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# AVIATION GLINT AND GLARE ASSESSMENT

## Proposed Solar PV Energy Development

## Land Development Agency, Sarsfield Road, Wilton, Co. Cork.

Prepared by Macro Works Ltd

December 2024

Registered Landscape Architect

# 1. AVIATION GLINT AND GLARE ASSESSMENT

## 1.1 INTRODUCTION

This Glint and Glare Assessment was carried out by Macro Works Ltd to determine the potential for solar reflectance effects upon aviation receptors in respect of proposed roof-mounted solar PV installations on the roof the proposed Land Development Agency residential buildings at Sarsfield Road, Wilton, Co. Cork. The proposed panels are to be oriented to the southeast with a pitch of 15 degrees. The proposed panels will remain in a fixed position throughout the day and year (i.e. they will not rotate to track the movement of the sun). Figure 1.1 refers.


Figure 1.1 Aerial view indicating the location of the proposed site location.

### 1.1.1 Statement of Authority

Macro Works' relevant experience includes twenty years of analysing the visual effects of a wide range of infrastructural and commercial development types. This experience includes numerous domestic and international wind and solar energy developments.

### 1.1.2 Guidance and Best Practice

Guidance has been prepared by the Federal Aviation Authority[1] to address the potential hazards that solar developments may pose to aviation activities, and this has been adopted for use by the Irish Aviation Authority. SGHAT was developed in conjunction with the FAA in harmony with this guidance and is commonly regarded as the accepted industry standard by aviation authorities internationally when considering the glint and glare effects upon aviation related receptors.

By virtue of their efficiency, the intensity of reflected light from modern PV solar panels is deliberately low and currently equates with that of the reflection from still water. Recent studies generally agree, however, that there still exists the potential for hazard or nuisance upon surrounding receptors. Macro Works' glint and glare analysis methods and determination of effects are based on a combination of available studies and established best practice. This methodology has been successfully implemented on numerous previous solar farm projects that met with the approval of both Planning Authorities and An Bord Pleanála.

#### Federal Aviation Authority

Within the FAA's interim policy, a 'Review of Solar Energy System Projects on Federally Obligated Airports'[2] it states:

> *"To obtain FAA approval to revise an airport layout plan to depict a solar installation and/or a ''no objection'' to a Notice of Proposed Construction Form 7460–1, the airport sponsor will be required to demonstrate that the proposed solar energy system meets the following standards:*
>
> *No potential for glint or glare in the existing or planned Airport Traffic Control Tower (ATCT) cab, and*
>
> *No potential for glare or ''low potential for after-image'' (shown in green in Figure 1[ Figure 1. refers]) along the final approach path for any existing landing threshold or future landing thresholds (including any planned interim phases of the landing thresholds) as shown on the current FAA-approved Airport Layout Plan (ALP). The final approach path is defined as two (2) miles from fifty (50) feet above the landing threshold using a standard three (3) degree glidepath."*

Furthermore, in November 2021 the FAA deprioritised runway approaches as critical aviation receptors, citing the following;

> *"Initially, FAA believed that solar energy systems could introduce a novel glint and glare effect to pilots on final approach. FAA has subsequently concluded that in most cases, the glint and glare from solar energy systems to pilots on final approach is similar to glint and glare pilots routinely experience from water bodies, glass-façade buildings, parking lots, and similar features. However, FAA has continued to receive reports of potential glint and glare from on-airport solar energy systems on personnel working in ATCT cabs. Therefore, FAA has determined the scope of agency policy should be focused on the impact of on-airport solar energy systems to federally-obligated towered airports, specifically the airport's ATCT" (Federal Aviation Administration 05/11/2021).*

In summary, glare at an ATCT is not acceptable and while still relevant glare with a ''low potential for after-image'' is generally acceptable along final approach paths to runways in most instances.

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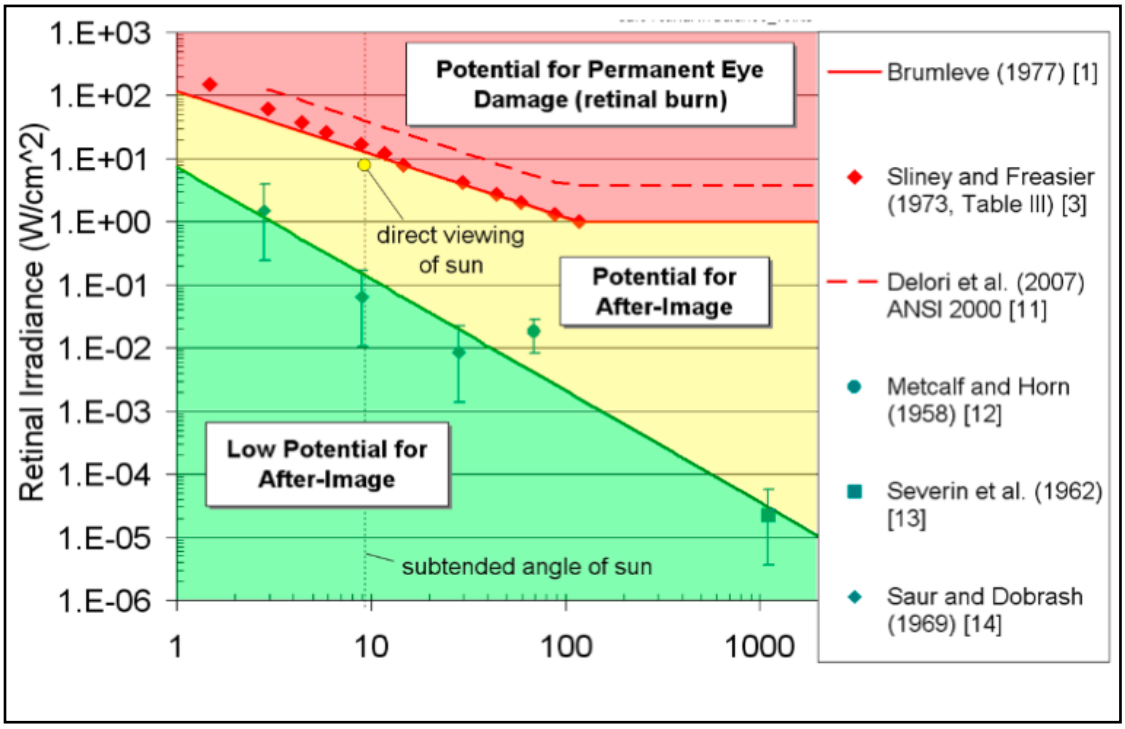
1 Harris, Miller, Miller & Hanson Inc.. (November 2010). Technical Guidance for Evaluating Selected Solar Technologies on Airports; 3.1.2 Reflectivity. Technical Guidance for Evaluating Selected Solar Technologies on Airports. Available at: https://www.faa.gov/airports/environmental/policy_guidance/media/airport-solar-guide.pdf

2 Federal Aviation Administration (FAA). (2013). Department of Transportation - Federal Aviation Administration. Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports. Vol 78 (No 205), 63276-63279.

