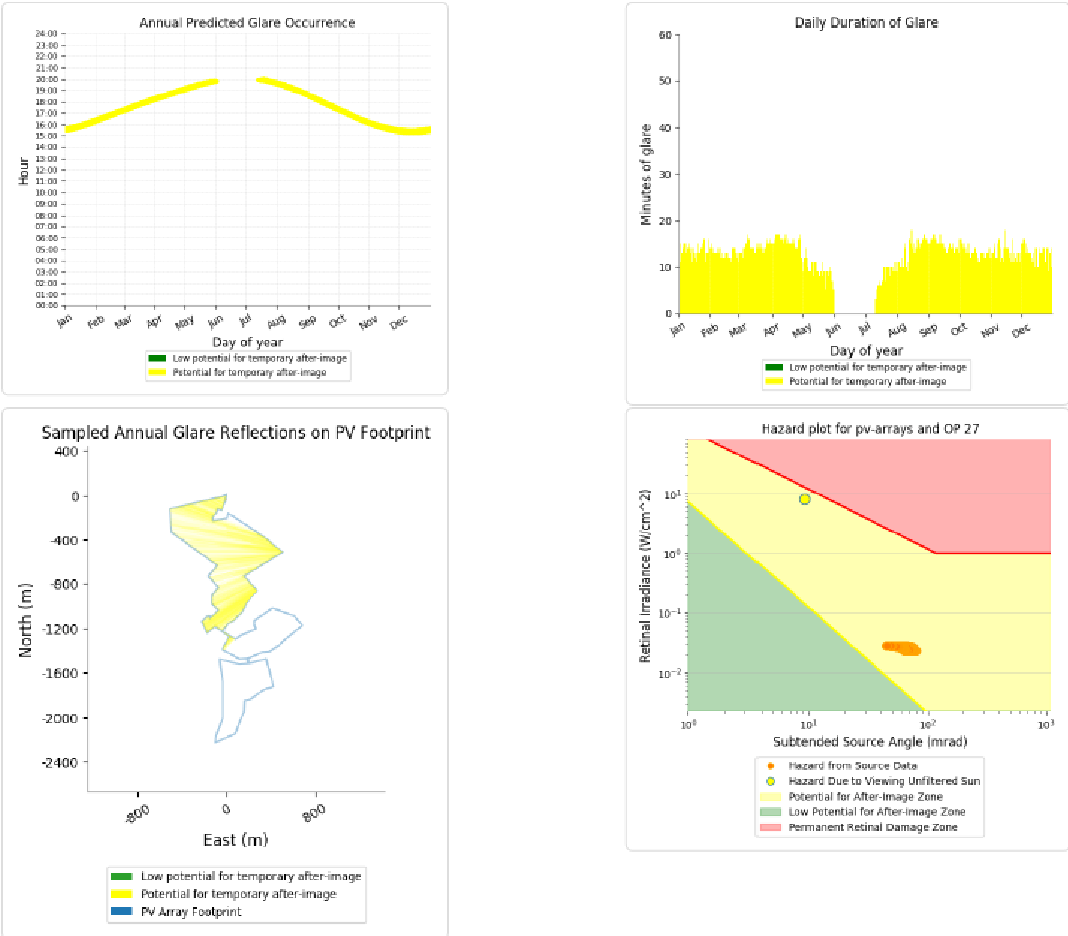




PV Arrays - OP Receptor (OP 27)

PV array is expected to produce the following glare for receptors at this location:

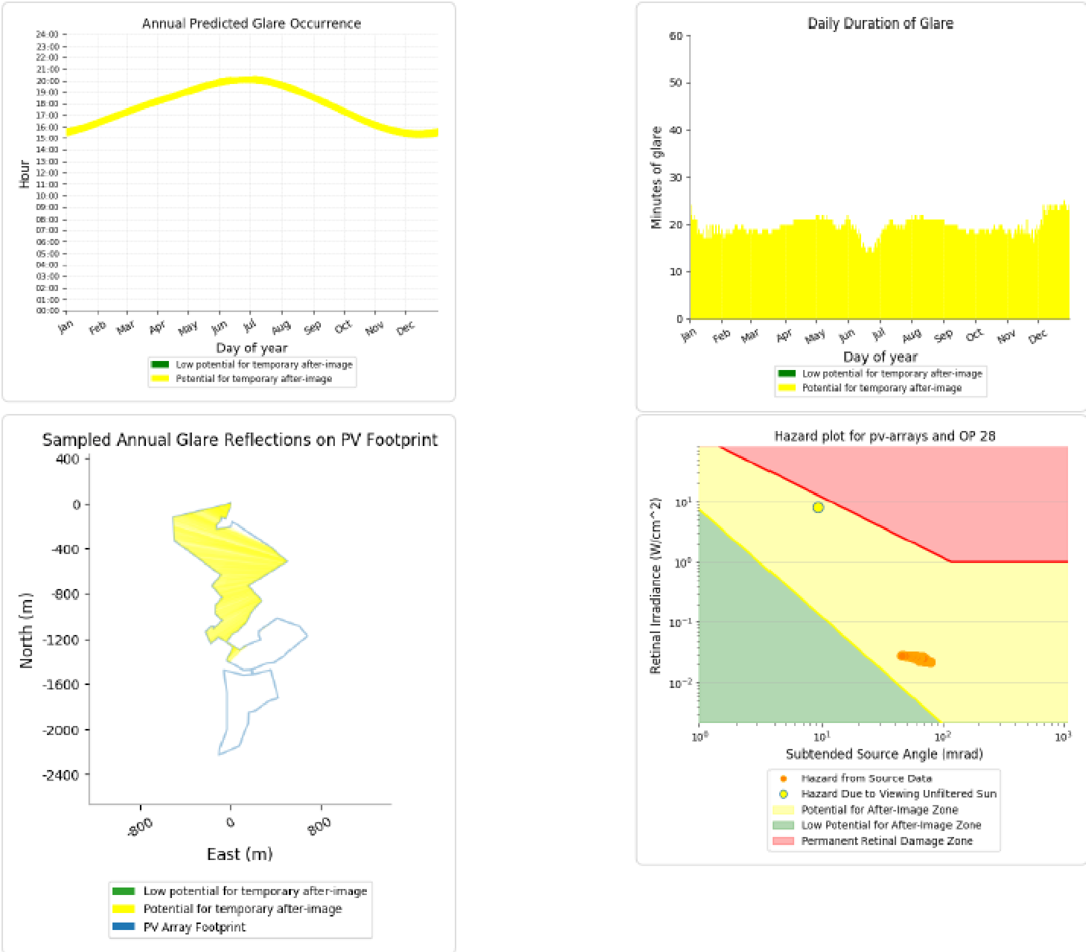
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 4,237 minutes of "yellow" glare with potential to cause temporary after-image.



