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Environmental Statement Appendix 2.5: Solar Photovoltaic Glint and Glare Study

June 2024

PAGERPOWER
Urban & Renewables

Solar Photovoltaic Glint and Glare Study

Enso Green Holdings D Limited

Helios Renewable Energy Project

May 2024

PLANNING SOLUTIONS FOR:

- Solar
- Telecoms
- Railways
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ADMINISTRATION PAGE

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Issue	Date	Detail of Changes
1	August 2022	Initial issue
2	June 2023	Second issue – layout revision
3	August 2023	Third issue – layout revision
4	September 2023	Fourth issue – minor amendments
5	September 2023	Fifth issue – minor amendments
6	February 2024	Sixth issue – minor layout changes
7	May 2024	Seventh issue – minor layout changes

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EXECUTIVE SUMMARY

Report Purpose

Pager Power has been commissioned to assess the possible effects of glint and glare from a solar photovoltaic (PV) array electricity generating facility (the 'Proposed Development') on land to the south-west of the village of Camblesforth and to the north of the village of Hirst Courtney in North Yorkshire (the 'Site'). The Site is located within the administrative area of North Yorkshire Council. This assessment pertains to the possible impact upon surrounding aviation activity, residential amenity, road safety, and railway operations and infrastructure.

Overall Conclusions

No significant impacts from the Proposed Development are predicted upon residential amenity, road safety, and train drivers travelling along the assessed section of railway track. Therefore no mitigation is required for these receptors.

Mitigation is recommended for the approach path towards the runway 25 threshold at Burn Airfield due to a lack of sufficient mitigating factors.

The results of this report should be made available to the safeguarding teams at Burn Airfield and Cliffe Airfield to discuss their position towards the Proposed Development.

The assessment results are presented on the following pages.

Guidance and Studies

Guidelines exist in the UK (produced by the Civil Aviation Authority) and in the USA (produced by the Federal Aviation Administration) with respect to solar developments and aviation activity. The UK CAA guidance is relatively high-level and does not prescribe a formal methodology. A specific national guidance policy for determining the impact of glint and glare on road safety and residential amenity has also not been produced to date. Therefore, in the absence of this, Pager Power reviewed more general existing planning guidelines and the available studies (discussed below) in the process of defining its own glint and glare assessment guidance and methodology[1]. This methodology defines the process for determining the impact upon road safety, residential amenity, and aviation activity.

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

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

[2] Formerly mandatory for on-airfield solar developments in the USA under the FAA's interim policy, superseded in 2021 with a policy that effectively requires individual airports to sign off on their on-airfield development as they see fit.

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[3].

Assessment Results - Aviation Receptors

The results of the analysis for Burn Airfield (runways 01/19, 07/25 and 15/33) and Cliffe Airfield (runway 10/28) have shown that no solar reflections towards pilots approaching runway 10 are geometrically possible. Therefore, no impacts from the Proposed Development are possible and mitigation is not required.

Solar reflections with 'potential for temporary after-image' are predicted towards runways, 01, 07, 15, 19, 33, and 28. However, following further assessment of the predicted reflections in an operational context, it can be concluded that the glare is operationally accommodatable.

Solar reflections from the Proposed Development with 'potential for temporary after-image' are predicted towards the runway 25 approach. Following further assessment of the predicted reflections in an operational context, the impacts are considered significant (prior to mitigation) and mitigation is required. Potential mitigation for the Proposed Development can include fixing the Single Access Tracker System at a resting angle that would avoid significant effects at the times at which glare for the runway 25 approach is predicted.

Assessment Results - Dwelling Receptors

The results of the analysis have shown that reflections from the Proposed Development are geometrically possible towards 104 out of the identified dwelling receptors for more than three months per year and less than 60 minutes per day.

For 98 dwellings, existing and proposed (please see Figures 7.8-7.10 Landscape Strategy of the Preliminary Environmental Information Report) screening in the form of vegetation, terrain and buildings removes the visibility of the reflecting panel areas. Therefore, no impacts from the Proposed Development are predicted and mitigation is not required.

For the remaining six dwellings, there are sufficient mitigating factors. These include:

- A large separation distance between the reflecting panel area and the dwelling. This reduces the proportion of an observer's field of view that is affected by glare.
- The effects coincide with direct sunlight, which is a more significant source of light; therefore the effects appear much less significant.
- The effects cannot be seen from an observer on the ground floor – which has the greatest impact on residential amenity.
- The effects occur outside the 1km assessment area and would therefore be a maximum of low impact, due to the separation distance and intervening terrain/vegetation.

Therefore, mitigation is not recommended for these dwellings.

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

Assessment Results - Road Receptors

The results of the analysis have shown that solar reflections from the Proposed Development are geometrically possible along approximately all of the assessed sections of road along the A1041, A645, Barlow Road, Common Lane, Hirst Road and Station Road.

Where solar reflections are geometrically possible inside a road user's primary field of view, along a combined 4.1km section of road, existing and proposed vegetation and buildings will remove visibility of any solar reflections. Therefore, no impacts from the Proposed Development are predicted, and mitigation is not required for these sections of road.

Assessment Results - Train Driver Receptors

The analysis has shown that reflections are geometrically possible towards 2.8km of railway track. Reflections are predicted to occur within the train driver's primary field of view (30 degrees either side of the direction of travel) along 200m of railway track; however, screening in the form of heavy existing vegetation is present. Therefore, no impacts from the Proposed Development are predicted and mitigation is not required.

A low impact from the Proposed Development is predicted for the remaining sections of railway track where solar reflections are geometrically possible. The reflections occur outside of the train driver's primary field of view. Therefore, no mitigation is required.

Assessment Results - High-Level Aviation

Considering the size of the Proposed Development and its location relative to Sherburn-in-Elmet Airfield (approximately 9.5km away), the following is applicable:

- In Pager Power's experience and expertise, it can be safely presumed that any predicted solar reflections towards pilots approaching runway thresholds 06, 19 and both runway 10 thresholds, 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.
- Any solar reflections will be outside a pilot's primary field of view (50 degrees either side of the approach bearing) along the approach paths towards runway thresholds 01, 24, and both runway 28 thresholds, which is acceptable in accordance with the associated guidance and industry best practice.

Therefore, no significant impacts, from the Proposed Development, upon aviation activity associated with Sherburn-in-Elmet are predicted, and no further detailed modelling is recommended.

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ABOUT PAGER POWER

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

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

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

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

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

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

1 INTRODUCTION

1.1 Overview

Pager Power has been commissioned to assess the possible effects of glint and glare from a solar photovoltaic (PV) array electricity generating facility (the 'Proposed Development') on land to the south-west of the village of Camblesforth and to the north of the village of Hirst Courtney in North Yorkshire (the 'Site'). The Site is located within the administrative area of North Yorkshire Council. This assessment pertains to the possible impact upon surrounding aviation activity, residential amenity, road safety, and railway operations and infrastructure.

This report contains the following:

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

1.2 Pager Power's Experience

Pager Power has undertaken over 1,000 Glint and Glare assessments in the UK and internationally. The studies have included assessment of civil and military aerodromes, railway infrastructure and other ground-based receptors including roads and dwellings.

1.3 Glint and Glare Definition

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

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

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

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[4] These definitions are aligned with those presented within the Draft National Policy Statement for Renewable Energy Infrastructure (EN-3) – published by the Department for Energy Security & Net Zero in March 2023 and the Federal Aviation Administration in the USA.

2 SOLAR DEVELOPMENT LOCATION AND DETAILS

2.1 Proposed Development Parameter Plan

Figure 1 below[5] shows the parameter plan for the Proposed Development. The light blue areas denote the panel areas.

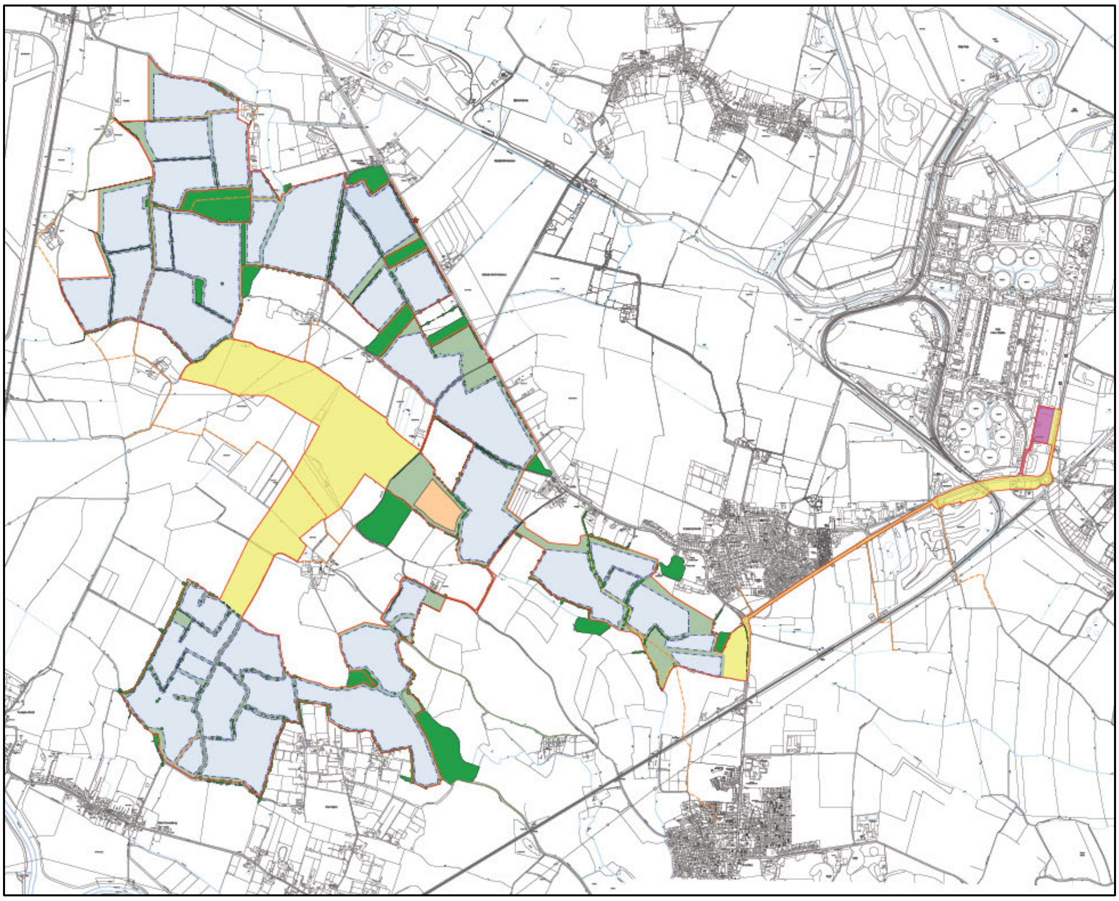


Figure 1 *Parameter plan*

2.2 Landscape Strategy

Figures 2-4 on the following pages show the landscape strategy for the Proposed Development.