Solar Glare Hazard Analysis Tool

The SGHAT was designed to determine whether a proposed solar energy project would result in the potential for ocular impact as depicted on the Solar Glare Hazard Analysis Plot (Figure 1.3 refers). SGHAT analyses ocular impact over the entire calendar year in one minute intervals from when the sun rises above the horizon until the sun sets below the horizon. One of the principal outputs from the SGHAT report is a glare plot per receptor that indicates the time of day and days per year that glare has the potential to occur. SGHAT plot classifies the intensity of ocular impact as either Green Glare, Yellow Glare or Red Glare. These colour classifications are equivalent to the FAA's definitions regarding the level of ocular impact e.g. 'Green Glare' in the SGHAT is synonymous to the FAA's ''low potential for after-image',' and so forth. The various correlations are illustrated on the Solar Glare Hazard Analysis Plot.




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

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

**Figure 1.3- Figure 1 from the FAA Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports**

## 1.2 METHODOLOGY

The process for dealing with aviation receptors is as follows:

1. The Federal Aviation Administration (FAA) approved Solar Glare Hazard Analysis Tool (SGHAT) is used to determine if any of these aviation receptors has the potential to theoretically experience glint or glare. This tool also calculates the intensity of such reflectance and whether it is acceptable by FAA standards.

2. SGHAT does not account for terrain screening or screening provided by surface elements such as existing vegetation or buildings, therefore the results of the SGHAT may need to be considered, in conjunction with an assessment of existing intervening screening that may be present, to establish if reflectance can actually be experienced at the receptors.

3. Finally, if necessary, additional assessment is undertaken using Macro Works' bespoke model which would into account any screening provided by any proposed mitigation measures.

### 1.2.1 Identification of Relevant Receptors

The Planning and Development (Solar Safeguarding Zone) Regulations 2022 set out 43 Solar Safeguarding Zones (SSZs). A SSZ is an area around an airport, aerodrome or helipad in which there is a potential for glint or glare from solar panels to impact aviation safety. The proposed development is located within the Cork Airport, Bishopstown, and Cork University Hospital SSZs.

#### Runways & Air Traffic Control Towers

This SGHAT analysis was produced to assess the potential for impacts upon aviation receptors, resulting from the proposed solar installation. Cork Airport is located approximately 3.1km south of the proposed development and comprises 2 active runways and one Air Traffic Control Tower (ATCT).

#### Observation Points

The proposed development also falls within the Bishopstown and Cork University Hospital SSZs. Bishopstown landing zone is located approximately 1.2km northwest of the proposed development. Cork University Hospital Helipad is located approximately 600m north of the proposed development. 26 Observation Points (OP), with heights ranging from 1.7m to 300m, were assessed for potential reflectance at each of these receptors.


**Figure 1.4 Aerial view showing the location of the proposed development relative to Cork Airport, Cork University Hospital and Bishopstown landing zone.**

## 1.3 RESULTS

### 1.3.1 Runway Approaches

The SGHAT results are contained in Appendix A and show that of the 4 runway approaches analysed, two showed potential for reflectance. Runway 25 recorded the greatest potential reflectance at 2,537 minutes of Green Glare over the course of the year.

None of the runway receptors showed any potential for Yellow Glare. The absence of Yellow Glare is regarded as a pass in this assessment as there would be no potential for after-image.

### 1.3.2 Air Traffic Control Towers

The SGHAT results contained in Appendix A also show there is no potential for glare at 1-ATCT as a result of the proposed development. Thus, there will be no potential for glint or glare to occur at Cork Airport ATCT.

### 1.3.3 Observation Points

The SGHAT results are contained in Appendix A and show that of the 26 Observation Points (OPs) analysed, at Bishopstown (OP15-27) and Cork University Hospital (OP2-14), none had any potential to experience any reflectance.

Thus, the results are considered a 'Pass' result as there is no potential for yellow glare.

## 1.4 OVERALL CONCLUSION

From the analysis and discussions contained herein, it is considered that the proposed array, at LDA Wilton, Cork, results in a 'Pass' at Cork Airport, Cork University Hospital, and Bishopstown aviation receptors.

# Appendix A

SGHAT Results

# FORGESOLAR GLARE ANALYSIS

Project: **Cork_Airport_**
Site configuration: **Wilton_Residential**
Analysis conducted by Luis Dominguez (luis@macroworks.ie) at 10:50 on 05 Dec, 2024.

## U.S. FAA 2013 Policy Adherence

The following table summarizes the policy adherence of the glare analysis based on the 2013 U.S. Federal Aviation Administration Interim Policy 78 FR 63276. This policy requires the following criteria be met for solar energy systems on airport property:

- No "yellow" glare (potential for after-image) for any flight path from threshold to 2 miles
- No glare of any kind for Air Traffic Control Tower(s) ("ATCT") at cab height.
- Default analysis and observer characteristics (see list below)

ForgeSolar does not represent or speak officially for the FAA and cannot approve or deny projects. Results are informational only.

| COMPONENT | STATUS | DESCRIPTION |
|---|---|---|
| Analysis parameters | PASS | Analysis time interval and eye characteristics used are acceptable |
| 2-mile flight path(s) | PASS | Flight path receptor(s) do not receive yellow glare |
| ATCT(s) | PASS | Receptor(s) marked as ATCT do not receive glare |

Default glare analysis parameters and observer eye characteristics (for reference only):

- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

FAA Policy 78 FR 63276 can be read at https://www.federalregister.gov/d/2013-24729

