Mallard Pass

Solar Farm

Mallard Pass Solar Farm

Environmental Statement Volume 2
Appendix 15.3: Glint and Glare Study

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PAGERPOWER
Urban & Renewables

Solar Photovoltaic Glint and Glare Study

LDA Design Consulting Ltd

Mallard Pass Solar Farm

August 2022

PLANNING SOLUTIONS FOR:

- Solar
- Telecoms
- Railways
- Defence
- Buildings
- Wind
- Airports
- Radar
- Mitigation

[redacted]

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EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to assess the possible effects of glint and glare from the proposed Mallard Pass Solar Farm, located at Essendine, Stamford, Lincolnshire. This assessment pertains to the possible effects upon road users, residential amenity, aviation activity, and railway operations and infrastructure.

The modelling has considered both fixed and single-axis tracker solar panel layouts.

Conclusions

No significant impacts upon surrounding aviation activity, road users, or railway operations and infrastructure are predicted for either fixed or tracker panel layouts.

Significant impacts upon one dwelling are predicted for both fixed and tracker panel layouts following expert assessment of the glare scenario. Mitigation in the form of screening has been recommended to remove these significant impacts.

Guidance and Studies

Pager Power has produced guidance for glint and glare and solar photovoltaic developments, which was published in early 2017, with the third edition originally published in 2020[1]. The guidance document sets out the methodology for assessing roads, dwellings, aviation activity, and railway operations and infrastructure with respect to solar reflections from solar panels.

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

The available studies have measured the intensity of reflections from solar panels with respect to other naturally occurring and manmade surfaces. The results show that the reflections produced are of intensity similar to or less than those produced from still water and significantly less than reflections from glass and steel[2].

[1] Pager Power Glint and Glare Guidance, Third Edition (3.1), April 2021.

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

Assessment Results – RAF Wittering

ATC Tower

The modelling has shown that no solar reflections are geometrically possible towards the ATC Tower at RAF Wittering from both fixed and tracker panel layouts.

No impacts upon ATC personnel are predicted and no mitigation is required.

Approach Paths

The modelling has shown that no solar reflections are geometrically possible towards either of the 2-mile approach paths for runway 07/25 at RAF Wittering from both fixed and tracker panel layouts.

No impacts upon approaching aircraft are predicted and no mitigation is required.

Assessment Results – High Level Aviation

Detailed modelling of Shacklewell Airfield, Castle Bytham Airfield and RAF Cottesmore is not recommended as all potential solar reflections are predicted to be acceptable in accordance with the associated guidance and industry best practice – see Section 9.

No significant impacts upon Shacklewell Airfield, Castle Bytham Airfield and RAF Cottesmore are predicted.

Assessment Result – Roads

Fixed Panels

The modelling has shown that solar reflections are geometrically possible towards approximately 2.3km of the B1176 and 2.3km of the A6121.

Significant screening in the form of existing vegetation and proposed screening / structure planting tree belt is predicted to significantly obstruct all views of the reflecting panels.

No impacts upon road users along the A6121 and B1176 are predicted, and no further mitigation is required.

Tracker Panels

The modelling has shown that solar reflections are geometrically possible towards approximately 2.7km of the B1176 and 2.0km of the A6121.

Significant screening in the form of existing vegetation and proposed screening / structure planting tree belt is predicted to significantly obstruct all views of the reflecting panels.

No impacts upon road users along the A6121 and B1176 are predicted, and no further mitigation is required.

Assessment Results – Dwellings

Fixed Panels

The modelling has shown that solar reflections are geometrically possible towards receptors 113 of the 179 assessed dwelling receptors. Solar reflections towards most of these dwellings are predicted to be significantly obstructed by existing and proposed screening, or they do not occur for a duration that could be considered significant.

Solar reflections towards seven dwellings occur for a duration which requires further consideration. Mitigation is not recommended for six of these dwellings because:

- The distance between the observer and the closest reflecting panel area is such that the proportion of an observer's field of vision that is taken up by the reflecting area is significantly reduced;
- Views are only predicted for observers above the ground floor, which is not considered to be the main living space of a dwelling; and/or
- Effects will coincide with direct sunlight, which is a far more significant source of light compared to a solar reflection.

Mitigation is recommended for one dwelling due to the duration of effects and the lack of sufficient mitigating factors to reduce the level of impact – see Section 8.2.1.

Tracker Panels

The modelling has shown that solar reflections are geometrically possible towards 108 of the 179 assessed dwelling receptors. Solar reflections towards most of these dwellings are predicted to be significantly obstructed by existing and proposed screening, or they do not occur for a duration that could be considered significant.

Solar reflections towards five dwellings occur for a duration which requires further consideration. Mitigation is not recommended for four of these dwellings because:

- The distance between the observer and the closest reflecting panel area is such that the proportion of an observer's field of vision that is taken up by the reflecting area is significantly reduced;
- Views are only predicted for observers above the ground floor, which is not considered to be the main living space of a dwelling; and/or
- Effects will coincide with direct sunlight, which is a far more significant source of light compared to a solar reflection.

Mitigation is recommended for one dwelling due to the duration of effects and the lack of sufficient mitigating factors to reduce the level of impact – see Section 8.2.2.

Assessment Results – Railway

Signals

No railway signals have been identified on the assessed section of railway line. No impacts upon railway signals are predicted.

This report will be updated if railway signals are identified by Network Rail at a later date.

Train Drivers (Fixed Panels)

The modelling has shown that solar reflections are geometrically possible towards train driver receptors along approximately 3.3km of railway line. Solar reflections towards most of these sections of railway line are predicted to be significantly obstructed by existing and proposed screening or occur from outside of a train driver's primary field of view (30 degrees either side of the direction of travel).

Solar reflections towards approximately 100m of railway line occur from within a train driver's primary field of view which requires further consideration. However, mitigation is not recommended for this section of railway line because:

- No views of railway signals, stations, level crossings, or switching points is required, suggesting that the workload of a train driver will be low;
- The distance between the observer and the closest reflecting panel area is such that the proportion of an observer's field of vision that is taken up by the reflecting area is significantly reduced;
- Effects will coincide with direct sunlight, which is a far more significant source of light compared to a solar reflection.

Train Drivers (Tracker Panels)

The modelling has shown that solar reflections are geometrically possible towards train drivers along approximately 1.2km of railway line.

Solar reflections towards all these sections of railway line are predicted to be significantly obstructed by existing and proposed screening or occur from outside of a train driver's primary field of view.

No significant upon train drivers along the assessed section of railway line are predicted, and no further mitigation is required.

Mitigation Overview

The optimal mitigation strategy is likely to involve the provision of screening to significantly obstruct visibility of the reflecting panels. It is recommended that the proposed screening is secured through the outline Landscape Ecological Management Plan (oLEMP).

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 54 countries within Europe, Africa, America, Asia and Australia.

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 the proposed Mallard Pass Solar Farm, located at Essendine, Stamford, Lincolnshire. This assessment pertains to the possible effects upon road users, residential amenity, aviation activity, and railway operations and infrastructure.

The modelling has considered both fixed and single-axis tracker solar panel layouts.

This report contains the following:

- Solar farm details;
- Explanation of glint and glare;
- Overview of relevant guidance;
- Overview of relevant studies;
- Overview of Sun movement;
- Assessment methodology;
- Identification of receptors;
- Glint and glare assessment for identified receptors;
- Results discussion; and
- High-level overview of mitigation options.

The relevant technical analysis is presented in each section. Following the assessment, conclusions and recommendations are made.

1.2 Pager Power's Experience

Pager Power has undertaken over 900 glint and glare assessments in the UK and internationally. The studies have included assessment of civil and military aerodromes, railway infrastructure and other ground-based receptors including roads and dwellings.

1.3 Glint and Glare Definition

The definition of glint and glare is as follows:

- Glint – a momentary flash of bright light typically received by moving receptors or from moving reflectors; and
- 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 Draft National Policy Statement for Renewable Energy Infrastructure. The term 'solar reflection' is used in this report to refer to both reflection types i.e. glint and glare.

2 PROPOSED SOLAR FARM LOCATION AND DETAILS

2.1 Proposed Development String Layouts

The string layouts for the proposed development are appended to the DCO application.

The fixed south facing panel string layouts are shown in:

- 7863_0170_Illustrative Layout FSF String Sheet 0 of 5;
- 7863_0171_Illustrative Layout FSF String Sheet 1 of 5;
- 7863_0172_Illustrative Layout FSF String Sheet 2 of 5;
- 7863_0173_Illustrative Layout FSF String Sheet 3 of 5;
- 7863_0174_Illustrative Layout FSF String Sheet 4 of 5;
- 7863_0175_Illustrative Layout FSF String Sheet 5 of 5.

The single-axis tracker panel string layouts are shown in:

- 7863_0190_Illustrative Layout_SAT String Sheet 0 of 5;
- 7863_0191_Illustrative Layout_SAT String Sheet 1 of 5;
- 7863_0192_Illustrative Layout_SAT String Sheet 2 of 5;
- 7863_0193_Illustrative Layout_SAT String Sheet 3 of 5;
- 7863_0194_Illustrative Layout_SAT String Sheet 4 of 5;
- 7863_0195_Illustrative Layout_SAT String Sheet 5 of 5.

The panel areas used for the purposes of this assessment are presented in Section 6.

2.2 Fixed Solar Panel Information

The technical information used for the modelling of the fixed solar panels are presented in Table 1 below. The centre of the solar panel has been used as the assessed height in metres above ground level (agl).

Fixed Solar Panel Technical Information	
Azimuth angle	180°
Elevation angle (tilt)	20°
Assessed centre height (agl)	2.15m

Table 1 *Fixed solar panel information*

2.3 Tracker Solar Panel Information

The technical information used for the modelling of the tracker solar panels are presented in Table 2 below.

Tracker Solar Panel Technical Information	
Assessed centre-height (m)	2.0 agl (above ground level)
Tracking	Horizontal Single Axis tracks Sun East to West
Tilt of tracking axis (°)	0
Orientation of tracking axis (°)	180
Offset angle of module (°)	0
Tracker Range of Motion (°)	±60
Resting angle (°)	0
Surface material	Smooth glass without an ARC (anti-reflective coating)

Table 2 *Tracker solar panel information*

2.3.1 Solar Panel Back Tracking

Shading considerations 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 angle in order to avoid the shading Figure 1 on the following page illustrates this.

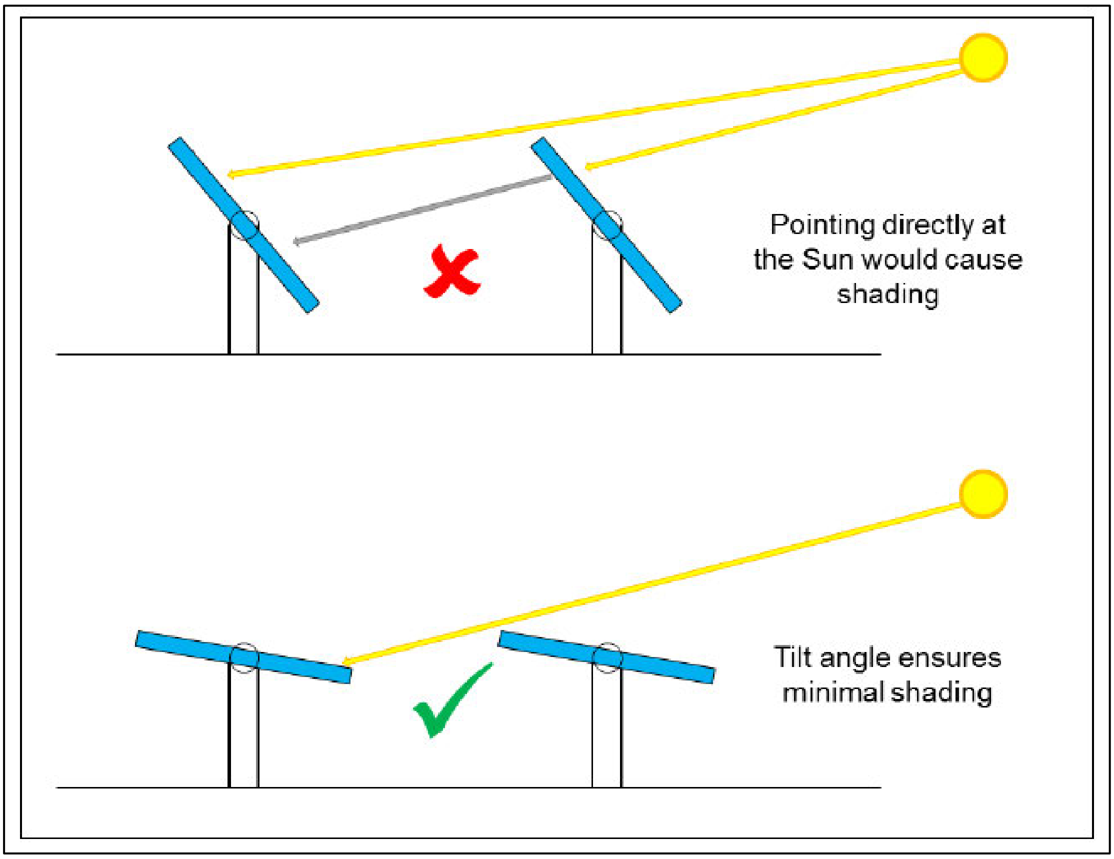

Figure 1 *Shading considerations*

Later in the day, the panels can be directed towards the Sun without any shading issues. This is illustrated in Figure 2 below.

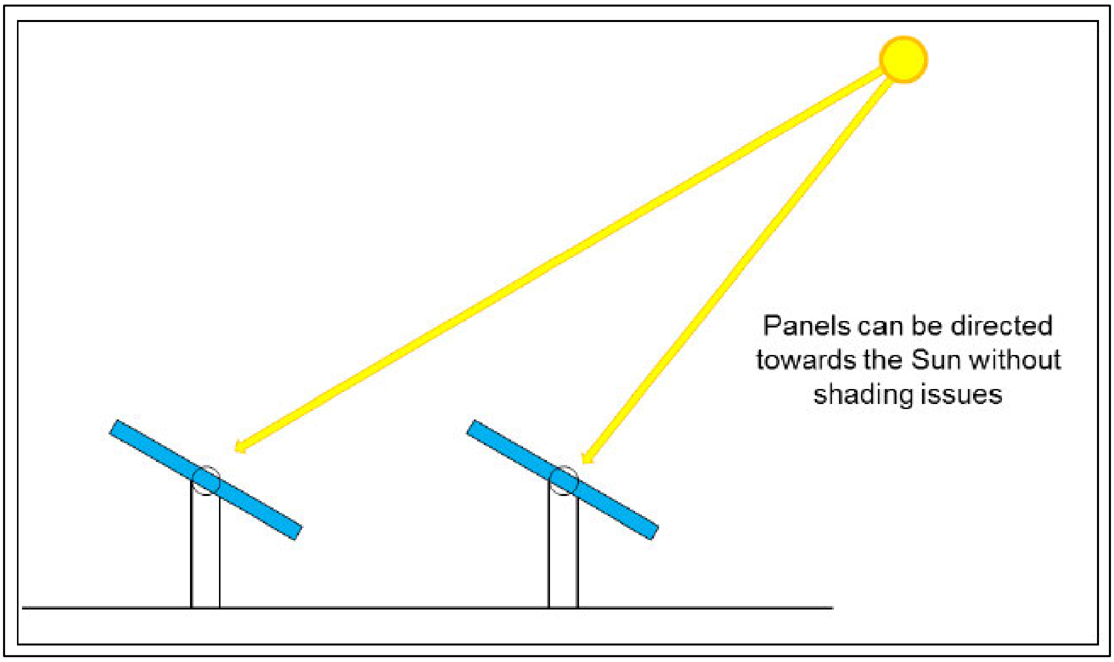

Figure 2 *Panel alignment at high solar angles*

Note that 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.

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

2.3.2 **Back Tracking Solar Panel Model**

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 back tracking system by assuming the panels instantaneously revert to its resting angle of 0 degrees whenever the sun is outside the rotation range (60 degrees in this instance). Panels with a maximum tracking angle of 60 degrees and resting angle of 0 degrees 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. This definition is taken from Forge (see Appendix E) and by rotation range it is assumed the panels remain at 0 degrees until the Sun reaches 30 degrees above the horizon – when the Sun is at right angles to the panels at 60 degrees. It is understood that this option was created specifically to account for back tracking to the extent possible.

Whilst this model simplifies the back tracking 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.

3 RAF WITTERING DETAILS

3.1 Overview

The following sections present general details regarding RAF Wittering.

3.2 Aerodrome Information

RAF Wittering is a Ministry of Defence (MoD) aerodrome and is the main operating base and headquarters for the RAF A4 Force.

The aerodrome is located approximately 6.7km south of the proposed development.

3.3 Runway Details

RAF Wittering has one runway:

- 07/25 – 2,757m by 56m (Asphalt).

The runway is shown in Figure 3[3] (aerodrome chart) on the following page.

3.4 Air Traffic Control Tower

RAF Wittering has an Air Traffic Control (ATC) Tower located approximately 240m south of the centre of runway 07/25 and is circled in red in Figure 3.

[3] Source: [redacted]

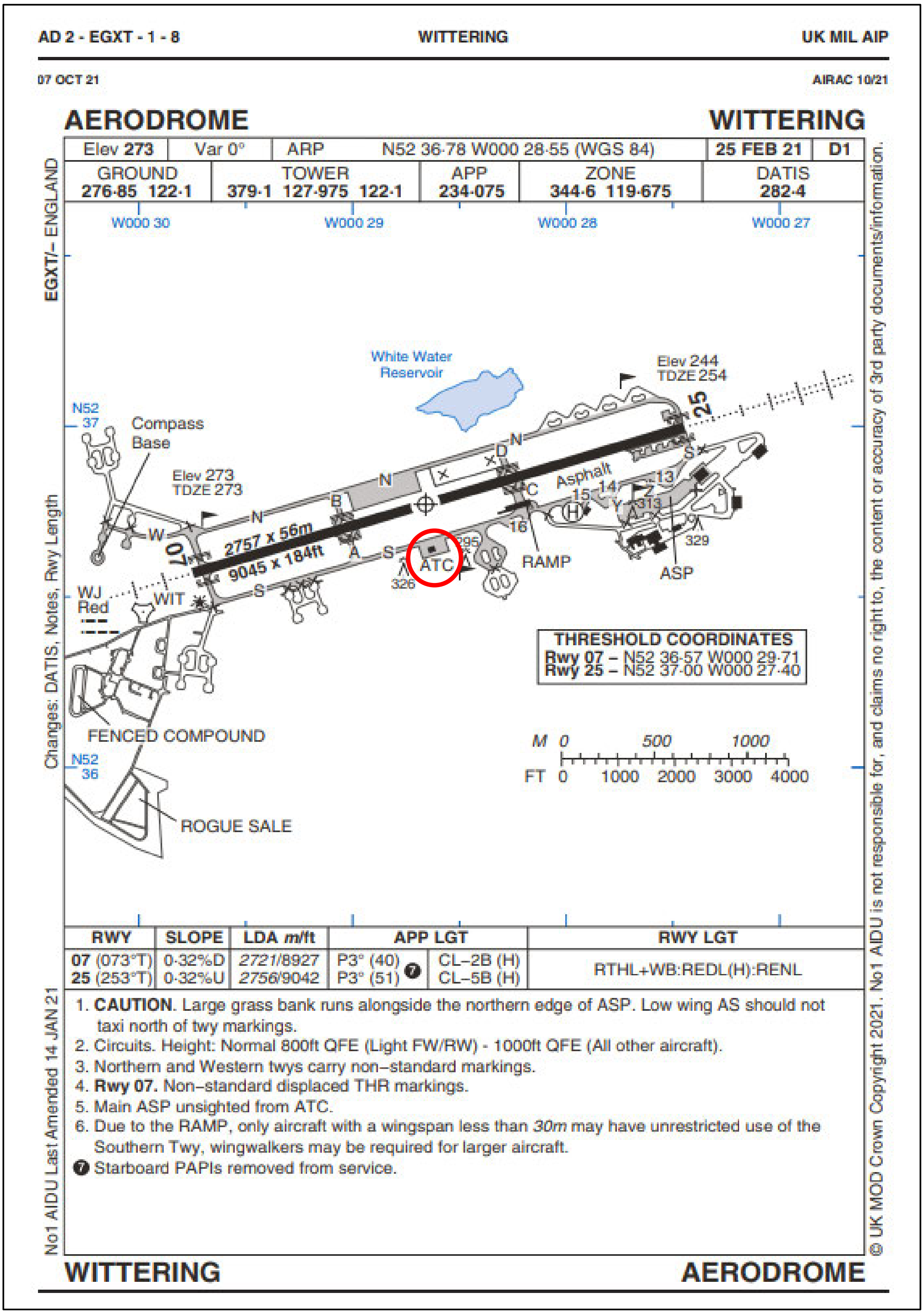

Figure 3 *RAF Wittering aerodrome chart*

4 GLINT AND GLARE ASSESSMENT METHODOLOGY

4.1 Guidance and Studies

Appendices A and B present a review of relevant guidance and independent studies regarding 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; and
- 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.

4.2 Background

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

4.3 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 this glint and glare assessment 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 – including intensity calculations where appropriate; and
- Determine whether a significant detrimental impact is expected in line with the process presented in Appendix D.

Within the Pager Power model, the solar development 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. Further technical details relating to the methodology of the geometric calculations and limitations are presented in Appendix E and F.

5 IDENTIFICATION OF RECEPTORS

5.1 Aviation Receptors

The aviation receptor details are presented in the following sub-sections. The receptor details are presented in Appendix G and the terrain elevations have been interpolated based on Ordnance Survey of Great Britain (OSGB) 50m Panorama data.

5.1.1 Air Traffic Control (ATC) Tower

It is important to determine whether a solar reflection can be experienced by personnel within the ATC Tower.

The coordinates and height of the ATC tower have been extrapolated from aerial and online imagery.

5.1.2 Approaching Aircraft

It is Pager Power's methodology to assess whether a solar reflection can be experienced on the approach paths for the associated runways. This is considered to be the most critical stage of the flight. The Pager Power approach for determining receptor (aircraft) locations on the approach path is to select locations along the extended runway centre line from 50ft above the runway threshold out to a distance of 2 miles. The height of the aircraft is determined by using a 3-degree descent path relative to the runway threshold height.

Figure 4 on the following page shows the assessed aviation receptor locations

Figure 4 *Assessed aviation receptors at RAF Wittering*

5.2 Ground-Based Receptors

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

The above parameters and extensive experience over a significant number of glint and glare assessments undertaken, shows that a 1km assessment area from the proposed panel area is appropriate for glint and glare effects on ground-based receptors (road users and dwellings), and a 500m assessment area is appropriate for railway receptors.

Potential receptors within the assessment areas 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 OSGB 50m Panorama data. Receptor details can be found in Appendix G.

5.2.1 Road Receptors

Road types can generally be categorised as:

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

Geometric modelling is not recommended for local roads, where traffic densities are likely to be relatively low. Any solar reflections from the proposed development that are experienced by a road user along a local road would be considered low impact in accordance with the guidance presented in Appendix D.

The analysis has therefore considered major national, national, and regional roads that:

- Are within the 1km assessment area; and
- Have a potential view of the panels.

The assessed receptors along the B1176 (1 – 39) and the A6121 (40 – 79); totalling approximately 8km of road, are shown in Figure 5 on the following page. The inset shows the specific numbering of the road receptors.