[5] Source: DX-01-P02 Rev11 Parameter Plan

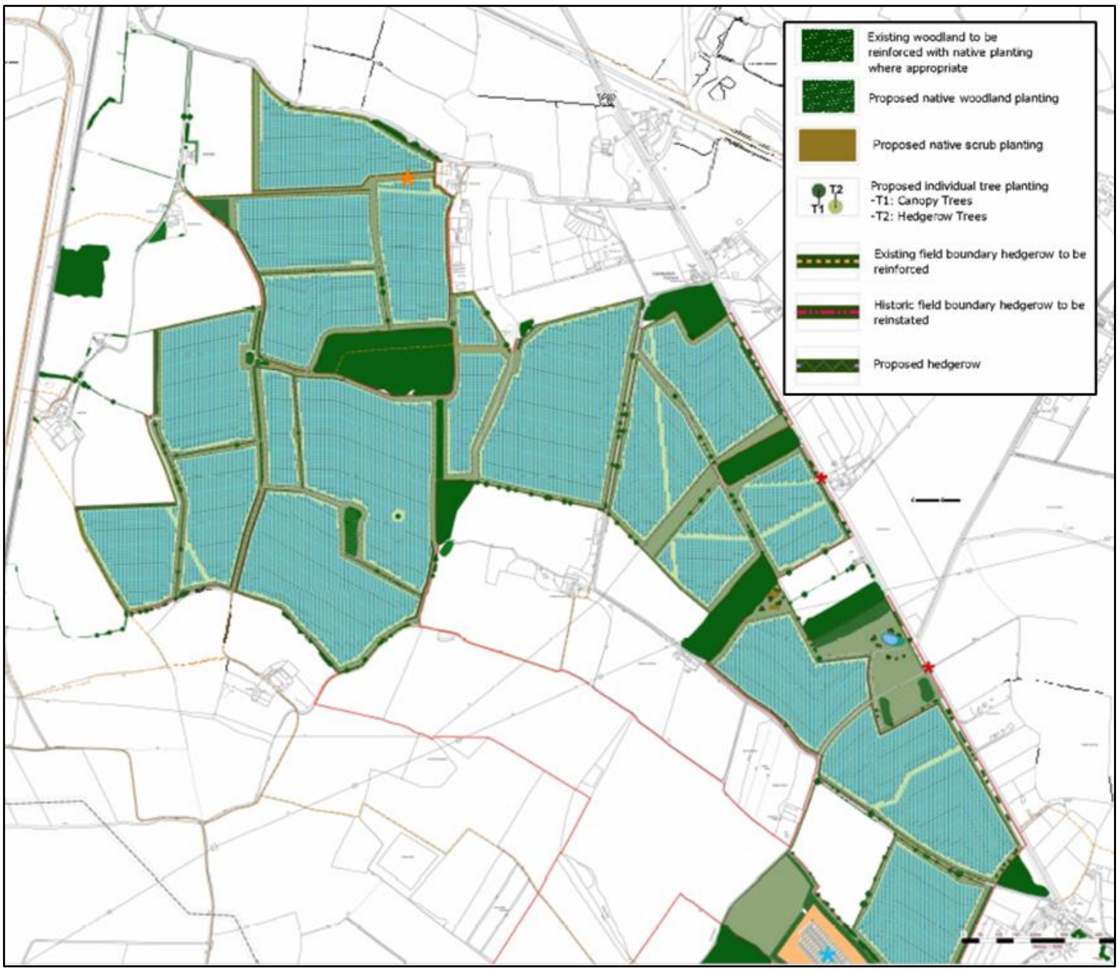


Figure 2 *Landscape strategy (Figure 7.8 of the PEIR)*

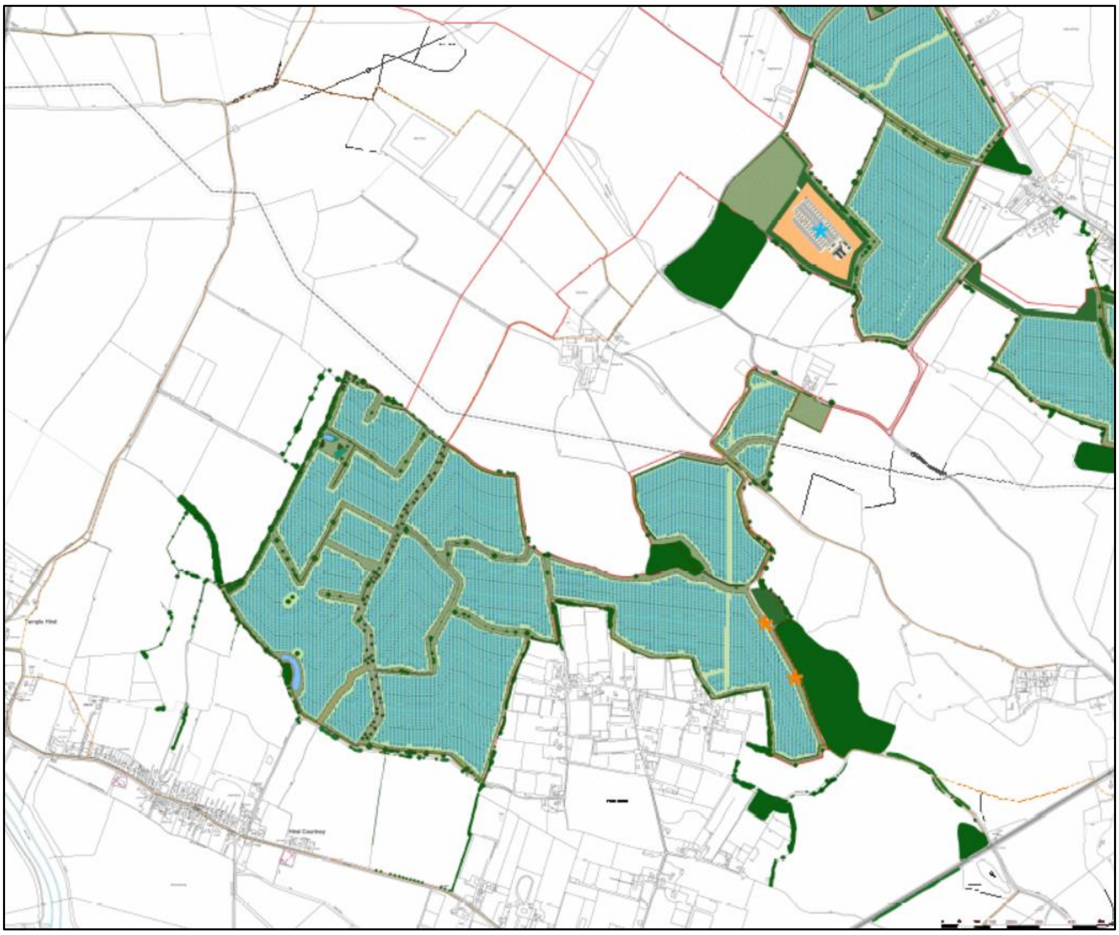


Figure 3 *Landscape strategy (Figure 7.9 of the PEIR)*

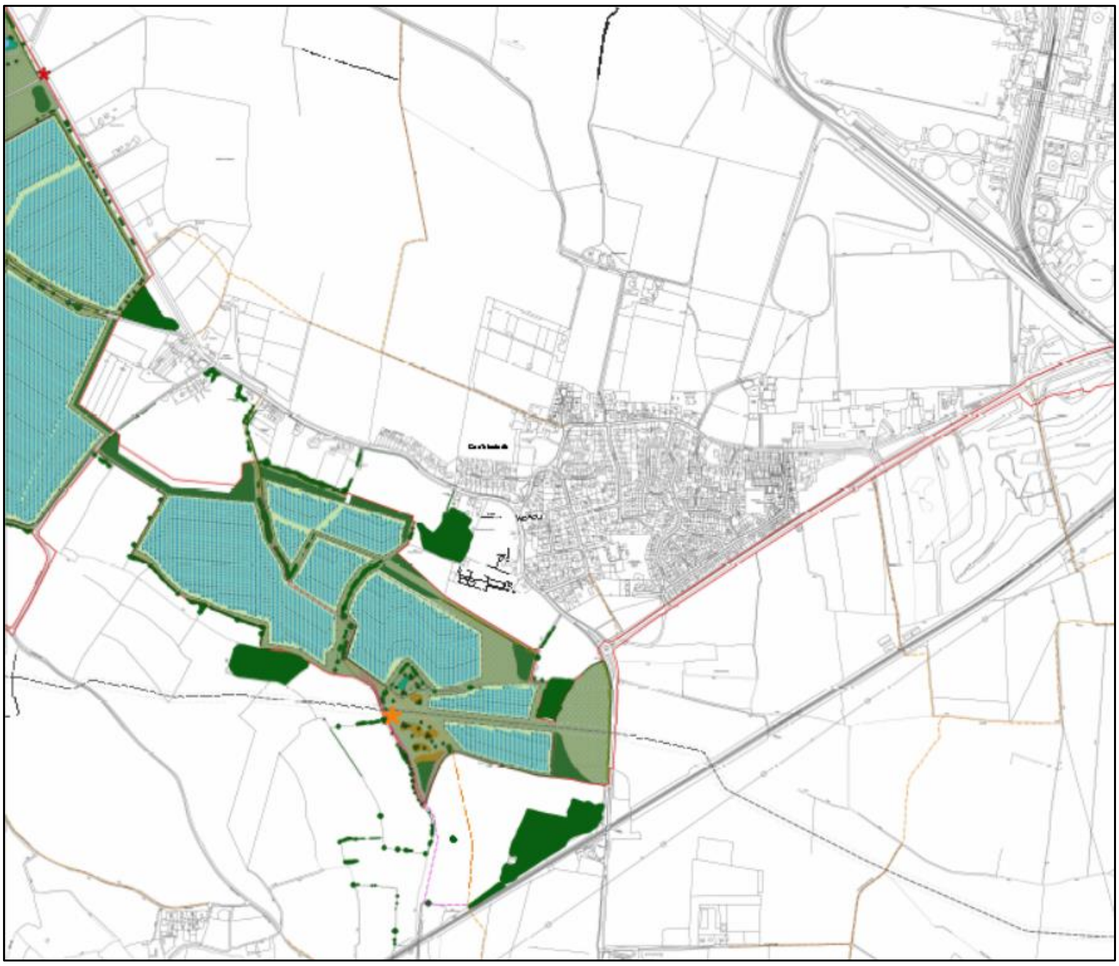


Figure 4 *Landscape strategy (Figure 7.10 of the PEIR)*

2.3 Proposed Development Location – Aerial Image

Figure 5 below shows the Proposed Development's solar PV panel areas overlaid onto aerial imagery (blue outlines).

Figure 5 *Proposed Development location – aerial image*

2.4 Solar Panel Technical Information

The technical information used for the modelling are presented in Table 1[6] below.

Solar Panel Technical Information	
Assessed centre-height (m)	2 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

[6] Based on information received from Enso Green Holdings D Ltd.

Solar Panel Technical Information	
Resting angle (°)	0
Surface material	Smooth glass without an anti-reflective coating (ARC)

Table 1 *Solar panel technical information*

2.4.1 Solar Panel Backtracking

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

- The elevation angle of the Sun;
- The vertical tilt of the panels; and
- 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 3 below illustrates this.

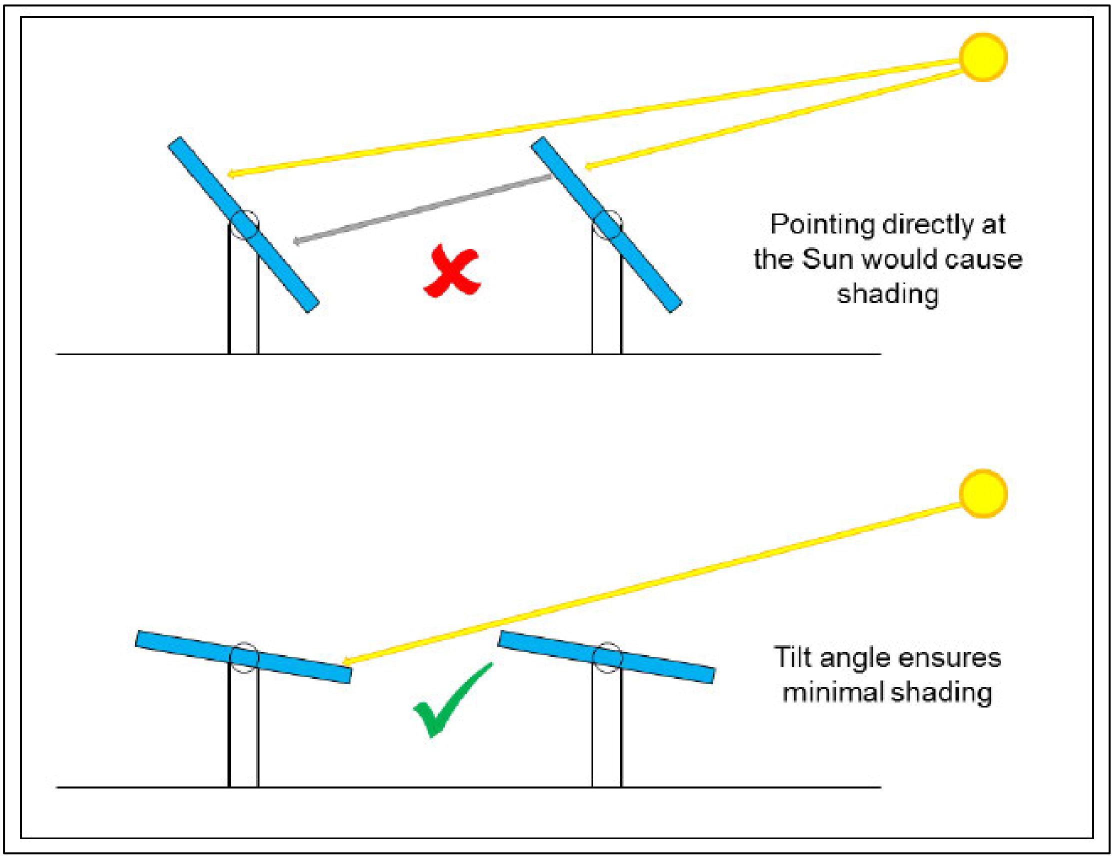


Figure 6 *Shading considerations*

Later in the day, the panels can be directed towards the Sun without any shading issues. This is illustrated in Figure 4 on the following page.

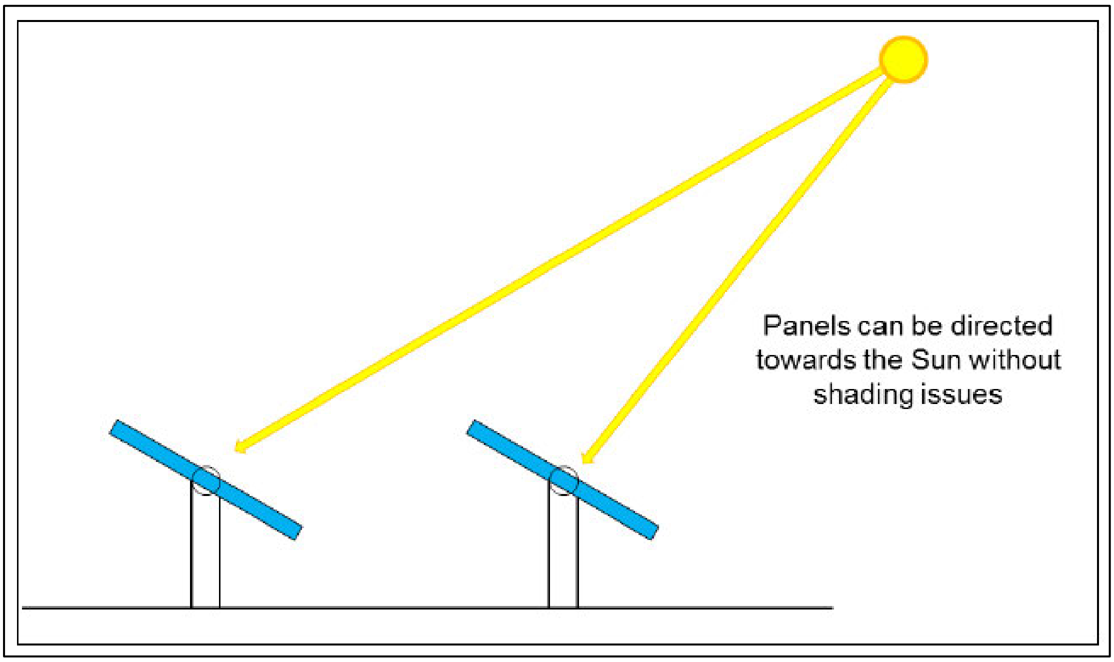


Figure 7 *Panel alignment at high solar angles*

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.

3 AIRFIELD DETAILS

3.1 Overview

The following subsections present details concerning the two identified airfields; Burn Airfield and Cliffe Airfield.

3.2 Airfield Information

3.2.1 Burn Airfield

Burn Airfield is an unlicensed aerodrome operated by Burn Gliding Club Ltd, primarily used for gliding operations.

3.2.2 Cliffe Airfield

Cliffe Airfield is an unlicensed aerodrome. It is not known who the aerodrome is owned or operated by.

3.3 Runway Details

3.3.1 Burn Airfield

Burn Airfield has three runways:

- 01/19 runway dimensions 1,100 x 46 m (asphalt);
- 07/25 runway dimensions 1,300 x 46 m (asphalt);
- 15/33 runway dimensions 950 x 46 m (asphalt).

The aerodrome chart for Burn Airfield is shown in Figure 8[7] on the following page.

3.3.2 Cliffe Airfield

Cliffe Airfield has one runway:

- 10/28 runway dimensions 600 x 15 m (grass).

An aerial image of the runway is shown in Figure 9 on page 24.

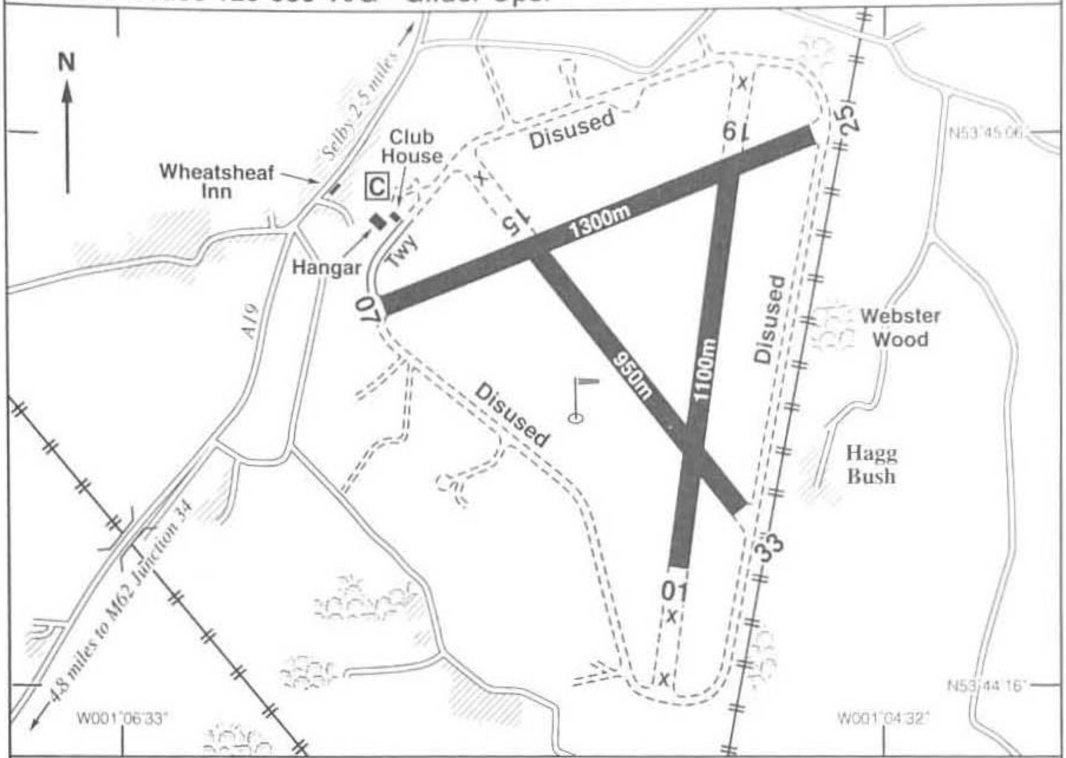
3.4 Air Traffic Control Tower

It is understood that neither Burn Airfield, nor Cliffe Airfield have an Air Traffic Control (ATC) Tower present.

[7] Burn (Selby), Pooleys Flight Guide 2021

N53 44.73 W001 04.97	BURN (SELBY)	20ft AMSL
6 nm SSE of Church Fenton. 2 nm S of Selby.		OTR 113·90 278 34·9 GAM 112·80 353 28·3

c/s **Burn Base 129·980 A/G - Glider Ops.**



Rwy	Dim(m)	Surface	TORA(m)	LDA(m)	Lighting
01/19	1100x46	Asphalt	Unlicensed		Nil
07/25	1300x46	Asphalt	Unlicensed		Nil
15/33	950x46	Asphalt	Unlicensed		Nil

Op hrs: PPR. Daylight use only.

Landing Fee: £10. BGA members free. **Customs:** Nil.

Hangarage: Nil. **Maintenance:** Nil.

Remarks: Operated by Burn Gliding Club Ltd., Park Lane, Burn, Selby, N Yorkshire YO8 8LW. Unlicensed aerodrome primarily used for gliding operations, mainly weekends and Thur. All runways have a 5m centre strip of tarmac from intersection to intersection.

All visiting pilots should obtain a briefing for safe integration with the expected gliding operation. When gliding not in progress, farming activity, horse riders and walkers use the runways.

No overhead joins. Glider launching is by winch to 3000ft agl and aerotows.

Variable circuits. Power and glider operations may not be on the same runway.

PPR preference is via website "Contact Us" form with 2 days notice.

Warnings: Disused sections of the runways are very rough, do not land short.

Obstructions on stubs to runways 01,15 and 19.

Chimneys - 873ft amsl, 3nm to E, and 690ft amsl, 2.5 nm to SW of the airfield.

Figure 8 *Burn Airfield aerodrome chart*

Figure 9 *Cliffe Airfield runway 10/28*

4 GLINT AND GLARE ASSESSMENT METHODOLOGY

4.1 Guidance and Studies

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

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

4.2 Background

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

4.3 Methodology

The glint and glare assessment methodology has been derived from the information provided to Pager Power through consultation with stakeholders and by reviewing the available guidance and studies. The methodology for a glint and glare assessments is as follows:

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

4.4 Assessment Methodology and Limitations

Further technical details regarding 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 of the two identified airfields 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 (OS) Terrain 50 Digital Terrain Model (DTM) data.

5.1.1 ATC Tower

It is standard practice to determine whether a solar reflection can be experienced by personnel within the ATC Tower. The identified airfields, Burn Airfield and Cliffe Airfield do not have ATC Towers present.

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. Burn Airfield has three operational runway with two associated approach paths, one for each bearing and Cliffe Airfield has one operational runway.

A geometric glint and glare assessment has been undertaken for all aircraft approach paths for each runway. 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 10 on the following page shows the assessed aviation receptors relative to the Proposed Development. The receptor details for each runway approach are presented in Appendix G.

Figure 10 *Assessed aviation receptors*

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. Receptors have been modelled with the panel areas respective to their 1km assessment area; however, a cumulative assessment area has been presented in the following figures.

Potential receptors within the 1km 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 OS Terrain 50m DTM data. Receptor details can be found in Appendix G.

5.3 Dwelling Receptors

The analysis has considered dwellings that:

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

The assessed dwelling receptors are shown in Figure 8 on the following page along with the 1km assessment area (the green outlined polygon). A total of 176 dwelling locations have been assessed.