# SITE CONFIGURATION

## Analysis Parameters

DNI: peaks at 1,000.0 W/m^2
Time interval: 1 min
Ocular transmission coefficient: 0.5
Pupil diameter: 0.002 m
Eye focal length: 0.017 m
Sun subtended angle: 9.3 mrad
Site Config ID: 136064.15222
Methodology: V2


## PV Array(s)

**Name**: PV array 1
**Axis tracking**: Fixed (no rotation)
**Tilt**: 15.0°
**Orientation**: 175.0°
**Rated power**: -
**Panel material**: Smooth glass without AR coating
**Reflectivity**: Vary with sun
**Slope error**: correlate with material


| Vertex | Latitude (°) | Longitude (°) | Ground elevation (m) | Height above ground (m) | Total elevation (m) |
|---|---|---|---|---|---|
| 1 | 51.878406 | -8.508752 | 13.78 | 18.83 | 32.60 |
| 2 | 51.878411 | -8.508659 | 13.78 | 18.83 | 32.60 |
| 3 | 51.878214 | -8.508633 | 13.78 | 18.83 | 32.60 |
| 4 | 51.878209 | -8.508726 | 13.78 | 18.83 | 32.60 |
| 5 | 51.878406 | -8.508752 | 13.78 | 18.83 | 32.60 |

**Name**: PV array 2
**Axis tracking**: Fixed (no rotation)
**Tilt**: 15.0°
**Orientation**: 175.0°
**Rated power**: -
**Panel material**: Smooth glass without AR coating
**Reflectivity**: Vary with sun
**Slope error**: correlate with material


| Vertex | Latitude (°) | Longitude (°) | Ground elevation (m) | Height above ground (m) | Total elevation (m) |
|---|---|---|---|---|---|
| 1 | 51.878201 | -8.508827 | 13.78 | 18.83 | 32.60 |
| 2 | 51.878206 | -8.508735 | 13.78 | 18.83 | 32.60 |
| 3 | 51.878009 | -8.508709 | 13.78 | 18.83 | 32.60 |
| 4 | 51.878005 | -8.508802 | 13.78 | 18.83 | 32.60 |
| 5 | 51.878201 | -8.508827 | 13.78 | 18.83 | 32.60 |

**Name**: PV array 3
**Axis tracking**: Fixed (no rotation)
**Tilt**: 15.0°
**Orientation**: 175.0°
**Rated power**: -
**Panel material**: Smooth glass without AR coating
**Reflectivity**: Vary with sun
**Slope error**: correlate with material


| Vertex | Latitude (°) | Longitude (°) | Ground elevation (m) | Height above ground (m) | Total elevation (m) |
|---|---|---|---|---|---|
| 1 | 51.878373 | -8.508290 | 13.28 | 18.83 | 32.10 |
| 2 | 51.878377 | -8.508196 | 13.28 | 18.83 | 32.10 |
| 3 | 51.878181 | -8.508170 | 13.28 | 18.83 | 32.10 |
| 4 | 51.878176 | -8.508264 | 13.28 | 18.83 | 32.10 |
| 5 | 51.878373 | -8.508290 | 13.28 | 18.83 | 32.10 |

**Name**: PV array 4
**Axis tracking**: Fixed (no rotation)
**Tilt**: 15.0°
**Orientation**: 175.0°
**Rated power**: -
**Panel material**: Smooth glass without AR coating
**Reflectivity**: Vary with sun
**Slope error**: correlate with material


| Vertex | Latitude (°) | Longitude (°) | Ground elevation (m) | Height above ground (m) | Total elevation (m) |
|---|---|---|---|---|---|
| 1 | 51.878170 | -8.508156 | 13.28 | 18.83 | 32.10 |
| 2 | 51.878174 | -8.508062 | 13.28 | 18.83 | 32.10 |
| 3 | 51.877978 | -8.508037 | 13.28 | 18.83 | 32.10 |
| 4 | 51.877973 | -8.508130 | 13.28 | 18.83 | 32.10 |
| 5 | 51.878170 | -8.508156 | 13.28 | 18.83 | 32.10 |

**Name**: PV array 5
**Axis tracking**: Fixed (no rotation)
**Tilt**: 15.0°
**Orientation**: 175.0°
**Rated power**: -
**Panel material**: Smooth glass without AR coating
**Reflectivity**: Vary with sun
**Slope error**: correlate with material


| Vertex | Latitude (°) | Longitude (°) | Ground elevation (m) | Height above ground (m) | Total elevation (m) |
|---|---|---|---|---|---|
| 1 | 51.878363 | -8.506408 | 14.90 | 18.60 | 33.50 |
| 2 | 51.878369 | -8.506262 | 14.90 | 18.60 | 33.50 |
| 3 | 51.878312 | -8.506255 | 14.90 | 18.60 | 33.50 |
| 4 | 51.878305 | -8.506400 | 14.90 | 18.60 | 33.50 |
| 5 | 51.878363 | -8.506408 | 14.90 | 18.60 | 33.50 |

## Flight Path Receptor(s)

**Name**: 07 Runway
**Description**: None
**Threshold height**: 15 m
**Direction**: 65.0°
**Glide slope**: 3.0°
**Pilot view restricted?** Yes
**Vertical view**: 30.0°
**Azimuthal view**: 120.0°


| Point | Latitude (°) | Longitude (°) | Ground elevation (m) | Height above ground (m) | Total elevation (m) |
|---|---|---|---|---|---|
| Threshold | 51.841758 | -8.495530 | 144.60 | 15.20 | 159.80 |
| Two-mile | 51.829539 | -8.537991 | 136.40 | 192.10 | 328.50 |

**Name**: 16 Runway
**Description**: None
**Threshold height**: 15 m
**Direction**: 160.0°
**Glide slope**: 3.0°
**Pilot view restricted?** Yes
**Vertical view**: 30.0°
**Azimuthal view**: 120.0°


| Point | Latitude (°) | Longitude (°) | Ground elevation (m) | Height above ground (m) | Total elevation (m) |
|---|---|---|---|---|---|
| Threshold | 51.849970 | -8.496259 | 145.90 | 15.20 | 161.10 |
| Two-mile | 51.877139 | -8.512286 | 14.30 | 315.50 | 329.80 |

