Glint and Glare Assessment

Quirindi 1B Solar Farm

Version 02
December 2023

ENGINEERING | STRATEGY | ANALYTICS | CONSTRUCTION

DOCUMENT CONTROL

Report Title		Glint and Glare Assessment – Quirindi 1B Solar Farm			
ITP Project Number		23073			
Ver	Date	Status	Author/s	Reviewed By	Approved
1	11/12/2023	First issue	D Thompson	N Logan	N Logan
2	11/01/2024	First revision	D Thompson	S Dedman	S Dedman

ITP Renewables

Office: Level 1, 19-23 Moore St
Turner ACT 2612

Postal: PO Box 6127
O'Connor ACT 2602
Australia

Email: info@itpau.com.au
Phone: +61 (0) 2 6257 3511

itpau.com.au

ABOUT ITP RENEWABLES

ITP Renewables (ITP) is a global leader in renewable energy engineering, strategy, construction, and energy sector analytics. Our technical and policy expertise spans the breadth of renewable energy, energy storage, energy efficiency and smart integration technologies. Our range of services cover the entire spectrum of the energy sector value chain, from technology assessment and market forecasting right through to project operations, maintenance, and quality assurance.

We were established in 2003 and operate out of offices in Canberra (Head Office), Sydney, North Coast NSW, and Adelaide. We are part of the international ITPEnergised Group, one of the world's largest, most experienced, and respected specialist engineering consultancies focussing on renewable energy, energy efficiency, and carbon markets. The Group has undertaken over 2,000 contracts in energy projects encompassing over 150 countries since it was formed in 1981.

Our regular clients include governments, energy utilities, financial institutions, international development donor agencies, project developers and investors, the R&D community, and private firms.

ABBREVIATIONS

AC	Alternating current
CASA	Civil Aviation Safety Authority
DC	Direct current
FAA	Federal Aviation Administration (United States)
ha	Hectare
ITP	ITP Renewables
ITPD	ITP Development
MW	Megawatt, unit of power (1 million Watts)
MWp	Megawatt-peak, unit of power at standard test conditions; used to indicate PV system capacity
NSW	New South Wales
OB	Obstruction
OP	Observation point
PV	Photovoltaic
SGHAT	Solar Glare Hazard Analysis Tool

TABLES

FIGURES

TABLE OF CONTENTS

EXECUTIVE SUMMARY

ITP Development (ITPD) has requested a glint and glare assessment for a proposed solar photovoltaic (PV) installation near Quirindi, NSW. This assessment forms part of the development application for the project.

ITP assessed the potential for glare at 11 observations points and along 2 road routes within 2 km of the proposed solar farm. Our results indicated that both road routes (Borah Creek Road and Porters Lane) received yellow glare, while both routes and two observation points received green glare. Yellow glare has the potential to cause after image to observers, while green glare has low potential to cause after image. In general, most of the glare occurred during early mornings and late evenings when backtracking is active. No observation points or routes received more than seven minutes of glare in any single day.

The existing roadside vegetation and terrain are expected to provide a physical obstruction between the solar farm many receptors. This will reduce the visual impact of the project. The glare impact from the project is low and further mitigation is not required.

1 INTRODUCTION

1.1 Overview

ITP Development (ITPD) has requested a glint and glare assessment for a proposed solar photovoltaic (PV) installation near Quirindi, NSW. This assessment forms part of the development application for the project. It includes:

- Identification of potential receptors of glint and glare from the proposed solar farm
- Assessment of the glint and glare hazard using the Solar Glare Hazard Analysis Tool (SGHAT) GlareGauge analysis

1.2 Glint and Glare

The United State Federal Aviation Administration (FAA) defines glint and glare as follows:[1]

- **Glint** is a momentary flash of bright light
- **Glare** is a continuous source of excessive brightness relative to ambient lighting.

Glint and glare can occur when light reflected off a surface (reflector) is viewed by a person (receptor). Glint typically occurs when either the receptor or the reflector is moving, while glare typically occurs when the reflector and receptor are completely or close to stationary. For a transparent material (e.g., glass, water) the quantity of light reflected depends on the surface itself (i.e., material and texture), and the angle at which the light intercepts it (angle of incidence). More light is reflected at higher angles of incidence, as shown in Figure 1.

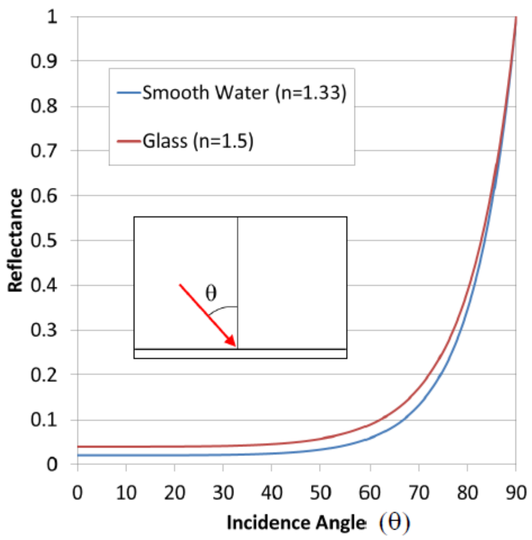


Figure 1: Angles of incidence and increased levels of reflected light

[1] Federal Aviation Administration (FAA), 2018

Potential visual impacts from glint and glare include distraction and temporary after-image; at its worst, it can cause retinal burn. The ocular hazard caused by glint or glare is a function of:

1. The intensity of the glare upon the eye (retinal irradiance)
2. The subtended angle of the glare source (i.e., the extent to which the glare occupies the receptor's field of vision; dependent on size and distance of the reflector).