For the dwellings, a height of 1.8 metres above ground level has been taken as typical eye level for an observer on the ground floor of the dwelling[8].

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

The dwellings, presented in the above area, buildings that are likely divided into multiple addresses. Modelling output has not been generated for every individual address independently.

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[8] This height is used for modelling purposes and all floors are considered in the results discussion.

The sampling resolution is sufficiently high to capture the level of effect for all potentially affected dwellings.

Close-up images to illustrate the dwelling receptors are presented in Figures 11-34 below and on the following pages.

Following the initial assessment, the following dwelling receptors have been excluded from the updated technical modelling where they now lie outside of the 1km assessment area: 111-133. These have been included in the following figures for completeness.

Figure 11 *Dwellings 1-8*

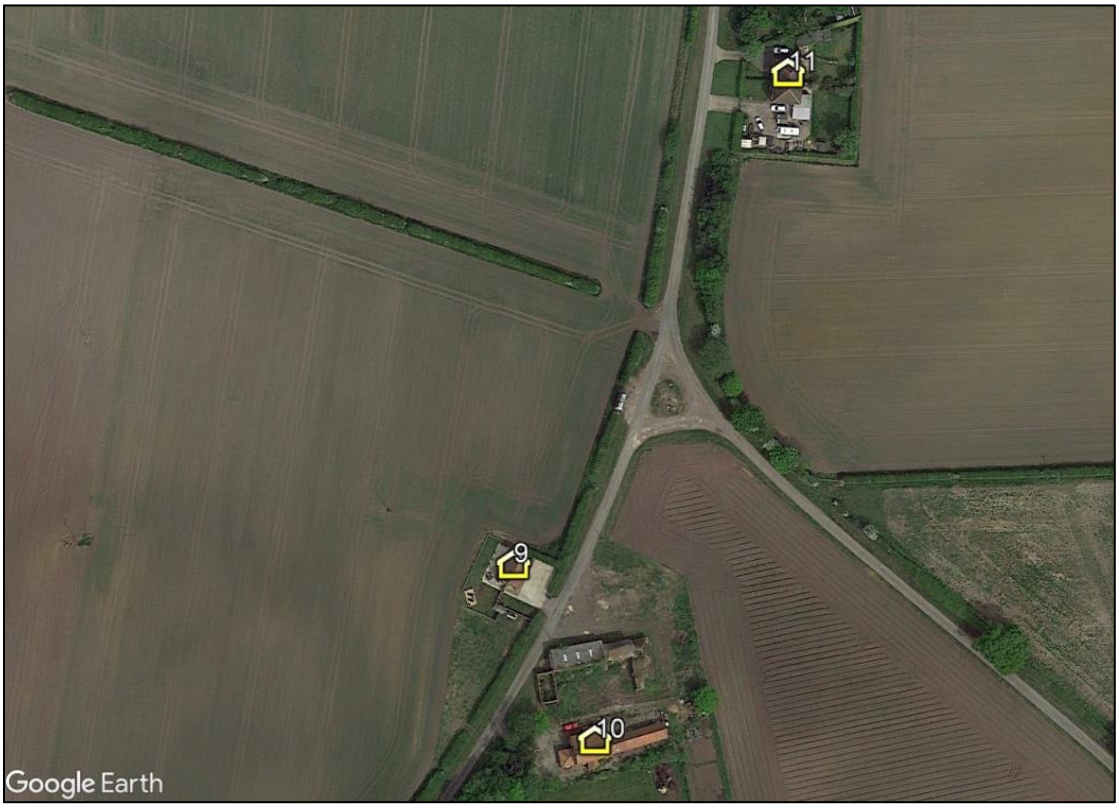

Figure 12 *Dwellings 9-11*

Figure 13 *Dwellings 12-13*

Figure 14 *Dwellings 14-17*

Figure 15 *Dwellings 18-21*

Figure 16 *Dwellings 22-24*

Figure 17 *Dwellings 25-39*

Figure 18 *Dwellings 40-52*

Figure 19 *Dwellings 53-54 and 57-77*

Figure 20 *Dwellings 55-56*

Figure 21 *Dwellings 78-80*

Figure 22 *Dwellings 81-106*

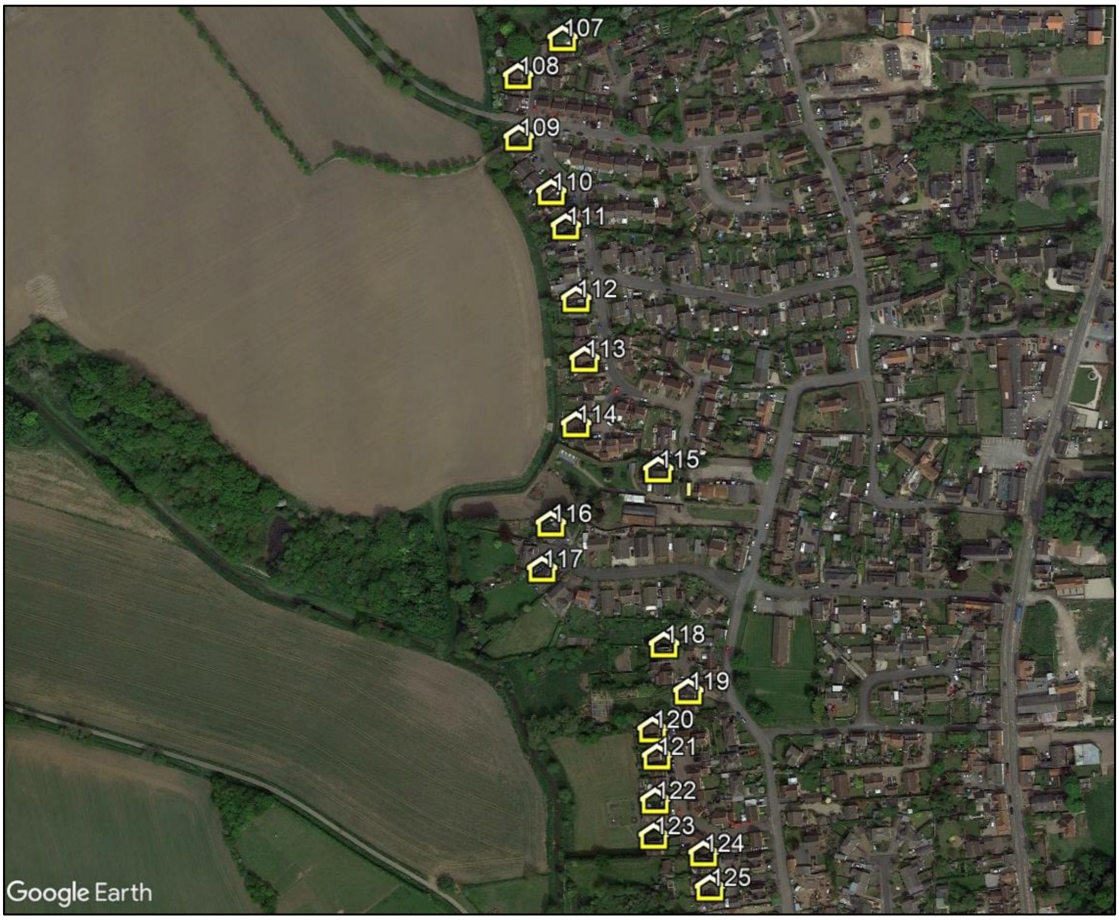

Figure 23 *Dwellings 107-125*

Figure 24 *Dwellings 126-134*

Figure 25 *Dwellings 135-136*

Figure 26 *Dwellings 138-152*

Figure 27 *Dwellings 137 and 153-160*

Figure 28 *Dwellings 161-177*

Figure 29 *Dwellings 178-185*

Figure 30 *Dwellings 186-189*

Figure 31 *Dwellings 190-192*

Figure 32 *Dwelling 193*

Figure 33 *Dwellings 194-196*

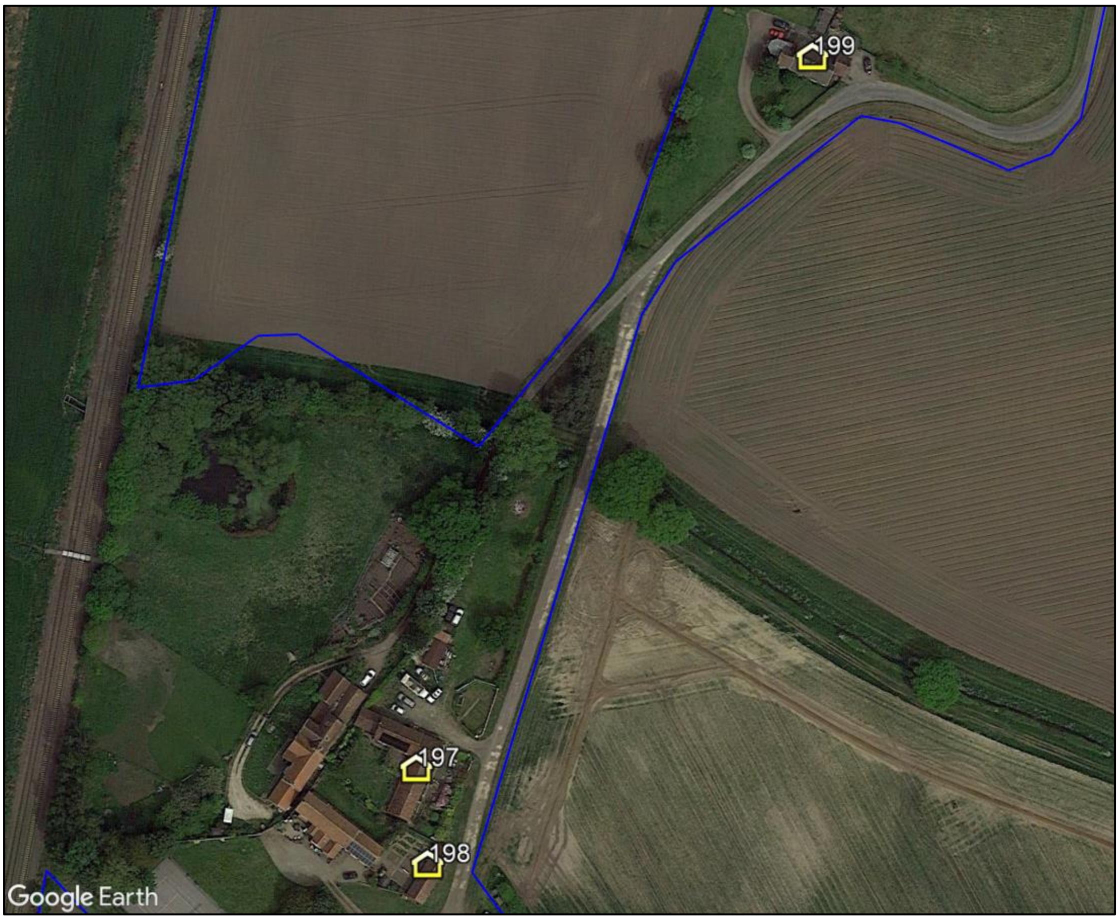

Figure 34 *Dwellings 197-199*

5.4 Road Receptors

Road types can generally be categorised as:

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

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

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

- Are within the 1km assessment areas.
- Have a potential view of the panels.

The assessed road receptor points along the A1041 (31-80), A645 (98-105), Barlow Road (106-117), Common Lane (4-30), Hirst Road (121-159) and Station Road (81-93), are shown in Figure 35 on the following page. A height of 1.5 metres above ground level has been taken as typical eye level for a road user[9]. The distance between road receptors is approximately 100m.

Following the initial assessment, the following receptors have been excluded from the updated technical modelling where they now lie outside of the 1km assessment area: 1-6; 94-97; 118-120, and 159-170.

[9] Views of the Proposed Development from the elevated seat of an HGV driver have been considered within the discussion section

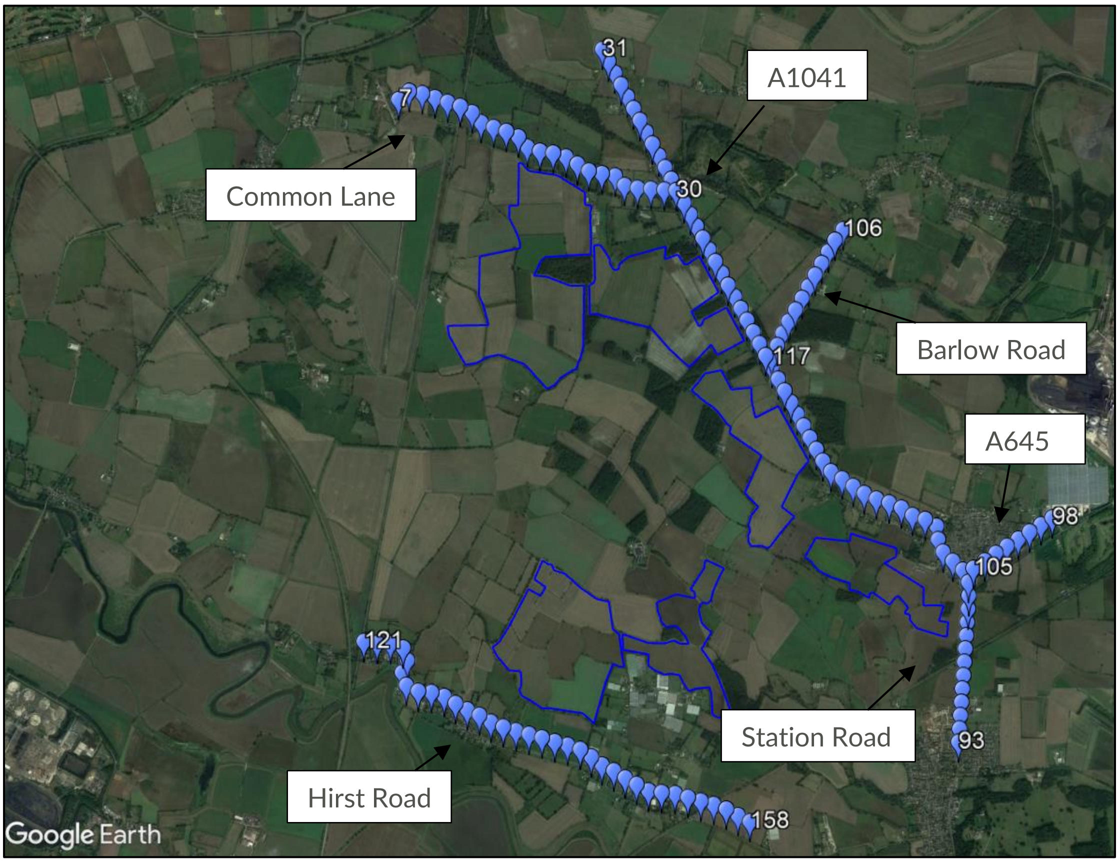

Figure 35 *Assessed road receptors*

5.5 Railway Receptors

Typical reasons stated by a railway stakeholder for requesting a glint and glare assessment often relate to the following:

1. The development producing solar reflections towards train drivers;
2. The development producing solar reflections that affect railway signals.

With respect to point 1, a reflective panel could produce solar reflections towards a train driver. If this reflection occurs where a railway signal, crossing etc., is present, or where the driver's workload is particularly high, the solar reflection may affect operations. This is deemed to be the most concern with respect to solar reflections.

Following from point 1, point 2 identifies whether a modelled solar reflection could be significant by determining its intensity. Only where a solar reflection occurs under certain conditions and is of a particular intensity may it cause a reaction from a train driver and thus potentially affect safe operations. Therefore, intensity calculations are undertaken where a solar reflection is identified and where its presence could potentially affect the safety of operations. Points 1 and 2 are completed in a 2-step approach.

With respect to all points, railway lines use light signals to manage trains on approach towards particular sections of track. If a signal is passed when not permitted, a Signal Passed At Danger (SPAD) is issued. The concerns will relate specifically to the possibility of the reflections appearing to illuminate signals that are not switched on (known as a phantom aspect illusion) or a distraction caused by the glare itself, both of which could lead to a SPAD. The definition is presented below:

'Light emitted from a Signal lens assembly that has originated from an external source (usually the sun) and has been internally reflected within the Signal Head in such a way that the lens assembly gives the appearance of being lit.[10]*'*

5.5.1 Glint and Glare Definition

As well as the glint and glare definition presented in Section 1.3, glare can also be categorised as causing visual discomfort whereby an observer would instinctively look away, or cause disability whereby objects become difficult to see. The guidance produced by the Commission Internationale de L'Eclairage ('CIE') describes disability glare as[11]:

'Disability glare is glare that impairs vision. It is caused by scattering of light inside the eye…The veiling luminance of scattered light will have a significant effect on visibility when intense light sources are present in the peripheral visual field and contrast of objects is seen to be low.'

'Disability glare is most often of importance at night when contrast sensitivity is low and there may well be one or more bright light sources near to the line of sight, such as car headlights, streetlights or floodlights. But even in daylight conditions disability glare may be of practical significance: think of traffic lights when the sun is close to them, or the difficulty viewing paintings hanging next to windows.'

These types of glare are of particular importance in the context of railway operations as they may cause a distraction to a train driver (discomfort) or may cause railway signals to be difficult to see (disability).

5.5.2 Railway Signal Receptors

The analysis has considered railway signal receptors that:

- Are within 500 metres of the Proposed Development;
- Have a potential view of the panels.