**Name**: 25 Runway
**Description**: None
**Threshold height**: 15 m
**Direction**: 246.0°
**Glide slope**: 3.0°
**Pilot view restricted?** Yes
**Vertical view**: 30.0°
**Azimuthal view**: 120.0°


| Point | Latitude (°) | Longitude (°) | Ground elevation (m) | Height above ground (m) | Total elevation (m) |
|---|---|---|---|---|---|
| Threshold | 51.846877 | -8.479584 | 153.10 | 15.20 | 168.30 |
| Two-mile | 51.858637 | -8.436778 | 96.90 | 240.10 | 337.00 |

**Name**: 34 Runway
**Description**: None
**Threshold height**: 15 m
**Direction**: 340.0°
**Glide slope**: 3.0°
**Pilot view restricted?** Yes
**Vertical view**: 30.0°
**Azimuthal view**: 120.0°


| Point | Latitude (°) | Longitude (°) | Ground elevation (m) | Height above ground (m) | Total elevation (m) |
|---|---|---|---|---|---|
| Threshold | 51.832575 | -8.485973 | 141.00 | 15.30 | 156.30 |
| Two-mile | 51.805399 | -8.469983 | 69.90 | 255.10 | 325.00 |

## Discrete Observation Receptors

| Name | ID | Latitude (°) | Longitude (°) | Elevation (m) | Height (m) |
|---|---|---|---|---|---|
| 1-ATCT | 1 | 51.844030 | -8.498096 | 143.80 | 18.00 |
| OP 2 | 2 | 51.883614 | -8.509548 | 31.10 | 1.70 |
| OP 3 | 3 | 51.883614 | -8.509548 | 31.10 | 25.00 |
| OP 4 | 4 | 51.883614 | -8.509548 | 31.10 | 50.00 |
| OP 5 | 5 | 51.883614 | -8.509548 | 31.10 | 75.00 |
| OP 6 | 6 | 51.883614 | -8.509548 | 31.10 | 100.00 |
| OP 7 | 7 | 51.883614 | -8.509548 | 31.10 | 125.00 |
| OP 8 | 8 | 51.883614 | -8.509548 | 31.10 | 150.00 |
| OP 9 | 9 | 51.883614 | -8.509548 | 31.10 | 175.00 |
| OP 10 | 10 | 51.883614 | -8.509548 | 31.10 | 200.00 |
| OP 11 | 11 | 51.883614 | -8.509548 | 31.10 | 225.00 |
| OP 12 | 12 | 51.883614 | -8.509548 | 31.10 | 250.00 |
| OP 13 | 13 | 51.883614 | -8.509548 | 31.10 | 275.00 |
| OP 14 | 14 | 51.883614 | -8.509548 | 31.10 | 300.00 |
| OP 15 | 15 | 51.884308 | -8.523573 | 36.90 | 1.70 |
| OP 16 | 16 | 51.884308 | -8.523573 | 36.90 | 25.00 |
| OP 17 | 17 | 51.884308 | -8.523573 | 36.90 | 50.00 |
| OP 18 | 18 | 51.884308 | -8.523573 | 36.90 | 75.00 |
| OP 19 | 19 | 51.884308 | -8.523573 | 36.90 | 100.00 |
| OP 20 | 20 | 51.884308 | -8.523573 | 36.90 | 125.00 |
| OP 21 | 21 | 51.884308 | -8.523573 | 36.90 | 150.00 |
| OP 22 | 22 | 51.884308 | -8.523573 | 36.90 | 175.00 |
| OP 23 | 23 | 51.884308 | -8.523573 | 36.90 | 200.00 |
| OP 24 | 24 | 51.884308 | -8.523573 | 36.90 | 225.00 |
| OP 25 | 25 | 51.884308 | -8.523573 | 36.90 | 250.00 |
| OP 26 | 26 | 51.884308 | -8.523573 | 36.90 | 275.00 |
| OP 27 | 27 | 51.884308 | -8.523573 | 36.90 | 300.00 |

*Map image of 1-ATCT*

# GLARE ANALYSIS RESULTS

## Summary of Glare

| PV Array Name | Tilt (°) | Orient (°) | "Green" Glare min | "Yellow" Glare min | Energy kWh |
|---|---|---|---|---|---|
| PV array 1 | 15.0 | 175.0 | 557 | 0 | - |
| PV array 2 | 15.0 | 175.0 | 650 | 0 | - |
| PV array 3 | 15.0 | 175.0 | 521 | 0 | - |
| PV array 4 | 15.0 | 175.0 | 594 | 0 | - |
| PV array 5 | 15.0 | 175.0 | 722 | 0 | - |

*Total annual glare received by each receptor*

| Receptor | Annual Green Glare (min) | Annual Yellow Glare (min) |
|---|---|---|
| 07 Runway | 0 | 0 |
| 16 Runway | 507 | 0 |
| 25 Runway | 2537 | 0 |
| 34 Runway | 0 | 0 |
| 1-ATCT | 0 | 0 |
| OP 2 | 0 | 0 |
| OP 3 | 0 | 0 |
| OP 4 | 0 | 0 |
| OP 5 | 0 | 0 |
| OP 6 | 0 | 0 |
| OP 7 | 0 | 0 |
| OP 8 | 0 | 0 |
| OP 9 | 0 | 0 |
| OP 10 | 0 | 0 |
| OP 11 | 0 | 0 |
| OP 12 | 0 | 0 |
| OP 13 | 0 | 0 |
| OP 14 | 0 | 0 |
| OP 15 | 0 | 0 |
| OP 16 | 0 | 0 |
| OP 17 | 0 | 0 |
| OP 18 | 0 | 0 |
| OP 19 | 0 | 0 |
| OP 20 | 0 | 0 |
| OP 21 | 0 | 0 |
| OP 22 | 0 | 0 |
| OP 23 | 0 | 0 |

| Receptor | Annual Green Glare (min) | Annual Yellow Glare (min) |
|---|---|---|
| OP 24 | 0 | 0 |
| OP 25 | 0 | 0 |
| OP 26 | 0 | 0 |
| OP 27 | 0 | 0 |