PV Arrays - OP Receptor (OP 28)

PV array is expected to produce the following glare for receptors at this location:

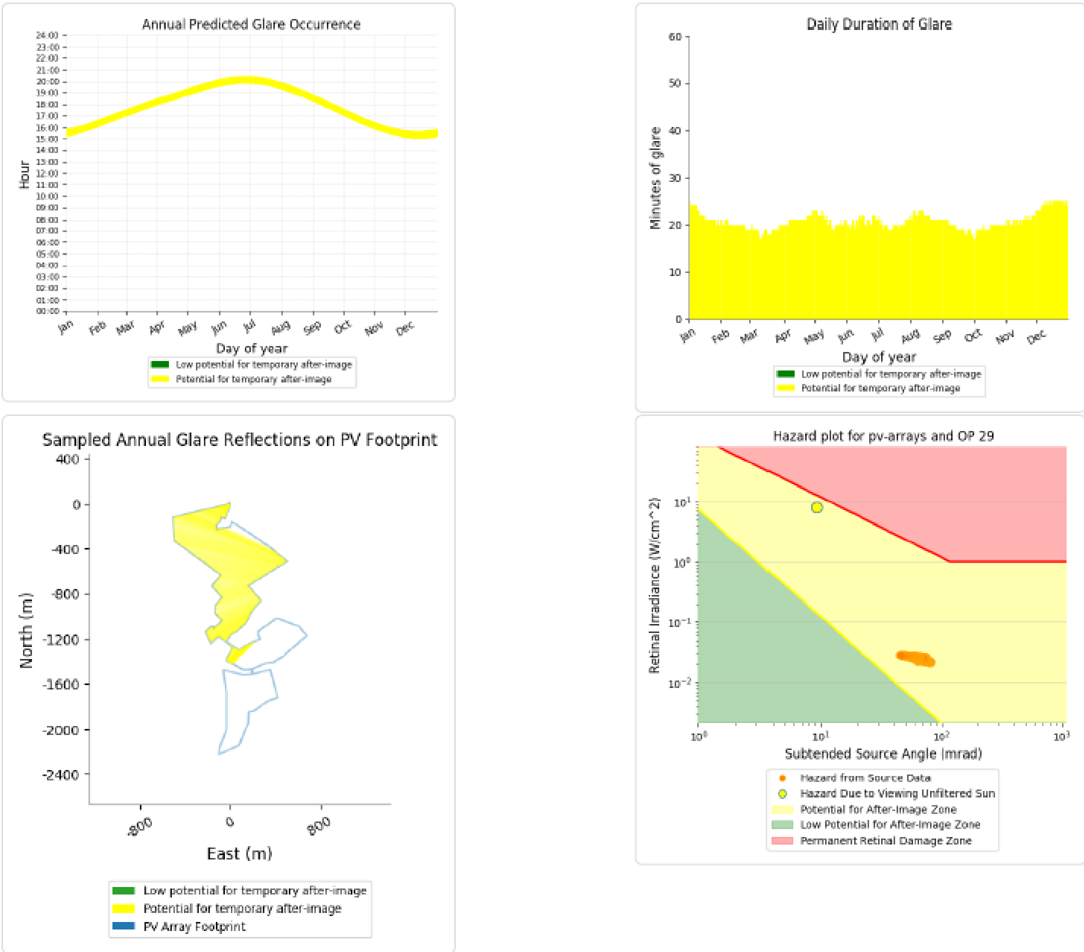
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 7,192 minutes of "yellow" glare with potential to cause temporary after-image.



PV Arrays - OP Receptor (OP 29)

PV array is expected to produce the following glare for receptors at this location:

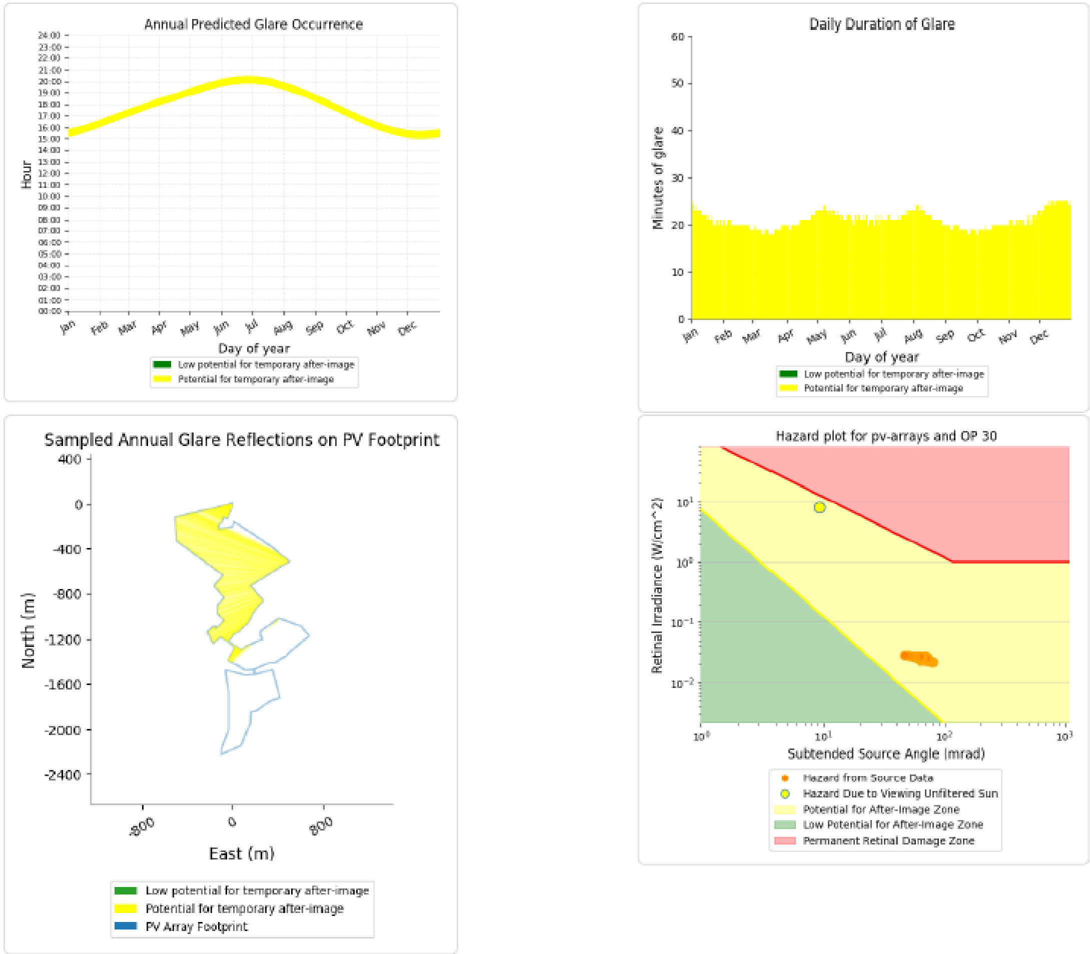
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 7,613 minutes of "yellow" glare with potential to cause temporary after-image.



PV Arrays - OP Receptor (OP 30)

PV array is expected to produce the following glare for receptors at this location:

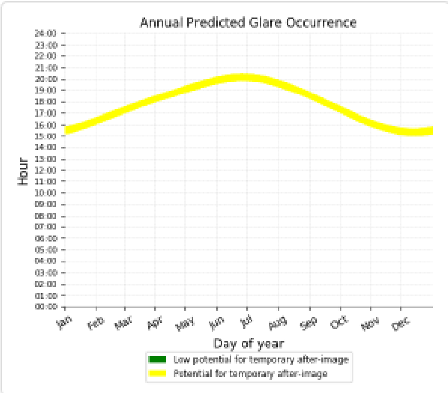
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 7,698 minutes of "yellow" glare with potential to cause temporary after-image.