Receptors are taken approximately every 100m and a height of 1.5 metres above ground level has been taken as typical eye level of a road user[4].

[4] Consideration of views of elevated drivers are also considered in the results discussion, where appropriate.

Figure 5 *Assessed road receptors*

5.2.2 Dwelling Receptors

The analysis has considered dwellings that:

- Are within the 1km assessment area; and
- Have a potential view of the panels.

An overview of the assessed dwelling receptor locations are shown in Figure 6 below. A total of 179 dwelling locations have been assessed and a height of 1.8m above ground level is used in the modelling to simulate the typical viewing height of a ground floor window[5].

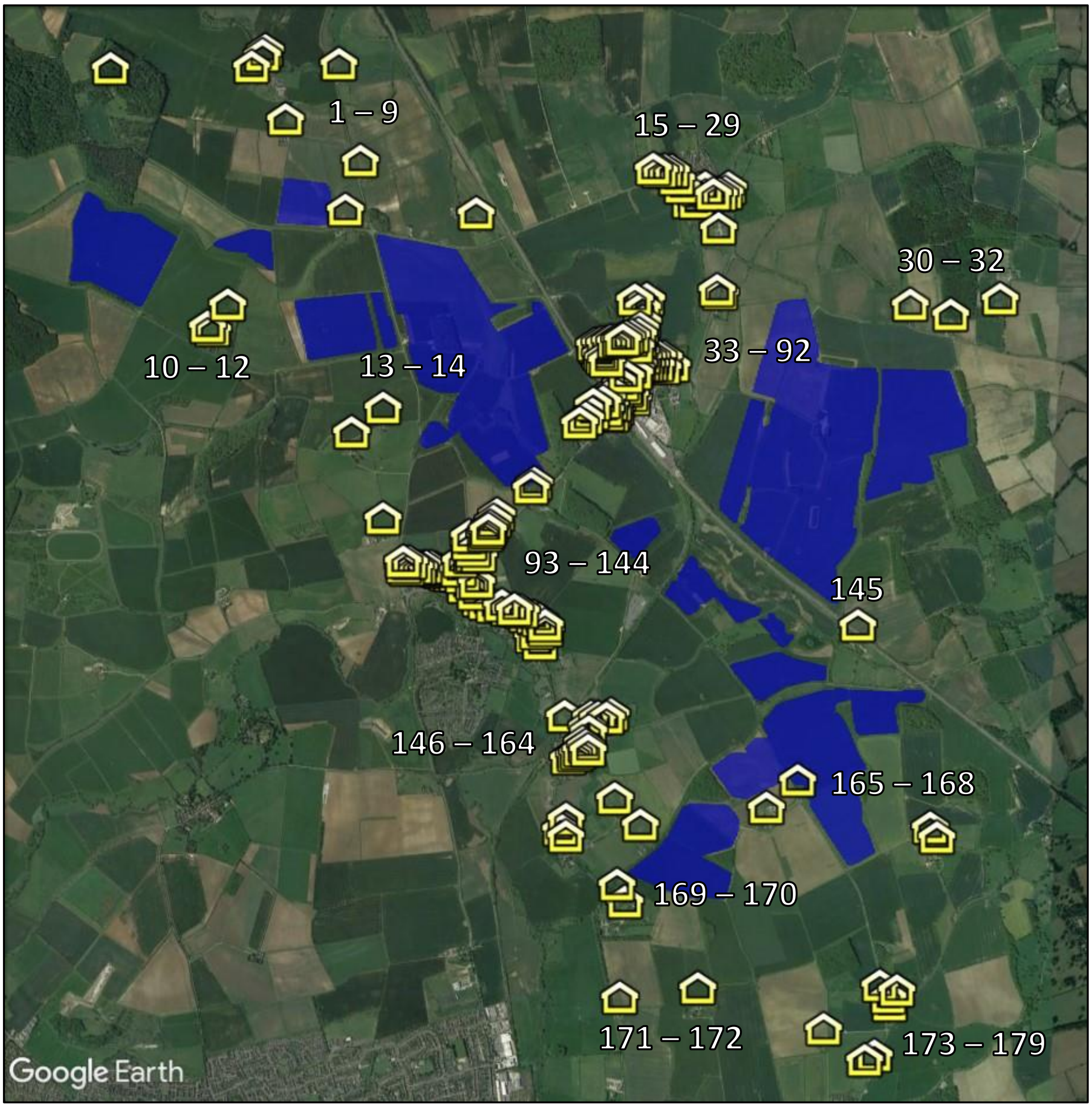

Figure 6 *Assessed dwelling receptor overview*

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

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

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

Close up images of the assessed dwelling receptors are shown in Figures 7 to 21 below and on the following pages.

Figure 7 *Assessed dwelling receptors 1 to 6*

Figure 8 *Assessed dwelling receptors 7 to 9*

Figure 9 *Assessed dwelling receptors 10 to 14*

Figure 10 *Assessed dwelling receptors 15 to 29*

Figure 11 *Assessed dwelling receptors 30 to 32*

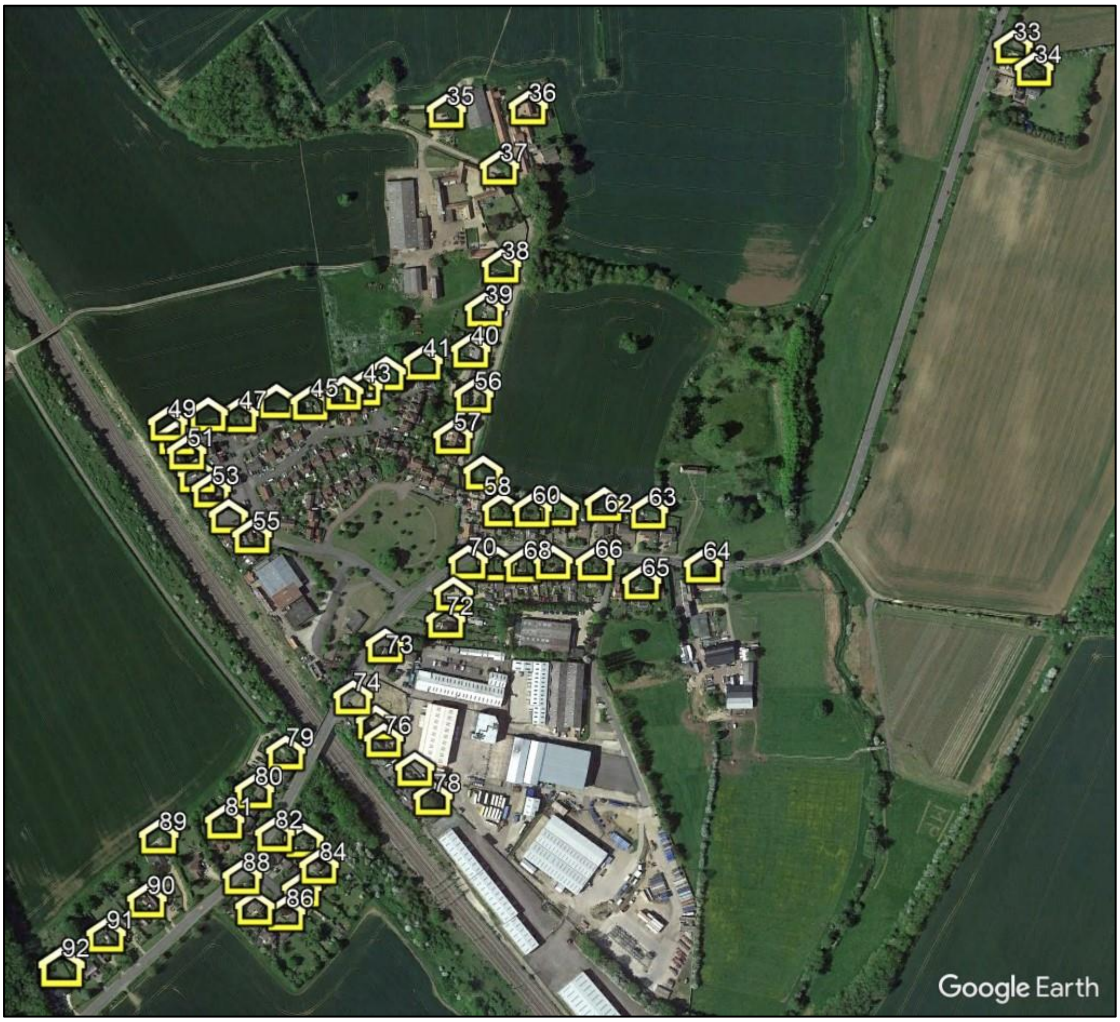

Figure 12 *Assessed dwelling receptors 33 to 92*

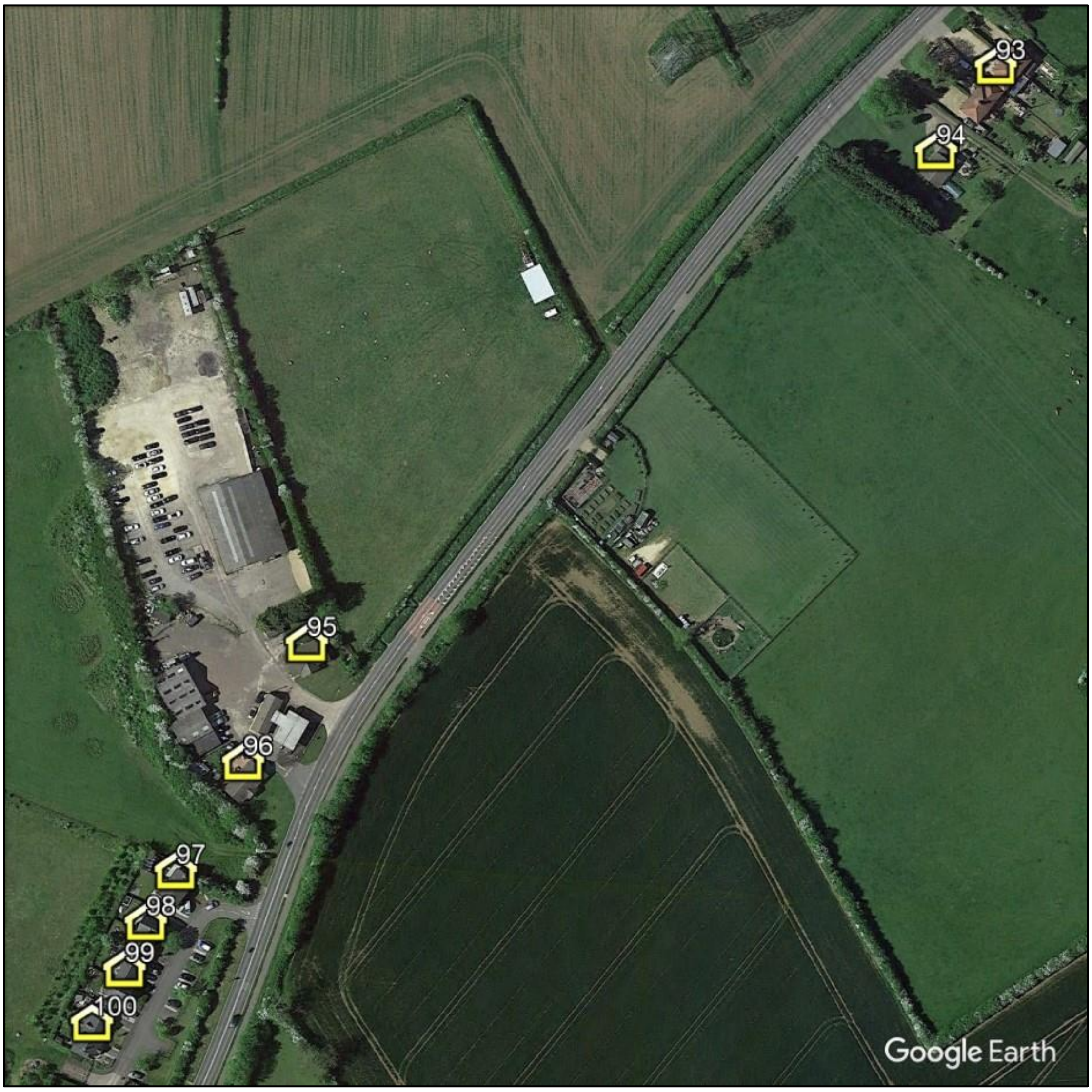

Figure 13 *Assessed dwelling receptors 93 to 100*

Figure 14 *Assessed dwelling receptors 101 to 125*

Figure 15 *Assessed dwelling receptors 126 to 144*

Figure 16 *Assessed dwelling receptor 145*

Figure 17 *Assessed dwelling receptors 146 to 159*

Figure 18 *Assessed dwelling receptors 160 to 164*

Figure 19 *Assessed dwelling receptors 165 to 168*

Figure 20 *Assessed dwelling receptors 169 to 172*

Figure 21 *Assessed dwelling receptors 173 to 179*

5.2.3 Railway Receptors

Railway Signals

The analysis has considered railway signals that:

- Are within the 500m assessment area;
- Have a potential view of the panels.

No railway signals have been identified on the assessed section of railway line. No impacts upon railway signals are predicted.

This report will be updated if railway signals are identified by Network Rail at a later date.

Train Drivers

The analysis has considered train driver locations that:

- Are within the 500m assessment area;
- Have a potential view of the panels.

The locations of the assessed train driver receptors along approximately 5.1km of railway line are shown in Figure 22 below. The inset shows the specific numbering of the train driver receptors.

Receptors are taken approximately every 100m and the driver's eye level is assessed at 2.75m above rail level[6].

Figure 22 *Assessed train driver receptors*

[6] This height may vary based on driver height however this figure is used as the industry standard.

6 ASSESSED REFLECTOR AREAS

6.1 Reflector Areas

The reflector areas used in this assessment are the maximum panel footprints of the fixed south facing and single-axis tracker panels. The specific panel areas associated with each panel mounting system have been considered in the results discussion.

A number of representative panel locations are selected within the proposed reflector areas. The number of modelled reflector points is determined by the size of the reflector areas and the assessment resolution. The bounding co-ordinates for the proposed solar development have been extrapolated from the site plans and can be found in Appendix G. All ground heights have been based on OSGB36 terrain data.

A resolution of 30m has been chosen for this assessment. This means that a geometric calculation is undertaken for each identified receptor every 30m from within the defined areas. This resolution is sufficiently high to maximise the accuracy of the results – increasing the resolution further would not significantly change the modelling output. If a reflection is experienced from an assessed panel location, then it is likely that a reflection will be viewable from similarly located panels within the proposed solar development.

The assessed reflector areas are shown in Figure 23 below.

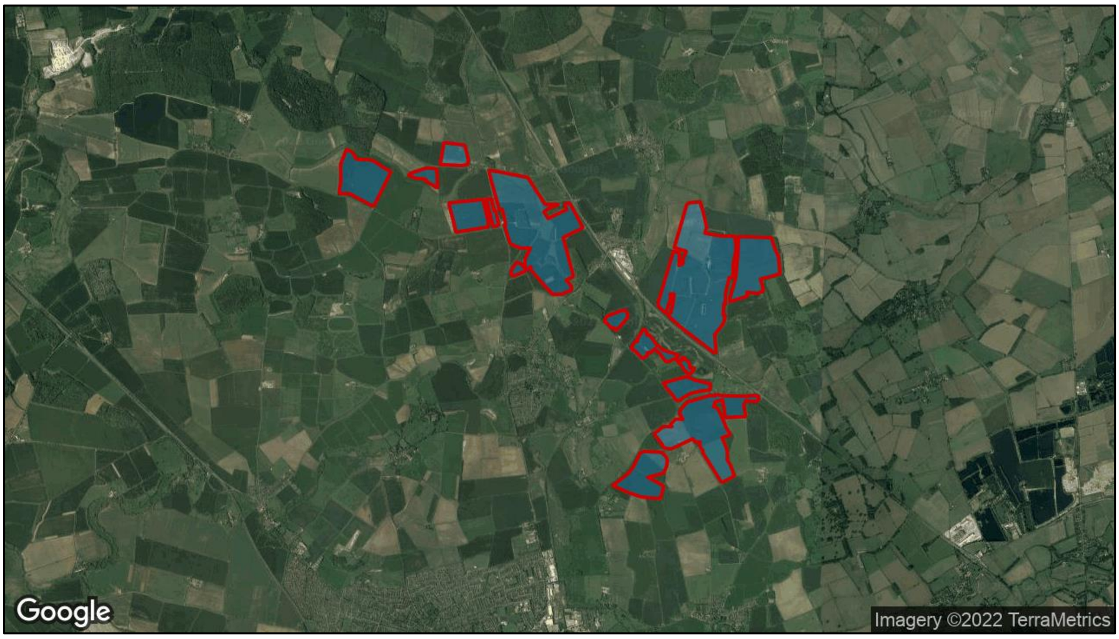

Figure 23 *Assessed reflector areas*

7 ASSESSMENT RESULTS AND DISCUSSION

7.1 Overview

The following sub-sections present the modelling results as well as the significance of any predicted impact in the context of existing and proposed screening implemented through the outline Landscape and Ecology Management Plan (oLEMP), as well as the relevant criteria set out in each sub-section. The criteria are determined by the assessment process for each receptor, which are set out in Appendix D.

When determining the visibility of the reflecting panels for an observer, a conservative review of the available imagery is undertaken, whereby it is assumed views of the panels are possible if it cannot be reliably determined that existing screening will remove effects.

The modelling output showing the precise predicted times and the reflecting panel areas for key receptors are presented in Appendix H.

7.1.1 Reflecting Solar Panels

Only solar reflections from solar panels within 1km of road and dwelling receptors, or 500m from railway receptors, are considered geometrically possible and included within the modelling output. This is because any solar reflections from panels beyond these distances are not considered significant in accordance with Pager Power's glint and glare guidance.

This approach is appropriate due to the complexity of the site as only glare that could be considered significant is considered and easier for interpretation of the modelling output.

7.2 Aviation Results

Where solar reflections are predicted for the aviation receptors, intensity calculations in line with Sandia National Laboratories' methodology are undertaken by a third-party model[7]. This model calculates the expected intensity of a reflection with respect to the potential for an after-image (or worse) occurring.

The designation used by the model is presented in Table 3 on the following page along with the associated colour coding.

[7] Forge Solar

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

Table 3 *Glare intensity designation*

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

In addition, the intensity model allows for assessment of a variety of solar panel surface materials. In the first instance, a surface material of 'smooth glass without an anti-reflective coating' has been assessed. Other surfaces that could be modelled include:

- Smooth glass without an anti-reflective coating;
- Light textured glass without an anti-reflective coating;
- Light textured glass with an anti-reflective coating; or
- Deeply textured glass[8].

7.2.1 ATC Tower

The results of the geometric modelling have shown that no solar reflections are geometrically possible towards the ATC tower at RAF Wittering from both fixed and tracker panel layouts.

No impacts upon ATC personnel are predicted and no mitigation is required.

7.2.2 Runway 07 Approach

The results of the geometric modelling have shown that no solar reflections are geometrically possible towards the runway 07 approach path from both fixed and tracker panel layouts.

No impacts upon approaching aircraft are predicted and no mitigation is required.

7.2.3 Runway 25 Approach

The results of the geometric modelling have shown that no solar reflections are geometrically possible towards the runway 25 approach path for both fixed and tracker panels.

No impacts upon approaching aircraft are predicted and no mitigation is required.

[8] Not believed to be commercially viable for solar panels currently.

7.3 Road Results

In accordance with Pager Power's glint and glare guidance, the key considerations for quantifying impact significance for road users along major national, national, and regional roads are:

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

Where reflections are not predicted to be experienced by a road user in practice, no impacts are predicted, and mitigation is not required.

Where reflections are predicted to be experienced from outside of a road user's primary field of view (50 degrees either side of the direction of travel), the impact significance is low, and mitigation is not required.

Where reflections are predicted to be experienced from inside of a road user's field of view but there are mitigating circumstances, expert assessment of the following mitigating factors is required to determine the mitigation requirement:

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

Where reflections are predicted to be experienced originate from directly in front of a road user and there are no further mitigating circumstances, the impact significance is high, and mitigation is required.

7.3.1 Fixed Panels

The modelling has shown that solar reflections are geometrically possible towards road receptors 12 – 35, 44 – 49, and 51 – 69, along approximately 2.3km of the B1176 and 2.3km of the A6121. The sections of road where solar reflections are considered geometrically possible are shown by the yellow lines in Figure 24 on the following page[9].

[9] The receptor numbers are not shown as the figure is intended to provide an indication of where solar reflections are geometrically possible.

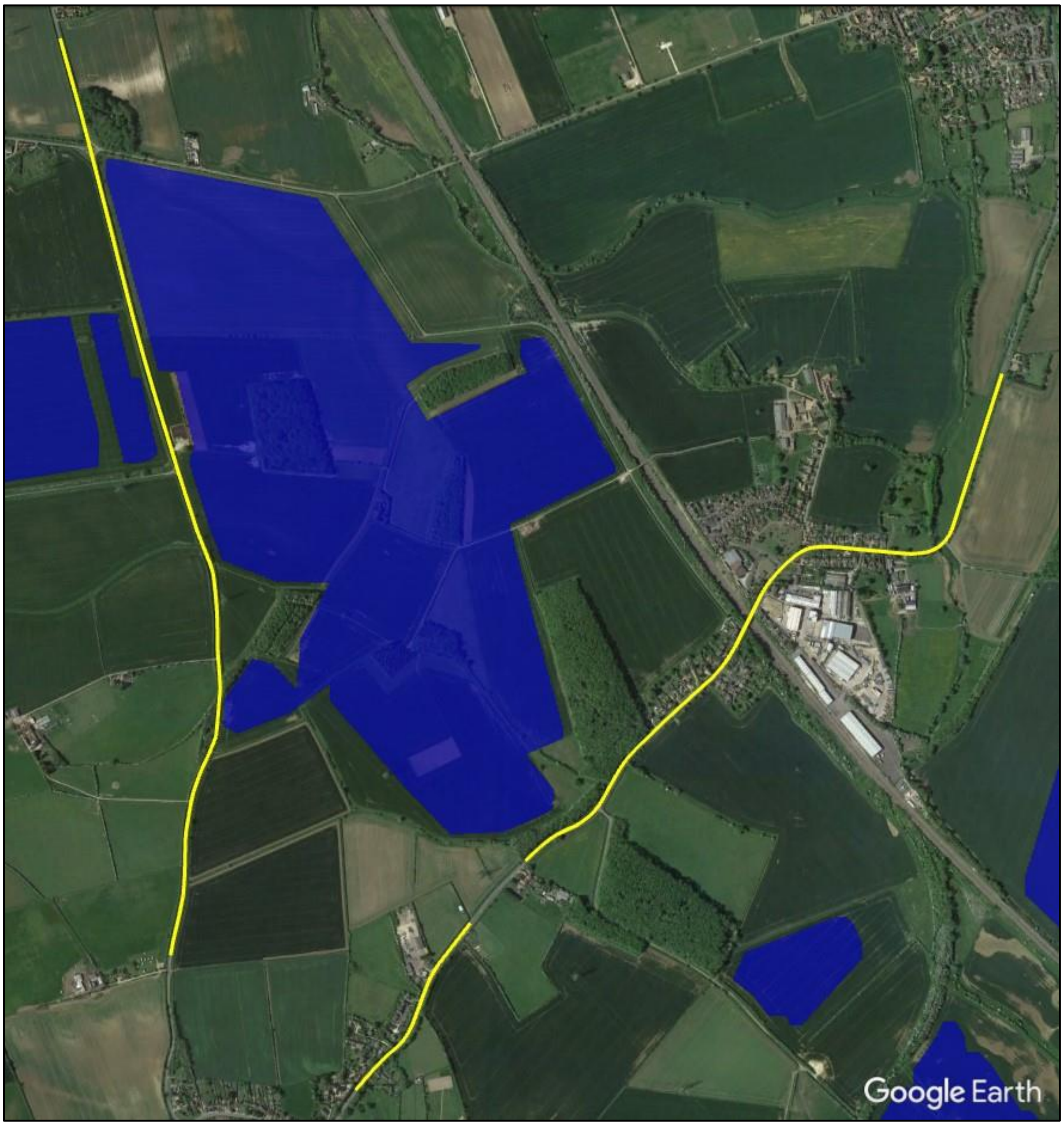

Figure 24 *Sections of road where solar reflections are geometrically possible – fixed panels*

Table 4 on the following page summarises the predicted impact significance and mitigation requirement for the road receptors where solar reflections are considered geometrically possible.