## Results for: PV array 1

| Receptor | Green Glare (min) | Yellow Glare (min) |
|---|---|---|
| 07 Runway | 0 | 0 |
| 16 Runway | 0 | 0 |
| 25 Runway | 557 | 0 |
| 34 Runway | 0 | 0 |
| 1-ATCT | 0 | 0 |
| OP 2 | 0 | 0 |
| OP 3 | 0 | 0 |
| OP 4 | 0 | 0 |
| OP 5 | 0 | 0 |
| OP 6 | 0 | 0 |
| OP 7 | 0 | 0 |
| OP 8 | 0 | 0 |
| OP 9 | 0 | 0 |
| OP 10 | 0 | 0 |
| OP 11 | 0 | 0 |
| OP 12 | 0 | 0 |
| OP 13 | 0 | 0 |
| OP 14 | 0 | 0 |
| OP 15 | 0 | 0 |
| OP 16 | 0 | 0 |
| OP 17 | 0 | 0 |
| OP 18 | 0 | 0 |
| OP 19 | 0 | 0 |
| OP 20 | 0 | 0 |
| OP 21 | 0 | 0 |
| OP 22 | 0 | 0 |
| OP 23 | 0 | 0 |
| OP 24 | 0 | 0 |
| OP 25 | 0 | 0 |
| OP 26 | 0 | 0 |
| OP 27 | 0 | 0 |

### Flight Path: 07 Runway

0 minutes of yellow glare

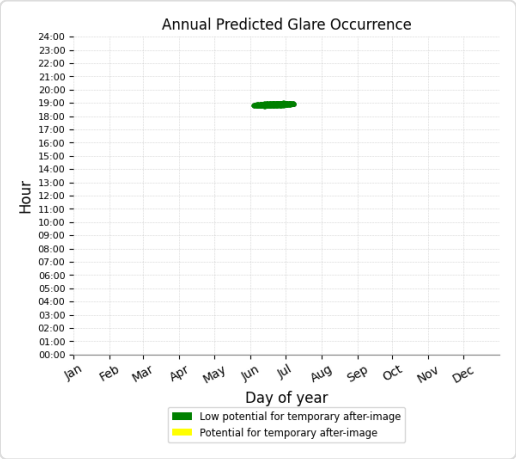
0 minutes of green glare

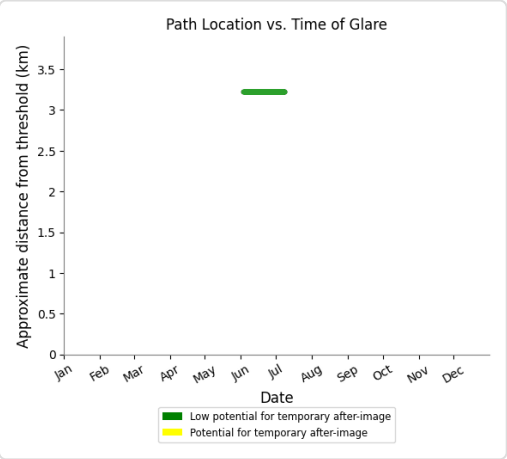
## Flight Path: 16 Runway

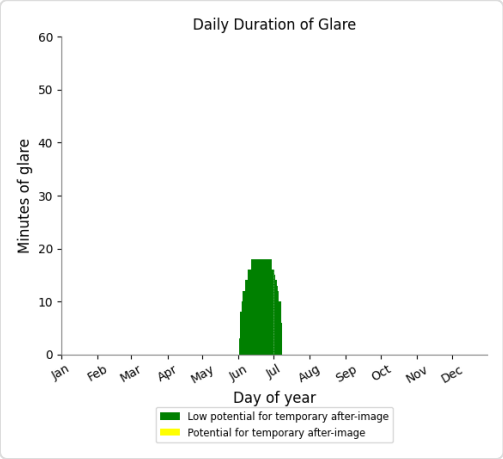
0 minutes of yellow glare
0 minutes of green glare

## Flight Path: 25 Runway

0 minutes of yellow glare
557 minutes of green glare




## Flight Path: 34 Runway

0 minutes of yellow glare
0 minutes of green glare

## Point Receptor: 1-ATCT

0 minutes of yellow glare
0 minutes of green glare

## Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 5

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 6

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 7

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 8

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 9

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 10

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 11

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 12

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 13

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 14

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 15

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 16

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 17

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 18

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 19

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 20

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 21

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 22

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 23

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 24

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 25

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 26

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 27

0 minutes of yellow glare
0 minutes of green glare

# Results for: PV array 2

| Receptor | Green Glare (min) | Yellow Glare (min) |
|---|---|---|
| 07 Runway | 0 | 0 |
| 16 Runway | 0 | 0 |
| 25 Runway | 650 | 0 |
| 34 Runway | 0 | 0 |
| 1-ATCT | 0 | 0 |
| OP 2 | 0 | 0 |
| OP 3 | 0 | 0 |
| OP 4 | 0 | 0 |
| OP 5 | 0 | 0 |
| OP 6 | 0 | 0 |
| OP 7 | 0 | 0 |
| OP 8 | 0 | 0 |
| OP 9 | 0 | 0 |
| OP 10 | 0 | 0 |
| OP 11 | 0 | 0 |
| OP 12 | 0 | 0 |
| OP 13 | 0 | 0 |
| OP 14 | 0 | 0 |
| OP 15 | 0 | 0 |
| OP 16 | 0 | 0 |
| OP 17 | 0 | 0 |
| OP 18 | 0 | 0 |
| OP 19 | 0 | 0 |
| OP 20 | 0 | 0 |
| OP 21 | 0 | 0 |
| OP 22 | 0 | 0 |
| OP 23 | 0 | 0 |
| OP 24 | 0 | 0 |
| OP 25 | 0 | 0 |
| OP 26 | 0 | 0 |
| OP 27 | 0 | 0 |

## Flight Path: 07 Runway

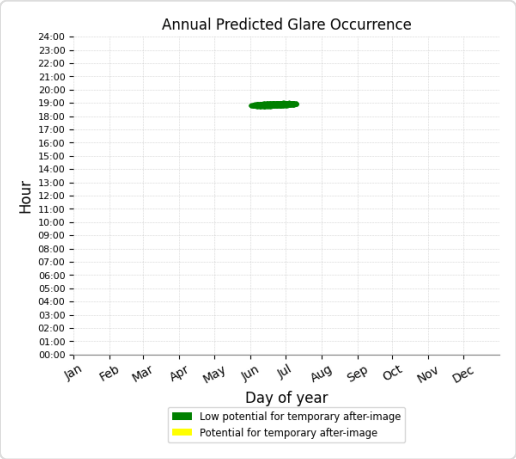
0 minutes of yellow glare
0 minutes of green glare