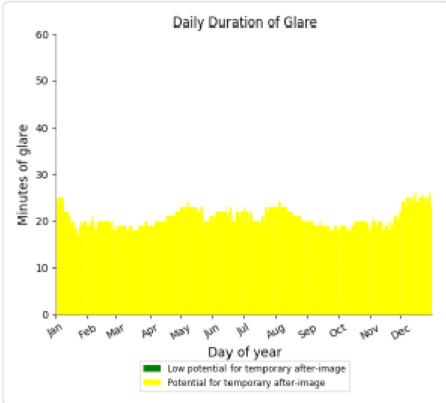


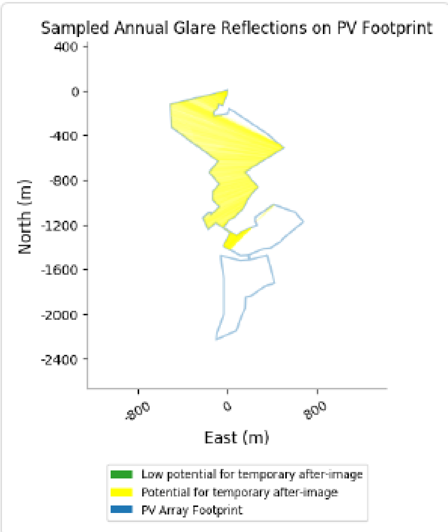
PV Arrays - OP Receptor (OP 31)

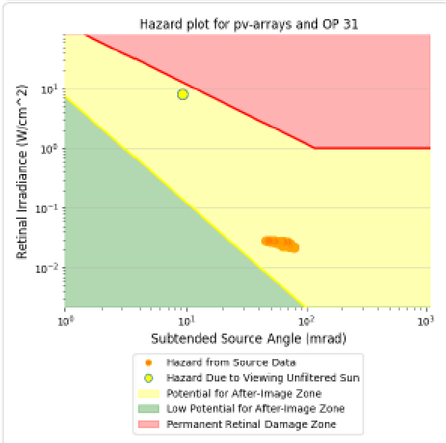
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 7,603 minutes of "yellow" glare with potential to cause temporary after-image.





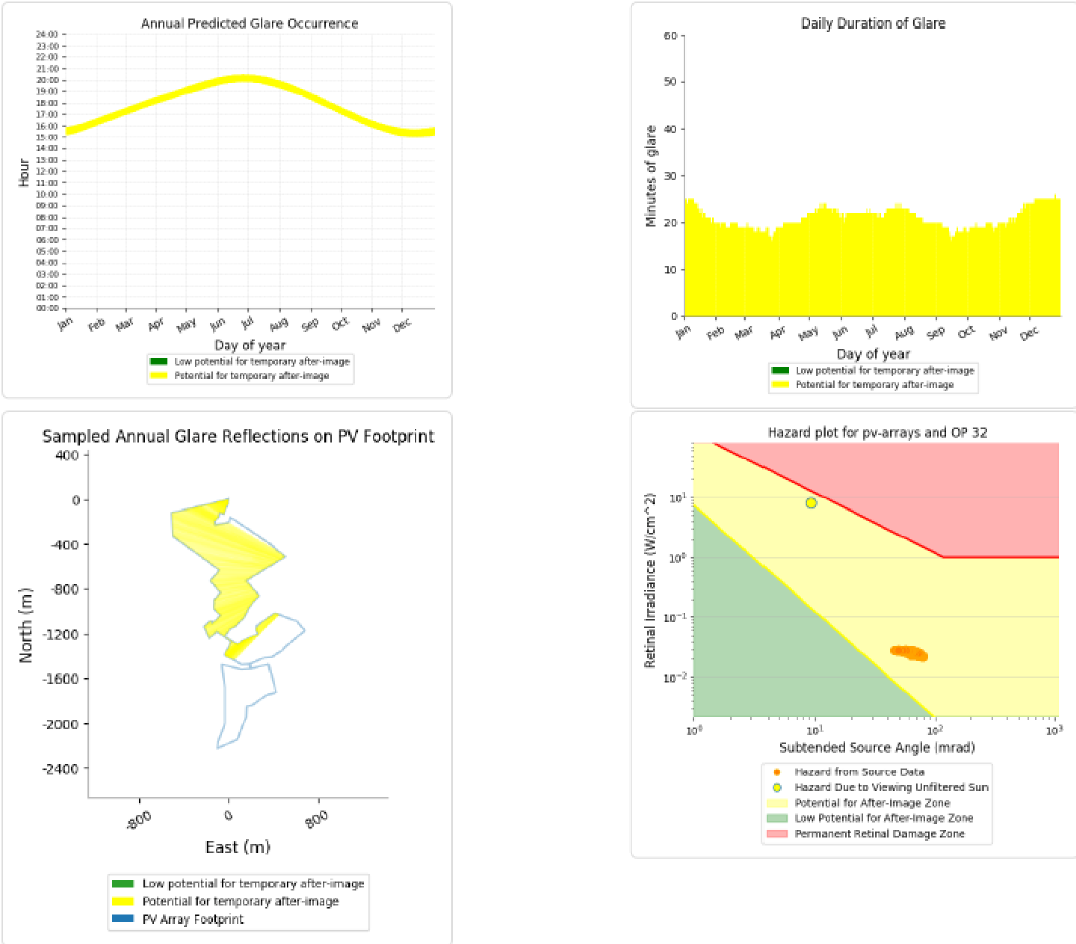




PV Arrays - OP Receptor (OP 32)

PV array is expected to produce the following glare for receptors at this location:

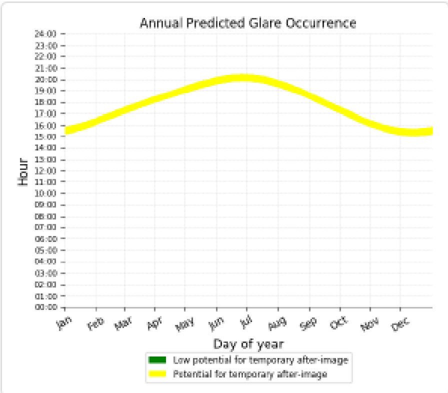
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 7,709 minutes of "yellow" glare with potential to cause temporary after-image.

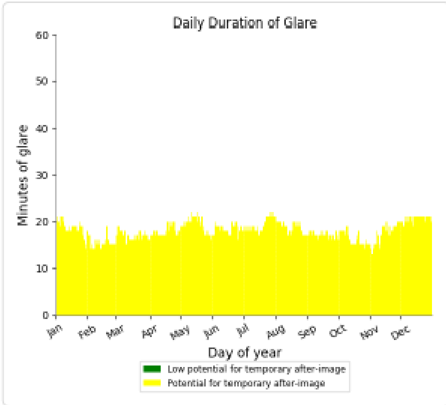


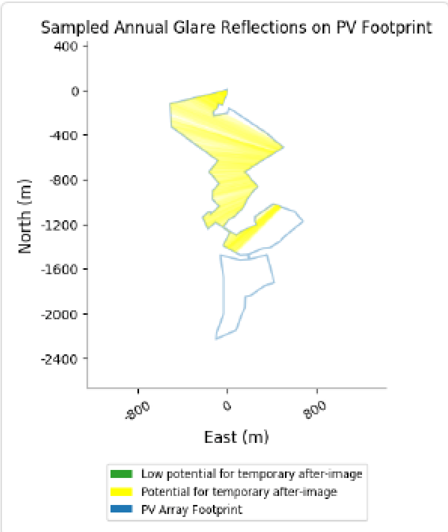
PV Arrays - OP Receptor (OP 33)

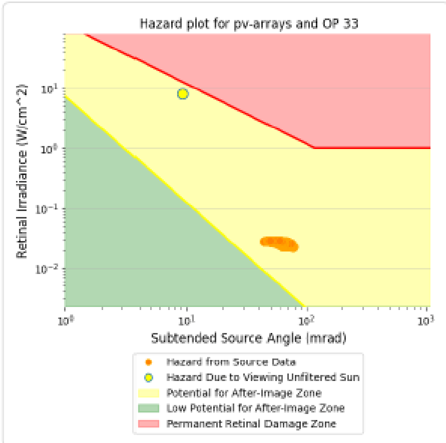
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 6,593 minutes of "yellow" glare with potential to cause temporary after-image.