<table>
<tr><th>Road Receptors</th><th>Identified Screening (Desk-Based Review)</th><th>Impact Classification</th><th>Relevant Factors</th><th>Mitigation Recommended?</th></tr>
<tr><td>12 – 35</td><td rowspan="3">Existing vegetation.
Predicted to significantly obstruct views of the reflecting panels.</td><td rowspan="4">No impact.</td><td rowspan="4">N/A</td><td rowspan="4">No.</td></tr>
<tr><td>44 – 49</td></tr>
<tr><td>51 – 62</td></tr>
<tr><td>63 – 69</td><td>Existing vegetation and proposed screening / structure planting tree belt.
Predicted to significantly obstruct views of the reflecting panels.</td></tr>
</table>

Table 4 *Assessment of impact significance and mitigation requirement – road receptors (fixed)*

7.3.2 Tracker Panels

The modelling has shown that solar reflections are geometrically possible towards road receptors 10 – 37 and 44 – 63, along approximately 2.7km of the B1176 and 2.0km of the A6121. The sections of road where solar reflections are considered geometrically possible are shown by the yellow lines in Figure 25 on the following page[9].

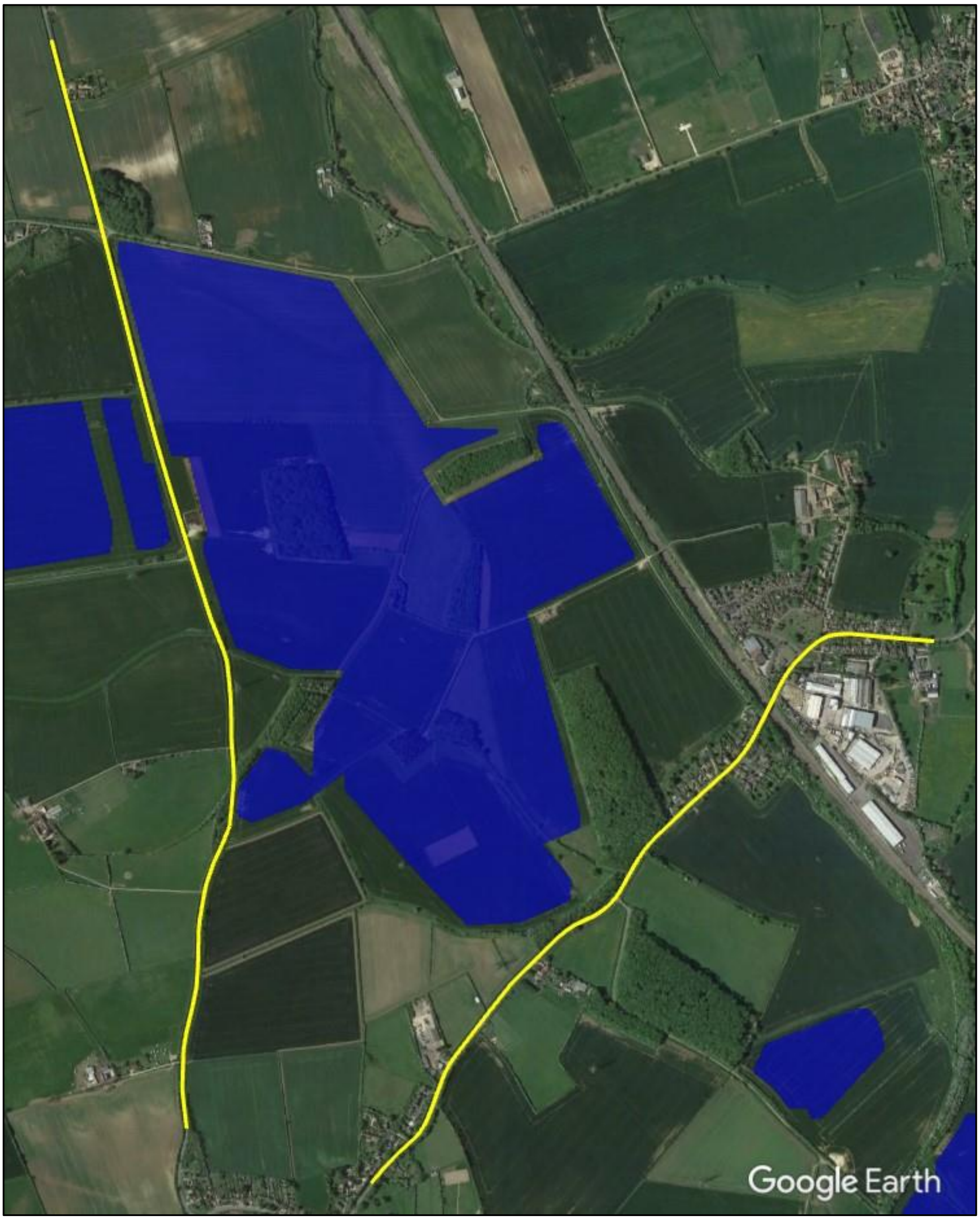

Figure 25 *Sections of road where solar reflections are geometrically possible – tracker panels*

Table 5 on the following page summarises the predicted impact significance and mitigation requirement for the road receptors where solar reflections are geometrically possible.

<table>
<tr><th>Road Receptors</th><th>Identified Screening (Desk-Based Review)</th><th>Impact Classification</th><th>Relevant Factors</th><th>Mitigation Recommended?</th></tr>
<tr><td>10 – 37</td><td rowspan="2">Existing vegetation and intervening terrain.
Predicted to significantly obstruct views of the reflecting panels.</td><td rowspan="3">No impact.</td><td rowspan="3">N/A</td><td rowspan="3">No.</td></tr>
<tr><td>44 – 62</td></tr>
<tr><td>63</td><td>Existing vegetation and proposed screening / structure planting tree belt.
Predicted to significantly obstruct views of the reflecting panels.</td></tr>
</table>

Table 5 *Assessment of impact significance and mitigation requirement – road receptors (tracker)*

7.4 Dwelling Results

In accordance with Pager Power's glint and glare guidance, the key considerations for quantifying impact significance for dwelling receptors are:

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

Where reflections are not predicted to be experienced by an observer in practice, no impacts are predicted, and mitigation is not required.

Where reflections are predicted to be experienced for less than 3 months per year and less than 60 minutes per day, the impact significance is low, and mitigation is not required.

Where reflections are predicted to be experienced for more than 3 months per year or for more than 60 minutes per day, expert assessment of the following mitigating factors is required to determine the mitigation requirement:

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

Where reflections are predicted to be experienced for more than 3 months per year and more than 60 minutes per day, the impact significance is high, and mitigation is required.

7.4.1 Fixed Panels

The modelling has shown that solar reflections are geometrically possible towards dwelling receptors 08 – 14, 30 – 31, 33 – 92, 95 – 106, 108, 127, 128, 136 – 143, 145, 149, 150, and 153 – 170; totalling 113 of the 179 assessed dwelling receptors. An overview of the dwellings where solar reflections are considered geometrically possible are shown in Figure 26 below[9].

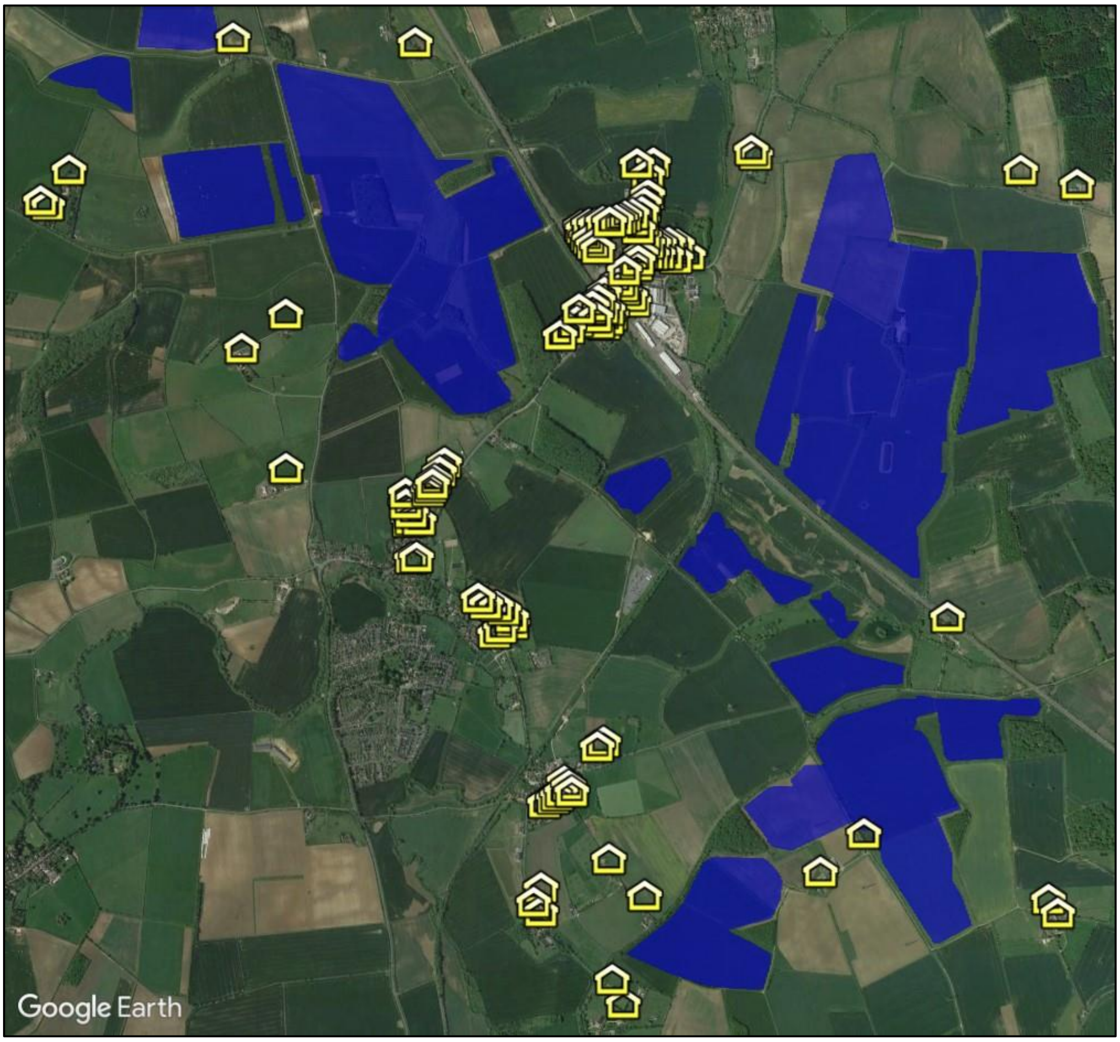

Figure 26 *Dwellings where solar reflections are geometrically possible – fixed panels*

Table 6 on the following page summarises the predicted impact significance and mitigation requirement for the dwelling receptors where solar reflections are geometrically possible. Cases where mitigation is recommended are shown in red for ease of reference and discussed further in Section 8.2.1.

Dwelling Receptor	Identified Screening (Desk-Based Review)	Impact Classification	Relevant Factors	Mitigation Recommended?
08	Existing vegetation and intervening terrain Partial views from above the ground floor considered possible.	Moderate.	The distance to the closest reflecting panel is approx. 60 metres. Effects would mostly coincide with direct sunlight. Effects only predicted to be experienced from above ground floor. Windows are not facing the reflecting panels.	No.
09 – 13	Existing vegetation and intervening terrain. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A	No.
14	Existing vegetation and intervening terrain. Predicted to sufficiently reduce the duration of effects to acceptable levels.	Low.	N/A	No.

Dwelling Receptor	Identified Screening (Desk-Based Review)	Impact Classification	Relevant Factors	Mitigation Recommended?
30 – 31	Existing vegetation, intervening terrain, and proposed screening / structure planting hedgerows. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A	No.
33 – 34	Existing vegetation and proposed screening / structure planting tree belt. Predicted to significantly obstruct views of the reflecting panels.			
35	Existing vegetation and other dwellings. Predicted to significantly obstruct views of the reflecting panels.			
36	Existing vegetation, surrounding buildings, and proposed screening / structure planting tree belt. Partial views of the reflecting panels to the east cannot be ruled out.	Low.	N/A	No.

Dwelling Receptor	Identified Screening (Desk-Based Review)	Impact Classification	Relevant Factors	Mitigation Recommended?
37 – 38	Existing vegetation and surrounding buildings. Predicted to significantly obstruct views of the reflecting panels.			
39 – 40	Existing vegetation, intervening terrain, and proposed screening / structure planting tree belt. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A	No.
41 – 55	Existing vegetation, intervening terrain, and other dwellings. Predicted to significantly obstruct views of the reflecting panels.			
56 – 63	Existing vegetation, intervening terrain, other dwellings, and proposed screening / structure planting tree belt. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A	No.

<table>
<tr><th>Dwelling Receptor</th><th>Identified Screening (Desk-Based Review)</th><th>Impact Classification</th><th>Relevant Factors</th><th>Mitigation Recommended?</th></tr>
<tr><td>64 – 78</td><td>Existing vegetation, other dwellings, and surrounding buildings.
Predicted to significantly obstruct views of the reflecting panels.</td><td>No impact.</td><td>N/A</td><td>No.</td></tr>
<tr><td>79 – 81</td><td>Existing vegetation, intervening terrain, and other dwellings.
Partial views from above the ground floor to the west cannot be ruled out based on the available imagery.</td><td>Moderate.</td><td>The distance to the closest reflecting panel is approx. 470 metres.
Effects would mostly coincide with direct sunlight.
Effects only predicted to be experienced from above ground floor.</td><td>No.</td></tr>
<tr><td>82 – 92</td><td>Existing vegetation and other dwellings.
Predicted to significantly obstruct views of the reflecting panels.</td><td rowspan="2">No impact.</td><td rowspan="2">N/A</td><td rowspan="2">No.</td></tr>
<tr><td>95 – 106</td><td>Existing vegetation and intervening terrain.
Predicted to significantly obstruct views of the reflecting panels.</td></tr>
</table>

<table>
<tr><th>Dwelling Receptor</th><th>Identified Screening (Desk-Based Review)</th><th>Impact Classification</th><th>Relevant Factors</th><th>Mitigation Recommended?</th></tr>
<tr><td>108</td><td rowspan="4">Existing vegetation and intervening terrain.
Predicted to significantly obstruct views of the reflecting panels.</td><td rowspan="6">No impact.</td><td rowspan="6">N/A</td><td rowspan="6">No.</td></tr>
<tr><td>127 – 128</td></tr>
<tr><td>136 – 143</td></tr>
<tr><td>145</td></tr>
<tr><td>149 – 150</td><td rowspan="2">Existing vegetation and proposed screening / structure planting tree belt.
Predicted to significantly obstruct views of the reflecting panels.</td></tr>
<tr><td>153 – 164</td></tr>
<tr><td>165</td><td>Existing vegetation and proposed screening / structure planting hedgerows.
Partial views from above the ground floor cannot be ruled out from panels to the west.
Partial views cannot be ruled out from panels to the east.</td><td>Moderate.</td><td>The distance to the closest reflecting panel is approx. 130 metres to the west and 340 metres to the east.
Effects would mostly coincide with direct sunlight.
Effects from the west only predicted to be experienced from above ground floor.</td><td>No.</td></tr>
</table>

Dwelling Receptor	Identified Screening (Desk-Based Review)	Impact Classification	Relevant Factors	Mitigation Recommended?
166	Existing vegetation and proposed screening / structure planting hedgerows Views of the reflecting panels to the west cannot be ruled out above the ground floor. Views of the reflecting panels to the east predicted.	Moderate.	The distance to the closest reflecting panel is approx. 80 metres. Effects would mostly coincide with direct sunlight. Effects from the east predicted to be experienced from all floors. Windows are facing the reflecting panels.	Yes – for panels to the east.
167 – 168	Proposed screening / structure planting tree belt. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A	No.
169	Existing vegetation and proposed screening / structure planting hedgerows. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A	No.

Dwelling Receptor	Identified Screening (Desk-Based Review)	Impact Classification	Relevant Factors	Mitigation Recommended?
170	Existing vegetation and proposed screening / structure planting hedgerows. Views of the reflecting panels cannot be ruled out based on the available imagery.	Moderate.	The distance to the closest reflecting panel is approx. 580 metres. Effects would mostly coincide with direct sunlight. Effects only predicted to be experienced from above ground floor.	No.

Table 6 *Assessment of mitigation requirement – dwelling receptors (fixed)*

7.4.2 Tracker Panels

The modelling has shown that solar reflections are geometrically possible towards dwelling receptors 07, 08, 10 – 14, 30, 31, 35, 37 – 63, 65 – 106, 108, 135, 136, 138 – 141, 147 – 160, 162 – 166, 169, and 170; totalling 108 of the 179 assessed dwelling receptors. An overview of the dwellings where solar reflections are considered geometrically possible are shown in Figure 27 on the following page[9].

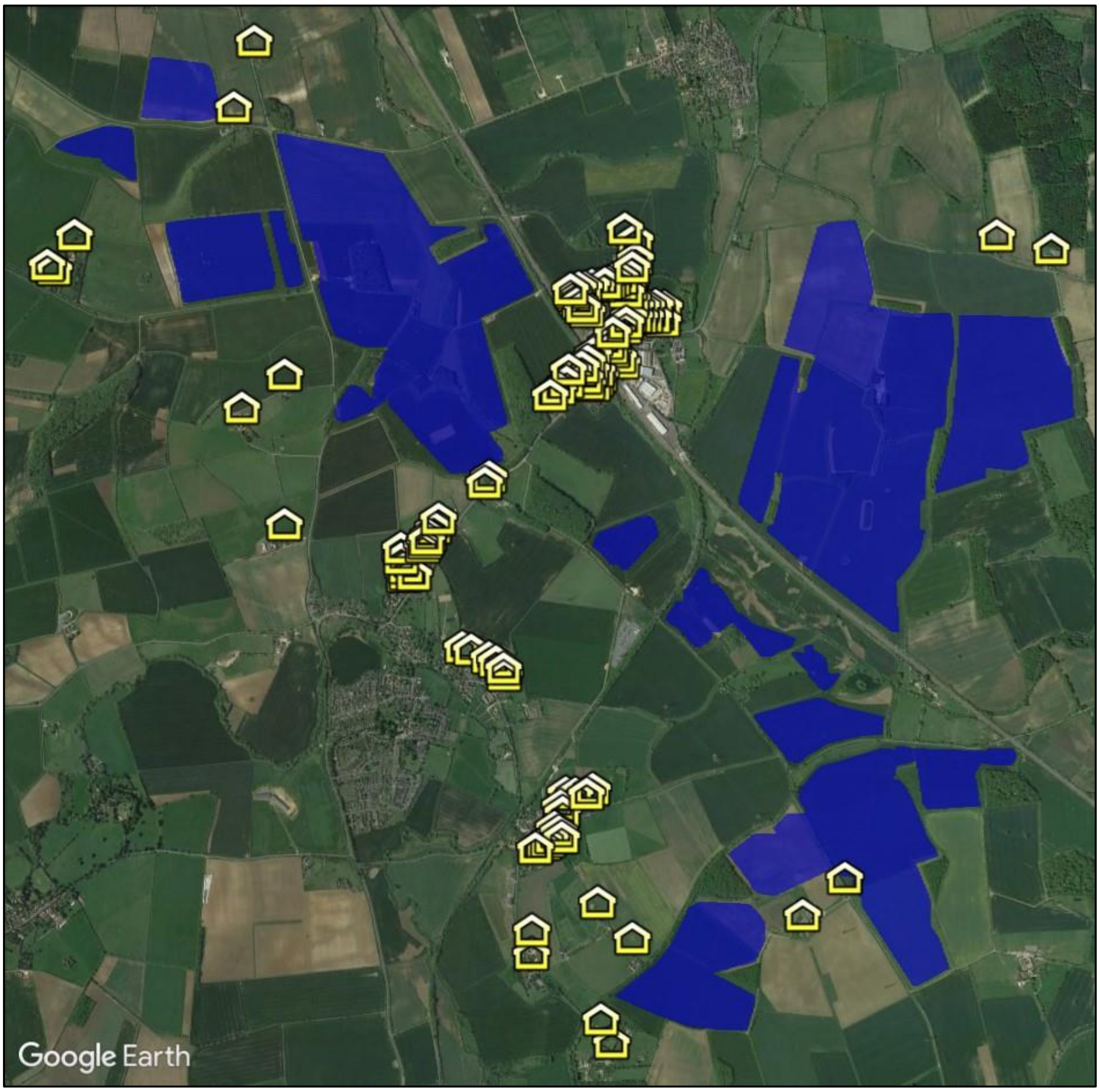

Figure 27 *Dwellings where solar reflections are geometrically possible – tracker panels*

Table 7 on the following page summarises the predicted impact significance and mitigation requirement for the dwelling receptors where solar reflections are geometrically possible. Cases where mitigation is recommended are shown in red for ease of reference and discussed further in Section 8.2.2.

Dwelling Receptor	Identified Screening (Desk-Based Review)	Impact Classification	Relevant Factors	Mitigation Recommended?
07	Existing vegetation and proposed screening / structure planting hedgerows. Partial views from above the ground floor cannot be ruled out based on the available imagery.	Moderate.	The distance to the closest reflecting panel is approx. 215 metres. Effects would coincide with direct sunlight. Effects only predicted to be experienced from above ground floor.	No.
08	Existing vegetation and intervening terrain. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A	No.
10 – 13				
14	Existing vegetation and intervening terrain. Partial views from above the ground floor cannot be ruled out based on the available imagery.	Moderate.	The distance to the closest reflecting panel is approx. 260 metres. Effects would coincide with direct sunlight. Effects only predicted to be experienced from above ground floor.	No.

Dwelling Receptor	Identified Screening (Desk-Based Review)	Impact Classification	Relevant Factors	Mitigation Recommended?
30 – 31	Existing vegetation, intervening terrain, and proposed screening / structure planting hedgerows. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A	No.
35	Existing vegetation, surrounding buildings, and proposed screening / structure planting tree belt. Predicted to significantly obstruct views of the reflecting panels.			
37 – 38				
39 – 40	Existing vegetation, intervening terrain, and proposed screening / structure planting tree belt. Predicted to significantly obstruct views of the reflecting panels.			
41 – 55	Existing vegetation, intervening terrain, and other dwellings. Predicted to significantly obstruct views of the reflecting panels.			