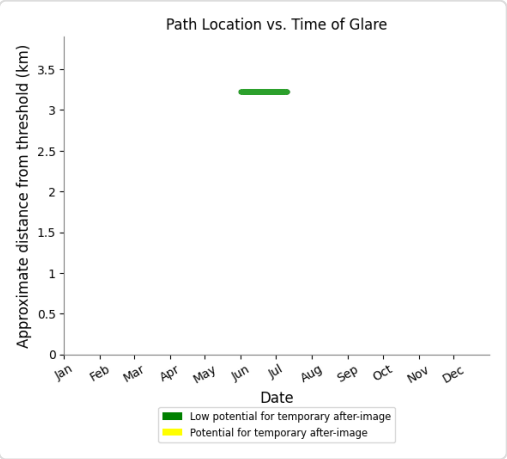
## Flight Path: 16 Runway

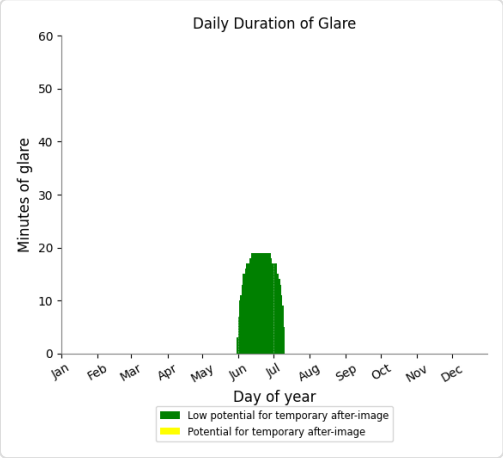
0 minutes of yellow glare
0 minutes of green glare

## Flight Path: 25 Runway

0 minutes of yellow glare
650 minutes of green glare




## Flight Path: 34 Runway

0 minutes of yellow glare
0 minutes of green glare

## Point Receptor: 1-ATCT

0 minutes of yellow glare
0 minutes of green glare

## Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

## Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 5

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 6

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 7

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 8

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 9

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 10

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 11

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 12

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 13

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 14

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 15

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 16

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 17

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 18

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 19

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 20

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 21

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 22

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 23

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 24

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 25

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 26

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 27

0 minutes of yellow glare
0 minutes of green glare

# Results for: PV array 3

| Receptor | Green Glare (min) | Yellow Glare (min) |
|---|---|---|
| 07 Runway | 0 | 0 |
| 16 Runway | 0 | 0 |
| 25 Runway | 521 | 0 |
| 34 Runway | 0 | 0 |
| 1-ATCT | 0 | 0 |
| OP 2 | 0 | 0 |
| OP 3 | 0 | 0 |
| OP 4 | 0 | 0 |
| OP 5 | 0 | 0 |
| OP 6 | 0 | 0 |
| OP 7 | 0 | 0 |
| OP 8 | 0 | 0 |
| OP 9 | 0 | 0 |
| OP 10 | 0 | 0 |
| OP 11 | 0 | 0 |
| OP 12 | 0 | 0 |
| OP 13 | 0 | 0 |
| OP 14 | 0 | 0 |
| OP 15 | 0 | 0 |
| OP 16 | 0 | 0 |
| OP 17 | 0 | 0 |
| OP 18 | 0 | 0 |
| OP 19 | 0 | 0 |
| OP 20 | 0 | 0 |
| OP 21 | 0 | 0 |
| OP 22 | 0 | 0 |
| OP 23 | 0 | 0 |
| OP 24 | 0 | 0 |
| OP 25 | 0 | 0 |
| OP 26 | 0 | 0 |
| OP 27 | 0 | 0 |

## Flight Path: 07 Runway

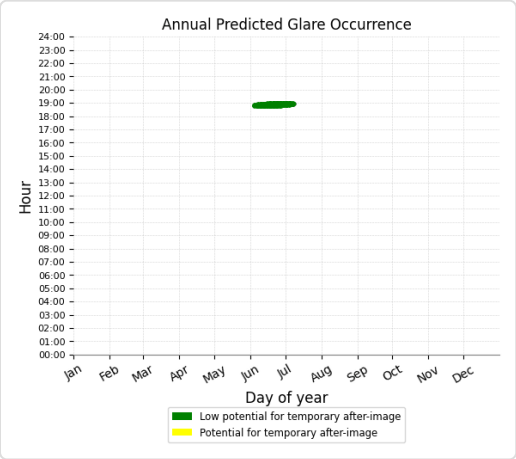
0 minutes of yellow glare
0 minutes of green glare

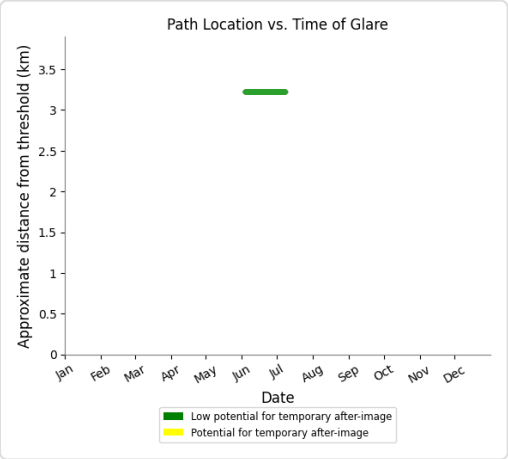
## Flight Path: 16 Runway

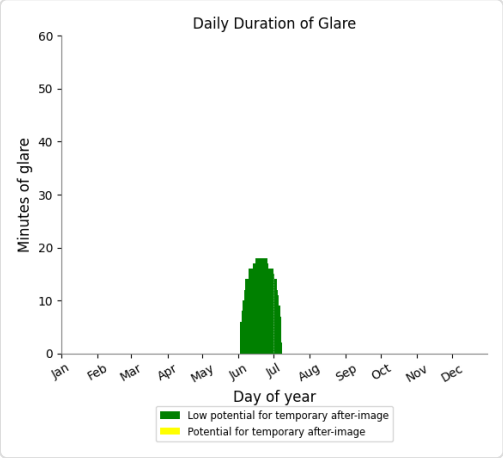
0 minutes of yellow glare
0 minutes of green glare