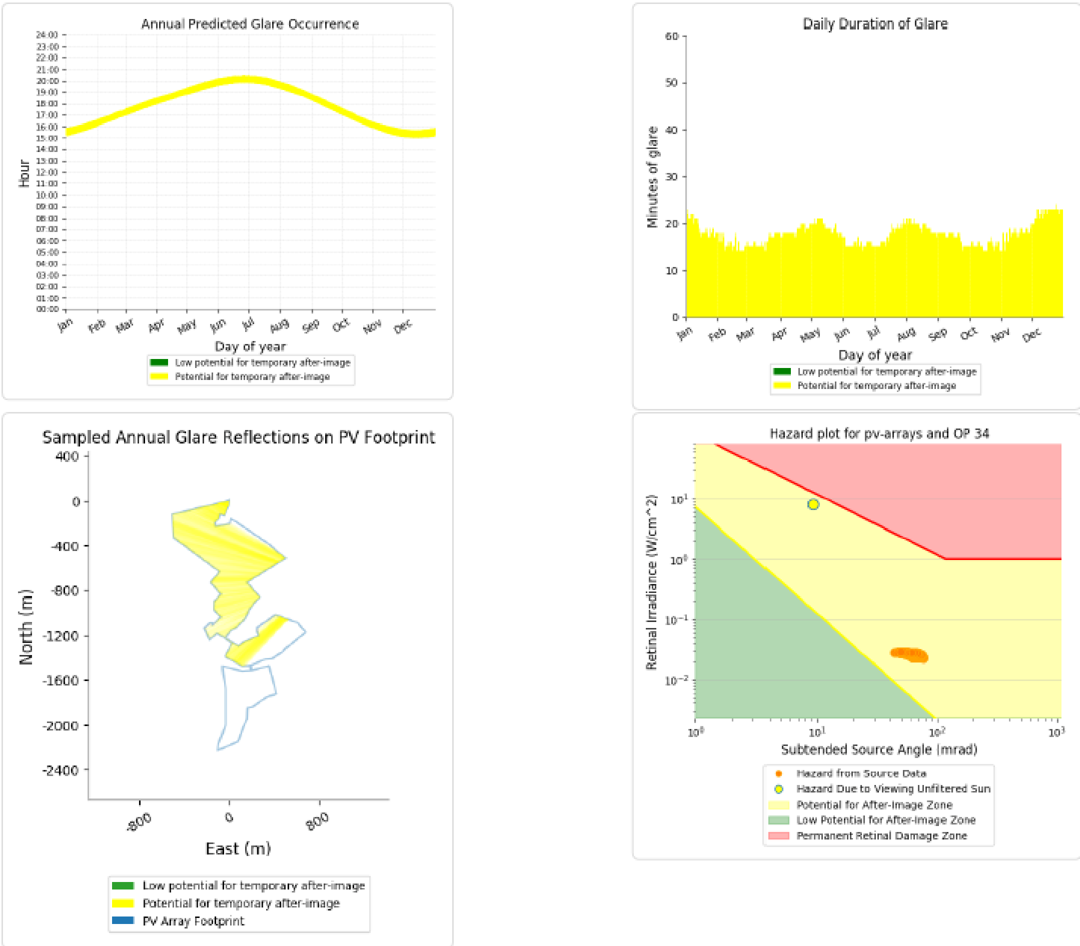




PV Arrays - OP Receptor (OP 34)

PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 6,506 minutes of "yellow" glare with potential to cause temporary after-image.



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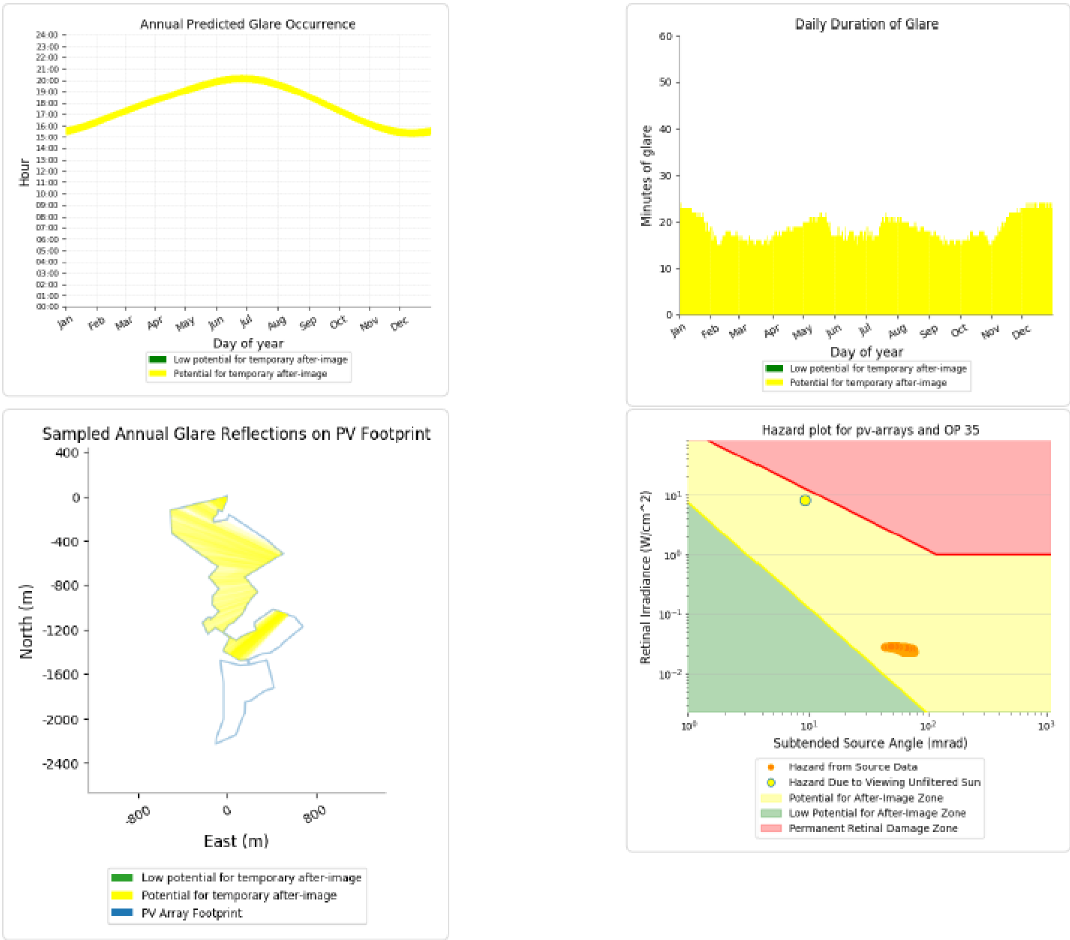
PV Arrays - OP Receptor (OP 35)