The impact of solar reflections upon railway signals has been assessed by considering the height and location of any identified signals. No potential signal locations were identified along the assessed section of railway line using available imagery and have therefore not been assessed. Network Rail has been contacted to confirm the location of any signals at these locations; however, no response has been received to date. Once a response has been received, the report would be updated, if required.

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[10] Source: Glossary of Signalling Terms, Railway Group Guidance Note GK/GN0802. Issue One. Date April 2004.
[11] CIE 146:2002 & CIE 147:2002 Collection on glare (2002).

5.5.3 Train Driver Receptors

The analysis has considered train driver receptors that:

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

Figure 36 below shows the section of railway identified within 500m of the Proposed Development.

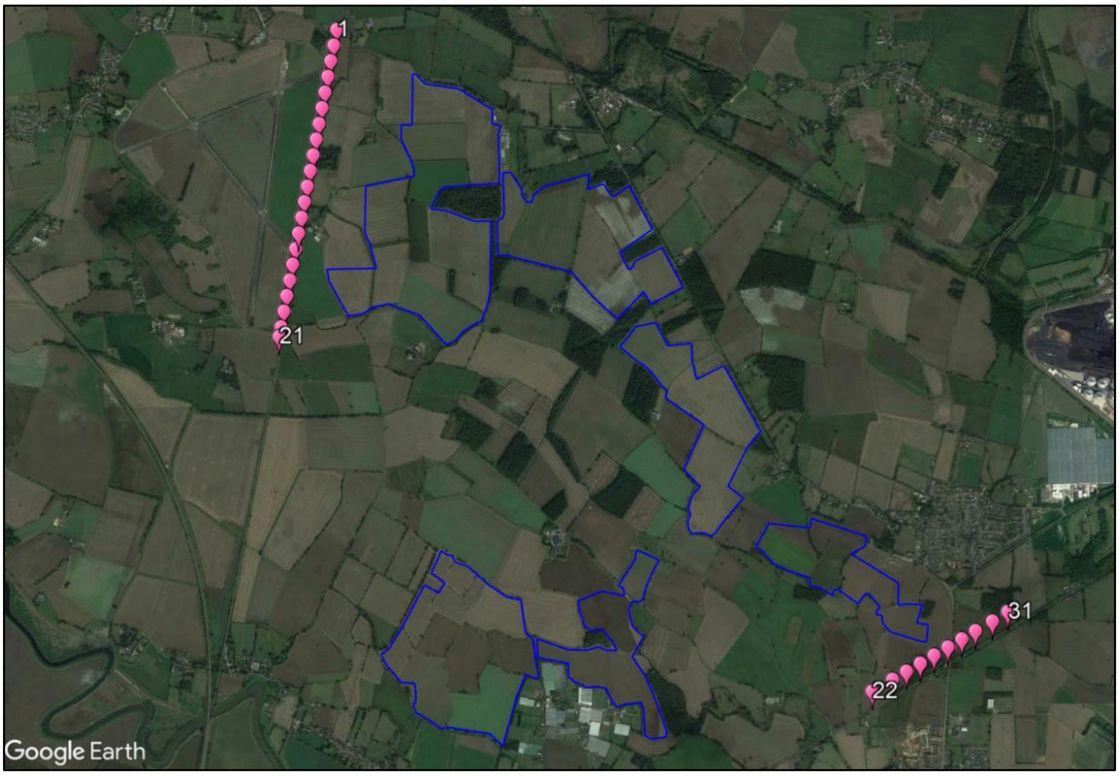

Figure 36 *Railway receptors - aerial image*

6 GLINT AND GLARE ASSESSMENT – TECHNICAL RESULTS

6.1 Evaluation of Effects

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

The significance of the predicted effects has been evaluated in accordance with Pager Power's published guidance document[12].

The flowcharts setting out the impact characterisation and presented in Appendix D[13]. The list of assumptions and limitations are presented in Appendix F. The modelling output for key receptors can be found in Appendix H.

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

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

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

[13] There is no standard methodology for evaluating effects on ground-based receptors beyond a kilometre. These receptors have been considered based on first principles and the general methodology for ground-based receptors, keeping in mind the relative safety/amenity implications for differing receptor types.

6.2 Aviation - Overview

The Pager Power and Forge models have been used to determine whether reflections are possible. Where solar reflections have been predicted, intensity calculations in line with the Sandia National Laboratories methodology have been undertaken for reference purposes. These calculations are routinely required for solar photovoltaic developments on or near aerodromes.

The intensity model calculates the expected intensity of a reflection with respect to the potential for an after-image (or worse) occurring. The designation used by the model is presented in Table 2 below along with the associated colour coding.

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

Table 2 *Glare intensity designation*

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

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

- Smooth glass with an ARC;
- Light textured glass without an ARC;
- Light textured glass with an ARC;
- Deeply textured glass.

6.3 Summary of Results

The tables in the following subsections summarise the results of the assessment. The predicted glare times are based solely on bare-earth terrain i.e. without consideration of screening from buildings and vegetation. The final column summarises the glare intensity designation defined in the previous sub-section.

The significance of any predicted impact from the Proposed Development is discussed in the subsequent report sections. The modelling output showing the precise predicted times and the reflecting panel area is shown in Appendix H.

6.4 Geometric Calculation Results – Runway Approach 07

The results of the geometric calculations for the runway approach are presented in Table 3 below.

Distance from threshold	Reflection possible towards the runway approach? (GMT)		Glare Type (Forge)	Comment
	am	pm		
0.0-2.0 miles	Yes.	No.		Potential for temporary after image. A significant impact is not predicted.

Table 3 *Geometric calculation results overview – runway approach 07*

6.5 Geometric Calculation Results – Runway Approach 25

The results of the geometric calculations for the runway approach are presented in Table 4 below.

Distance from threshold	Reflection possible towards the runway approach? (GMT)		Glare Type (Forge)	Comment
	am	pm		
0-0.45 miles	No.	No.	N/A	No solar reflections geometrically possible. No impact predicted.
0.45-2.0 miles	Yes.	Yes.		Potential for temporary after image. A significant impact from the Proposed Development is predicted, prior to mitigation.

Table 4 *Geometric calculation results overview – runway approach 25*

6.6 Geometric Calculation Results – Runway Approach 15

The results of the geometric calculations for the runway approach are presented in Table 5 below.

Distance from threshold	Reflection possible towards the runway approach? (GMT)		Glare Type (Forge)	Comment
	am	pm		
0.0-2.0 miles	Yes.	No.		Potential for temporary after image. A significant impact is not predicted.

Table 5 *Geometric calculation results overview – runway approach 15*

6.7 Geometric Calculation Results – Runway Approach 33

The results of the geometric calculations for the runway approach are presented in Table 6 below.

Distance from threshold	Reflection possible towards the runway approach? (GMT)		Glare Type (Forge)	Comment
	am	pm		
0-1.5 miles	No.	No.	n/a	No solar reflections geometrically possible. No impact predicted.
1.5-2.0 miles	No.	Yes.		Potential for temporary after image. A significant impact is not predicted.

Table 6 *Geometric calculation results overview – runway approach 33*

6.8 Geometric Calculation Results – Runway Approach 01

The results of the geometric calculations for the runway approaches are presented in Table 7 below.

Distance from threshold	Reflection possible towards the runway approach? (GMT)		Glare Type (Forge)	Comment
	am	pm		
0-2.0 miles	Yes.	No.		Potential for temporary after image. A significant impact is not predicted.

Table 7 *Geometric calculation results overview – runway approach 01*

6.9 Geometric Calculation Results – Runway Approach 19

The results of the geometric calculations for the runway approach are presented in Table 8 below.

Distance from threshold	Reflection possible towards the runway approach? (GMT)		Glare Type (Forge)	Comment
	am	pm		
0-0.16 miles	No.	No.	n/a	No solar reflections geometrically possible. No impact predicted.
0.16-0.93 miles	Yes.	No.		Potential for temporary after image. A significant impact is not predicted.
0.93-2.0 miles	No.	No.	n/a	No solar reflections geometrically possible. No impact predicted.

Table 8 *Geometric calculation results overview – runway approach 19*

6.10 Geometric Calculation Results – Runway Approach 10

The results of the geometric calculations for the runway approach are presented in Table 9 below.

Distance from threshold	Reflection possible towards the runway approach? (GMT)		Glare Type (Forge)	Comment
	am	pm		
0-2 miles	No.	No.	n/a	No solar reflections geometrically possible. No impact predicted.

Table 9 *Geometric calculation results overview – runway approach 10*

6.11 Geometric Calculation Results– Runway Approach 28

The results of the geometric calculations for the runway approach are presented in Table 10 below.

Distance from threshold	Reflection possible towards the runway approach? (GMT)		Glare Type (Forge)	Comment
	am	pm		
0.0-2.0 miles	No.	Yes.		Potential for temporary after image. A significant impact is not predicted.

Table 10 *Geometric calculation results overview – runway approach 28*

6.12 Geometric Calculation Results – Dwelling Receptors

Dwelling(s)	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
1-5	No.	No.	No solar reflections geometrically possible within 1km of the receptor. A low impact from the Proposed Development is predicted.
6-8	Yes.	No.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. Existing screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.
9-13	No.	Yes.	The model output shows potential effects that would last for less than three months per year and less than 60 minutes per day. A low impact from the Proposed Development is predicted.
14-16	No.	Yes.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. Proposed screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.
17	Yes.	Yes.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. Existing screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.
18	No.	No.	No solar reflections geometrically possible within 1km of the receptor. A low impact from the Proposed Development is predicted.

Dwelling(s)	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
19-21	No.	Yes.	The model output shows potential effects that would last for less than three months per year and less than 60 minutes per day. A low impact from the Proposed Development is predicted and further consideration is not required.
22-27	No.	Yes.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. Existing screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.
28	No.	Yes.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. Existing screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.
29-31	No.	Yes.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. A low impact from the Proposed Development is predicted due to mitigating factors.
32-42	No.	Yes.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. Existing screening is present so no impact from the Proposed Development is predicted and mitigation is not required.
43-49	No.	Yes.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. Proposed screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.

Dwelling(s)	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
50-54	No.	Yes.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. Existing screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.
55-56	No.	Yes.	The model output shows potential effects that would last for less than three months per year and less than 60 minutes per day. A low impact from the Proposed Development is predicted and further consideration is not required.
57-64	No.	Yes.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. Existing screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.
65-67	No.	Yes.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. Proposed screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.
68-77	No.	Yes.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. Existing screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.
78	Yes.	Yes.	The model output shows potential effects that would last for less than three months per year and less than 60 minutes per day. A low impact from the Proposed Development is predicted and further consideration is not required.

Dwelling(s)	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
79	No.	Yes.	The model output shows potential effects that would last for less than three months per year and less than 60 minutes per day. A low impact from the Proposed Development is predicted and further consideration is not required.
80-110, 134-140	No.	No.	No solar reflections geometrically possible. No impacts from the Proposed Development are predicted.
141-143	No.	Yes.	The model output shows potential effects that would last for less than three months per year and less than 60 minutes per day. Existing screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.
144-153	Yes.	Yes.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. Existing screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.
154-160	No.	No.	No solar reflections geometrically possible. No impacts from the Proposed Development are predicted.
161-183	Yes.	No.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. Existing screening is present so no impact from the Proposed Development is predicted and mitigation is not required.

Dwelling(s)	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
184-186	Yes.	No.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. A low impact from the Proposed Development is predicted due to mitigating factors.
187-191	Yes.	No.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. Existing screening is present so no impact from the Proposed Development is predicted and mitigation is not required.
192	Yes.	Yes.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. Existing screening is present so no impact from the Proposed Development is predicted and mitigation is not required.
193	No.	Yes.	No solar reflections geometrically possible within the 1km assessment area. A low impact from the Proposed Development is predicted and further consideration is not required.
194-195	No.	Yes.	The model output shows potential effects that would last for less than three months per year and less than 60 minutes per day. Existing screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.
196	Yes.	Yes.	The model output shows potential effects that would last for more than three months per year and less than 60 minutes per day. Existing screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.

Dwelling(s)	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
197-199	Yes.	No.	No solar reflections geometrically possible within the 1km assessment area. A low impact from the Proposed Development is predicted and further consideration is not required.

Table 11 *Geometric analysis results for dwelling receptors*

6.13 Geometric Calculation Results – Road Receptors

Road Receptor(s)	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
7-13	Yes.	No.	No solar reflections geometrically possible within the 1km assessment area. A low impact from the Proposed Development is predicted and further consideration is not required.
14-18	Yes.	No.	Reflections would originate within a driver's primary field of view when facing the direction of travel. Proposed screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.
19-22	Yes.	Yes.	Reflections would originate within a driver's primary field of view when facing the direction of travel. Proposed screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.
24-25	No.	Yes.	Reflections would originate within a driver's primary field of view when facing the direction of travel. Proposed screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.
26	No.	Yes.	Reflections would originate outside a driver's primary field of view when facing the direction of travel. A low impact from the Proposed Development is predicted and further consideration is not required.
27	Yes.	Yes.	Reflections would originate within a driver's primary field of view when facing the direction of travel. Existing screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.

Road Receptor(s)	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
28-30	No.	Yes	Reflections would originate within a driver's primary field of view when facing the direction of travel. Existing screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.
31-40	No.	Yes.	Reflections would originate outside a driver's primary field of view when facing the direction of travel. A low impact from the Proposed Development is predicted and further consideration is not required.
41-50	No.	Yes.	Reflections would originate within a driver's primary field of view when facing the direction of travel. Existing screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.
51-81	No.	Yes.	No solar reflections geometrically possible within 1km of the receptor. A low impact from the Proposed Development is predicted.
82-89	No.	Yes.	Reflections would originate outside a driver's primary field of view when facing the direction of travel. A low impact from the Proposed Development is predicted and further consideration is not required.
90-93, 98-117	No.	No.	No solar reflections geometrically possible within 1km of the receptor. A low impact from the Proposed Development is predicted.
121-137	No.	Yes.	Reflections would originate within a driver's primary field of view when facing the direction of travel. Existing and proposed screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.

Road Receptor(s)	Are Solar Reflections Geometrically Possible? (GMT)		Comment
	am	pm	
138-139	Yes.	No.	Reflections would originate outside a driver's primary field of view when facing the direction of travel. A low impact from the Proposed Development is predicted and further consideration is not required.
140-146	No.	No.	No solar reflections geometrically possible within 1km of the receptor. A low impact from the Proposed Development is predicted.
147-149	No.	Yes.	Reflections would originate within a driver's primary field of view when facing the direction of travel. Existing screening removes visibility of the reflecting area and no impact from the Proposed Development is predicted.
150-158	No.	No.	No solar reflections geometrically possible within 1km of the receptor. A low impact from the Proposed Development is predicted.

Table 12 *Geometric analysis results for road receptors*

6.14 Geometric Calculation Results – Train Driver Receptors

Receptor	Reflection Possible Towards Receptor? (GMT)		Comments
	am	pm	
1-21	Yes.	No.	Reflections would originate outside a train driver's primary field of view when facing the direction of travel. A low impact from the Proposed Development is predicted and further consideration is not required.
22-23	No.	No.	No solar reflections are geometrically possible. No impacts from the Proposed Development are predicted.

Receptor	Reflection Possible Towards Receptor? (GMT)		Comments
	am	pm	
24-29	No.	Yes.	Reflections would originate outside a train driver's primary field of view when facing the direction of travel. A low impact from the Proposed Development is predicted and further consideration is not required.
30-31	No.	Yes.	Reflections would originate within a train driver's primary field of view when facing the direction of travel. Existing screening is present so no impact from the Proposed Development is predicted and mitigation is not required.

Table 13 *Geometric analysis results for the identified train driver receptors*

7 GEOMETRIC ASSESSMENT RESULTS AND DISCUSSION

7.1 Aviation Receptors

7.1.1 Overview

The following analysis pertains to the runway approach paths at Burn Airfield (runways 01/19, 07/25, and 15/33) and Cliffe Airfield (10/28).

7.1.2 Runway 01, 07, 15, 19, 28 and 33 Approach Paths

Solar reflections are geometrically possible towards pilots between:

- 0.0-2.0 miles from the runway 01 threshold;
- 0.0-2.0 miles from the runway 07 threshold;
- 0.0-2.0 miles from the runway 15 threshold;
- 0.16-0.93 miles from the runway 19 threshold;
- 0.0-2.0 miles from the runway 28 threshold; and
- 1.5-2.0 miles from the runway 33 threshold.

The modelling for the Proposed Development has shown that all predicted glare intensities have a 'potential for temporary after-image' (yellow), which requires assessment in an operational context to determine its acceptability.

The results of the Forge modelling and the yellow glare are presented in Appendix B. The modelling results have identified the following:

- Predicted glare for runway approach path 01 (between 4:40am-5:50am during early May to early August) occur outside Burn Airfields operational hours, 8am-5pm. Predicted glare towards runway approach path 33 during late March to mid September between 16:50 and 19:30 also occurs outside the Airfield's operational hours (for the majority).
- Predicted glare for runway approach path 07 occurs between 5:30am and 8:30am during January to early Mary and August to early November. The majority of the predicted glare will occur at a time outside the Airfield's operational hours, and the predicted glare will coincide with the effects of sunrise. The same is applicable for runway approach path 15 where glare is predicted between 6:00am-9:15am during mid September-late March.
- Predicted glare towards runway approach path 28 occurs between 15:30 and 17:30 during January to March and early October to December. A pilot would have to look in the direction of the sunset to experience the effects of the Proposed Development. The effects would less significant than the existing sunlight effects experienced by the pilot.
- The weather would have to be clear at sunny at the very specific times when the glare was possible to be experienced. A pilot would also have to be on the approach path at these times.