<table>
<tr><th>Dwelling Receptor</th><th>Identified Screening (Desk-Based Review)</th><th>Impact Classification</th><th>Relevant Factors</th><th>Mitigation Recommended?</th></tr>
<tr><td>56 – 63</td><td>Existing vegetation, intervening terrain, other dwellings, and proposed screening / structure planting tree belt.
Predicted to significantly obstruct views of the reflecting panels.</td><td rowspan="7">No impact.</td><td rowspan="7">N/A</td><td rowspan="7">No.</td></tr>
<tr><td>65 – 106</td><td>Existing vegetation, other dwellings, and surrounding buildings.
Predicted to significantly obstruct views of the reflecting panels.</td></tr>
<tr><td>108</td><td rowspan="3">Existing vegetation and intervening terrain.
Predicted to significantly obstruct views of the reflecting panels.</td></tr>
<tr><td>135 – 136</td></tr>
<tr><td>138 – 141</td></tr>
<tr><td>147 – 160</td><td rowspan="2">Existing vegetation and proposed screening / structure planting tree belt.
Predicted to significantly obstruct views of the reflecting panels.</td></tr>
<tr><td>162 – 164</td></tr>
</table>

Dwelling Receptor	Identified Screening (Desk-Based Review)	Impact Classification	Relevant Factors	Mitigation Recommended?
165	Existing vegetation. Partial views cannot be ruled out based on the available imagery.	Moderate.	The distance to the closest reflecting panel is approx. 350 metres. Effects would coincide with direct sunlight. Effects predicted to be experienced on all floors.	No.
166	Existing vegetation and proposed screening / structure planting hedgerows Partial views of the reflecting panels to the west cannot be ruled out above the ground floor. Partial views of the reflecting panels to the east predicted.	Moderate.	The distance to the closest reflecting panel is approx. 80 metres. Effects would coincide with direct sunlight. Effects from the east predicted to be experienced from all floors. Windows are facing the reflecting panels.	Yes – for panels to the east.
169	Existing vegetation and proposed screening / structure planting hedgerows. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A	No.

Dwelling Receptor	Identified Screening (Desk-Based Review)	Impact Classification	Relevant Factors	Mitigation Recommended?
170	Existing vegetation and proposed screening / structure planting hedgerows. Views of the reflecting panels cannot be ruled out based on the available imagery.	Moderate.	The distance to the closest reflecting panel is approx. 350 metres. Effects would mostly coincide with direct sunlight. Effects only predicted to be experienced from above ground floor.	No.

Table 7 *Assessment of mitigation requirement – dwelling receptors (tracker)*

7.5 Train Driver Results

In accordance with Pager Power's glint and glare guidance, the key considerations for quantifying impact significance for train driver receptors are:

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

Where reflections are not predicted to be experienced by a train driver in practice, no impacts are predicted, and mitigation is not required.

Where reflections originate from outside of a train driver's primary field of view (30 degrees either side of the direction of travel), the impact significance is low, and mitigation is not required.

Where reflections originate from inside of a train driver's field of view but there are mitigating circumstances, expert assessment of the following mitigating factors is required to determine the mitigation requirement:

- Whether the solar reflection originates from directly in front of a train driver – a solar reflection that is directly in front of a road user is more hazardous than a solar reflection to one side;
- The separation distance to the panel area – larger separation distances reduce the proportion of an observer's field of view that is affected by glare;
- The position of the Sun – effects that coincide with direct sunlight appear less prominent than those that do not;

- Whether a signal, station, level crossing, or switching point is located within the reflection zone – a train driver with a higher workload will be more impacted than a train driver with a lower workload.

Where reflections originate from directly in front of a train driver and there are no further mitigating circumstances, the impact significance is high, and mitigation is required.

7.5.1 Fixed Panels

The modelling has shown that solar reflections are geometrically possible towards train driver receptors 07 – 17, 24 – 42, and 48 – 52, along approximately 3.3km of railway line. The sections of railway line where solar reflections are considered geometrically possible are shown by the yellow lines in Figure 28 below[9].

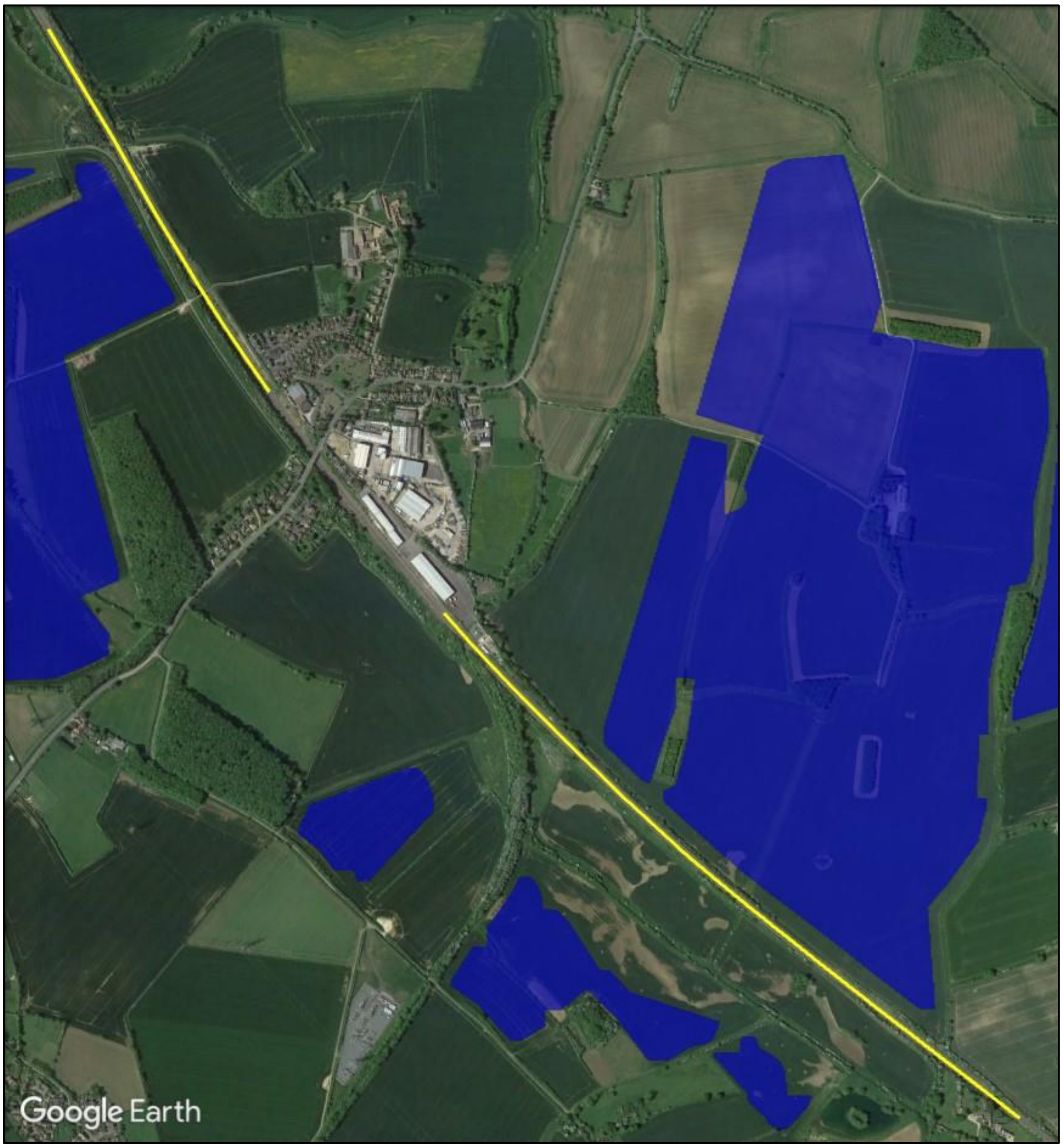

Figure 28 *Sections of railway line where solar reflections are geometrically possible – fixed panels*

Table 8 below summarises the predicted impact significance and mitigation requirement for the train driver receptors where solar reflections are geometrically possible.

Train Driver Receptors	Identified Screening (Desk-Based Review)	Impact Classification	Relevant Factors	Mitigation Recommended?
07 – 10	Many layers of existing vegetation. Predicted to completely obstruct views of the reflecting panels.	No impact.	N/A	No.
11 – 17	Existing vegetation. Views of the reflecting panels may be filtered or significantly obstructed. As this vegetation could be removed, it is assumed views of the reflecting panels are possible.	Low.	N/A	No.
24 – 38	Existing vegetation and proposed screening / structure planting tree belt. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A	No.

Train Driver Receptors	Identified Screening (Desk-Based Review)	Impact Classification	Relevant Factors	Mitigation Recommended?
39	Inconclusive. Views of the reflecting panels considered possible.	Moderate.	Effects do not originate from directly in front of a train driver. The distance to the closest reflecting panel is approx. 470 metres. Effects coincide with direct sunlight. No views signals, stations, level crossings, or switching points required.	No.
40 – 42	Many layers of existing vegetation. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A	No.
48 – 52	Proposed screening / structure planting hedgerows. Hedgerows must be maintained at 4m agl. Predicted to significantly obstruct views of the reflecting panels.	No impact.	N/A	No.

Table 8 *Assessment of mitigation requirement – train driver receptors (fixed)*

7.5.2 Tracker Panels

The modelling has shown that solar reflections are geometrically possible towards train driver receptors 11 – 17, 32, 34, 37 – 40, 47 – 52, along approximately 1.2km of railway line. The sections of railway line where solar reflections are considered geometrically possible are shown by the yellow lines in Figure 29 below[9].

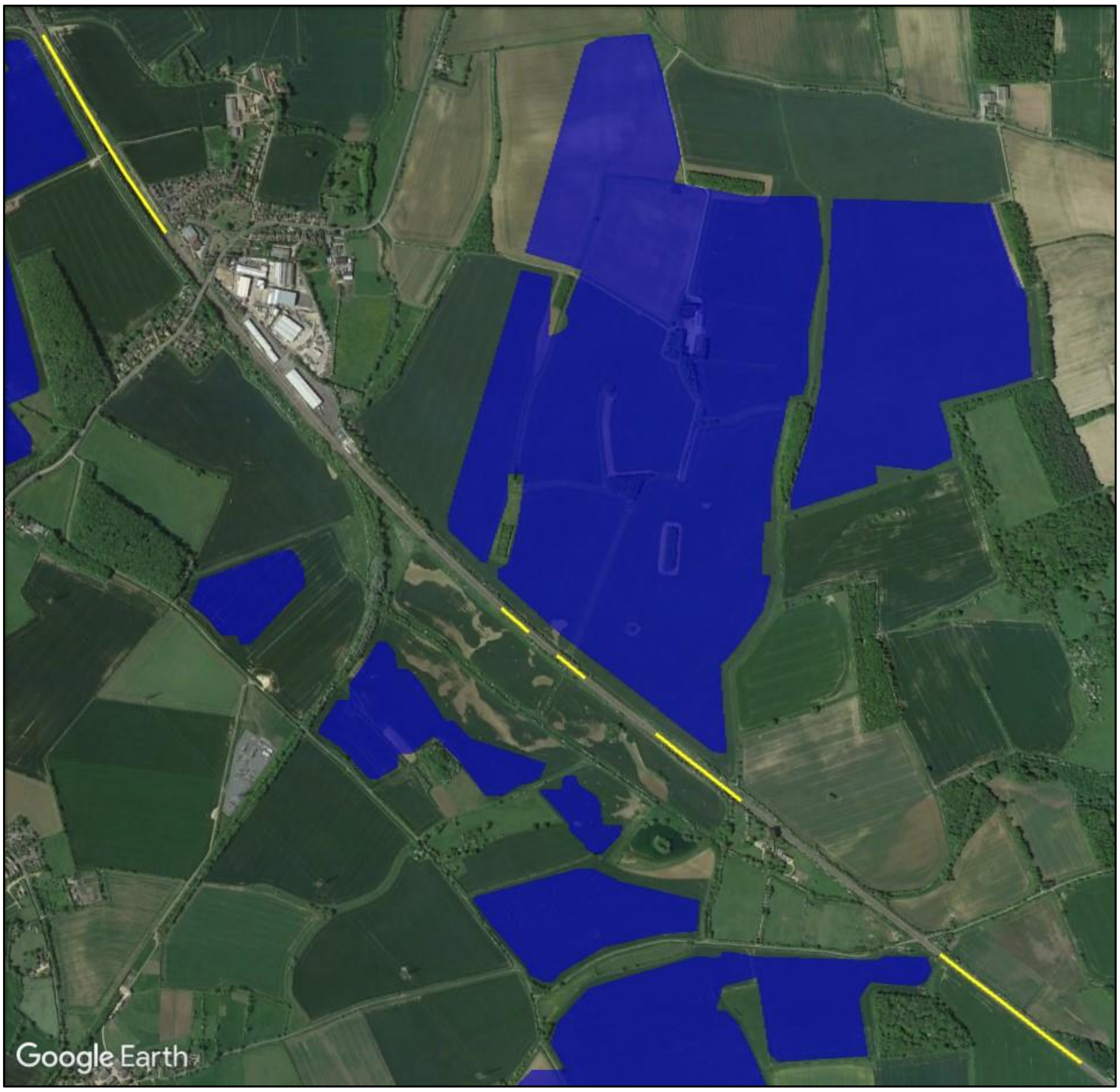

Figure 29 *Sections of railway line where solar reflections are geometrically possible – tracker panels*

Table 9 on the following page summarises the predicted impact significance and mitigation requirement for the train driver receptors where solar reflections are geometrically possible. Cases where mitigation is recommended are shown in red and discussed further in Section 8.2.2.

<table>
<tr><th>Train Driver Receptors</th><th>Identified Screening (Desk-Based Review)</th><th>Impact Classification</th><th>Relevant Factors</th><th>Mitigation Recommended?</th></tr>
<tr><td>11 – 17</td><td>Existing vegetation.
Views of the reflecting panels may be filtered or significantly obstructed.
As this vegetation could be removed, it is assumed views of the reflecting panels are possible.</td><td>Low.</td><td>N/A</td><td>No.</td></tr>
<tr><td>32</td><td rowspan="2">Large areas of existing vegetation, surrounding dwellings, and surrounding buildings.
Predicted to completely obstruct views of the reflecting panels.</td><td rowspan="4">No impact.</td><td rowspan="4">N/A</td><td rowspan="4">No.</td></tr>
<tr><td>34</td></tr>
<tr><td>37 – 40</td><td>Existing vegetation and proposed screening / structure planting hedgerows.
Predicted to significantly obstruct views of the reflecting panels.</td></tr>
<tr><td>47 – 52</td><td>Proposed screening / structure planting hedgerows.
Hedgerows must be maintained at 4m agl.
Predicted to significantly obstruct views of the reflecting panels.</td></tr>
</table>

Table 9 *Assessment of mitigation requirement – train driver receptors (tracker)*

8 HIGH-LEVEL MITIGATION OVERVIEW

8.1 Overview

It is possible that a site survey or other detailed screening analysis would reveal that the reflecting areas are already significantly obscured from view relative to the identified receptors. Ordinarily, mitigation for ground-based receptors is achieved where necessary via screening in the form of planting to obstruct views. The optimal strategy may therefore include:

- Provision of screening (planting or opaque fence) within the site boundary – this is the preferred solution by stakeholders as the screening is under the developer's control;
- Provision of screening (planting or opaque fence) outside of the site boundary – less favoured by stakeholders but is still a suitable solution if it can be maintained.

The relevant reflecting areas that should be obscured from view (yellow areas) and potential screening locations (pink lines), have therefore been defined in this section. The required height will depend on the relative elevation of the receptors, the base of the planting itself, and the reflecting panels. For dwelling receptors, views of the reflecting panels should be obstructed from the ground floor at the minimum.

8.2 Dwellings

8.2.1 Fixed Panels

The reflecting panel areas and potential screening locations for the fixed panel layout are shown in Figure 30 below.

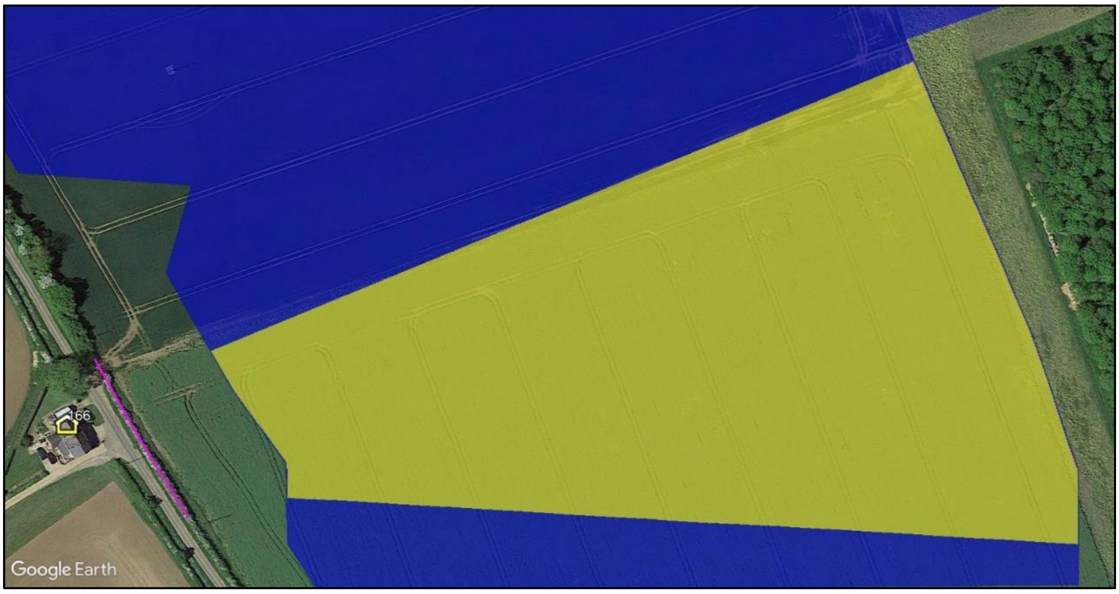

Figure 30 *Reflecting panel area and potential screening location for dwelling receptor 166 (fixed)*

8.2.2 Tracker Panels

The reflecting panel area and potential screening location for the tracker panel layout are shown in Figure 31 below.

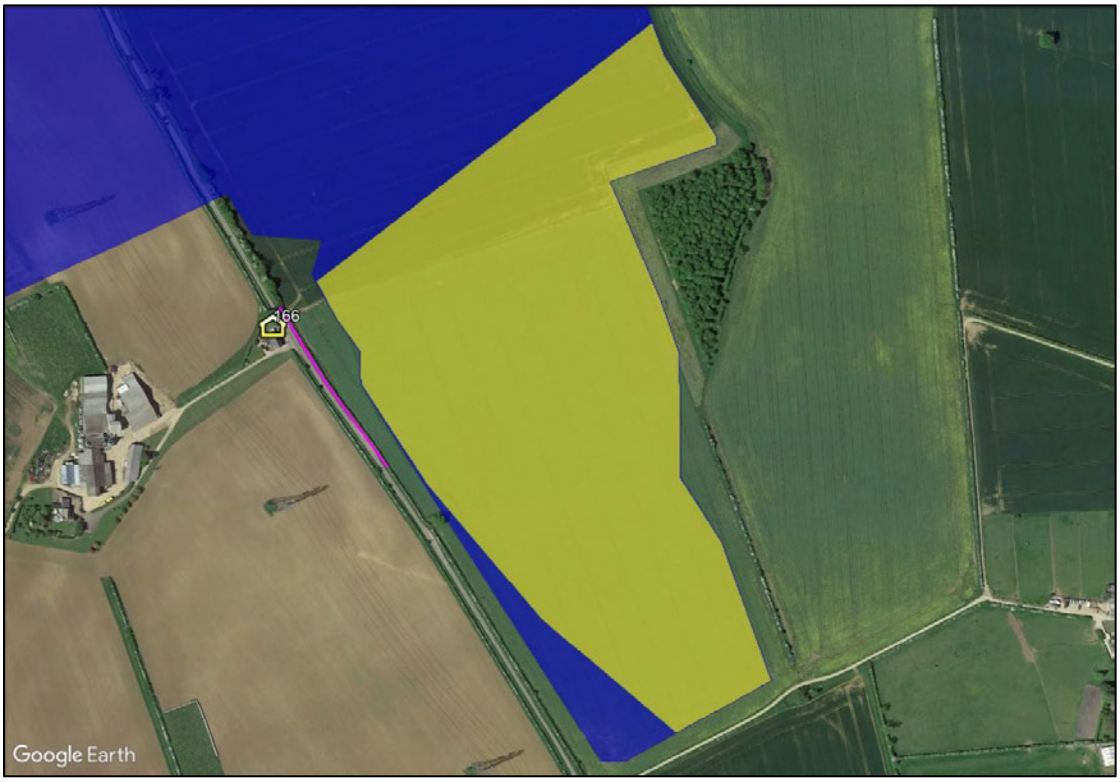

Figure 31 *Reflecting panel area and potential screening location for dwelling receptor 166 (tracker)*

9 HIGH-LEVEL AVIATION CONSIDERATIONS

9.1 Overview

Shacklewell Airfield is an unlicensed aerodrome located approximately 8.3km southwest of the proposed solar panel areas, which is understood to not have an ATC Tower. The airfield has one runway:

- 06/24 – 700 metres (Grass).

Castle Bytham Airfield is an unlicensed aerodrome located approximately 7.7km north northwest of the solar panel areas, which is understood to not have an ATC Tower. The airfield has one runway:

- 15/33 – 500 metres (Grass).

RAF Cottesmore is an MoD aerodrome located approximately 10.0km northwest of the proposed solar panel areas and has an ATC Tower. The airfield has one runway:

- 04/22 – 2,744 metres (Asphalt)

The locations of Shacklewell Airfield, Castle Bytham Airfield and RAF Cottesmore relative to the proposed development are shown in Figure 33 on the following page.