PV array is expected to produce the following glare for receptors at this location:

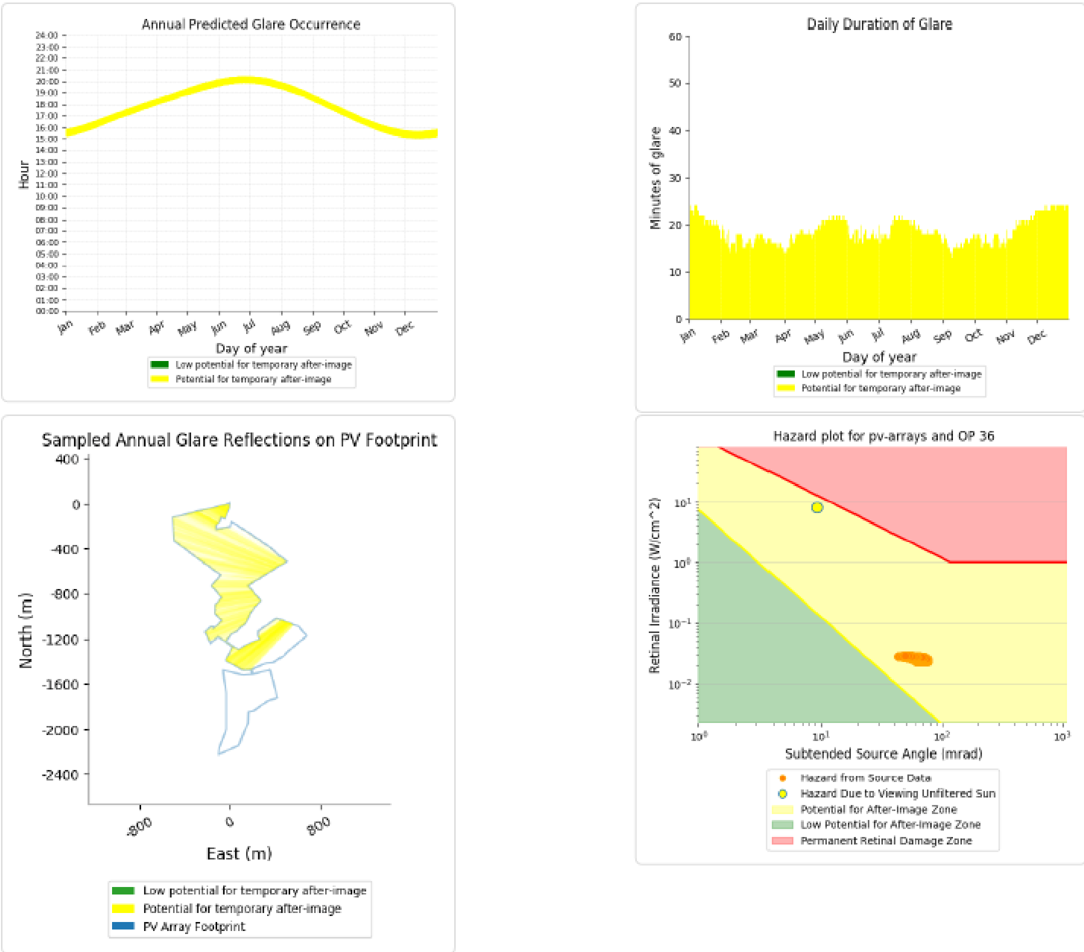
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 6,857 minutes of "yellow" glare with potential to cause temporary after-image.



PV Arrays - OP Receptor (OP 36)

PV array is expected to produce the following glare for receptors at this location:

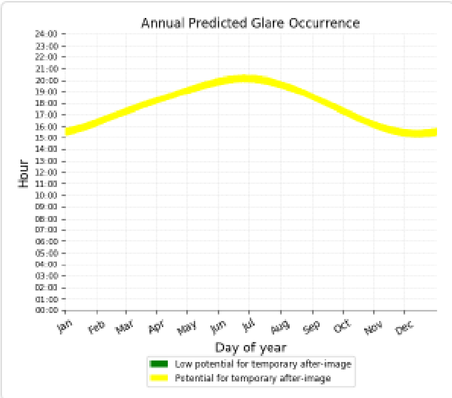
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 6,849 minutes of "yellow" glare with potential to cause temporary after-image.

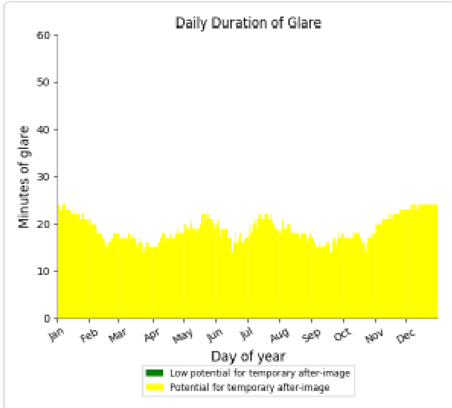


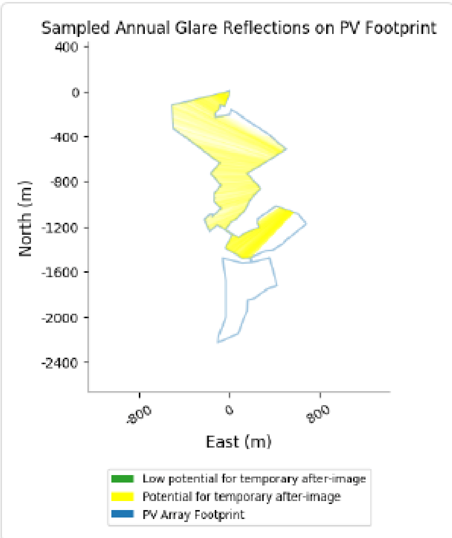
PV Arrays - OP Receptor (OP 37)

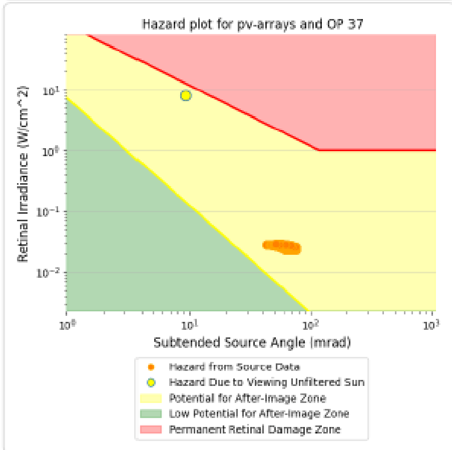
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 6,941 minutes of "yellow" glare with potential to cause temporary after-image.