- Effects would be less significant than existing sunlight effects experienced by approaching pilots for all approach paths.

Further to this, there are several measures that pilots regularly employ to counter the effects of direct sunlight. It is also known that direct solar reflections from reflective surfaces, including solar panels, can be a distraction to pilots. The mitigation measures pilots use to mitigate the effects of direct sunlight can all be used to mitigate the effects of direct solar reflections from the solar panels. These measures include:

a) Wearing sunglasses.
b) Using darkened cockpit sun visors to reduce the intensity of the sun.
c) Overflying the airfield and inspecting the runway prior to landing.
d) Landing in the opposite direction if wind conditions allow.
e) Landing at an alternate airfield.
f) Planning the flight to land at a different time.
g) Aborting their landing if uncertain that it is to be successful (known as a missed approach or a go-around).

It is known that direct solar reflections from reflective surfaces, including solar panels, can be a distraction to pilots. The mitigation measures pilots use to mitigate the effects of direct sunlight can all be used to mitigate the effects of direct solar reflections from the solar panels.

7.1.3 Runway 25 Approach Path

Solar reflections are geometrically possible from 0.45 miles from the runway threshold to the end of the 2-mile approach path of runway 25. The modelling has shown that glare with 'potential for temporary after-image' is predicted.

The glare is predicted to occur from January through until December, between 10:30am and 11:15am and 13:30 and 17:15. Therefore, mitigation is recommended.

Potential mitigation for the Proposed Development can include fixing the Single Access Tracker System at a resting angle that would avoid significant effects at the times at which glare for the runway 25 approach is predicted. Further modelling is required to confirm this mitigation solution. However, on the basis that this mitigation solution would reduce the glare to acceptable intensity or reduce the glare to times/durations that can be operationally accommodated, the predicted impact will be low at worst and therefore not significant.

7.1.4 Runway 10 Approach Path

The results of the analysis have shown that no solar reflections towards pilots approaching runway 10 are geometrically possible. Therefore, no mitigation is required.

7.2 Dwelling Results

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

- Whether a significant 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 predicted to be experienced for less than 3 months per year and less than 60 minutes per day or where the separation distance to the nearest visible reflecting panel is over 1km, 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, the impact significance is moderate and 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. The Sun is a far more significant source of light.
- Whether solar reflections will be experienced from all storeys. The ground floor is typically considered the main living space and therefore has a greater significance with respect to residential amenity.
- Whether the dwelling appears to have windows facing the reflecting areas. An observer may need to look at an acute angle to observe the reflecting areas.

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.

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

Solar reflections lasting for more than 3 months per year and less than 60 minutes on any one day have been predicted for 104 of the 177 assessed dwellings. These dwellings are discussed below and on the following pages.

For dwellings 1-5, 18, 193, and 197-199, no solar reflections are geometrically possible within the 1km assessment area. Therefore, a low impact from the Proposed Development is predicted, and mitigation is not recommended.

For dwellings 6-8, 14-17, 22-28, 32-54, 57-77, 141-153, 161-183, 187-192, and 194-196, there is existing and proposed (please see Figures 7.8-7.10 Landscape Strategy of the PEIR) screening in the form of vegetation, terrain and buildings which removes the visibility of the reflecting panel areas. Therefore, no impact from the Proposed Development is predicted and no mitigation is required. Figures 37-46 on the following pages show the existing screening.

Figure 37 *Existing screening for dwellings 6-8*

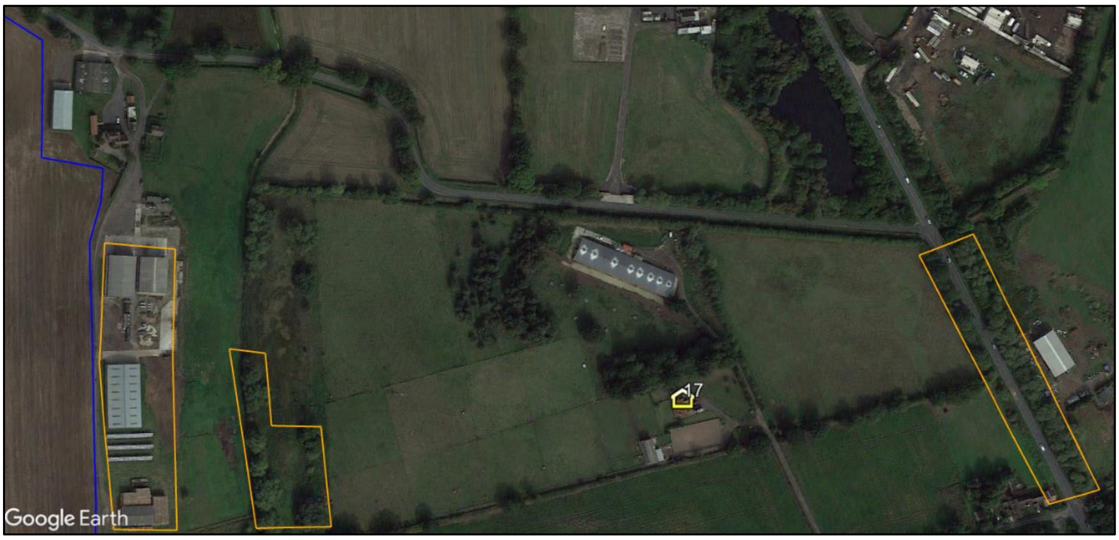

Figure 38 *Existing screening for dwelling 17*

Figure 39 *Existing screening for dwellings 22-28 and 32-35*

Figure 40 *Existing screening for dwellings 36-42*

Figure 41 *Existing screening for dwellings 50-63 and 68-77*

Figure 42 *Existing screening for dwellings 141-153*

Figure 43 *Existing screening for dwellings 161-183 and 187-189*

Figure 44 *Existing screening for dwellings 191-192*

Figure 45 *Existing screening for dwellings 194-195*

Figure 46 *Existing screening for dwelling 196*

For dwellings 29-31 and 184-186, it cannot be conclusively determined whether the existing screening will remove views of the reflecting panel area; however there are other mitigating factors that can be considered, including the following:

- There is a large separation distance of approximately 795m for dwellings 29-31 and 411m for dwellings 184-186, between the reflecting panel area and the dwelling. This reduces the proportion of an observer's field of view that is affected by glare.
- Views from a ground floor observer are removed by existing vegetation; the ground floor is typically considered the main living space and therefore has a greater significance with respect to residential amenity;
- The effects coincide with direct sunlight, which is a more significant source of light; therefore the glint and glare effects will appear much less significant.

For dwellings 9-13, 19-21, 55-56, and 78-79, a reflection is geometrically possible; however, the predicted impact of the reflecting solar panel is of low significance due to the duration of effects. Therefore, mitigation is not recommended.

7.3 Road Results

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 panels relative to a road user's direction of travel (a reflection directly in front of a driver is more hazardous than a reflection from a location off to one side).

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 primary field of view but there are mitigating circumstances, the impact significance is moderate and 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 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.

The results of the analysis have shown that solar reflections from the Proposed Development towards the assessed surrounding roads are geometrically possible along all sections of the assessed roads.

At road locations 14-25, 27-30, 41-50, 121-137, and 147-149 reflections are found to be geometrically possible within the driver's primary field of vision; however, existing and proposed (see Figure 7.8 Landscape Strategy of the PEIR) screening has been identified that would remove views of the reflecting solar panel areas. Therefore, no impact from the Proposed Development upon road users at these locations are predicted. Figures 47-52 on the following pages highlights the existing screening from selected receptors, representative of selected locations above.

Figure 47 *Street view image from location 27 showing views towards the solar panel area*

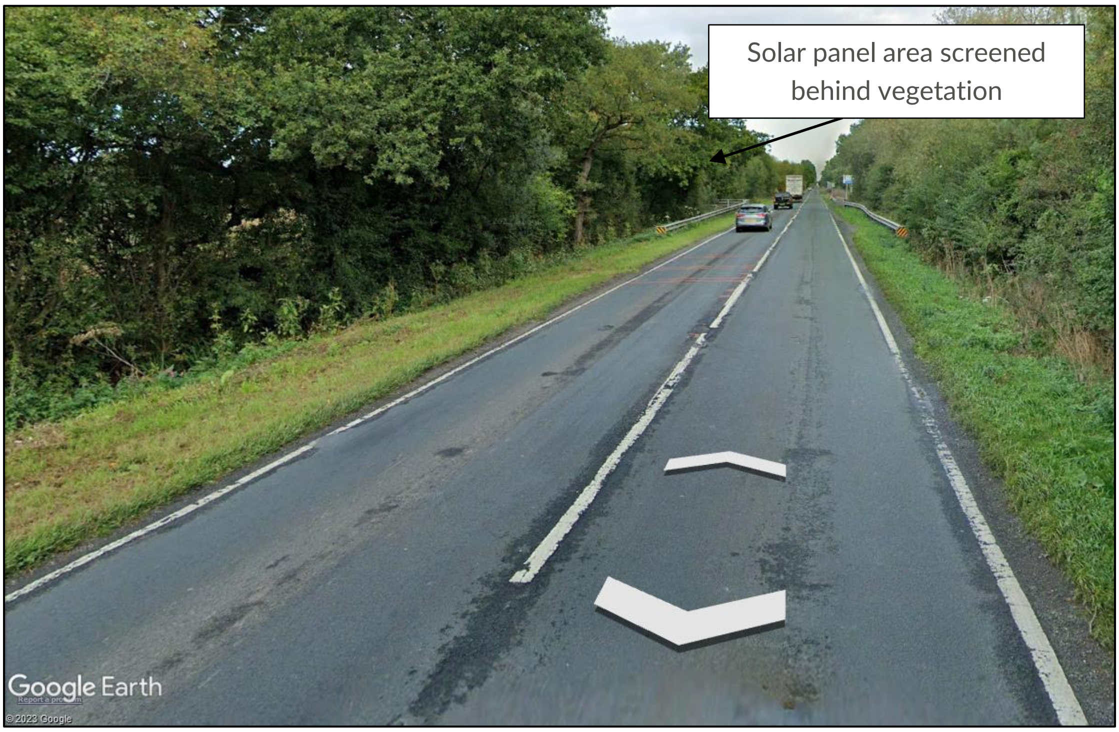

Figure 48 *Street view image from location 44 showing views towards the solar panel area*

Figure 49 *Street view image from location 122 showing views towards the solar panel area*

Figure 50 *Street view image from location 128 showing views towards the solar panel area*

Figure 51 *Street view image from location 131 showing views towards the solar panel area*

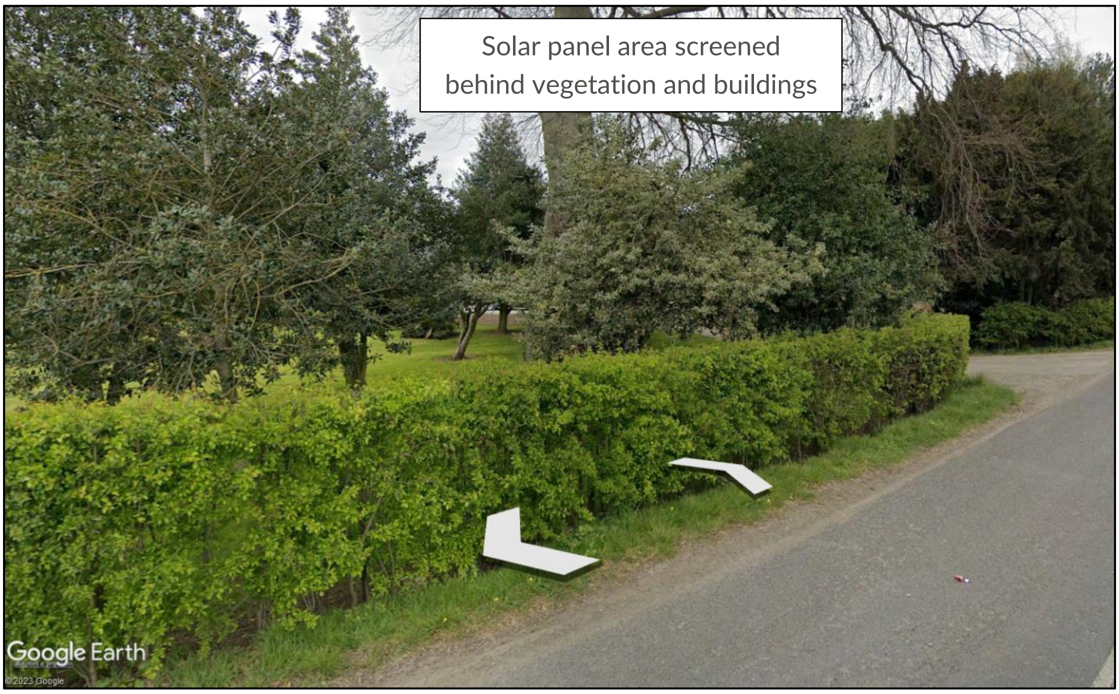

Figure 52 *Street view image from location 148 showing views towards the solar panel area*

Reflections between receptors 26, 31-40, 82-89, and 138-39 are not significant because they would occur from a bearing that is outside a driver's primary field of view. There is a low impact predicted upon road users from the Proposed Development and mitigation measures are not recommended.

Furthermore, for receptors 7-13, 51-81, 90-93, 98-117, 140-146, and 150-159, solar reflections occur outside of the 1km assessment area. Therefore, a low impact from the Proposed Development is predicted and mitigation is not recommended.

7.4 Train Driver Receptors

The results of the modelling indicate that solar reflections are geometrically possible towards a combined 2.8km section of railway track, between receptors 1-21 and 24-31.

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.
- The workload of a train driver experiencing a solar reflection.

Where reflections originate from outside of a train driver's 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, the impact significance is moderate and expert assessment of the mitigating factors is required to determine the mitigation requirement (if any). Of particular relevance is whether the solar reflection originates from directly in front of a train driver and the workload of the train driver along the section of railway line.

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.

Between receptors 30-31, the predicted solar reflections originate from within the train drivers' primary field of view (30 degrees either side of the direction of travel).

For these receptors there is existing heavy vegetation that screens the reflections from the solar panel area, thus no impact from the Proposed Development is predicted; however, in the circumstances that this vegetation was removed the impact significance would remain moderate and mitigation would need to be implemented. Therefore, although mitigation is not recommended, the existing screening along the boundary of the Proposed Development should be maintained to ensure views of the reflecting solar panel area continue to be removed. Figure 53 below shows the existing screening outlined in orange.

Figure 53 *Existing screening for receptors 30-31*

Where solar reflections are predicted to be experienced outside the train drivers' primary field of view (30 degrees either side of the direction of travel), at receptors 1-21 and 24-29, a low impact from the Proposed Development is predicted and mitigation is not recommended.

8 HIGH-LEVEL AVIATION CONSIDERATIONS

8.1 Overview

Sherburn-in-Elmet is an unlicensed airfield located approximately 9.5km northwest of the Proposed Development, which is understood to not have an ATC Tower. The airfield has four runways:

- 01/19 – 585 metres (Grass);
- 06/24 – 793 metres (Grass);
- 10/28 – 830 metres (Tarmac); and
- 10/28 – 616 metres (Grass).

The location of Sherburn-in-Elmet Airfield relative to the Proposed Development is shown in Figure 54 below.

Figure 54 *Sherburn-in-Elmet airfield relative to the Proposed Development*

8.2 High-Level Conclusion

Considering the size of the Proposed Development and its location relative to Sherburn-in-Elmet Airfield (approximately 9.5km away), the following is applicable:

- In Pager Power's experience and expertise, it can be safely presumed that any predicted solar reflections towards pilots approaching runway thresholds 06, 19 and both runway 10 thresholds, 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.
- Any solar reflections will be outside a pilot's primary field of view (50 degrees either side of the approach bearing) along the approach paths towards runway thresholds 01, 24, and both runway 28 thresholds, which is acceptable in accordance with the associated guidance and industry best practice.

Therefore, no significant impacts, from the Proposed Development, upon aviation activity associated with Sherburn-in-Elmet are predicted, and no further detailed modelling is recommended.

9 OVERALL CONCLUSIONS

9.1 Aviation Receptors

The results of the analysis for Burn Airfield (runways 01/19, 07/25 and 15/33) and Cliffe Airfield (runway 10/28) have shown that no solar reflections towards pilots approaching runway 10 are geometrically possible. Therefore, no impacts from the Proposed Development are possible and mitigation is not required.

Solar reflections with 'potential for temporary after-image' are predicted towards runways, 01, 07, 15, 19, 33, and 28. However, following further assessment of the predicted reflections in an operational context, it can be concluded that the glare is operationally accommodatable.

Solar reflections from the Proposed Development with 'potential for temporary after-image' are predicted towards the runway 25 approach. Following further assessment of the predicted reflections in an operational context, the impacts are considered significant (prior to mitigation) and mitigation is required. Potential mitigation for the Proposed Development can include fixing the Single Access Tracker System at a resting angle that would avoid significant effects at the times at which glare for the runway 25 approach is predicted.

9.2 Dwelling Receptors

The results of the analysis have shown that reflections from the Proposed Development are geometrically possible towards 104 out of the identified dwelling receptors for more than three months per year and less than 60 minutes per day.