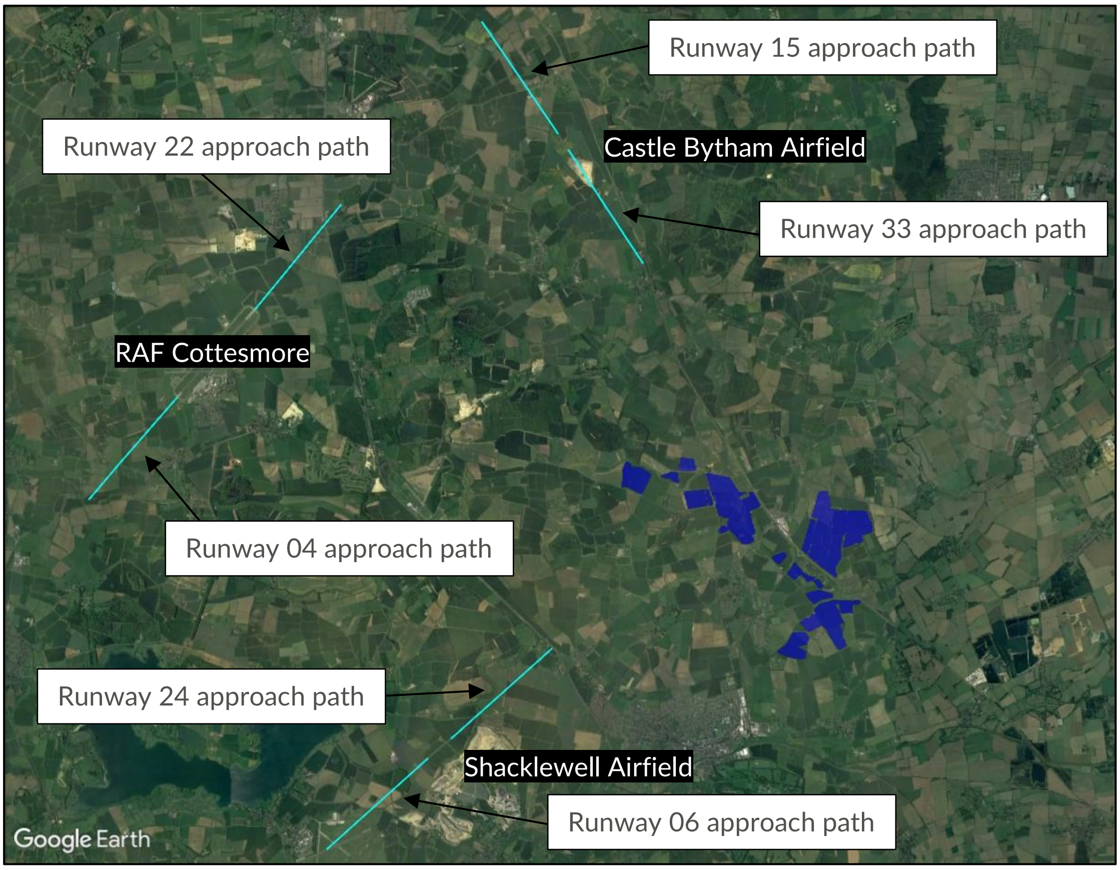

Figure 32 *Identified aerodromes relative to the proposed development*

9.2 High-Level Conclusion

Considering the size of the proposed development, its location relative to Shacklewell Airfield, Castle Bytham Airfield and RAF Cottesmore, and its distance from the aerodromes, the following is applicable:

- It can be safely presumed that any predicted solar reflections towards pilots approaching runway thresholds 04, 06, and 15 and would have intensities no greater than 'low potential for temporary after image', which is acceptable in accordance with the associated guidance and industry best practice;
- The proposed development will be outside a pilot's primary field of view (50 degrees either side of the approach bearing) along the 2-mile approach path towards runway thresholds 22, 24, and 33 which is acceptable in accordance with the associated guidance and industry best practice;
- Views of the proposed development from the ATC Tower at RAF Cottesmore are not considered possible considering its height above ground level, the separation distance, and the screening.

Therefore, no significant impacts upon aviation activity associated with Shacklewell Airfield, Castle Bytham Airfield and RAF Cottesmore are predicted for both fixed and tracking layout plans, and no further detailed modelling is recommended.

10 OVERALL CONCLUSIONS

10.1 Assessment Results – RAF Wittering

10.1.1 ATC Tower

The modelling has shown that no solar reflections are geometrically possible towards the ATC Tower at RAF Wittering from both fixed and tracker panel layouts.

No impacts upon ATC personnel are predicted and no mitigation is required.

10.1.2 Approach Paths

The modelling has shown that no solar reflections are geometrically possible towards either of the 2-mile approach paths for runway 07/25 at RAF Wittering from both fixed and tracker panel layouts.

No impacts upon approaching aircraft are predicted and no mitigation is required.

10.2 Assessment Results – High Level Aviation

Detailed modelling of Shacklewell Airfield, Castle Bytham Airfield and RAF Cottesmore is not recommended as all potential solar reflections are predicted to be acceptable in accordance with the associated guidance and industry best practice.

No significant impacts upon Shacklewell Airfield, Castle Bytham Airfield and RAF Cottesmore are predicted.

10.3 Assessment Result – Roads

10.3.1 Fixed Panels

The modelling has shown that solar reflections are geometrically possible towards approximately 2.3km of the B1176 and 2.3km of the A6121.

Significant screening in the form of existing vegetation and proposed screening / structure planting tree belt is predicted to significantly obstruct all views of the reflecting panels.

No impacts upon road users along the A6121 and B1176 are predicted, and no further mitigation is required.

10.3.2 Tracker Panels

The modelling has shown that solar reflections are geometrically possible towards approximately 2.7km of the B1176 and 2.0km of the A6121.

Significant screening in the form of existing vegetation and proposed screening / structure planting tree belt is predicted to significantly obstruct all views of the reflecting panels.

No impacts upon road users along the A6121 and B1176 are predicted, and no further mitigation is required.

10.4 Assessment Results – Dwellings

10.4.1 Fixed Panels

The modelling has shown that solar reflections are geometrically possible towards receptors 113 of the 179 assessed dwelling receptors. Solar reflections towards most of these dwellings are predicted to be significantly obstructed by existing and proposed screening, or they do not occur for a duration that could be considered significant.

Solar reflections towards seven dwellings occur for a duration which requires further consideration. Mitigation is not recommended for six of these dwellings because:

- The distance between the observer and the closest reflecting panel area is such that the proportion of an observer's field of vision that is taken up by the reflecting area is significantly reduced;
- Views are only predicted for observers above the ground floor, which is not considered to be the main living space of a dwelling; and/or
- Effects will coincide with direct sunlight, which is a far more significant source of light compared to a solar reflection.

Mitigation is recommended for one dwelling due to the duration of effects and the lack of sufficient mitigating factors to reduce the level of impact – see Section 8.2.1.

10.4.2 Tracker Panels

The modelling has shown that solar reflections are geometrically possible towards 108 of the 179 assessed dwelling receptors. Solar reflections towards most of these dwellings are predicted to be significantly obstructed by existing and proposed screening, or they do not occur for a duration that could be considered significant.

Solar reflections towards five dwellings occur for a duration which requires further consideration. Mitigation is not recommended for four of these dwellings because:

- The distance between the observer and the closest reflecting panel area is such that the proportion of an observer's field of vision that is taken up by the reflecting area is significantly reduced;
- Views are only predicted for observers above the ground floor, which is not considered to be the main living space of a dwelling; and/or
- Effects will coincide with direct sunlight, which is a far more significant source of light compared to a solar reflection.

Mitigation is recommended for one dwelling due to the duration of effects and the lack of sufficient mitigating factors to reduce the level of impact – see Section 8.2.2.

10.5 Assessment Results – Railway

10.5.1 Signals

No railway signals have been identified on the assessed section of railway line. No impacts upon railway signals are predicted.

This report will be updated if railway signals are identified by Network Rail at a later date.

10.5.2 Train Drivers (Fixed Panels)

The modelling has shown that solar reflections are geometrically possible towards train driver receptors along approximately 3.3km of railway line. Solar reflections towards most of these sections of railway line are predicted to be significantly obstructed by existing and proposed screening or occur from outside of a train driver's primary field of view (30 degrees either side of the direction of travel).

Solar reflections towards approximately 100m of railway line occur from within a train driver's primary field of view which requires further consideration. However, mitigation is not recommended for this section of railway line because:

- No views of railway signals, stations, level crossings, or switching points is required, suggesting that the workload of a train driver will be low;
- The distance between the observer and the closest reflecting panel area is such that the proportion of an observer's field of vision that is taken up by the reflecting area is significantly reduced;
- Effects will coincide with direct sunlight, which is a far more significant source of light compared to a solar reflection.

10.5.3 Train Drivers (Tracker Panels)

The modelling has shown that solar reflections are geometrically possible towards train drivers along approximately 1.2km of railway line.

Solar reflections towards all these sections of railway line are predicted to be significantly obstructed by existing and proposed screening or occur from outside of a train driver's primary field of view.

No significant upon train drivers along the assessed section of railway line are predicted, and no further mitigation is required.

10.6 Mitigation Overview

The optimal mitigation strategy is likely to involve the provision of screening to significantly obstruct visibility of the reflecting panels. It is recommended that the proposed screening is secured through the outline Landscape Ecological Management Plan (oLEMP).

APPENDIX A – OVERVIEW OF GLINT AND GLARE GUIDANCE

Overview

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

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

UK Planning Policy

Renewable and Low Carbon Energy

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

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

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

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

…

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

…

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

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

Draft National Policy Statement for Renewable Energy Infrastructure

The Draft National Policy Statement for Renewable Energy Infrastructure (EN-3)[11] sets out the primary policy for decisions by the Secretary of State for nationally significant renewable energy infrastructure. Section 2.52 states:

'2.52.1 *Solar panels may reflect the sun's rays, causing glint and glare. Glint is defined as a momentary flash of light that may be produced as a direct reflection of the sun in the solar panel. Glare is a continuous source of excessive brightness experienced by a stationary observer located in the path of reflected sunlight from the face of the panel. The effect occurs when the solar panel is stationed between or at an angle of the sun and the receptor.*

2.52.2 *In some instances, it may be necessary to seek a glint and glare assessment as part of the application. This may need to account for 'tracking' panels if they are proposed as these may cause differential diurnal and/or seasonal impacts. The potential for solar PV panels, frames and supports to have a combined reflective quality should be assessed. This assessment needs to consider the likely reflective capacity of all of the materials used[12] in the construction of the solar PV farm.*

2.52.3 *Applicants should consider using, and in some cases the Secretary of State may require, solar panels to be of a non-glare/ non-reflective type and the front face of the panels to comprise of (or be covered) with a non-reflective coating for the lifetime of the permission.*

2.52.4 *Solar PV panels are designed to absorb, not reflect, irradiation. However, the Secretary of State should assess the potential impact of glint and glare on nearby homes and motorists.*

2.52.5 *There is no evidence that glint and glare from solar farms interferes in any way with aviation navigation or pilot and aircraft visibility or safety. Therefore, the Secretary of State is unlikely to have to give any weight to claims of aviation interference as a result of glint and glare from solar farms.'*

Consultation to determine whether EN-3 provides a suitable framework to support decision making for nationally significant energy infrastructure ended in November 2021. Pager Power is aware that aviation stakeholders were not consulted prior to the publication of the draft policy and understands that they will still request a glint and glare assessment on the basis that glare may lead to impact upon aviation safety. It is possible that the draft policy will change in light of the consultation responses from aviation stakeholders.

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

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[11] Draft National Policy Statement for Renewable Energy Infrastructure (EN-3), Department for Business, Energy & Industrial Strategy, date: September 2021, accessed on: 01/11/2021.

[12] In Pager Power's experience, the solar panels themselves are the overriding source of specular reflections which have the potential to cause significant impacts upon safety or amenity.

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

Aviation Assessment Guidance

The UK Civil Aviation Authority (CAA) issued interim guidance relating to Solar Photovoltaic Systems (SPV) on 17 December 2010 and was subject to a CAA information alert 2010/53. The formal policy was cancelled on September 7th, 2012[14] however the advice is still applicable[15] until a formal policy is developed. The relevant aviation guidance from the CAA is presented in the section below.

CAA Interim Guidance

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

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

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

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

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

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[13] Pager Power Glint and Glare Guidance, Third Edition (3.1), April 2021.

[14] Archived at Pager Power

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

12. If an installation of SPV systems is planned on-aerodrome (i.e. within its licensed boundary) then it is recommended that data on the reflectivity of the solar panel material should be included in any assessment before installation approval can be granted. Although approval for installation is the responsibility of the ALH[16]*, as part of a condition of a CAA Aerodrome Licence, the ALH is required to obtain prior consent from CAA Aerodrome Standards Department before any work is begun or approval to the developer or LPA is granted, in accordance with the procedures set out in CAP 791 Procedures for Changes to Aerodrome Infrastructure.*

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

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

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

FAA Guidance

The most comprehensive guidelines available for the assessment of solar developments near aerodromes 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'*[17] and the 2013 update is entitled '*Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports'*[18]. In April 2018 the FAA released a new version (Version 1.1) of the '*Technical Guidance for Evaluating Selected Solar Technologies on Airports'*[19].

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.*

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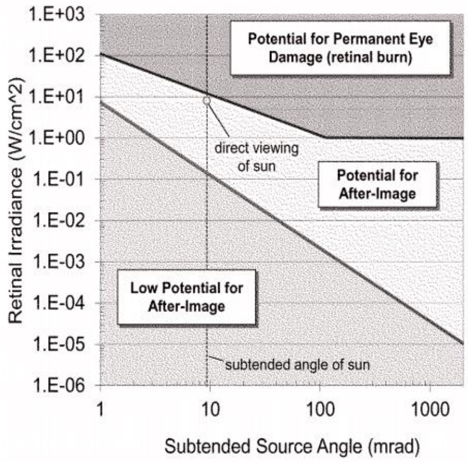
[16] Aerodrome Licence Holder.
[17] Archived at Pager Power
[18] Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports, Department of Transportation, Federal Aviation Administration (FAA), date: 10/2013, accessed on: 20/03/2019
[19] Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019

Figure 1



Solar Glare Ocular Hazard Plot: The potential ocular hazard from solar glare is a function of retinal irradiance and the subtended angle (size/distance) of the glare source. It should be noted that the ratio of spectrally weighted solar illuminance to solar irradiance at the earth's surface yields a conversion factor of ~100 lumens/W. Plot adapted from Ho et al., 2011.

Chart References: Ho, C.K., C.M. Ghanbari, and R.B. Diver, 2011, Methodology to Assess Potential Glint and Glare Hazards from Concentrating Solar Power Plants: Analytical Models and Experimental Validation, J. Solar Energy Engineering, August 2011, Vol. 133, 031021-1 – 031021-9.

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[20]*.*

- *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*[21]*, 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.*
- ***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*

[20] 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.
[21] First figure in Appendix B.

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 question22 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.*

Air Navigation Order (ANO) 2016

In some instances, an aviation stakeholder can refer to the ANO 2016[23] with regard to safeguarding. Key points from the document are presented below.

Lights liable to endanger

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

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

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

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[22] 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.
[23] The Air Navigation Order 2016. [online] Available at: <https://www.legislation.gov.uk/uksi/2016/765/contents/made> [Accessed 4 February 2022].

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

(a) to extinguish or screen the light; and

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

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

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

Lights which dazzle or distract

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

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

Endangering safety of an aircraft

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

Endangering safety of any person or property

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

Railway Assessment Guidelines

The following section provides an overview of the relevant railway guidance with respect to the siting of signals on railway lines. Network Rail is the stakeholder of the UK's railway infrastructure. Whilst the guidance is not strictly applicable in Ireland, the general principles within the guidance is expected to apply.

A railway operator's concerns would likely to relate to the following:

1. The development producing solar glare that affects train drivers; and
2. The development producing solar reflections that affect railway signals and create a risk of a phantom aspect signal.

Railway guidelines are presented below. These relate specifically to the sighting distance for railway signals.

Reflections and Glare

The extract below is taken from Section A5 – Reflections and glare (pages 64-65) of the 'Signal Sighting Assessment Requirements'24 which details the requirement for assessing glare towards railway signals.

Reflections and glare

Rationale

Reflections can alter the appearance of a display so that it appears to be something else.

Guidance

A5 is present if direct glare or reflected light is directed into the eyes or into the lineside signalling asset that could make the asset appear to show a different aspect or indication to the one presented.

A5 is relevant to any lineside signalling asset that is capable of presenting a lit signal aspect or indication.

The extent to which excessive illumination could make an asset appear to show a different signal aspect or indication to the one being presented can be influenced by the product being used. Requirements for assessing the phantom display performance of signalling products are set out in GKRT0057 section 4.1.

Problems arising from reflection and glare occur when there is a very large range of luminance, that is, where there are some objects that are far brighter than others. The following types of glare are relevant:

- *a) Disability glare, caused by scattering of light in the eye, can make it difficult to read a lit display.*
- *b) Discomfort glare, which is often associated with disability glare. While being unpleasant, it does not affect the signal reading time directly, but may lead to distraction and fatigue.*

Examples of the adverse effect of disability glare include:

- *a) When a colour light signal presenting a lit yellow aspect is viewed at night but the driver is unable to determine whether the aspect is a single yellow or a double yellow.*
- *b) Where a colour light signal is positioned beneath a platform roof painted white and the light reflecting off the roof can make the signal difficult to read.*

Options for militating against A5 include:

- *a) Using a product that is specified to achieve high light source: phantom ratio values.*
- *b) Alteration to the features causing the glare or reflection.*
- *c) Provision of screening.*

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24 Source: Signal Sighting Assessment Requirements, June 2016. Railway Group Guidance Note. Last accessed 18.10.2016.

Glare is possible and should be assessed when the luminance is much brighter than other light sources. Glare may be unpleasant and therefore cause distraction and fatigue, or may make the signal difficult to read and increase the reading time.

Determining the Field of Focus

The extract below is taken from Appendix F - Guidance on Field of Vision (pages 98-101) of the 'Signal Sighting Assessment Requirements'25 which details the visibility of signals, train drivers' field of vision and the implications with regard to signal positioning.

Asset visibility

The effectiveness of an observer's visual system in detecting the existence of a target asset will depend upon its:

a) *Position in the observer's visual field.*
b) *Contrast with its background.*
c) *Luminance properties.*
d) *The observer's adaptation to the illumination level of the environment.*

It is also influenced by the processes relating to colour vision, visual accommodation, and visual acuity. Each of these issues is described in the following sections.

Field of vision

The field of vision, or visual field, is the area of the visual environment that is registered by the eyes when both eyes and head are held still. The normal extent of the visual field is approximately 135o in the vertical plane and 200o in the horizontal plane.

The visual field is usually described in terms of central and peripheral regions: the central field being the area that provides detailed information. This extends from the central point (0^o) to approximately 30^o at each eye. The peripheral field extends from 30o out to the edge of the visual field.

F.6.3 Objects positioned towards the centre of the observer's field of vision are seen more quickly and identified more accurately because this is where our sensitivity to contrast is the highest. Peripheral vision is particularly sensitive to movement and light.

[25] Source: Signal Sighting Assessment Requirements, June 2016. Railway Group Guidance Note. Last accessed 28.08.2020.

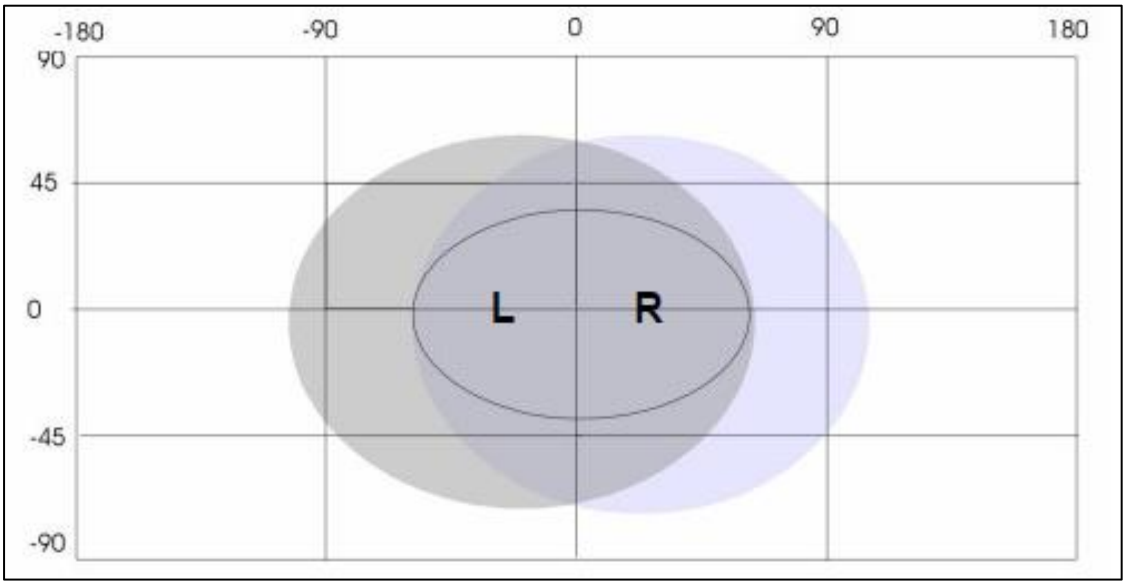

Figure G 21 - Field of view

In Figure G 21, the two shaded regions represent the view from the left eye (L) and the right eye (R) respectively. The darker shaded region represents the region of binocular overlap. The oval in the centre represents the central field of vision.

Research has shown that drivers search for signs or signals towards the centre of the field of vision.

Signals, indicators and signs should be positioned at a height and distance from the running line that permits them to be viewed towards the centre of the field of vision. This is because:

a) *As train speed increases, drivers become increasingly dependent on central vision for asset detection. At high speeds, drivers demonstrate a tunnel vision effect and focus only on objects in a field of + 8º from the direction of travel.*
b) *Sensitivity to movement in the peripheral field, even minor distractions can reduce the visibility of the asset if it is viewed towards the peripheral field of vision. The presence of clutter to the sides of the running line can be highly distracting (for example, fence posts, lamp-posts, traffic, or non-signal lights, such as house, compatibility factors or security lights).*

Figure G 22 and Table G 5 identify the radius of an 8o cone at a range of close-up viewing distances from the driver's eye. This shows that, depending on the lateral position of a stop signal, the optimal (normal) train stopping point could be as far as 25 m back from the signal to ensure that it is sufficiently prominent.

The dimensions quoted in Table G 5 assume that the driver is looking straight ahead. Where driver-only operation (DOO) applies, the drivers' line of sight at the time of starting the train is influenced by the location of DOO monitors and mirrors. In this case it may be appropriate to provide supplementary information alongside the monitors or mirrors using one of the following:

a) *A co-acting signal.*
b) *A miniature banner repeater indicator.*
c) *A right away indicator.*

d) A sign to remind the driver to check the signal aspect.

In order to prevent misreading by trains on adjacent lines, the co-acting signal or miniature banner repeater may be configured so that the aspect or indication is presented only when a train is at the platform to which it applies.

'Car stop' signs should be positioned so that the relevant platform starting signals and / or indicators can be seen in the driver's central field of vision.

If possible, clutter and non-signal lights in a driver's field of view should be screened off or removed so that they do not cause distraction.

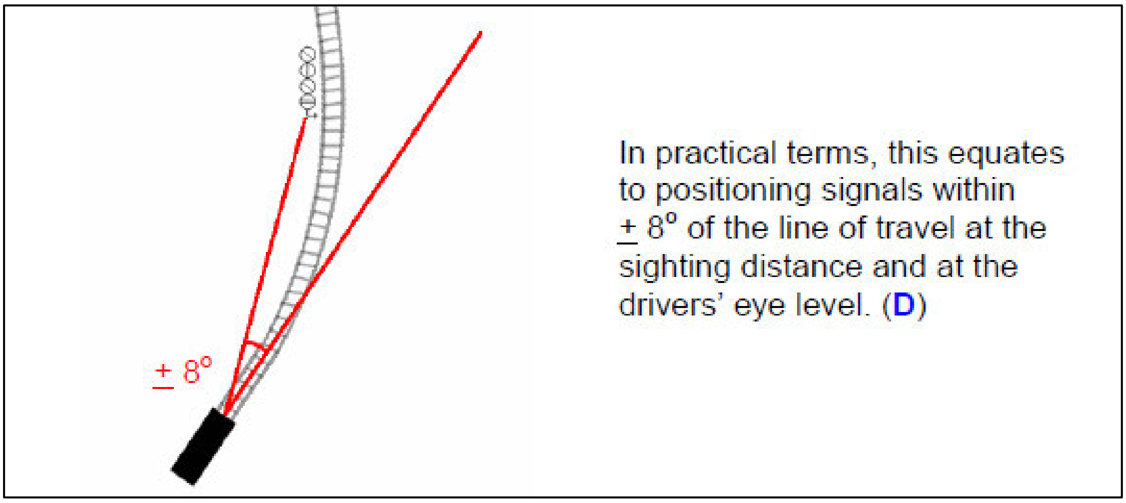

Figure G 22 - Signal positioning

'A' (m)	'B' (m)	Typical display positions
5	0.70	-
6	0.84	-
7	0.98	-
8	1.12	-
9	1.26	-
10	1.41	-
11	1.55	-
12	1.69	-
13	1.83	-
14	1.97	-

15	*2.11*	*A stop aspect positioned 3.3 m above rail level and 2.1 m from the left hand rail is within the 8° cone at 15.44 m in front of the driver*
16	*2.25*	*-*
17	*2.39*	*-*
18	*2.53*	*A stop aspect positioned 5.1 m above rail level and 0.9 m from the left hand rail is within the 8° cone at 17.93 m in front of the driver*
19	*2.67*	*-*
20	*2.81*	*-*
21	*2.95*	*-*
22	*3.09*	*-*
23	*3.23*	*-*
24	*3.37*	*-*
25	*3.51*	*A stop aspect positioned 3.3 m above rail level and 2.1 m from the right hand rail is within the 8° cone at 25.46 m in front of the driver*

Table G 5 – 8° cone angle co-ordinates for close-up viewing

The distance at which the 8° cone along the track is initiated is dependent on the minimum reading time and distance which is associated to the speed of trains along the track. This is discussed below.