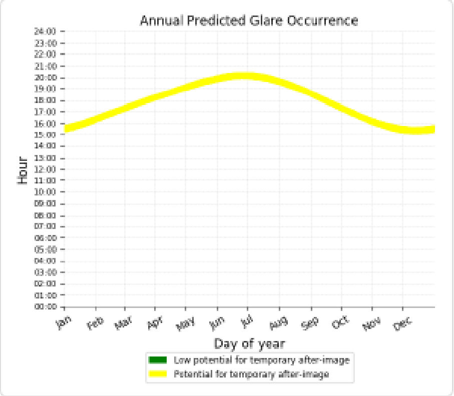


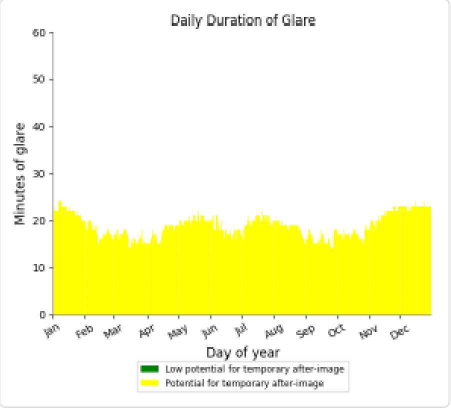


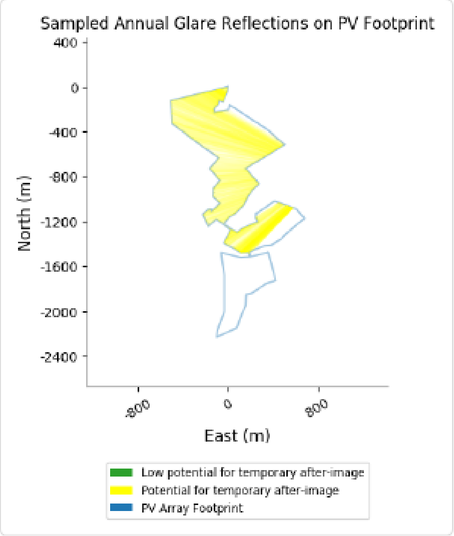
PV Arrays - OP Receptor (OP 38)

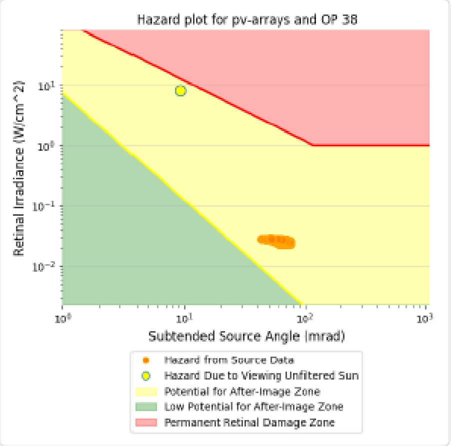
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 6,913 minutes of "yellow" glare with potential to cause temporary after-image.





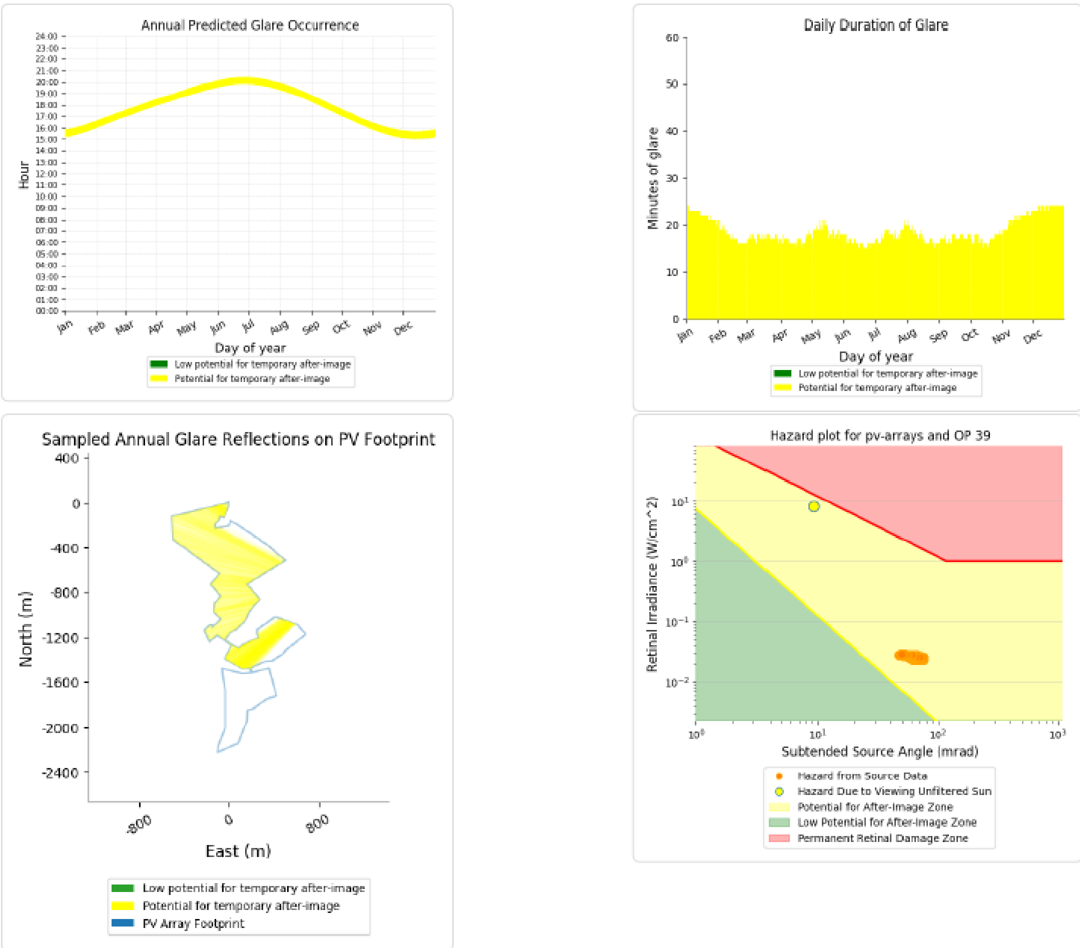




PV Arrays - OP Receptor (OP 39)

PV array is expected to produce the following glare for receptors at this location:

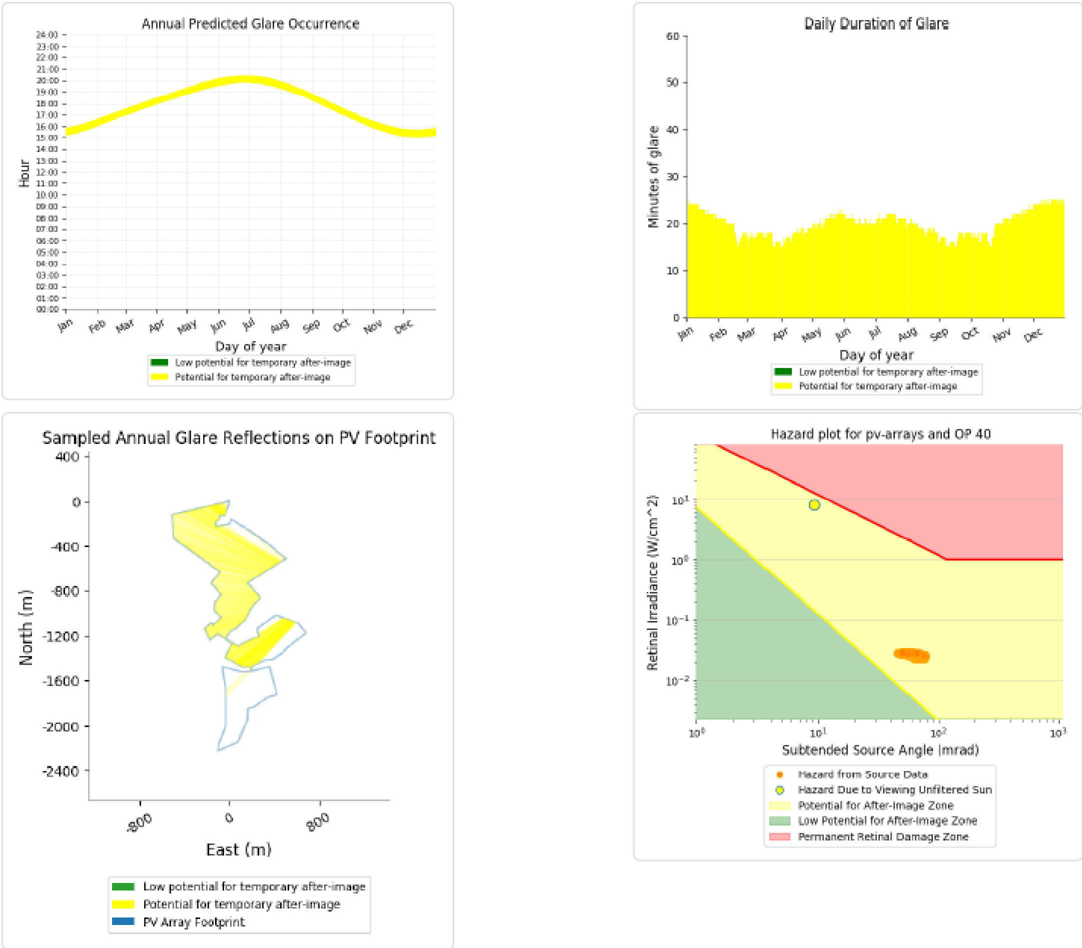
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 6,797 minutes of "yellow" glare with potential to cause temporary after-image.