For 98 dwellings, existing and proposed (please see Figures 7.8-7.10 Landscape Strategy of the Preliminary Environmental Information Report) screening in the form of vegetation, terrain and buildings removes the visibility of the reflecting panel areas. Therefore, no impacts from the Proposed Development are predicted and mitigation is not required.

For the remaining six dwellings, there are sufficient mitigating factors. These include:

- A large separation distance between the reflecting panel area and the dwelling. This reduces the proportion of an observer's field of view that is affected by glare.
- The effects coincide with direct sunlight, which is a more significant source of light; therefore the effects appear much less significant.
- The effects cannot be seen from an observer on the ground floor – which has the greatest impact on residential amenity.
- The effects occur outside the 1km assessment area and would therefore be a maximum of low impact, due to the separation distance and intervening terrain/vegetation.

Therefore, mitigation is not recommended for these dwellings.

9.3 Road Receptors

The results of the analysis have shown that solar reflections from the Proposed Development are geometrically possible along approximately all of the assessed sections of road along the A1041, A645, Barlow Road, Common Lane, Hirst Road and Station Road.

Where solar reflections are geometrically possible inside a road user's primary field of view, along a combined 4.1km section of road, existing and proposed vegetation and buildings will remove visibility of any solar reflections. Therefore, no impacts from the Proposed Development are predicted, and mitigation is not required for these sections of road.

9.4 Train Driver Receptors

The analysis has shown that reflections are geometrically possible towards 2.8km of railway track. Reflections are predicted to occur within the train driver's primary field of view (30 degrees either side of the direction of travel) along 200m of railway track; however, screening in the form of heavy existing vegetation is present. Therefore, no impacts from the Proposed Development are predicted and mitigation is not required.

A low impact from the Proposed Development is predicted for the remaining sections of railway track where solar reflections are geometrically possible. The reflections occur outside of the train driver's primary field of view. Therefore, no mitigation is required.

9.5 High-Level Aviation

Considering the size of the Proposed Development and its location relative to Sherburn-in-Elmet Airfield (approximately 9.5km away), the following is applicable:

- In Pager Power's experience and expertise, it can be safely presumed that any predicted solar reflections towards pilots approaching runway thresholds 06, 19 and both runway 10 thresholds, 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.
- Any solar reflections will be outside a pilot's primary field of view (50 degrees either side of the approach bearing) along the approach paths towards runway thresholds 01, 24, and both runway 28 thresholds, which is acceptable in accordance with the associated guidance and industry best practice.

Therefore, no significant impacts, from the Proposed Development, upon aviation activity associated with Sherburn-in-Elmet are predicted, and no further detailed modelling is recommended.

APPENDIX A – OVERVIEW OF GLINT AND GLARE GUIDANCE

Overview

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

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

UK Planning Policy

- The National Planning Policy Framework under the planning practice guidance for Renewable and Low Carbon Energy[14] (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.'*

[14] 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)[15] sets out the primary policy for decisions by the Secretary of State for nationally significant renewable energy infrastructure. Sections 3.10.93-97 state:

'3.10.93 Solar panels are specifically designed to absorb, not reflect, irradiation.[16] However, solar panels may reflect the sun's rays at certain angles, causing glint and glare. Glint is defined as a momentary flash of light that may be produced as a direct reflection of the sun in the solar panel. Glare is a continuous source of excessive brightness experienced by a stationary observer located in the path of reflected sunlight from the face of the panel. The effect occurs when the solar panel is stationed between or at an angle of the sun and the receptor.

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

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

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

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

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

Sections 3.10.125-127 state:

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

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

3.10.127 Applicants may consider adjusting the azimuth alignment of or changing the elevation tilt angle of a solar panel, within the economically viable range, to alter the angle of incidence.

[15] Draft National Policy Statement for Renewable Energy Infrastructure (EN-3), Department for Energy Security & Net Zero, date: March 2023, accessed on: 05/04/2023.

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

In practice this is unlikely to remove the potential impact altogether but in marginal cases may contribute to a mitigation strategy.

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

Sections 3.10.149-150 state:

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

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

The latest version of the draft EN-3 goes some way in referencing that the issue is more complex than presented in the previous issue; though, this is still unlikely to be welcomed by aviation stakeholders, who will still request a glint and glare assessment on the basis that glare may lead to impact upon aviation safety. It is possible that the final issue of the policy will change in light of further consultation responses from aviation stakeholders.

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

Assessment Process – Ground-Based Receptors

No process for determining and contextualising the effects of glint and glare is 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[17] which was produced due to the absence of existing guidance and a specific standardised assessment methodology.

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

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

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'[18] 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.

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

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.

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'19 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.

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

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.

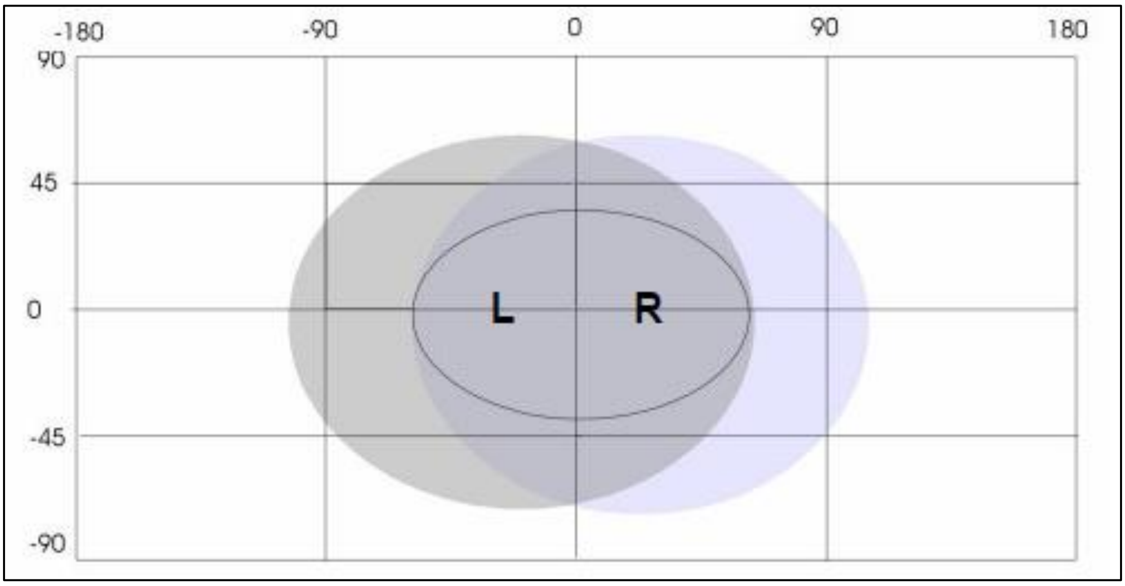


Figure G 21 - Field of view

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 + 8^o 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.

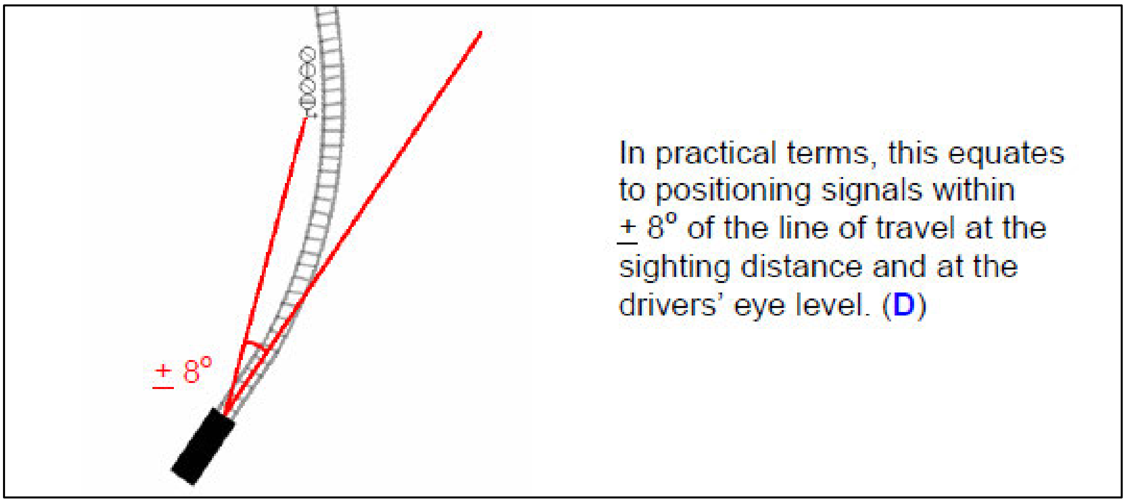


Figure G 22 - Signal positioning

'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[20];

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

- 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[21,22,23] claim that LED signal lights significantly reduce or completely remove the likelihood of a phantom aspect illumination occurring.

[21] Source: http://www.unipartdorman.co.uk/assets/unipart_dorman_rail_brochure.pdf. (Last accessed 21.02.18).
[22] Source: http://www.vmstech.co.uk/downloads/Rail.pdf. (Last accessed 21.02.18).
[23] 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

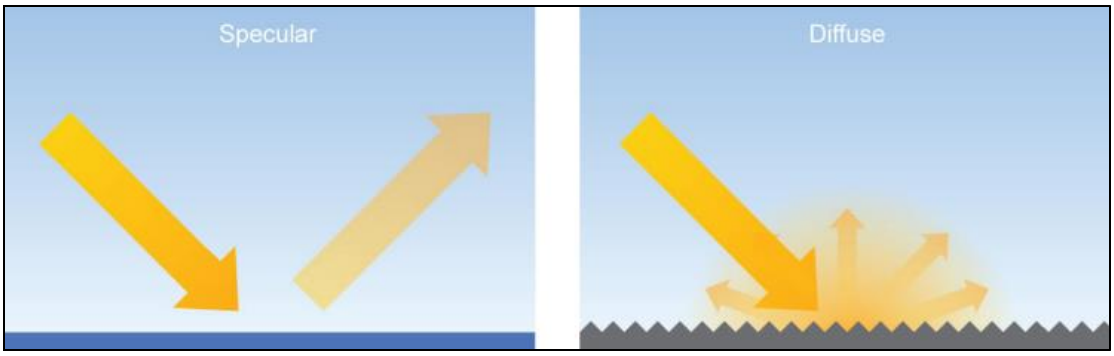
Overview

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

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

Reflection Type from Solar Panels

Based on the surface conditions reflections from light can be specular and diffuse. A specular reflection has a reflection characteristic similar to that of a mirror; a diffuse will reflect the incoming light and scatter it in many directions. The figure below, taken from the FAA guidance[24], 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

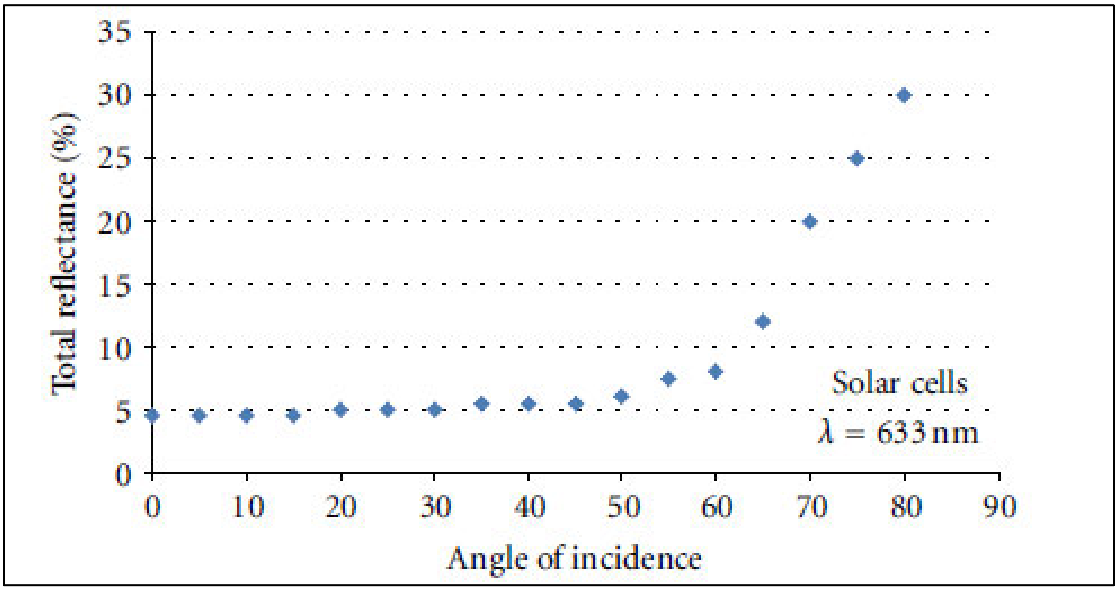
[24]Technical Guidance for Evaluating Selected Solar Technologies on Airports, Federal Aviation Administration (FAA), date: 04/2018, accessed on: 20/03/2019.

Solar Reflection Studies

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

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

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



Total reflectance % when compared to angle of incidence

The conclusions of the research study were:

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

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[25] 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"[26]

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

Surface	Approximate Percentage of Light Reflected[27]
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).

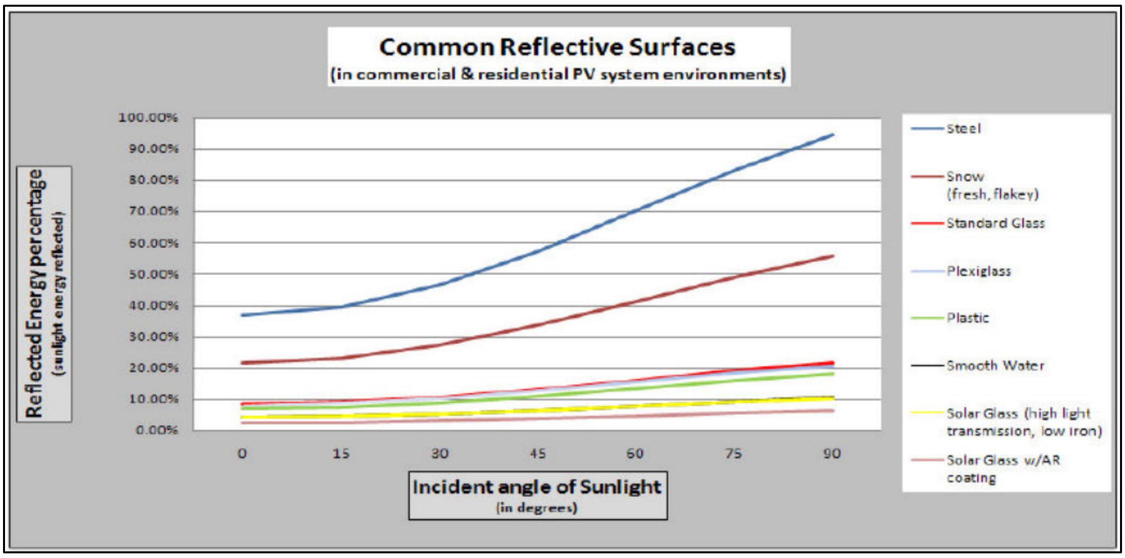
An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel. The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

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

SunPower Technical Notification (2009)

SunPower published a technical notification[28] to '*increase awareness concerning the possible glare and reflectance impact of PV Systems on their surrounding environment*'.