## Flight Path: 25 Runway

0 minutes of yellow glare
521 minutes of green glare




## Flight Path: 34 Runway

0 minutes of yellow glare
0 minutes of green glare

## Point Receptor: 1-ATCT

0 minutes of yellow glare
0 minutes of green glare

## Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

## Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 5

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 6

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 7

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 8

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 9

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 10

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 11

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 12

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 13

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 14

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 15

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 16

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 17

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 18

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 19

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 20

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 21

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 22

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 23

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 24

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 25

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 26

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 27

0 minutes of yellow glare
0 minutes of green glare

## Results for: PV array 4

| Receptor | Green Glare (min) | Yellow Glare (min) |
|---|---|---|
| 07 Runway | 0 | 0 |
| 16 Runway | 0 | 0 |
| 25 Runway | 594 | 0 |
| 34 Runway | 0 | 0 |
| 1-ATCT | 0 | 0 |
| OP 2 | 0 | 0 |
| OP 3 | 0 | 0 |
| OP 4 | 0 | 0 |
| OP 5 | 0 | 0 |
| OP 6 | 0 | 0 |
| OP 7 | 0 | 0 |
| OP 8 | 0 | 0 |
| OP 9 | 0 | 0 |
| OP 10 | 0 | 0 |
| OP 11 | 0 | 0 |
| OP 12 | 0 | 0 |
| OP 13 | 0 | 0 |
| OP 14 | 0 | 0 |
| OP 15 | 0 | 0 |
| OP 16 | 0 | 0 |
| OP 17 | 0 | 0 |
| OP 18 | 0 | 0 |
| OP 19 | 0 | 0 |
| OP 20 | 0 | 0 |
| OP 21 | 0 | 0 |
| OP 22 | 0 | 0 |
| OP 23 | 0 | 0 |
| OP 24 | 0 | 0 |
| OP 25 | 0 | 0 |
| OP 26 | 0 | 0 |
| OP 27 | 0 | 0 |

### Flight Path: 07 Runway

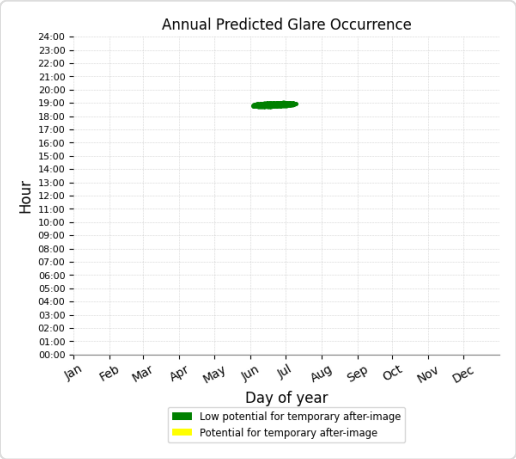
0 minutes of yellow glare
0 minutes of green glare

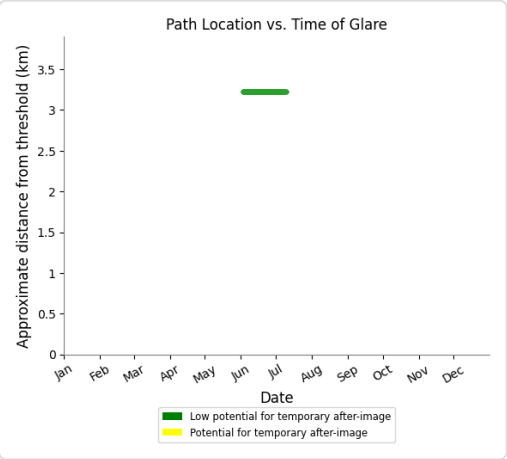
### Flight Path: 16 Runway

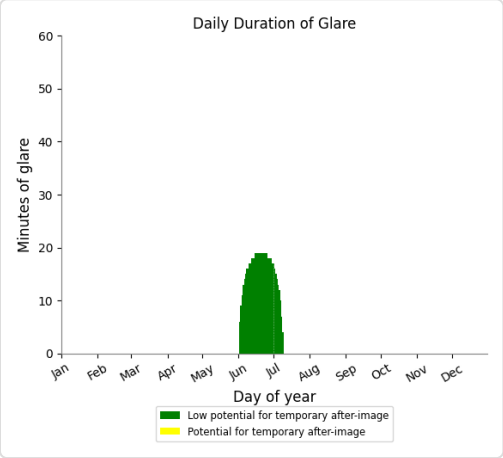
0 minutes of yellow glare
0 minutes of green glare

## Flight Path: 25 Runway

0 minutes of yellow glare
594 minutes of green glare




## Flight Path: 34 Runway

0 minutes of yellow glare
0 minutes of green glare

## Point Receptor: 1-ATCT

0 minutes of yellow glare
0 minutes of green glare

## Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

## Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 5

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 6

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 7

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 8

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 9

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 10

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 11

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 12

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 13

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 14

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 15

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 16

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 17

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 18

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 19

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 20

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 21

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 22

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 23

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 24

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 25

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 26

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 27

0 minutes of yellow glare
0 minutes of green glare

# Results for: PV array 5

| Receptor | Green Glare (min) | Yellow Glare (min) |
|---|---|---|
| 07 Runway | 0 | 0 |
| 16 Runway | 507 | 0 |
| 25 Runway | 215 | 0 |
| 34 Runway | 0 | 0 |
| 1-ATCT | 0 | 0 |
| OP 2 | 0 | 0 |
| OP 3 | 0 | 0 |
| OP 4 | 0 | 0 |
| OP 5 | 0 | 0 |
| OP 6 | 0 | 0 |
| OP 7 | 0 | 0 |
| OP 8 | 0 | 0 |
| OP 9 | 0 | 0 |
| OP 10 | 0 | 0 |
| OP 11 | 0 | 0 |
| OP 12 | 0 | 0 |
| OP 13 | 0 | 0 |
| OP 14 | 0 | 0 |
| OP 15 | 0 | 0 |
| OP 16 | 0 | 0 |
| OP 17 | 0 | 0 |
| OP 18 | 0 | 0 |
| OP 19 | 0 | 0 |
| OP 20 | 0 | 0 |
| OP 21 | 0 | 0 |
| OP 22 | 0 | 0 |
| OP 23 | 0 | 0 |
| OP 24 | 0 | 0 |
| OP 25 | 0 | 0 |
| OP 26 | 0 | 0 |
| OP 27 | 0 | 0 |