PV Arrays - OP Receptor (OP 40)

PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 7,272 minutes of "yellow" glare with potential to cause temporary after-image.



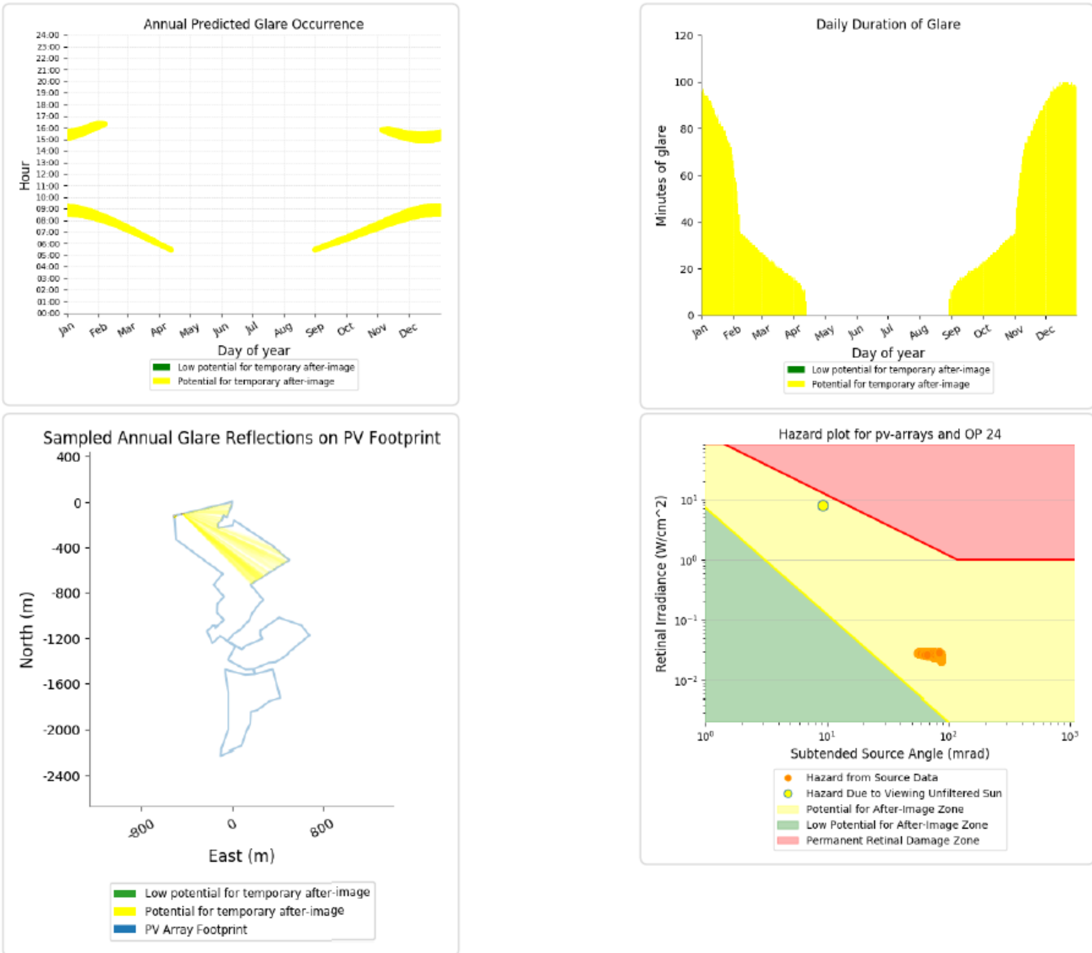
Road Receptors

The charts below relate to the road receptors where moderate impacts have been predicted. Modelling output for the remaining receptors can be provided on request.

PV Arrays - OP Receptor (OP 24)

PV array is expected to produce the following glare for receptors at this location:

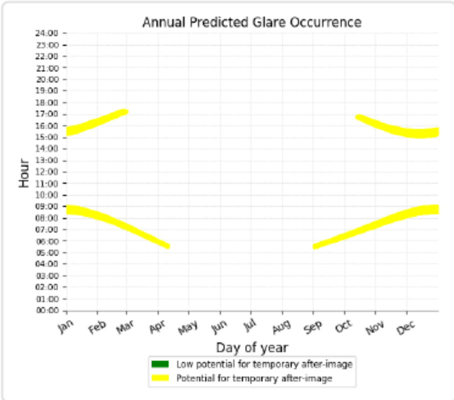
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 11,142 minutes of "yellow" glare with potential to cause temporary after-image.

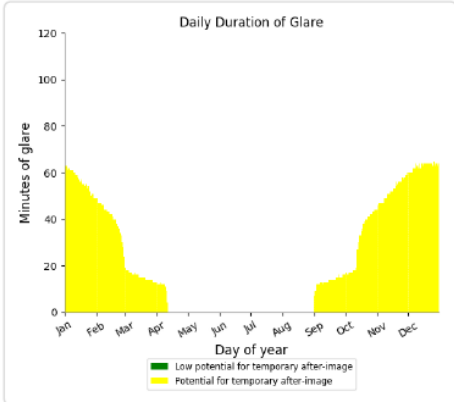


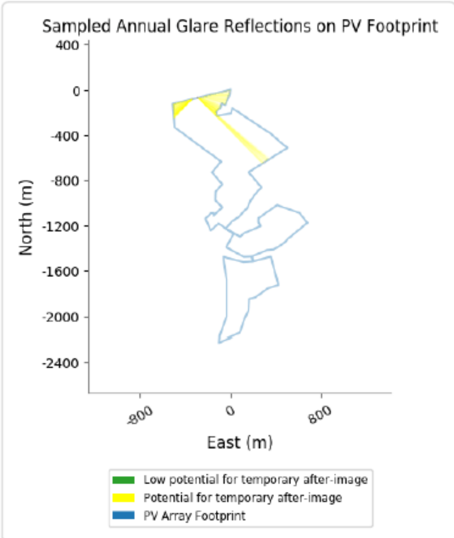
PV Arrays - OP Receptor (OP 25)

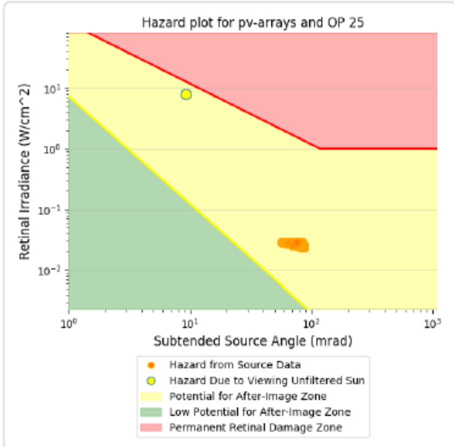
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 8,360 minutes of "yellow" glare with potential to cause temporary after-image.