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



Common reflective surfaces

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

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

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

APPENDIX C – OVERVIEW OF SUN MOVEMENTS AND RELATIVE REFLECTIONS

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

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

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

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

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

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

APPENDIX D – GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

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

Impact Significance Definition

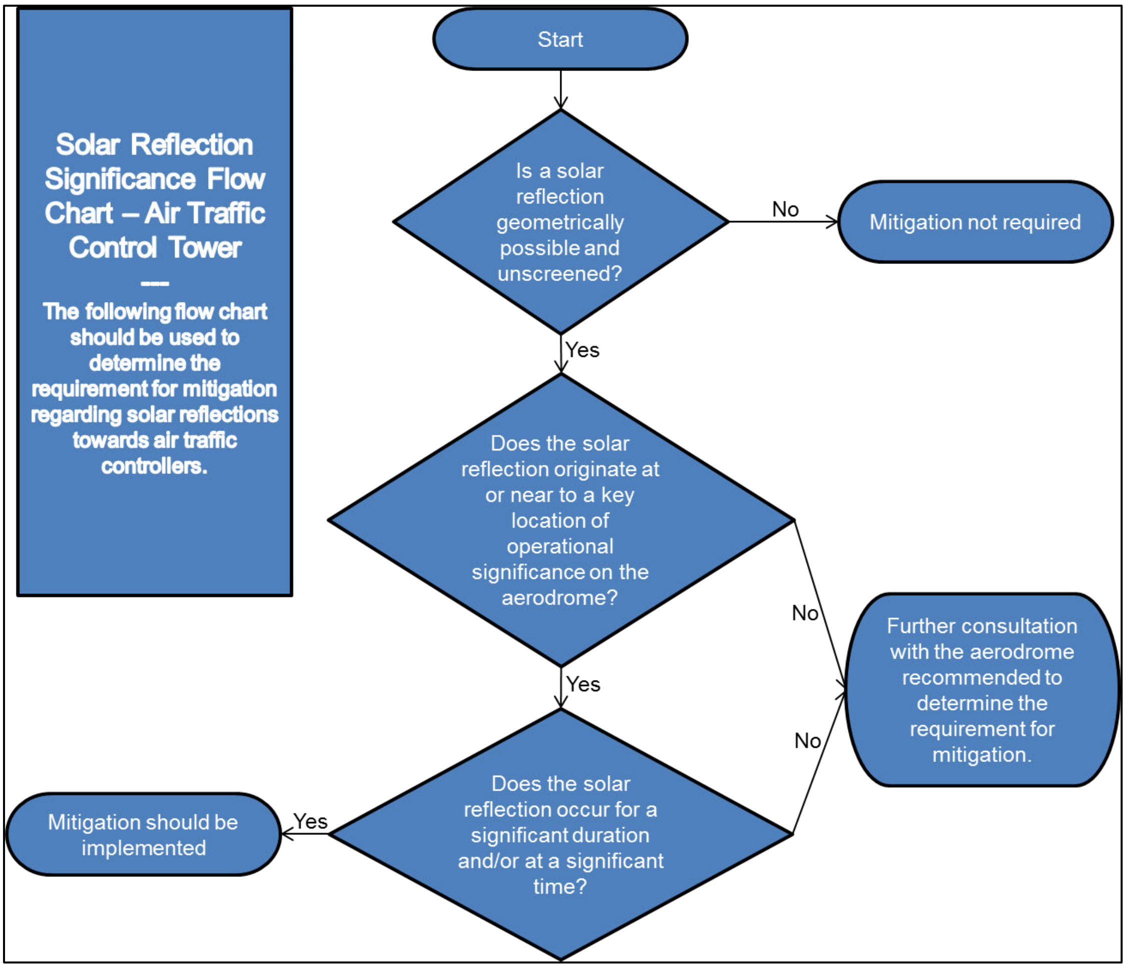
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

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

Impact significance definition

Impact Significance Determination for ATC Tower

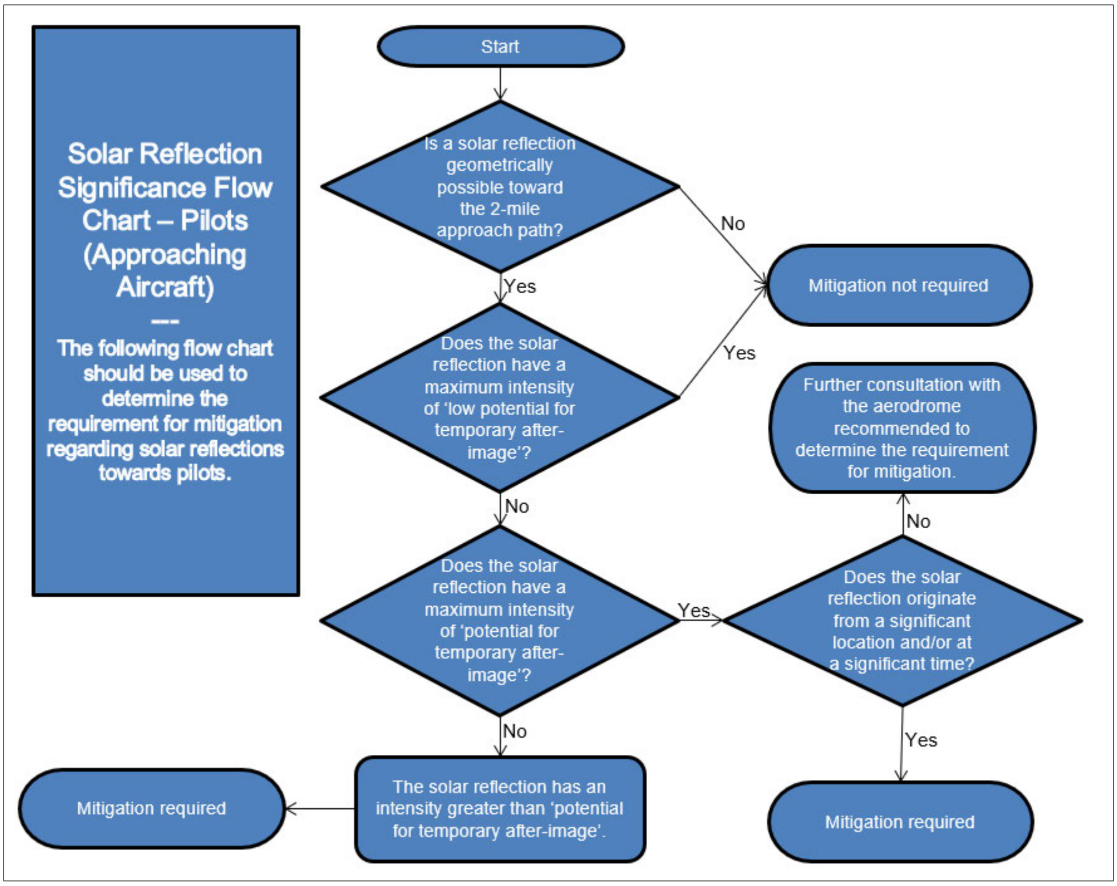
The charts relate to the determining the potential impact upon the ATC Tower.



ATC Tower mitigation requirement flow chart

Impact Significance Determination for Approaching Aircraft

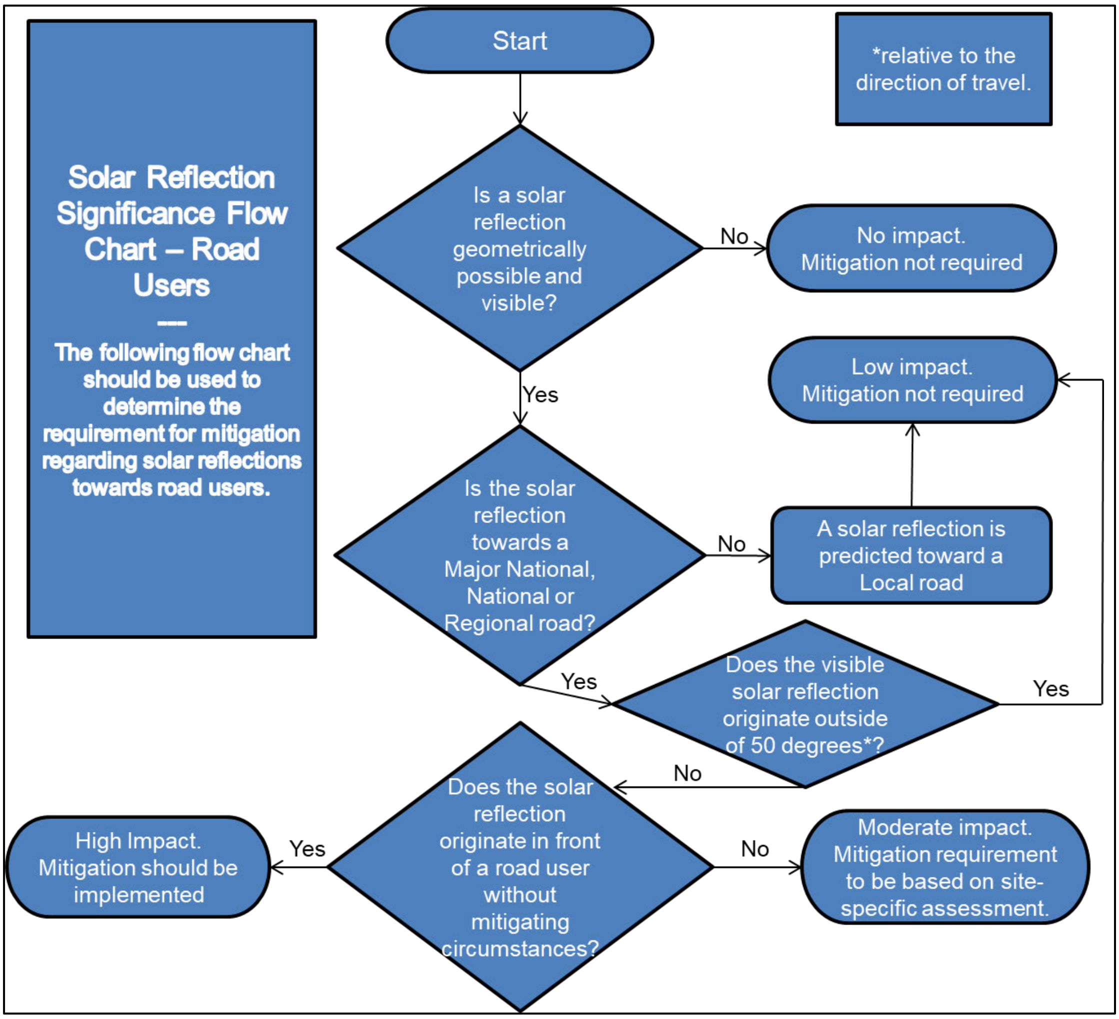
The charts relate to the determining the potential impact upon approaching aircraft.



Approaching aircraft receptor mitigation requirement flow chart

Impact Significance Determination for Road Receptors

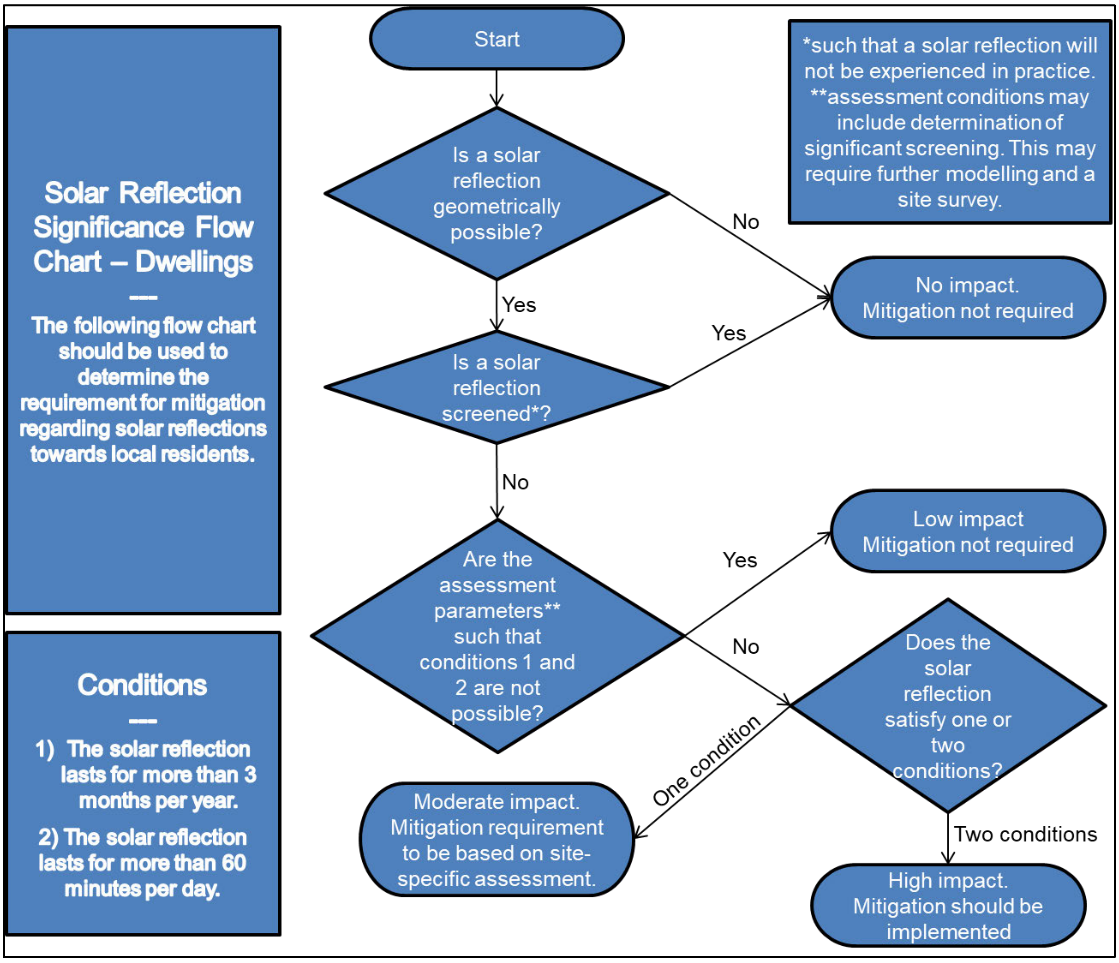
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



Road user impact significance flow chart

Impact Significance Determination for Dwelling Receptors

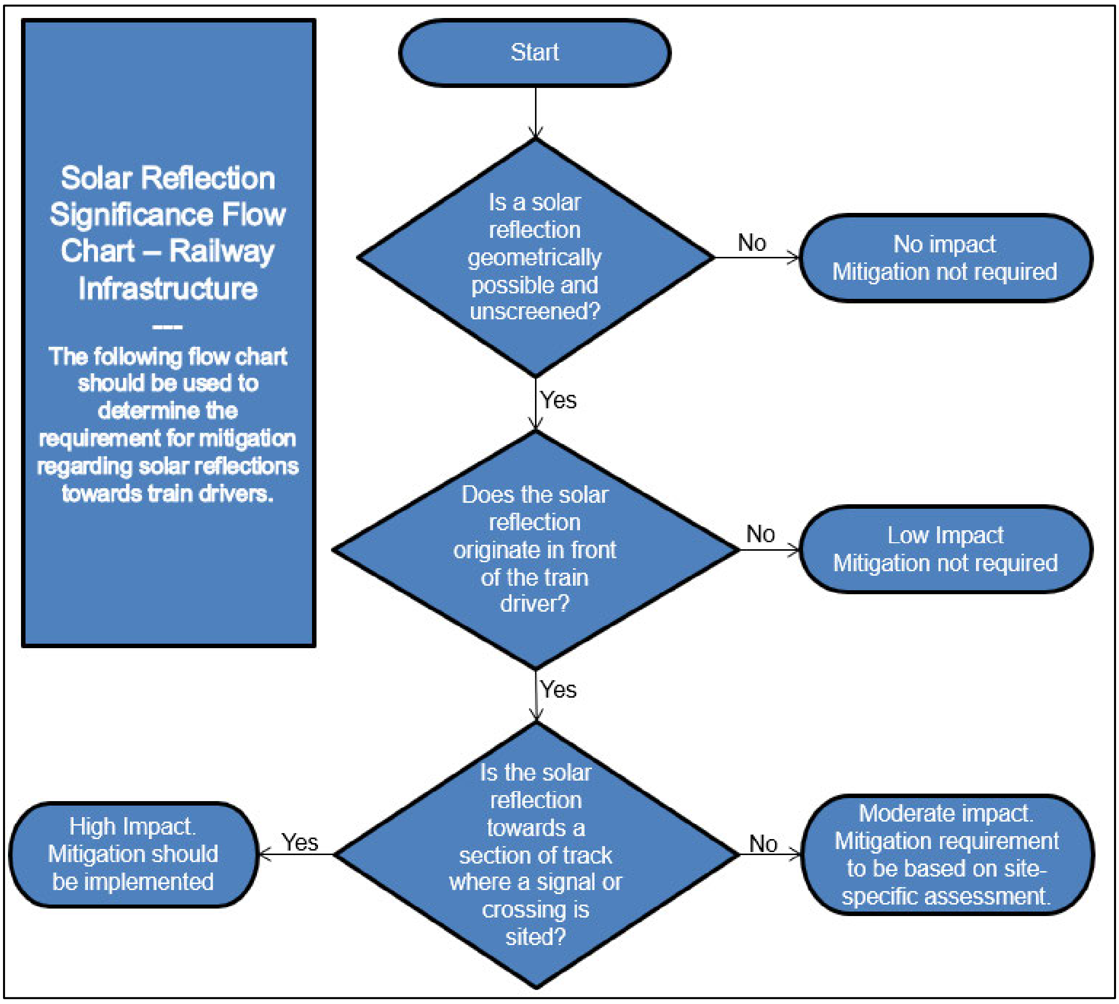
The flow chart presented below has been followed when determining the mitigation requirement for dwelling receptors.



Dwelling impact significance flow chart

Impact Significance Determination for Railway Receptors

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



Train driver impact significance flow chart

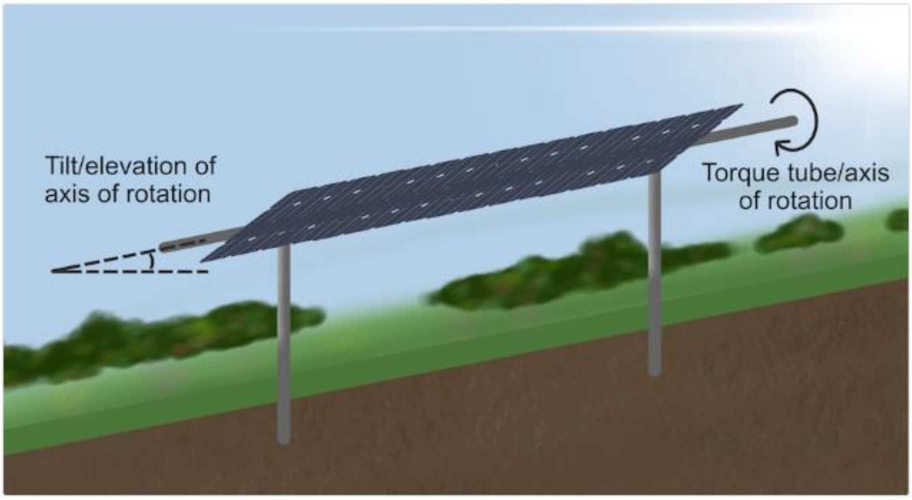
APPENDIX E – REFLECTION CALCULATIONS METHODOLOGY

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

Forge's Sandia National Laboratories' (SGHAT) Model[29]

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.