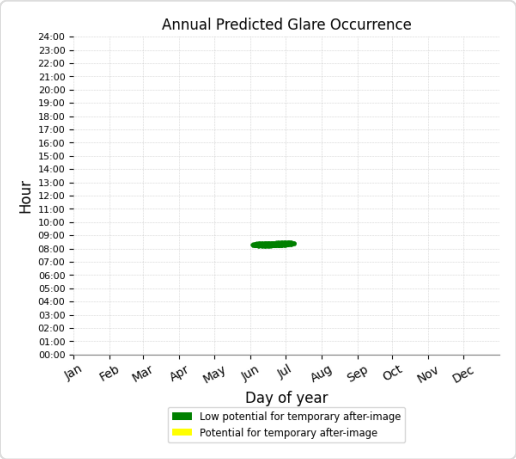
## Flight Path: 07 Runway

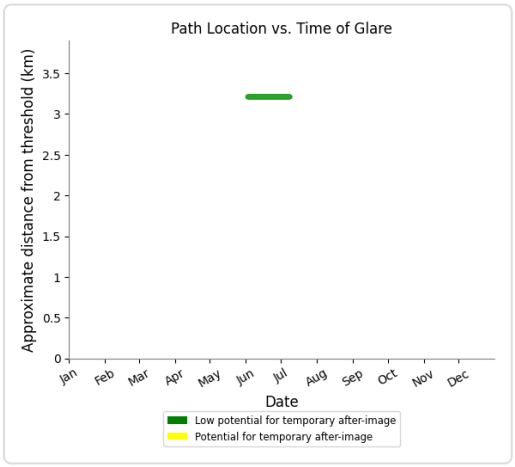
0 minutes of yellow glare
0 minutes of green glare

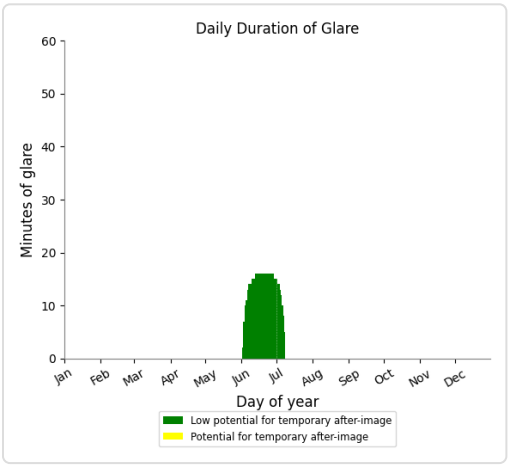
## Flight Path: 16 Runway

0 minutes of yellow glare

507 minutes of green glare

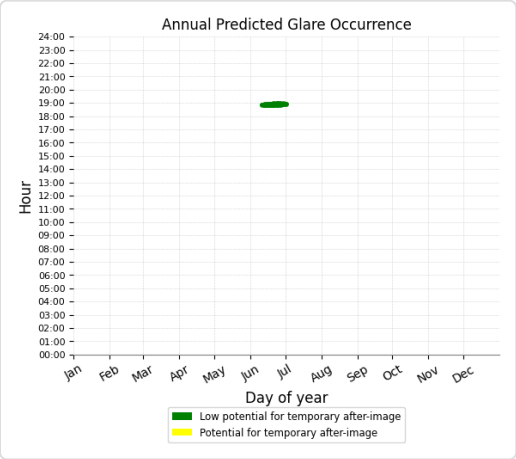


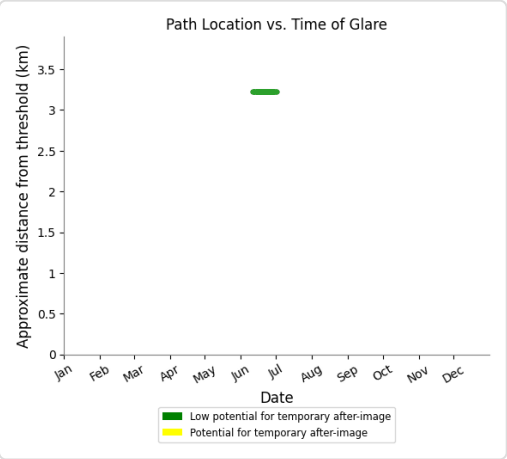



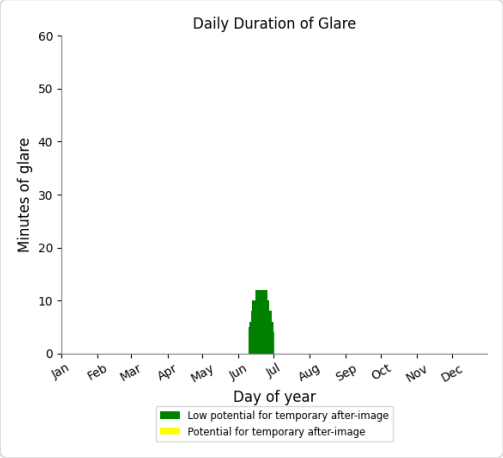



## Flight Path: 25 Runway

0 minutes of yellow glare
215 minutes of green glare




## Flight Path: 34 Runway

0 minutes of yellow glare
0 minutes of green glare

## Point Receptor: 1-ATCT

0 minutes of yellow glare
0 minutes of green glare

## Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

## Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 5

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 6

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 7

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 8

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 9

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 10

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 11

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 12

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 13

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 14

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 15

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 16

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 17

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 18

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 19

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 20

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 21

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 22

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 23

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 24

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 25

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 26

0 minutes of yellow glare
0 minutes of green glare

### Point Receptor: OP 27

0 minutes of yellow glare
0 minutes of green glare

# Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to V1 algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
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.)
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual results and glare occurrence may differ.
Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.