Determining the Assessed Minimum Reading Time

The extract below is taken from section B5 (pages 8-9) of the 'Guidance on Signal Positioning and Visibility' which details the required minimum reading time for a train driver when approaching a signal.

'B5.2.2 Determining the assessed minimum reading time GE/RT8037

The assessed minimum reading time shall be no less than eight seconds travelling time before the signal.

The assessed minimum reading time shall be greater than eight seconds where there is an increased likelihood of misread or failure to observe. Circumstances where this applies include, but are not necessarily limited to, the following:

a) the time taken to identify the signal is longer (for example, because the signal being viewed is one of a number of signals on a gantry, or because the signal is viewed against a complex background)

b) the time taken to interpret the information presented by the signal is longer (for example, because the signal is capable of presenting route information for a complex layout ahead)

c) *there is a risk that the need to perform other duties could cause distraction from viewing the signal correctly (for example, the observance of lineside signs, a station stop between the caution and stop signals, or DOO (P) duties)*

d) *the control of the train speed is influenced by other factors (for example, anticipation of the signal aspect changing).*

The assessed minimum reading time shall be determined using a structured format approved by the infrastructure controller.'

The distance at which a signal should be clearly viewable is determined by the maximum speed of the trains along the track. If there are multiple signals present at a location then an additional 0.2 seconds reading time is added to the overall viewing time.

Signal Design and Lighting System

Many railway signals are now LED lights and not filament (incandescent) bulbs. The benefits of an LED signal over a filament bulb signal with respect to possible phantom aspect illuminations are as follows:

- An LED railway signal produces a more intense light making them more visible to approaching trains when compared to the traditional filament bulb technology[26];
- No reflective mirror is present within the LED signal itself unlike a filament bulb. The presence of the reflective surfaces greatly increases the likelihood of incoming light being reflecting out making the signal appear illuminated.

Many LED signal manufacturers[27,28,29] claim that LED signal lights significantly reduce or completely remove the likelihood of a phantom aspect illumination occurring.

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[26] Source: Wayside LED Signals – Why it's Harder than it Looks, Bill Petit.

[27] Source:[redacted] (Last accessed 21.02.18).

[28] Source: [redacted](Last accessed 21.02.18).

[29] Source: Siemens, Sigmaguard LED Tri-Colour L Signal – LED Signal Technology at Incandescent Prices. Datasheet 1A-23. (Last accessed 22.02.18).

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

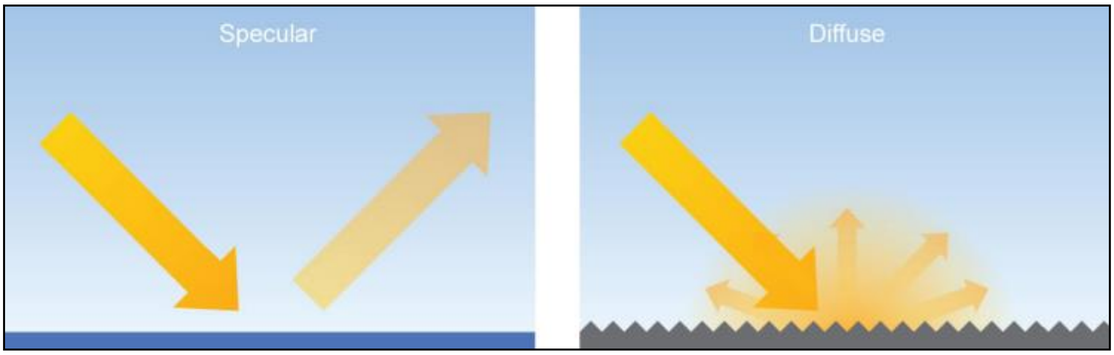
Overview

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

There are no specific studies for determining the effect of reflections from solar panels with respect to roads and dwellings. 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[30], taken from the FAA guidance, 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

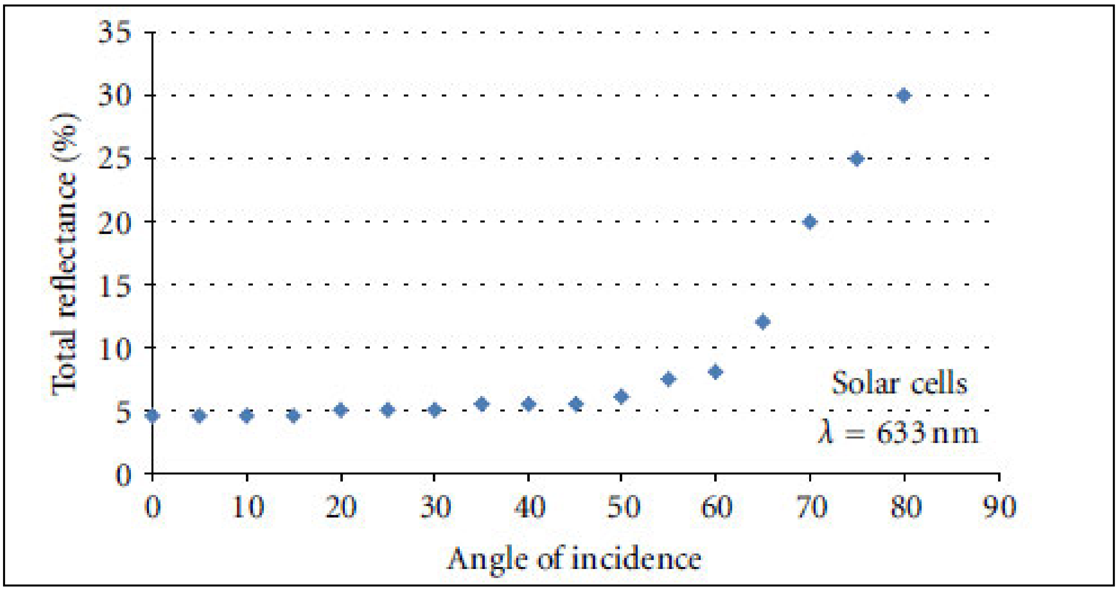
30 [redacted]

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*[31]". 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.

[31] 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"[32]

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[33] within the FAA guidance, is presented below.

Surface	Approximate Percentage of Light Reflected[34]
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.

[32] FAA, November (2010): *Technical Guidance for Evaluating Selected Solar Technologies on Airports.*
[33] [redacted]
[34] Extrapolated data, baseline of 1,000 W/m^2 for incoming sunlight.

SunPower Technical Notification (2009)

SunPower published a technical notification[35] to '*increase awareness concerning the possible glare and reflectance impact of PV Systems on their surrounding environment*'. The study revealed that the reflectivity of a solar panel is considerably lower than that 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.

Figures within the document show the relative reflectivity of solar panels compared to other natural and manmade materials including smooth water, standard glass and steel. 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 produced from these surfaces.

[35] 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).

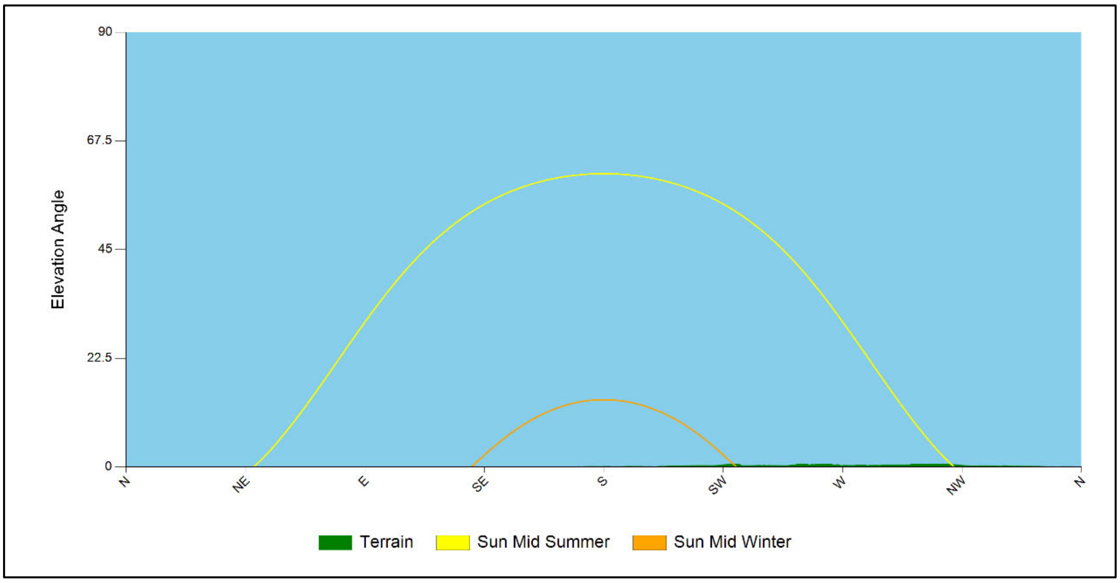
The Sun's position can be accurately calculated for a specific location. The following data being used for the calculation:

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

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

- The Sun is at its highest around midday and is to the south at this time;
- The Sun rises highest on 21 June reaching a maximum elevation of approximately 60-65 degrees (longest day);
- On 21 December, the maximum elevation reached by the Sun is approximately 10-15 degrees (shortest day).

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



Sunrise and sunset curves throughout the year

APPENDIX D – GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

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

Impact Significance Definition

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

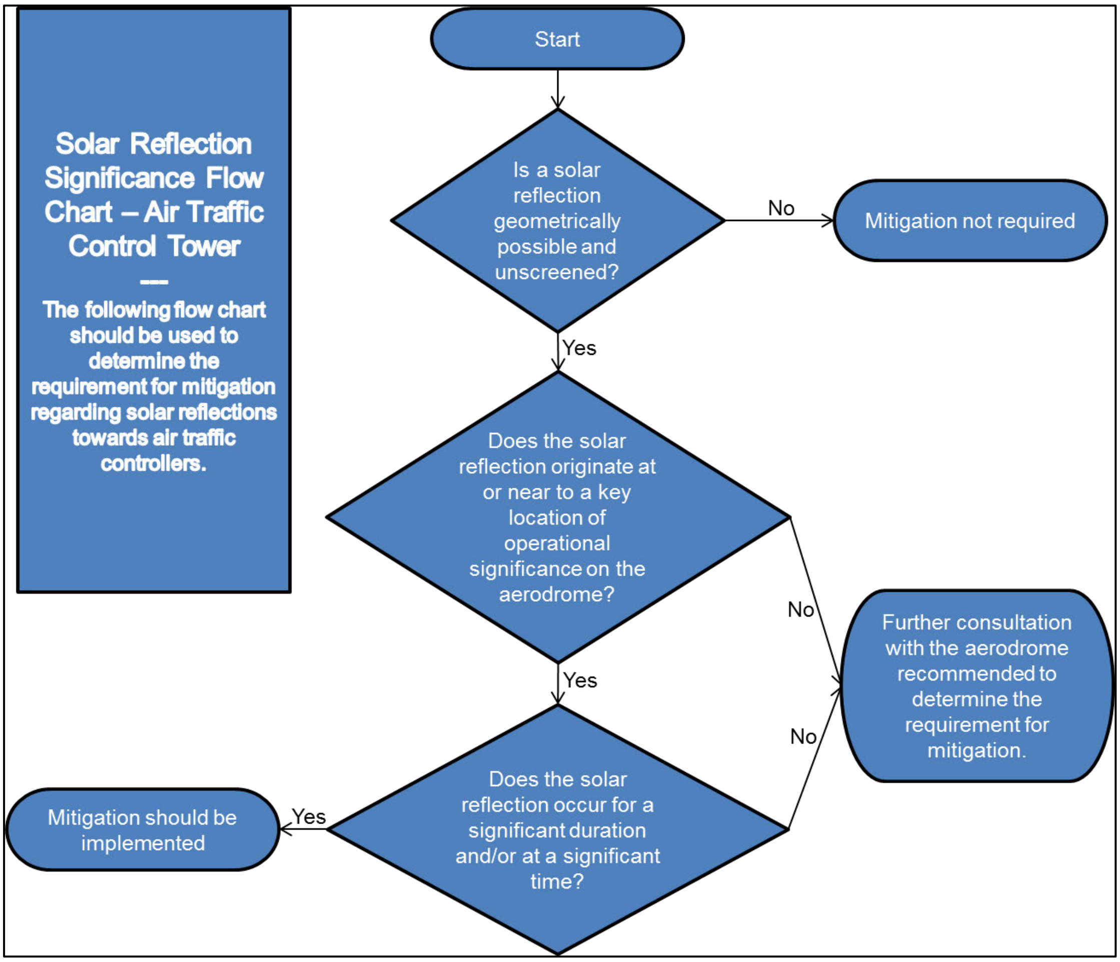
Impact Significance	Definition	Mitigation Requirement
No Impact	A solar reflection is not geometrically possible or will not be visible from the assessed receptor.	No mitigation required.
Low	A solar reflection is geometrically possible however any impact is considered to be small such that mitigation is not required e.g. intervening screening will limit the view of the reflecting solar panels.	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

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

Impact Significance Determination for an ATC Tower

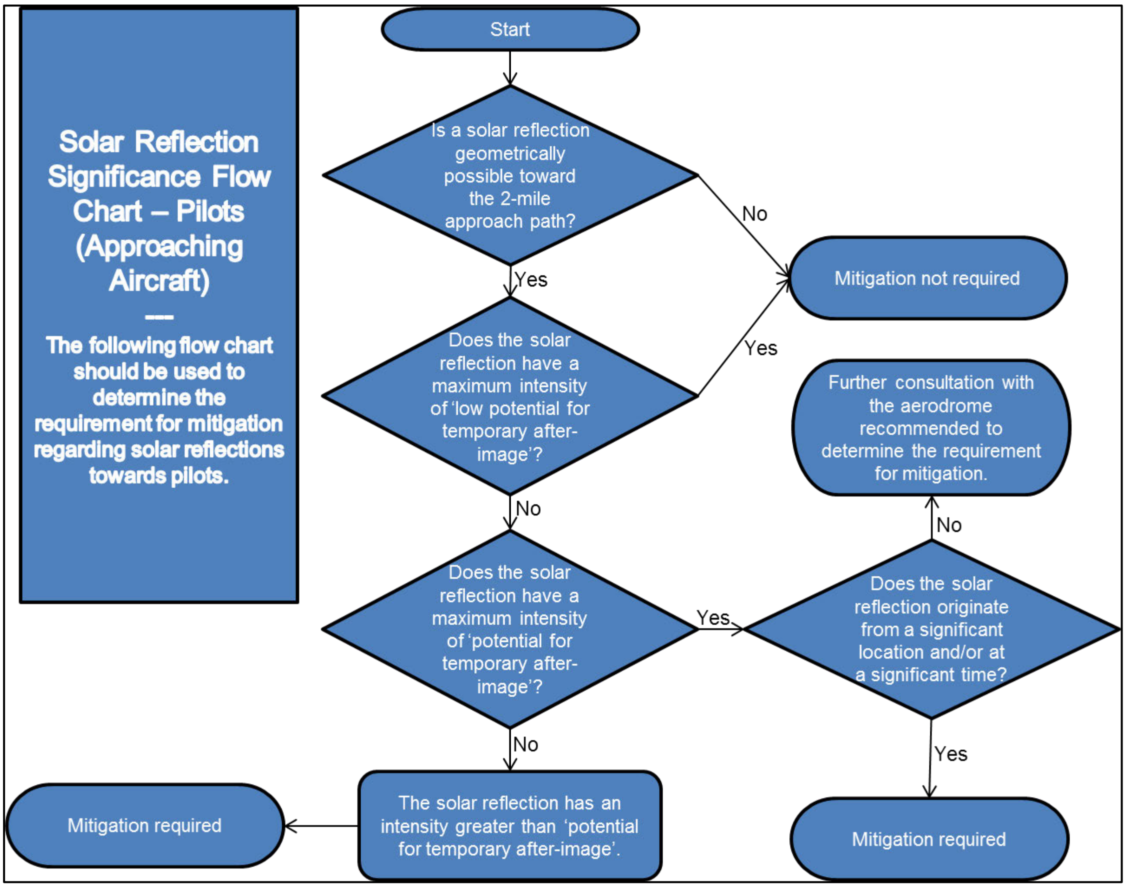
The flow chart presented below has been followed when determining the mitigation requirement for an ATC Tower.



ATC Tower mitigation requirement flow chart

Impact Significance Determination for Approaching Aircraft

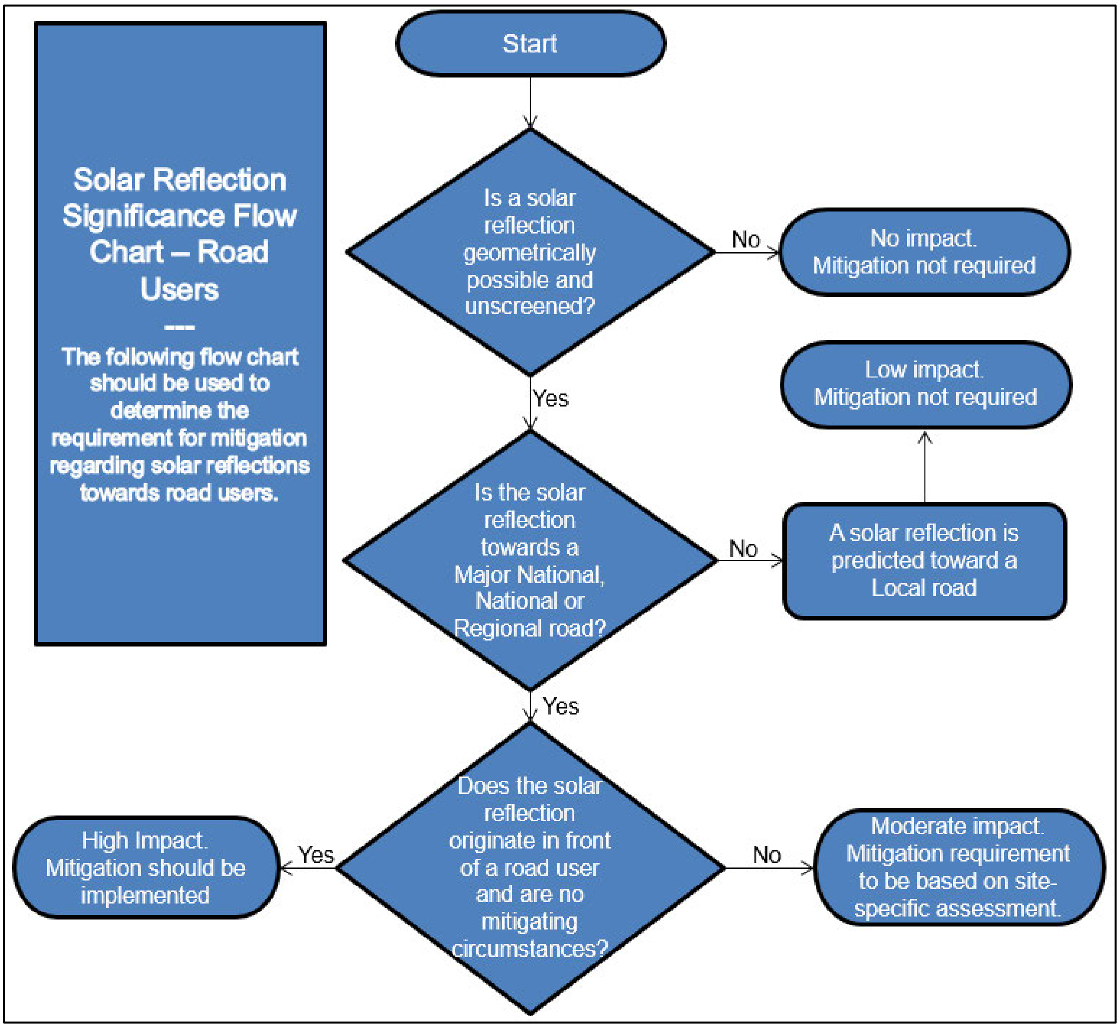
The flow chart presented below has been followed when determining the mitigation requirement for approaching aircraft.