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

APPENDIX G – RECEPTOR AND REFLECTOR AREA DETAILS

Dwelling Receptor Data

The dwelling receptor data is presented in the table below.

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.07808	53.75427	101	-1.02404	53.71281
2	-1.07765	53.75420	102	-1.02369	53.71244
3	-1.07747	53.75418	103	-1.02345	53.71221
4	-1.07729	53.75397	104	-1.02380	53.71189
5	-1.07642	53.75427	105	-1.02412	53.71181
6	-1.07550	53.75329	106	-1.02464	53.71191
7	-1.07489	53.75384	107	-1.02532	53.71187
8	-1.07387	53.75414	108	-1.02578	53.71164
9	-1.07419	53.74856	109	-1.02577	53.71127
10	-1.07382	53.74809	110	-1.02544	53.71094
11	-1.07294	53.74988	111	-1.02529	53.71073
12	-1.05824	53.75537	112	-1.02519	53.71029
13	-1.05810	53.75498	113	-1.02510	53.70992
14	-1.06133	53.74900	114	-1.02519	53.70952
15	-1.06088	53.74907	115	-1.02434	53.70925
16	-1.05483	53.75150	116	-1.02545	53.70892
17	-1.05462	53.74716	117	-1.02554	53.70864
18	-1.04447	53.74113	118	-1.02429	53.70819
19	-1.02829	53.73867	119	-1.02404	53.70790
20	-1.02891	53.73852	120	-1.02441	53.70767
21	-1.02892	53.73828	121	-1.02436	53.70750
22	-1.03840	53.73511	122	-1.02438	53.70724

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
23	-1.03771	53.73447	123	-1.02440	53.70702
24	-1.03656	53.73276	124	-1.02388	53.70692
25	-1.03575	53.72990	125	-1.02382	53.70671
26	-1.03565	53.72976	126	-1.02948	53.70530
27	-1.03543	53.72969	127	-1.03418	53.70566
28	-1.03512	53.72967	128	-1.03485	53.70548
29	-1.03569	53.72880	129	-1.03581	53.70510
30	-1.03502	53.72886	130	-1.03989	53.70434
31	-1.03439	53.72908	131	-1.04085	53.70471
32	-1.03438	53.73014	132	-1.04142	53.70314
33	-1.03448	53.73006	133	-1.04193	53.70295
34	-1.03434	53.72988	134	-1.04177	53.70576
35	-1.03415	53.72963	135	-1.02661	53.71561
36	-1.03271	53.72874	136	-1.03766	53.71202
37	-1.03212	53.72851	137	-1.05176	53.70799
38	-1.03177	53.72840	138	-1.04931	53.71133
39	-1.03149	53.72824	139	-1.05002	53.71154
40	-1.03082	53.72795	140	-1.05214	53.71186
41	-1.03007	53.72769	141	-1.05261	53.71348
42	-1.02874	53.72740	142	-1.05368	53.71463
43	-1.02749	53.72775	143	-1.05353	53.71498
44	-1.02697	53.72756	144	-1.05140	53.71544
45	-1.02631	53.72740	145	-1.05101	53.71567
46	-1.02577	53.72708	146	-1.05064	53.71591
47	-1.02518	53.72685	147	-1.05100	53.71609

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
48	-1.02441	53.72676	148	-1.05436	53.71660
49	-1.02463	53.72626	149	-1.05625	53.71655
50	-1.02409	53.72613	150	-1.05758	53.71634
51	-1.02370	53.72656	151	-1.05760	53.71477
52	-1.02326	53.72652	152	-1.05774	53.71316
53	-1.02280	53.72653	153	-1.05352	53.71108
54	-1.02236	53.72650	154	-1.05516	53.70860
55	-1.01829	53.73164	155	-1.05696	53.70885
56	-1.01756	53.73118	156	-1.05833	53.70930
57	-1.02149	53.72645	157	-1.05937	53.70969
58	-1.02143	53.72615	158	-1.06041	53.71001
59	-1.02174	53.72579	159	-1.06214	53.71020
60	-1.02166	53.72551	160	-1.06151	53.71055
61	-1.02111	53.72517	161	-1.06967	53.71212
62	-1.02277	53.72469	162	-1.07027	53.71222
63	-1.02189	53.72423	163	-1.07158	53.71244
64	-1.02175	53.72438	164	-1.07202	53.71298
65	-1.02127	53.72417	165	-1.07188	53.71351
66	-1.02074	53.72393	166	-1.07237	53.71299
67	-1.02029	53.72367	167	-1.07282	53.71271
68	-1.02001	53.72380	168	-1.07332	53.71288
69	-1.01934	53.72398	169	-1.07372	53.71301
70	-1.01898	53.72433	170	-1.07415	53.71315
71	-1.01766	53.72548	171	-1.07457	53.71341

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
72	-1.01719	53.72544	172	-1.07501	53.71348
73	-1.01675	53.72443	173	-1.07544	53.71363
74	-1.01664	53.72426	174	-1.07642	53.71386
75	-1.01618	53.72427	175	-1.07675	53.71395
76	-1.01617	53.72395	176	-1.07708	53.71412
77	-1.01628	53.72383	177	-1.07743	53.71426
78	-1.02257	53.71772	178	-1.07807	53.71444
79	-1.01482	53.71581	179	-1.07858	53.71460
80	-1.01733	53.71521	180	-1.07901	53.71475
81	-1.01511	53.71380	181	-1.07959	53.71481
82	-1.01552	53.71380	182	-1.08038	53.71488
83	-1.01605	53.71380	183	-1.07896	53.71599
84	-1.01652	53.71378	184	-1.08263	53.71626
85	-1.01685	53.71379	185	-1.08209	53.71703
86	-1.01732	53.71368	186	-1.08327	53.71796
87	-1.01916	53.71354	187	-1.08354	53.71858
88	-1.01998	53.71245	188	-1.08226	53.71888
89	-1.02041	53.71242	189	-1.08179	53.71964
90	-1.02069	53.71244	190	-1.05536	53.72527
91	-1.02088	53.71202	191	-1.05479	53.72593
92	-1.02118	53.71201	192	-1.04598	53.72454
93	-1.02135	53.71312	193	-1.04700	53.73188
94	-1.02180	53.71312	194	-1.05632	53.73836
95	-1.02208	53.71312	195	-1.05529	53.73968

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
96	-1.02241	53.71312	196	-1.07031	53.73579
97	-1.02269	53.71312	197	-1.07860	53.74326
98	-1.02295	53.71257	198	-1.07856	53.74303
99	-1.02348	53.71311	199	-1.07699	53.74497
100	-1.02410	53.71321			

Dwelling receptor data

Road Receptor Data

The road receptor data is presented in the table below.

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.09173	53.75396	85	-1.01880	53.71844
2	-1.09020	53.75390	86	-1.01892	53.71755
3	-1.08867	53.75380	87	-1.01903	53.71665
4	-1.08721	53.75354	88	-1.01914	53.71575
5	-1.08573	53.75335	89	-1.01928	53.71485
6	-1.08462	53.75397	90	-1.01938	53.71395
7	-1.08352	53.75459	91	-1.01950	53.71305
8	-1.08232	53.75515	92	-1.01960	53.71216
9	-1.08081	53.75500	93	-1.01972	53.71126
10	-1.07937	53.75472	94	-1.01992	53.71037
11	-1.07793	53.75441	95	-1.02034	53.70951
12	-1.07648	53.75414	96	-1.02064	53.70862
13	-1.07513	53.75372	97	-1.02072	53.70779
14	-1.07411	53.75304	98	-1.00898	53.72637
15	-1.07269	53.75272	99	-1.01028	53.72590
16	-1.07124	53.75245	100	-1.01158	53.72543
17	-1.06985	53.75208	101	-1.01287	53.72494

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
18	-1.06885	53.75140	102	-1.01416	53.72446
19	-1.06740	53.75112	103	-1.01544	53.72398
20	-1.06589	53.75099	104	-1.01670	53.72347
21	-1.06443	53.75073	105	-1.01798	53.72298
22	-1.06313	53.75025	106	-1.03283	53.74582
23	-1.06183	53.74978	107	-1.03376	53.74510
24	-1.06033	53.74960	108	-1.03452	53.74432
25	-1.05882	53.74945	109	-1.03528	53.74354
26	-1.05775	53.74881	110	-1.03603	53.74276
27	-1.05627	53.74862	111	-1.03679	53.74197
28	-1.05474	53.74856	112	-1.03752	53.74118
29	-1.05322	53.74850	113	-1.03827	53.74040
30	-1.05188	53.74846	114	-1.03905	53.73963
31	-1.06028	53.75797	115	-1.03972	53.73882
32	-1.05957	53.75718	116	-1.04034	53.73801
33	-1.05885	53.75638	117	-1.04097	53.73718
34	-1.05815	53.75559	118	-1.09193	53.71860
35	-1.05743	53.75479	119	-1.09044	53.71844
36	-1.05671	53.75399	120	-1.08895	53.71826
37	-1.05599	53.75319	121	-1.08747	53.71806
38	-1.05529	53.75239	122	-1.08596	53.71794
39	-1.05457	53.75160	123	-1.08445	53.71791
40	-1.05384	53.75080	124	-1.08300	53.71763
41	-1.05313	53.75001	125	-1.08251	53.71678
42	-1.05241	53.74922	126	-1.08312	53.71596
43	-1.05168	53.74843	127	-1.08264	53.71511

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
44	-1.05098	53.74763	128	-1.08129	53.71471
45	-1.05026	53.74684	129	-1.07977	53.71463
46	-1.04955	53.74605	130	-1.07833	53.71436
47	-1.04882	53.74525	131	-1.07703	53.71388
48	-1.04811	53.74446	132	-1.07570	53.71345
49	-1.04740	53.74366	133	-1.07431	53.71309
50	-1.04667	53.74287	134	-1.07301	53.71262
51	-1.04595	53.74208	135	-1.07159	53.71230
52	-1.04520	53.74130	136	-1.07014	53.71205
53	-1.04450	53.74051	137	-1.06866	53.71181
54	-1.04379	53.73971	138	-1.06718	53.71156
55	-1.04308	53.73892	139	-1.06573	53.71130
56	-1.04237	53.73813	140	-1.06427	53.71107
57	-1.04167	53.73733	141	-1.06282	53.71078
58	-1.04095	53.73653	142	-1.06157	53.71028
59	-1.04024	53.73574	143	-1.06035	53.70974
60	-1.03951	53.73495	144	-1.05900	53.70934
61	-1.03880	53.73417	145	-1.05771	53.70886
62	-1.03807	53.73337	146	-1.05640	53.70843
63	-1.03734	53.73258	148	-1.05505	53.70799
64	-1.03663	53.73179	149	-1.05354	53.70787
65	-1.03589	53.73100	150	-1.05202	53.70780
66	-1.03515	53.73022	151	-1.05055	53.70755
67	-1.03423	53.72950	152	-1.04908	53.70730
68	-1.03295	53.72901	153	-1.04762	53.70706
69	-1.03170	53.72851	156	-1.04618	53.70676

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
70	-1.03043	53.72803	157	-1.04485	53.70632
71	-1.02905	53.72766	158	-1.04349	53.70591
72	-1.02760	53.72739	159	-1.04216	53.70546
73	-1.02620	53.72705	160	-1.04084	53.70503
74	-1.02494	53.72655	161	-1.03950	53.70459
75	-1.02349	53.72627	162	-1.03802	53.70439
76	-1.02218	53.72581	163	-1.03649	53.70445
77	-1.02201	53.72492	164	-1.03513	53.70486
78	-1.02145	53.72408	165	-1.03375	53.70523
79	-1.02034	53.72346	166	-1.03228	53.70547
80	-1.01920	53.72285	167	-1.03078	53.70568
81	-1.01856	53.72203	168	-1.02930	53.70550
82	-1.01851	53.72113	169	-1.02779	53.70564
83	-1.01859	53.72023	170	-1.02630	53.70579
84	-1.01870	53.71934			

Road receptor data

Train Driver Receptor Data

The train driver receptor data is presented in the table below.

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
1	-1.07701	53.75316	17	-1.08176	53.73819
2	-1.07730	53.75228	18	-1.08204	53.73731
3	-1.07759	53.75140	19	-1.08232	53.73644
4	-1.07785	53.75052	20	-1.08261	53.73556
5	-1.07814	53.74964	21	-1.02554	53.71613
6	-1.07841	53.74876	22	-1.02423	53.71659
7	-1.07869	53.74787	23	-1.02291	53.71705

No.	Longitude (°)	Latitude (°)	No.	Longitude (°)	Latitude (°)
8	-1.07898	53.74699	24	-1.02159	53.71750
9	-1.07926	53.74611	25	-1.02029	53.71796
10	-1.07954	53.74523	26	-1.01897	53.71841
11	-1.07982	53.74435	27	-1.01766	53.71886
12	-1.08010	53.74347	28	-1.01635	53.71933
13	-1.08036	53.74259	29	-1.01503	53.71978
14	-1.08065	53.74171	30	-1.01372	53.72023
15	-1.08093	53.74083	31	-1.02554	53.71613
16	-1.08121	53.73996			

Train Driver Receptor Data

APPENDIX H – DETAILLED MODELLING RESULTS

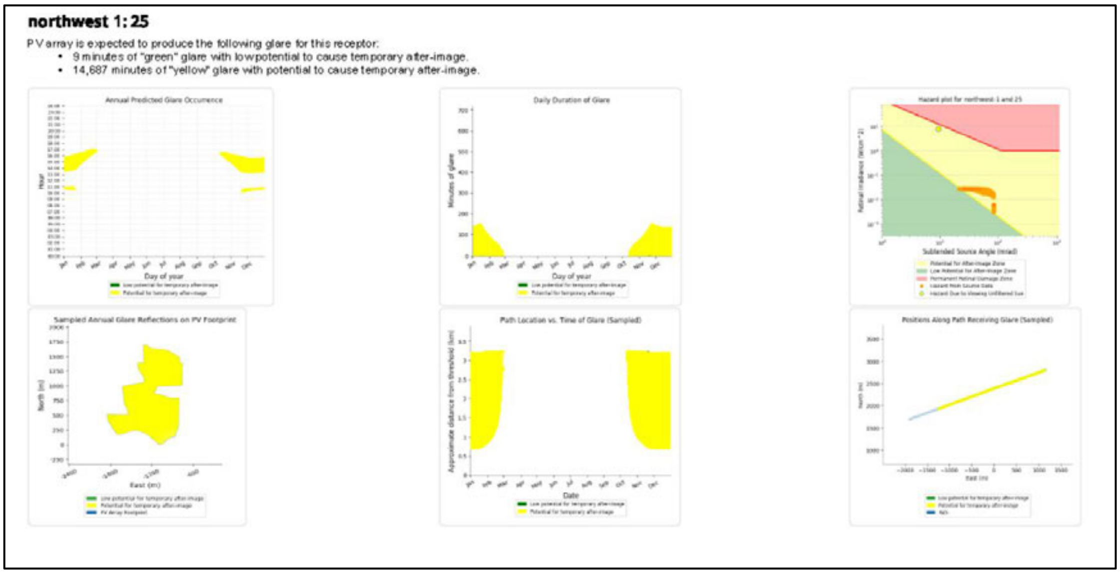
Overview

The output charts are taken from Forge and present relevant information for the receptors in which solar reflections are predicted to be experienced. Each chart shows:

- The reflection date/time graph – top left graph. This relates to reflections from the yellow areas;
- The daily duration of glare – top right image;
- Hazard plot categorising the glare – middle left image;
- The positions along the approach path where glare is received – middle right and bottom right images;
- The reflecting panels – bottom left 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 charts below pertain to the receptor where mitigation has been recommended.

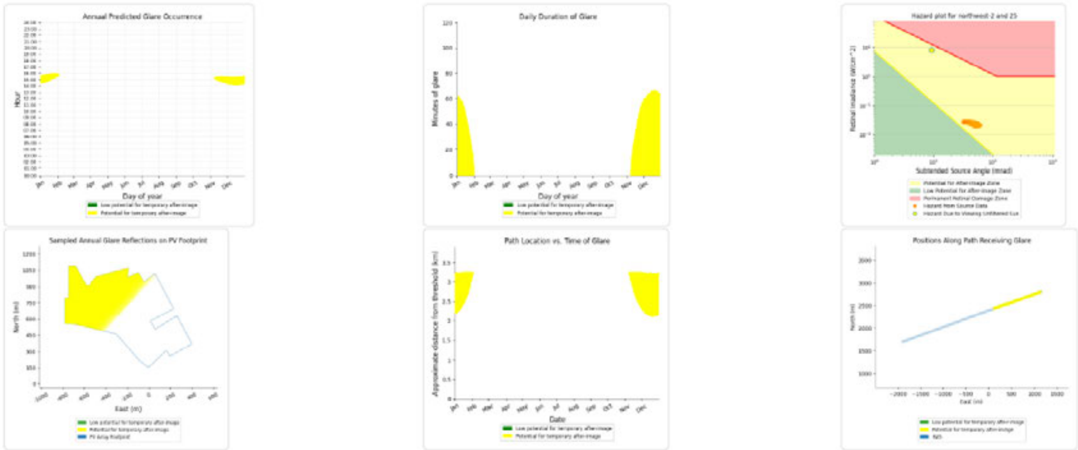
Runway Approach Path 25



northwest 2: 25

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

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 4,291 minutes of "yellow" glare with potential to cause temporary after-image.



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