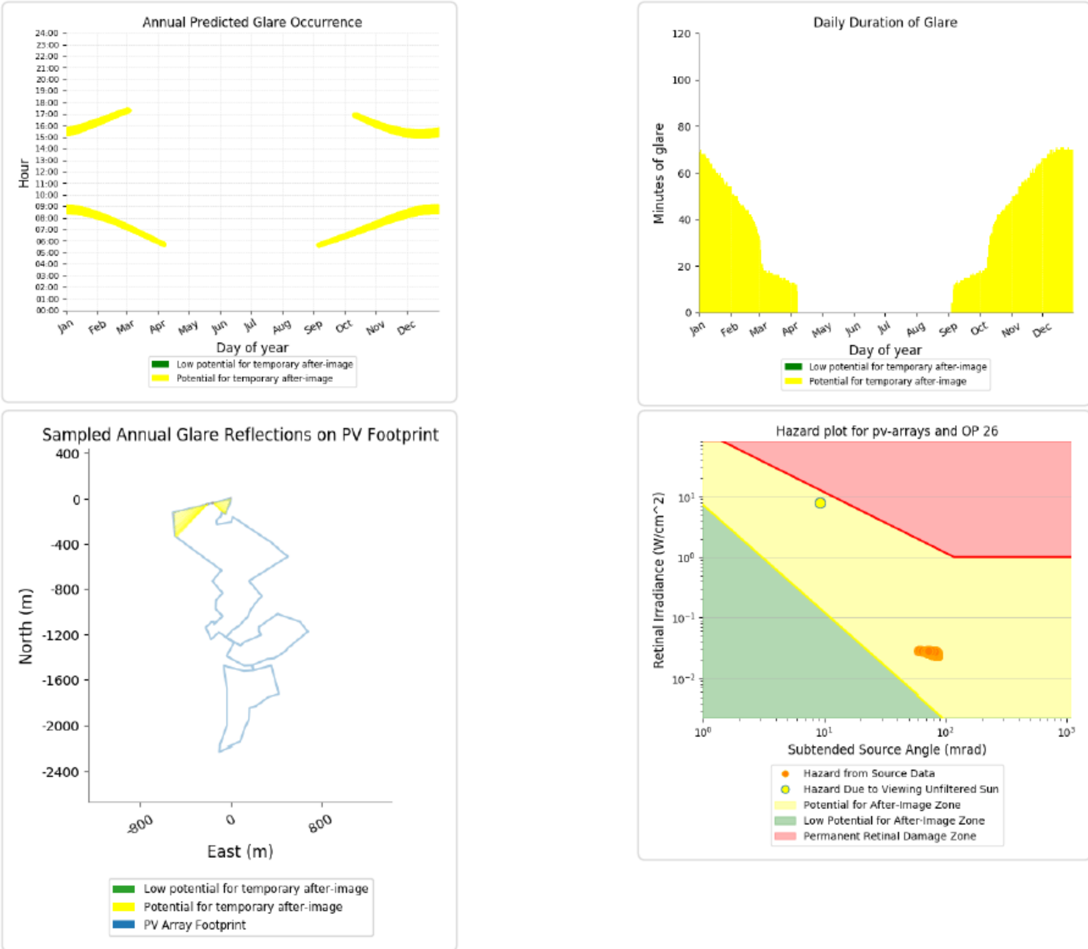




PV Arrays - OP Receptor (OP 26)

PV array is expected to produce the following glare for receptors at this location:

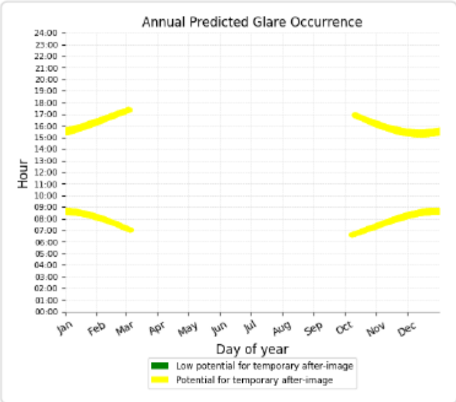
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 9,127 minutes of "yellow" glare with potential to cause temporary after-image.

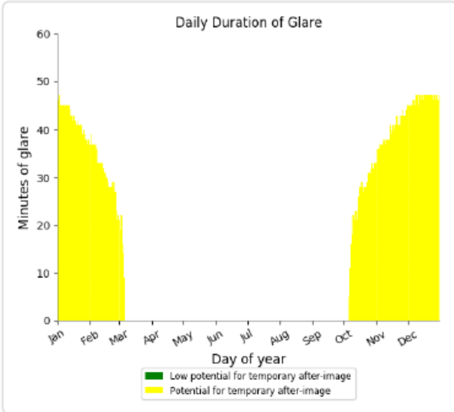


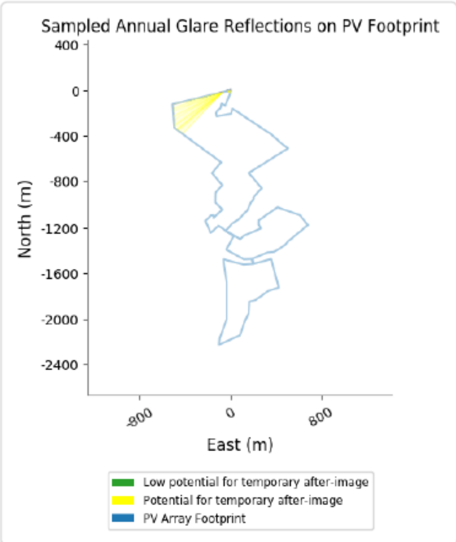
PV Arrays - OP Receptor (OP 27)

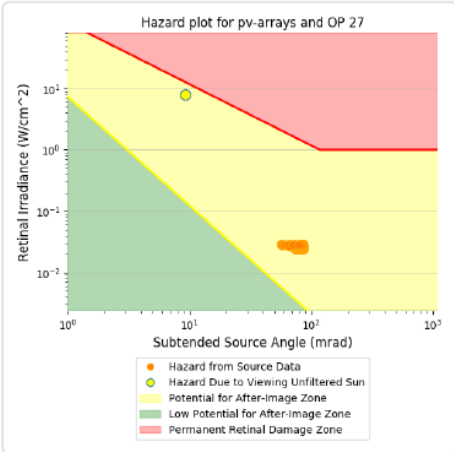
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 5,592 minutes of "yellow" glare with potential to cause temporary after-image.









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