Approaching aircraft receptor mitigation requirement flow chart

Impact Significance Determination for Road Receptors

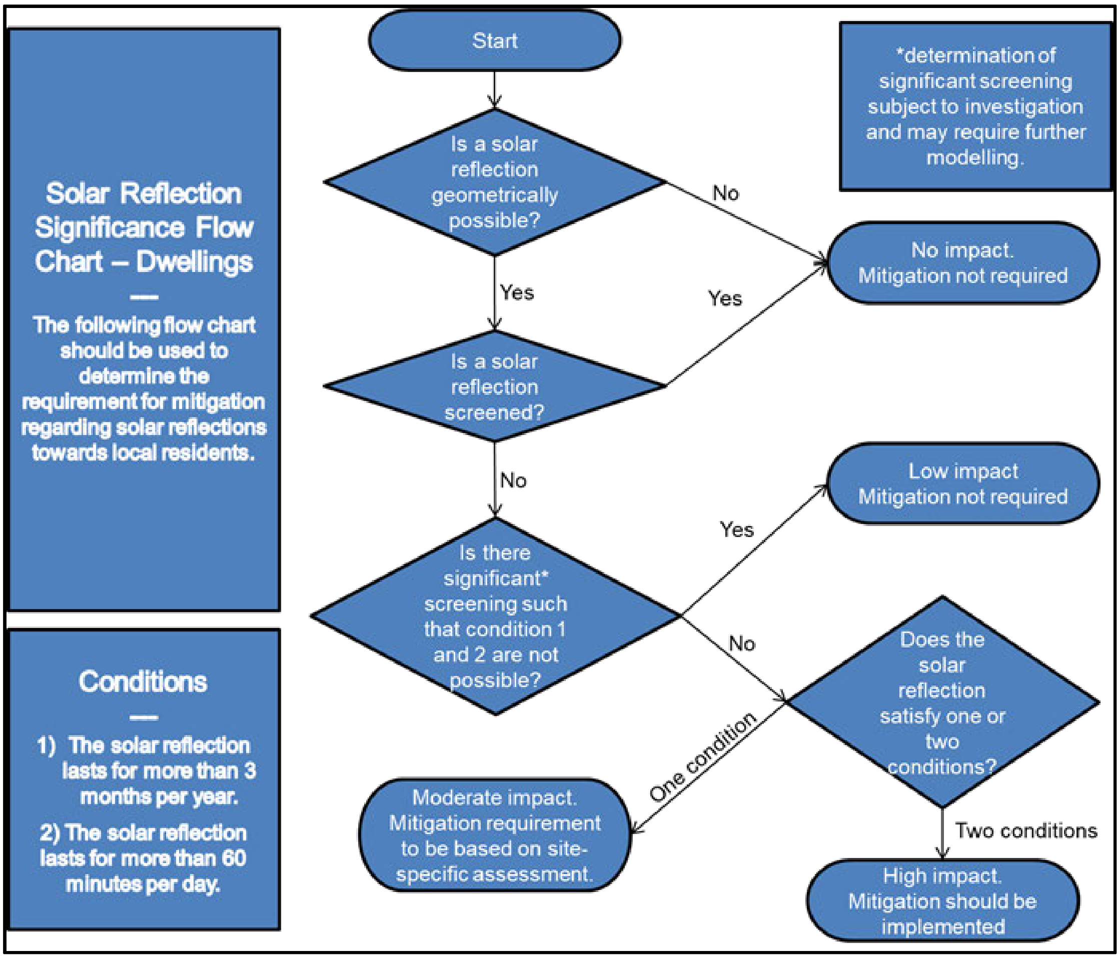
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



Road receptor mitigation requirement flow chart

Impact Significance Determination for Dwelling Receptors

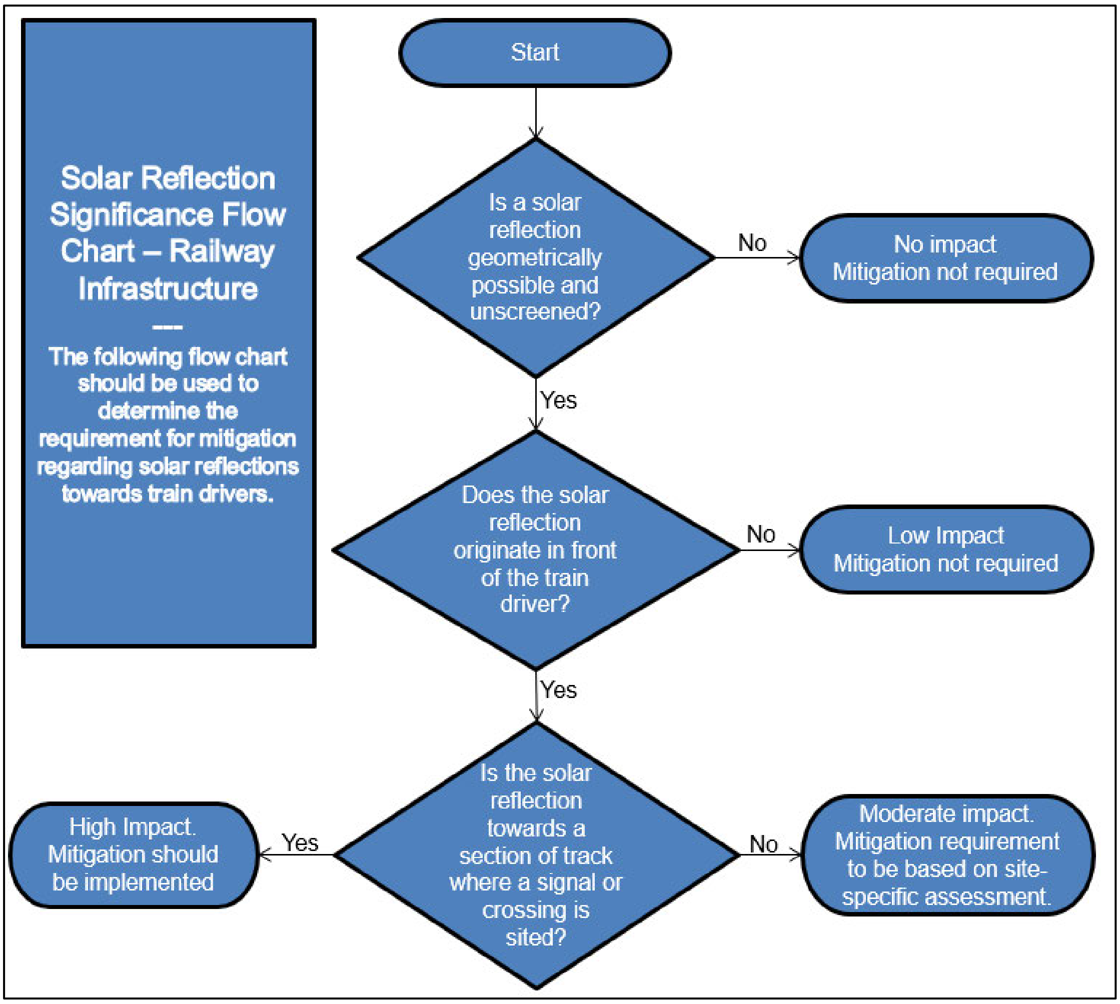
The flow chart presented below has been followed when determining the mitigation requirement for dwelling receptors.



Dwelling receptor mitigation requirement flow chart

Impact Significance Determination for Railway Receptors

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



Railway receptor impact significance flow chart

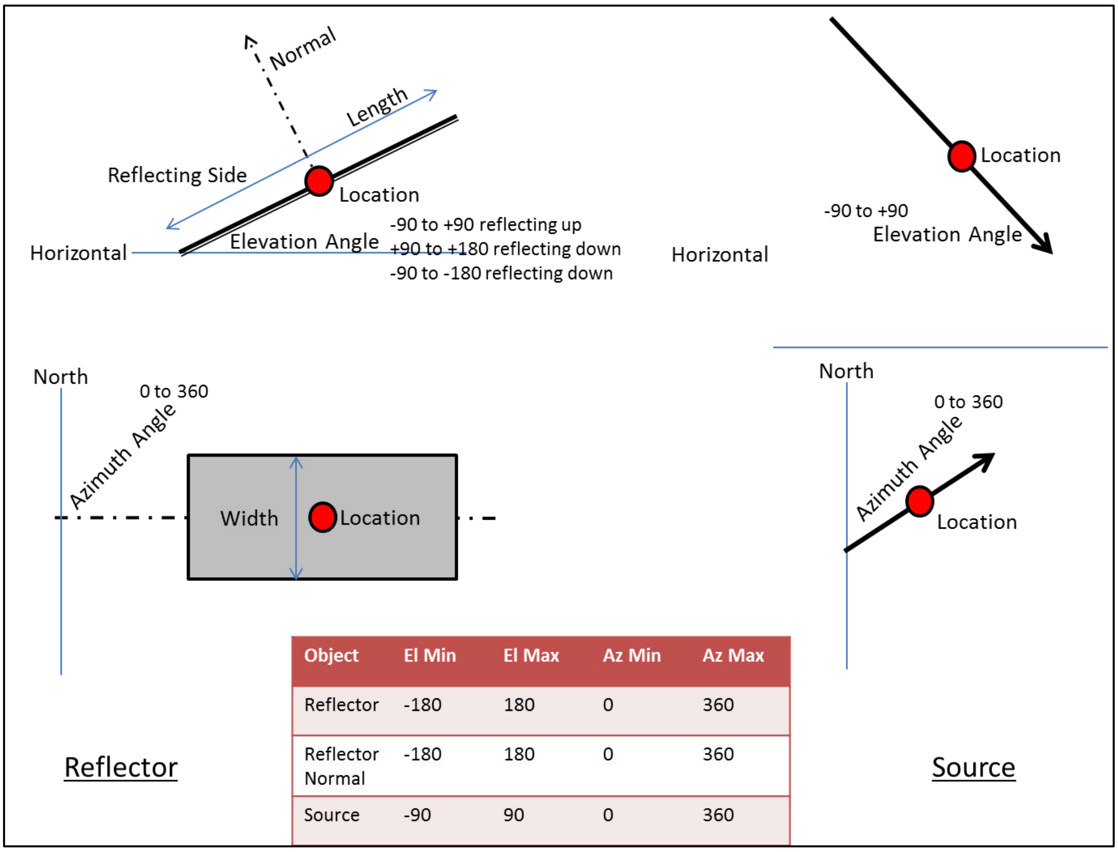
APPENDIX E – REFLECTION CALCULATIONS METHODOLOGY

Pager Power Reflection Calculations Methodology

The calculations are three dimensional and complex, accounting for:

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

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



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

Reflection calculation process

The following process is used to determine the 3D azimuth and elevation of a reflection:

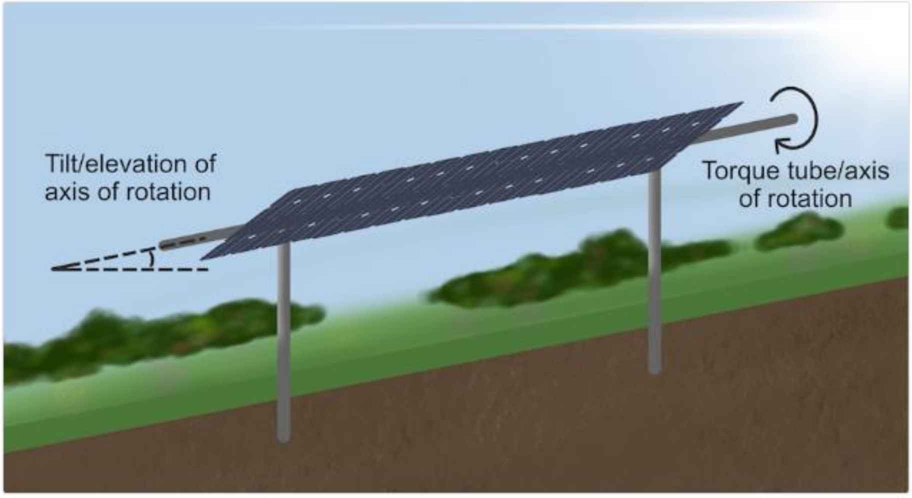
- Use the Latitude and Longitude of reflector as the reference for calculation purposes;
- Calculate the Azimuth and Elevation of the normal to the reflector;
- Calculate the 3D angle between the source and the normal;
- If this angle is less than 90 degrees a reflection will occur. If it is greater than 90 degrees no reflection will occur because the source is behind the reflector;
- Calculate the Azimuth and Elevation of the reflection in accordance with the following:
  - The angle between source and normal is equal to angle between normal and reflection;
  - Source, Normal and Reflection are in the same plane.

Forge Reflection Calculations Methodology

Extracts taken from the Forge Solar Model.

Tracking System Parameters

Single-axis module tracking systems are described by a unique set of parameters. These angular inputs model the tracking axis, rotation range and backtracking behavior. Dual-axis module tracking systems are assumed to track the sun at all times.



Single-axis tracking system with torque tube tilted due to geography

Tilt of tracking axis (°)
Tilt above flat ground of axis over which panels rotate (e.g. torque tube). System on flat, level ground would have axis tilt of 0°.

Orientation of tracking axis (°)
Azimuthal angle of axis over which panels rotate. Angle represents the facing of the axis and system. For example, typical tracking system in northern hemisphere has tracking axis oriented north-south with an orientation of 180°, allowing panels to rotate east-west with potential south-facing tilt. Typical tracking system in southern hemisphere runs south-north with axis orientation of 0°, yielding east-west rotation with potential north-facing tilt.

Offset angle of module (°)
Additional tilt angle of PV module elevated above tracking axis/torque tube. Offset angle is measured from the torque tube.

Maximum tracking angle (°)
Maximum angle of rotation of tracking system in one direction. For example, a typical system with a 120° range of rotation has a *max tracking angle* of 60° (east/west).

Resting angle (°)
Angle of rotation of panels when sun is outside tracking range. Used to model backtracking. Panels will revert to the position described by this rotation angle at all times when the sun is outside the rotation range. Setting this equal to the *maximum tracking angle* implies the panels do not backtrack.

ForgeSolar utilizes a simplified model of backtracking which assumes panels instantaneously revert to the *resting angle* whenever the sun is outside the rotation range. For example, panels with *max tracking angle* of 60° and *resting angle* of 0° would lie flat from sunrise until the sun enters the rotation range, and immediately after the sun leaves the rotation range until sunset daily.

Tracking System Parameters

APPENDIX F – ASSESSMENT LIMITATIONS AND ASSUMPTIONS

Pager Power's Model

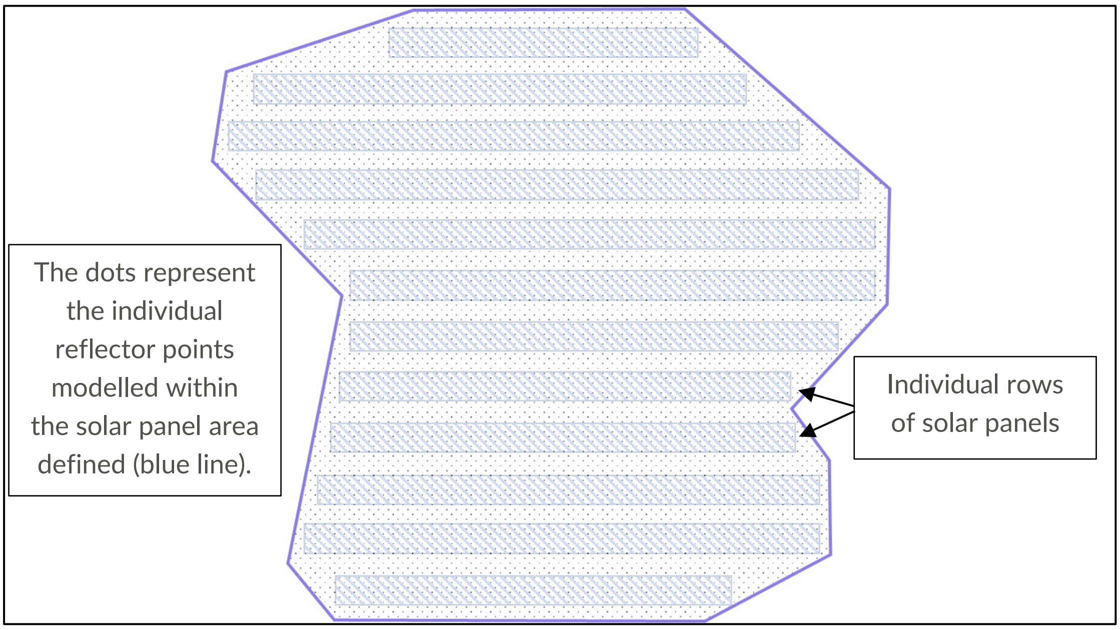
It is assumed that the panel elevation angle provided by the developer represents the elevation angle for all of the panels within each solar panel area defined.

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

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

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

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



Solar panel area modelling overview

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

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

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

Forge's Sandia National Laboratories' (SGHAT) Model[36]

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.

36 [redacted]

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Aviation Receptor Data

ATC Tower

The table below presents the data for the ATC Tower.

Longitude (°)	Latitude (°)	Ground Height (m amsl)	Observer Height (m agl)	Assessed Altitude (m amsl)
-0.476662	52.610596	76.00	9.00	85.00

ATC tower receptor details

Runway 07 Approach

The table below presents the data for the assessed locations for aircraft on approach to runway 07.

ID	Longitude (°)	Latitude (°)	Assessed Altitude (metres amsl)
Receptor 01 – Threshold	-0.495122	52.609519	181.10
Receptor 02	-0.497405	52.609100	189.93
Receptor 03	-0.499688	52.608680	199.36
Receptor 04	-0.501971	52.608261	207.78
Receptor 05	-0.504253	52.607842	217.20
Receptor 06	-0.506536	52.607422	227.86
Receptor 07	-0.508819	52.607003	238.05
Receptor 08	-0.511102	52.606584	247.23
Receptor 09	-0.513385	52.606164	256.63
Receptor 10	-0.515668	52.605745	266.32
Receptor 11 – 1 mile	-0.517951	52.605326	274.74
Receptor 12	-0.520234	52.604906	282.16
Receptor 13	-0.522516	52.604487	290.04

ID	Longitude (°)	Latitude (°)	Assessed Altitude (metres amsl)
Receptor 14	-0.524799	52.604068	299.01
Receptor 15	-0.527082	52.603648	306.92
Receptor 16	-0.529365	52.603229	312.29
Receptor 17	-0.531648	52.602810	314.80
Receptor 18	-0.533931	52.602390	315.70
Receptor 19	-0.536214	52.601971	315.56
Receptor 20	-0.538497	52.601552	315.91
Receptor 21 – 2 miles	-0.540779	52.601132	315.19

Assessed receptor (aircraft) locations on the approach path for runway 07

Runway 25 Approach

The table below presents the data for the assessed locations for aircraft on approach to runway 25.

ID	Longitude (°)	Latitude (°)	Assessed Altitude (metres amsl)
Receptor 01 – Threshold	-0.456686	52.616592	164.39
Receptor 02	-0.454403	52.617011	169.81
Receptor 03	-0.452119	52.617429	175.51
Receptor 04	-0.449835	52.617848	179.70
Receptor 05	-0.447552	52.618266	183.35
Receptor 06	-0.445268	52.618685	191.65
Receptor 07	-0.442984	52.619104	199.82
Receptor 08	-0.440701	52.619522	202.24
Receptor 09	-0.438417	52.619941	205.05
Receptor 10	-0.436134	52.620359	206.31
Receptor 11 – 1 mile	-0.433850	52.620778	222.56

ID	Longitude (°)	Latitude (°)	Assessed Altitude (metres amsl)
Receptor 12	-0.431566	52.621197	232.15
Receptor 13	-0.429283	52.621615	240.25
Receptor 14	-0.426999	52.622034	253.73
Receptor 15	-0.424716	52.622452	263.58
Receptor 16	-0.422432	52.622871	271.00
Receptor 17	-0.420148	52.623290	278.23
Receptor 18	-0.417865	52.623708	283.85
Receptor 19	-0.415581	52.624127	289.27
Receptor 20	-0.413298	52.624545	294.69
Receptor 21 – 2 miles	-0.411014	52.624964	300.01

Assessed receptor (aircraft) locations on the approach path for runway 25

Road Receptor Data

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

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-0.483095	52.722753	41	-0.472103	52.689350
2	-0.483038	52.721847	42	-0.470701	52.689029
3	-0.482427	52.721014	43	-0.469268	52.689280
4	-0.481824	52.720182	44	-0.468420	52.690025
5	-0.481569	52.719285	45	-0.467430	52.690700
6	-0.481273	52.718403	46	-0.466424	52.691368
7	-0.480921	52.717526	47	-0.465888	52.692212
8	-0.480556	52.716649	48	-0.465148	52.692994
9	-0.480206	52.715771	49	-0.464234	52.693717
10	-0.479830	52.714897	50	-0.463299	52.694427

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
11	-0.479484	52.714018	51	-0.462242	52.695075
12	-0.479108	52.713138	52	-0.461086	52.695654
13	-0.478740	52.712258	53	-0.459808	52.696132
14	-0.478377	52.711379	54	-0.459011	52.696905
15	-0.478024	52.710500	55	-0.458091	52.697621
16	-0.477647	52.709633	56	-0.457020	52.698257
17	-0.477267	52.708766	57	-0.455918	52.698863
18	-0.476904	52.707900	58	-0.454913	52.699529
19	-0.476512	52.707028	59	-0.454212	52.700327
20	-0.476122	52.706152	60	-0.453509	52.701132
21	-0.475684	52.705280	61	-0.452463	52.701784
22	-0.475260	52.704414	62	-0.451005	52.701963
23	-0.474835	52.703552	63	-0.449522	52.701882
24	-0.474410	52.702691	64	-0.448035	52.701838
25	-0.473901	52.701839	65	-0.446808	52.702359
26	-0.473538	52.700957	66	-0.446333	52.703221
27	-0.473437	52.700063	67	-0.445889	52.704089
28	-0.473357	52.699158	68	-0.445424	52.704946
29	-0.473375	52.698273	69	-0.444958	52.705802
30	-0.473676	52.697409	70	-0.444545	52.706590
31	-0.474243	52.696569	71	-0.444044	52.707534
32	-0.474477	52.695679	72	-0.443572	52.708393
33	-0.474548	52.694779	73	-0.443017	52.709234
34	-0.474732	52.693881	74	-0.442887	52.710142

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
35	-0.475046	52.693011	75	-0.442904	52.711061
36	-0.475113	52.692110	76	-0.442921	52.711967
37	-0.474986	52.691211	77	-0.443051	52.712876
38	-0.475295	52.690328	78	-0.443182	52.713782
39	-0.475076	52.689437	79	-0.442975	52.714686
40	-0.473585	52.689467			

Road Receptor data

Dwelling Receptor Data

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

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-0.503395	52.719127	91	-0.457184	52.698503
2	-0.489796	52.719288	92	-0.457765	52.698217
3	-0.488500	52.720279	93	-0.462162	52.694656
4	-0.488776	52.719984	94	-0.462477	52.694382
5	-0.481330	52.719478	95	-0.465799	52.692806
6	-0.486413	52.716142	96	-0.466133	52.692426
7	-0.479136	52.713708	97	-0.466486	52.692078
8	-0.480660	52.710828	98	-0.466642	52.691914
9	-0.467933	52.710649	99	-0.466753	52.691765
10	-0.492012	52.705195	100	-0.466925	52.691593
11	-0.493978	52.703885	101	-0.468518	52.691523
12	-0.493484	52.703701	102	-0.468503	52.691068
13	-0.479943	52.697653	103	-0.468146	52.690689
14	-0.476905	52.699108	104	-0.467591	52.690369
15	-0.450624	52.713271	105	-0.468122	52.690403

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
16	-0.450010	52.713131	106	-0.468320	52.690309
17	-0.449499	52.713178	107	-0.469387	52.690053
18	-0.448851	52.713152	108	-0.476876	52.692567
19	-0.448347	52.712682	109	-0.474977	52.690013
20	-0.447833	52.712196	110	-0.474364	52.689962
21	-0.447065	52.711332	111	-0.474929	52.689706
22	-0.446425	52.711301	112	-0.474640	52.689556
23	-0.446138	52.712076	113	-0.473873	52.689674
24	-0.445545	52.712172	114	-0.473466	52.689642
25	-0.444756	52.711781	115	-0.473051	52.689654
26	-0.444179	52.711768	116	-0.472748	52.689683
27	-0.443619	52.711859	117	-0.472257	52.689691
28	-0.443286	52.712166	118	-0.471817	52.689583
29	-0.444244	52.709763	119	-0.471576	52.689487
30	-0.425525	52.705240	120	-0.471316	52.689420
31	-0.421579	52.704645	121	-0.470797	52.689263
32	-0.416750	52.705578	122	-0.470288	52.689231
33	-0.444407	52.706111	123	-0.469760	52.689222
34	-0.444112	52.705917	124	-0.469586	52.689510
35	-0.452407	52.705526	125	-0.469172	52.689116
36	-0.451261	52.705560	126	-0.468980	52.688534
37	-0.451660	52.705044	127	-0.468164	52.688756
38	-0.451633	52.704207	128	-0.467811	52.688797
39	-0.451868	52.703832	129	-0.468021	52.688113

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
40	-0.452061	52.703482	130	-0.467527	52.687734
41	-0.452726	52.703377	131	-0.466956	52.687543
42	-0.453243	52.703288	132	-0.466178	52.687367
43	-0.453568	52.703159	133	-0.465368	52.687432
44	-0.453837	52.703121	134	-0.464731	52.687196
45	-0.454308	52.703034	135	-0.464151	52.687184
46	-0.454784	52.703051	136	-0.463505	52.687073
47	-0.455315	52.702931	137	-0.462966	52.686817
48	-0.455747	52.702939	138	-0.462229	52.686735
49	-0.456317	52.702859	139	-0.461712	52.686567
50	-0.456187	52.702742	140	-0.461165	52.686255
51	-0.456050	52.702612	141	-0.461111	52.685975
52	-0.455900	52.702419	142	-0.461927	52.685796
53	-0.455704	52.702289	143	-0.462354	52.685581
54	-0.455457	52.702071	144	-0.461655	52.685138
55	-0.455126	52.701901	145	-0.430645	52.686253
56	-0.452019	52.703095	146	-0.459263	52.680872
57	-0.452308	52.702746	147	-0.456667	52.680821
58	-0.451890	52.702443	148	-0.455970	52.680780
59	-0.451632	52.702127	149	-0.455148	52.680766
60	-0.451208	52.702123	150	-0.454717	52.680977
61	-0.450831	52.702134	151	-0.457038	52.680244
62	-0.450200	52.702175	152	-0.456874	52.679971
63	-0.449580	52.702108	153	-0.457466	52.679313

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
64	-0.448810	52.701644	154	-0.457146	52.679119
65	-0.449675	52.701502	155	-0.456932	52.678867
66	-0.450333	52.701662	156	-0.457627	52.678867
67	-0.450916	52.701676	157	-0.457930	52.678703
68	-0.451329	52.701652	158	-0.458212	52.678570
69	-0.451693	52.701666	159	-0.458840	52.678388
70	-0.452100	52.701680	160	-0.459071	52.674801
71	-0.452309	52.701409	161	-0.459598	52.674176
72	-0.452414	52.701178	162	-0.459097	52.673768
73	-0.453265	52.700969	163	-0.454329	52.676019
74	-0.453720	52.700526	164	-0.451831	52.674460
75	-0.453404	52.700313	165	-0.439550	52.675458
76	-0.453295	52.700158	166	-0.436506	52.677076
77	-0.452859	52.699910	167	-0.423578	52.674265
78	-0.452609	52.699661	168	-0.422927	52.673677
79	-0.454666	52.700055	169	-0.454077	52.670920
80	-0.455101	52.699727	170	-0.453310	52.669909
81	-0.455513	52.699469	171	-0.453830	52.664229
82	-0.454817	52.699357	172	-0.446230	52.664784
83	-0.454414	52.699307	173	-0.428499	52.664900
84	-0.454202	52.699080	174	-0.426835	52.664614
85	-0.454447	52.698885	175	-0.427659	52.664199
86	-0.454671	52.698682	176	-0.427537	52.663753
87	-0.455101	52.698730	177	-0.433987	52.662335

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
88	-0.455271	52.698995	178	-0.429975	52.660484
89	-0.456446	52.699341	179	-0.429040	52.660755
90	-0.456598	52.698801			

Dwelling receptor data

Railway Receptor Data

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

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-0.468040	52.714083	27	-0.446678	52.695109
2	-0.467283	52.713309	28	-0.445643	52.694466
3	-0.466543	52.712531	29	-0.444573	52.693853
4	-0.465778	52.711753	30	-0.443514	52.693213
5	-0.465015	52.710971	31	-0.442418	52.692610
6	-0.464266	52.710190	32	-0.441319	52.691999
7	-0.463505	52.709409	33	-0.440178	52.691423
8	-0.462760	52.708639	34	-0.439036	52.690842
9	-0.461988	52.707857	35	-0.437867	52.690281
10	-0.461213	52.707087	36	-0.436712	52.689712
11	-0.460473	52.706298	37	-0.435523	52.689173
12	-0.459726	52.705522	38	-0.434354	52.688612
13	-0.458976	52.704744	39	-0.433167	52.688057
14	-0.458202	52.703979	40	-0.431976	52.687505
15	-0.457412	52.703217	41	-0.430812	52.686949
16	-0.456578	52.702478	42	-0.429648	52.686386
17	-0.455725	52.701743	43	-0.428470	52.685833
18	-0.454864	52.700994	44	-0.427281	52.685286

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
19	-0.453995	52.700262	45	-0.426102	52.684736
20	-0.453477	52.699841	46	-0.424923	52.684188
21	-0.452568	52.699130	47	-0.423757	52.683627
22	-0.451628	52.698436	48	-0.422589	52.683075
23	-0.450665	52.697755	49	-0.421410	52.682529
24	-0.449706	52.697075	50	-0.420238	52.681977
25	-0.448729	52.696408	51	-0.419076	52.681428
26	-0.447718	52.695752	52	-0.417894	52.680881

Railway receptor data

Modelled Reflector Areas

The tables in the following sub-sections present the data for the modelled reflector areas.

Area 1

ID	Longitude (°)	Latitude (°)	ID	Longitude (°)	Latitude (°)
1	-0.506942	52.710761	11	-0.498958	52.711023
2	-0.506924	52.709492	12	-0.500480	52.711676
3	-0.506926	52.709147	13	-0.501865	52.711798
4	-0.507215	52.708043	14	-0.503604	52.711818
5	-0.507184	52.707750	15	-0.504022	52.711971
6	-0.505247	52.707727	16	-0.504344	52.712415
7	-0.500685	52.706267	17	-0.504779	52.712725
8	-0.500363	52.706262	18	-0.505506	52.712947
9	-0.497050	52.710275	19	-0.505839	52.712952
10	-0.497053	52.710361	20	-0.506988	52.711171

Reflector area 1 data

Area 2

ID	Longitude	Latitude	ID	Longitude	Latitude
1	-0.490073	52.709438	9	-0.488227	52.710707
2	-0.490063	52.709228	10	-0.489052	52.710776
3	-0.489335	52.708939	11	-0.489950	52.710790
4	-0.488735	52.708782	12	-0.492787	52.710230
5	-0.488105	52.708482	13	-0.493068	52.710157
6	-0.487790	52.708469	14	-0.493408	52.710015
7	-0.487776	52.709051	15	-0.493445	52.709878
8	-0.487944	52.710619	16	-0.492040	52.709565

Reflector area 2 data

Area 3

ID	Longitude	Latitude	ID	Longitude	Latitude
1	-0.483872	52.711105	6	-0.482610	52.713533
2	-0.482938	52.711089	7	-0.485829	52.713790
3	-0.481820	52.711227	8	-0.486485	52.713799
4	-0.481663	52.711734	9	-0.487242	52.711221
5	-0.482300	52.713384			

Reflector area 3 data

Area 4

ID	Longitude	Latitude	ID	Longitude	Latitude
1	-0.484147	52.703148	6	-0.484859	52.706654
2	-0.483814	52.703139	7	-0.485445	52.706597
3	-0.477765	52.703746	8	-0.485461	52.706356
4	-0.477732	52.704417	9	-0.484620	52.704422
5	-0.478796	52.707026			

Reflector area 4 data

Area 5

ID	Longitude	Latitude	ID	Longitude	Latitude
1	-0.478054	52.707017	6	-0.476255	52.705675
2	-0.476793	52.703827	7	-0.476570	52.705675
3	-0.476454	52.703814	8	-0.477086	52.706946
4	-0.475919	52.703884	9	-0.477032	52.707083
5	-0.475643	52.704029	10	-0.477971	52.707091

Reflector area 5 data

Area 6

ID	Longitude	Latitude	ID	Longitude	Latitude
1	-0.474294	52.704211	24	-0.460955	52.698063
2	-0.474457	52.703827	25	-0.462893	52.702477
3	-0.473665	52.702262	26	-0.461324	52.702937
4	-0.473268	52.701682	27	-0.459047	52.703616
5	-0.471385	52.701229	28	-0.459036	52.703720
6	-0.469385	52.701193	29	-0.461344	52.706321
7	-0.470411	52.699959	30	-0.461678	52.706588
8	-0.470462	52.698787	31	-0.461986	52.706581
9	-0.471435	52.699389	32	-0.462464	52.706525
10	-0.472131	52.699501	33	-0.462464	52.706155
11	-0.473119	52.698625	34	-0.462186	52.705826
12	-0.473155	52.698031	35	-0.465882	52.704741
13	-0.472659	52.697891	36	-0.466689	52.705548
14	-0.470759	52.698334	37	-0.465778	52.705948
15	-0.469304	52.698983	38	-0.463986	52.706357
16	-0.469277	52.698594	39	-0.463988	52.706440

ID	Longitude	Latitude	ID	Longitude	Latitude
17	-0.466480	52.696643	40	-0.466505	52.706461
18	-0.464933	52.695669	41	-0.469900	52.709655
19	-0.463042	52.695716	42	-0.477165	52.710501
20	-0.461297	52.696194	43	-0.477488	52.710500
21	-0.461271	52.696642	44	-0.477504	52.710133
22	-0.462291	52.697411	45	-0.475563	52.705863
23	-0.460933	52.697767	46	-0.474957	52.705851

Reflector area 6 data

Area 7

ID	Longitude	Latitude	ID	Longitude	Latitude
1	-0.453444	52.691672	8	-0.450660	52.693791
2	-0.452788	52.691661	9	-0.451013	52.693793
3	-0.452635	52.691436	10	-0.454268	52.693048
4	-0.452292	52.691434	11	-0.454682	52.692494
5	-0.450087	52.692894	12	-0.454682	52.692430
6	-0.450117	52.693259	13	-0.453971	52.692102
7	-0.450408	52.693646			

Reflector area 7 data

Area 8

ID	Longitude	Latitude	ID	Longitude	Latitude
1	-0.438530	52.700831	26	-0.430816	52.693015
2	-0.439220	52.699748	27	-0.430815	52.693152
3	-0.439107	52.699606	28	-0.431183	52.693163
4	-0.439139	52.699435	29	-0.431075	52.694525
5	-0.439342	52.699280	30	-0.430795	52.694522

ID	Longitude	Latitude	ID	Longitude	Latitude
6	-0.439976	52.699125	31	-0.430731	52.695785
7	-0.439858	52.700633	32	-0.430029	52.697661
8	-0.441057	52.700806	33	-0.429462	52.697717
9	-0.444087	52.694688	34	-0.429222	52.698195
10	-0.444090	52.694292	35	-0.429231	52.699285
11	-0.442804	52.693541	36	-0.428666	52.701014
12	-0.442570	52.693474	37	-0.428688	52.701629
13	-0.441650	52.695100	38	-0.428857	52.702496
14	-0.441673	52.695726	39	-0.428953	52.702638
15	-0.440929	52.695699	40	-0.429816	52.702645
16	-0.441183	52.694426	41	-0.431593	52.702640
17	-0.441601	52.693443	42	-0.434805	52.703004
18	-0.442048	52.693305	43	-0.434488	52.703644
19	-0.442050	52.693091	44	-0.434721	52.704387
20	-0.439345	52.691618	45	-0.435253	52.705733
21	-0.433116	52.688733	46	-0.435782	52.706727
22	-0.432617	52.688726	47	-0.436104	52.706728
23	-0.432886	52.690871	48	-0.437762	52.706635
24	-0.432027	52.691488	49	-0.438409	52.706441
25	-0.431124	52.692253	50	-0.440878	52.701267

Reflector area 8 data

Area 9

ID	Longitude	Latitude	ID	Longitude	Latitude
1	-0.428332	52.700170	10	-0.423397	52.696636
2	-0.428687	52.697868	11	-0.423836	52.697503
3	-0.429077	52.696820	12	-0.421469	52.697858
4	-0.429877	52.695205	13	-0.419992	52.698132
5	-0.429873	52.694804	14	-0.420230	52.700181
6	-0.426384	52.695471	15	-0.420928	52.701075
7	-0.426453	52.695934	16	-0.421680	52.702460
8	-0.424392	52.695795	17	-0.426689	52.702569
9	-0.423264	52.696102	18	-0.428157	52.702578

Reflector area 9 data

Area 10

ID	Longitude	Latitude	ID	Longitude	Latitude
1	-0.448462	52.688823	17	-0.444302	52.689501
2	-0.447345	52.688069	18	-0.445354	52.690493
3	-0.446986	52.688063	19	-0.445813	52.690787
4	-0.446223	52.688355	20	-0.446292	52.690795
5	-0.446204	52.688700	21	-0.446387	52.691169
6	-0.445631	52.688699	22	-0.446507	52.691314
7	-0.444737	52.689144	23	-0.446710	52.691476
8	-0.443696	52.688543	24	-0.447067	52.691478
9	-0.442576	52.687636	25	-0.447331	52.691169
10	-0.441911	52.687627	26	-0.447920	52.690648
11	-0.441126	52.687904	27	-0.448158	52.690447
12	-0.440630	52.687968	28	-0.448161	52.690021

ID	Longitude	Latitude	ID	Longitude	Latitude
13	-0.440383	52.688054	29	-0.448658	52.690024
14	-0.440132	52.688420	30	-0.449381	52.689337
15	-0.443235	52.689043	31	-0.449419	52.689218
16	-0.443957	52.689497			

Reflector area 10 data

Area 11

ID	Longitude	Latitude	ID	Longitude	Latitude
1	-0.439055	52.686711	10	-0.438064	52.687611
2	-0.438453	52.686385	11	-0.438782	52.687898
3	-0.438395	52.686265	12	-0.438903	52.688109
4	-0.438101	52.686178	13	-0.439265	52.688106
5	-0.437759	52.686176	14	-0.439364	52.688023
6	-0.437075	52.686610	15	-0.439364	52.687760
7	-0.436933	52.686845	16	-0.440299	52.687763
8	-0.437780	52.686861	17	-0.440283	52.687697
9	-0.437876	52.687382	18	-0.439144	52.686935

Reflector area 11 data

Area 12

ID	Longitude	Latitude	ID	Longitude	Latitude
1	-0.443026	52.685078	9	-0.439497	52.683176
2	-0.443027	52.685003	10	-0.437706	52.683818
3	-0.442566	52.684614	11	-0.435258	52.684162
4	-0.442212	52.684321	12	-0.433867	52.684213
5	-0.440932	52.683412	13	-0.433760	52.684964
6	-0.440678	52.683108	14	-0.437023	52.685447

ID	Longitude	Latitude	ID	Longitude	Latitude
7	-0.440155	52.682964	15	-0.438089	52.685762
8	-0.439822	52.682957	16	-0.438749	52.685775

Reflector area 12 data

Area 13

ID	Longitude	Latitude	ID	Longitude	Latitude
1	-0.439573	52.681927	30	-0.431435	52.678536
2	-0.439843	52.681413	31	-0.429824	52.678872
3	-0.439178	52.680728	32	-0.429808	52.678948
4	-0.440623	52.680743	33	-0.430610	52.679705
5	-0.441619	52.680118	34	-0.430930	52.680227
6	-0.441374	52.679840	35	-0.431604	52.681205
7	-0.442680	52.679864	36	-0.432152	52.681866
8	-0.443155	52.679802	37	-0.432613	52.682186
9	-0.444834	52.679013	38	-0.433100	52.682203
10	-0.444835	52.678944	39	-0.432789	52.682832
11	-0.443278	52.677690	40	-0.431303	52.683064
12	-0.443214	52.677497	41	-0.430804	52.681117
13	-0.442801	52.677303	42	-0.430449	52.680931
14	-0.441817	52.677187	43	-0.426776	52.681067
15	-0.441478	52.677187	44	-0.427157	52.682500
16	-0.437194	52.678410	45	-0.426663	52.682949
17	-0.436810	52.678033	46	-0.425598	52.682860
18	-0.435775	52.677989	47	-0.424654	52.682848
19	-0.435923	52.677669	48	-0.424381	52.682937

ID	Longitude	Latitude	ID	Longitude	Latitude
20	-0.435540	52.677253	49	-0.424131	52.683194
21	-0.435211	52.676971	50	-0.424301	52.683537
22	-0.435197	52.676675	51	-0.426098	52.683558
23	-0.431569	52.673213	52	-0.426378	52.683463
24	-0.431212	52.673213	53	-0.431395	52.683550
25	-0.428989	52.673949	54	-0.432379	52.683662
26	-0.429745	52.675224	55	-0.432771	52.683672
27	-0.430373	52.675822	56	-0.432837	52.683529
28	-0.430383	52.676947	57	-0.433924	52.683559
29	-0.430679	52.677460	58	-0.438328	52.682772

Reflector area 13 data

Area 14

ID	Longitude	Latitude	ID	Longitude	Latitude
1	-0.449049	52.674979	11	-0.446149	52.673771
2	-0.450020	52.674236	12	-0.443030	52.674286
3	-0.453059	52.672784	13	-0.442395	52.675084
4	-0.450021	52.671962	14	-0.442258	52.675834
5	-0.447681	52.671471	15	-0.442398	52.676061
6	-0.445753	52.671308	16	-0.442728	52.676368
7	-0.443637	52.671271	17	-0.443430	52.676778
8	-0.443210	52.672103	18	-0.446971	52.676877
9	-0.443039	52.672740	19	-0.447637	52.676680
10	-0.444394	52.673226			

Reflector area 14 data

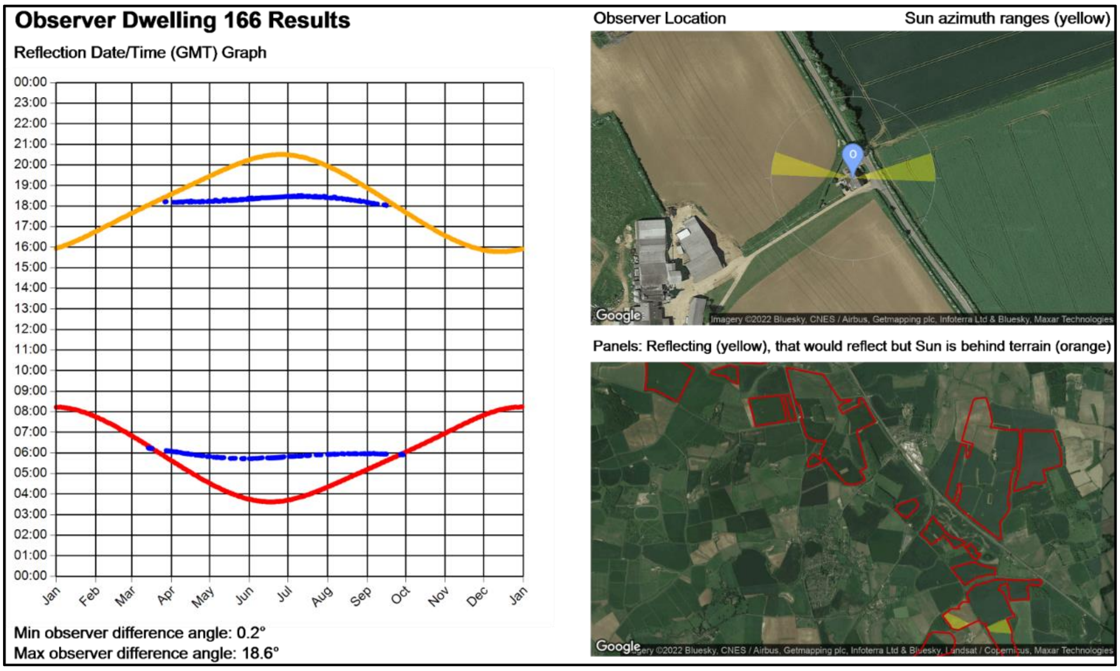
APPENDIX H – GEOMETRIC CALCULATION RESULTS

Overview

The charts for the receptors for which mitigation has been recommended are shown on the following pages. Each chart shows:

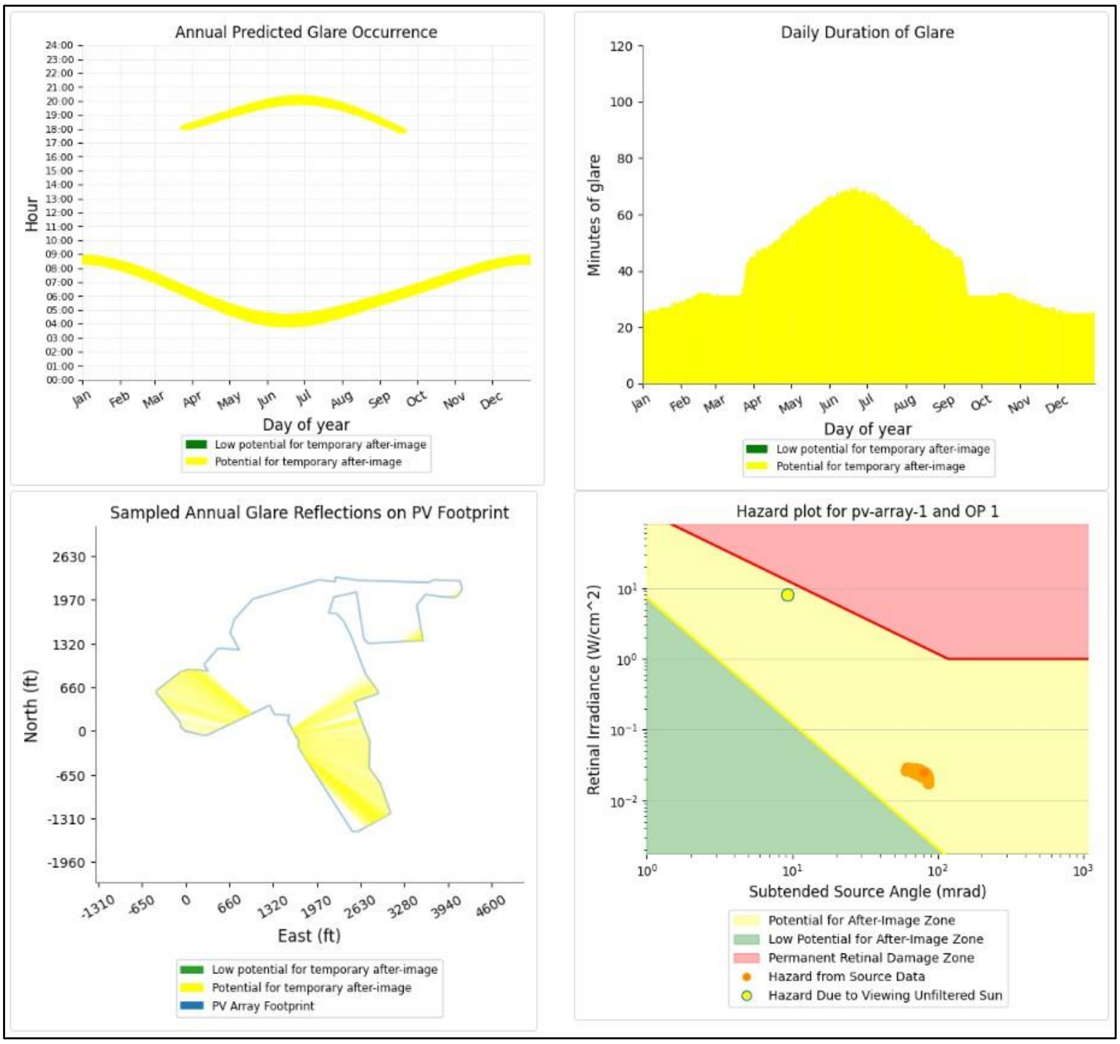
- The receptor (observer) location – top right image. This also shows the azimuth range of the Sun itself at times when reflections are possible. If sunlight is experienced from the same direction as the reflecting panels, the overall impact of the reflection is reduced as discussed within the body of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

Fixed Panels



Tracker Panels

Dwelling 166



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