The severity of the ocular hazard can be divided into three levels, as shown in Figure 2:

- **Green glare**, which has low potential to cause temporary after-image
- **Yellow glare**, which has potential to cause temporary after-image
- **Red glare**, which can cause retinal burn and is not expected for PV.

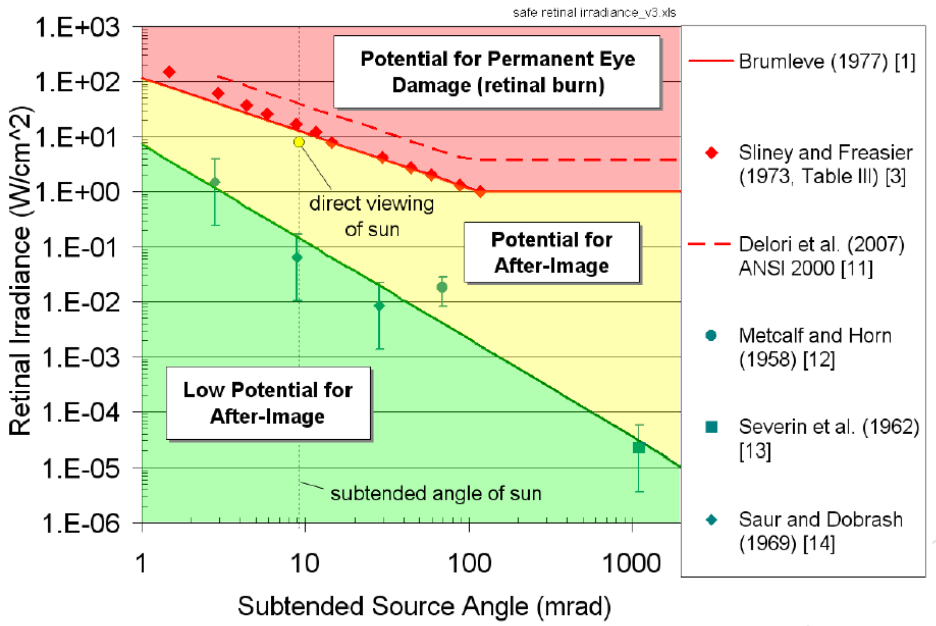


Figure 2: Classification of glare based on severity of ocular effects

1.3 Glare from Solar PV

Solar photovoltaic (PV) cells are designed to absorb as much light as possible to maximise efficiency (generally around 98% of the light received). To limit reflection, solar cells are constructed from dark, light-absorbing material and are treated with an anti-reflective coating. PV modules generate less glare than many other surfaces, as shown in Figure 3.

The small percentage of light reflected from PV modules varies depending on the angle of incidence. Figure 4 shows an example of this with a solar module. A larger angle of incidence will result in a higher percentage of reflected light.

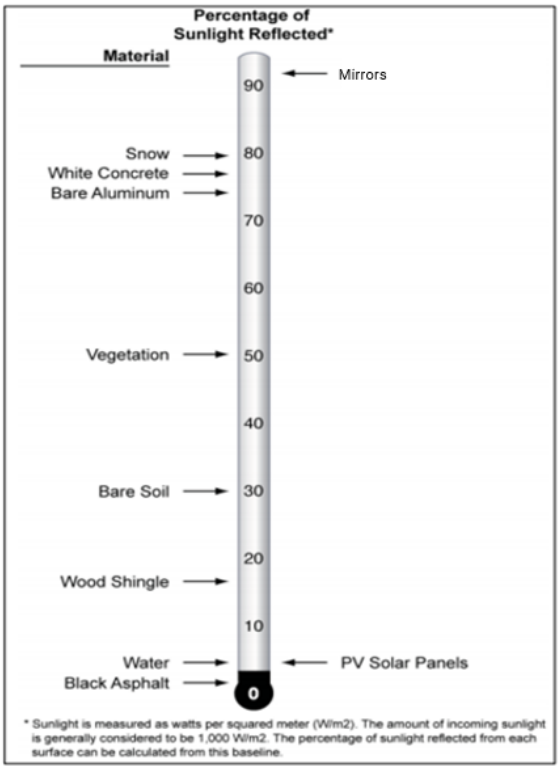


Figure 3: Typical percentage of sunlight reflected from different surfaces (Source: Adapted from Journal of Airport Management, 2014)

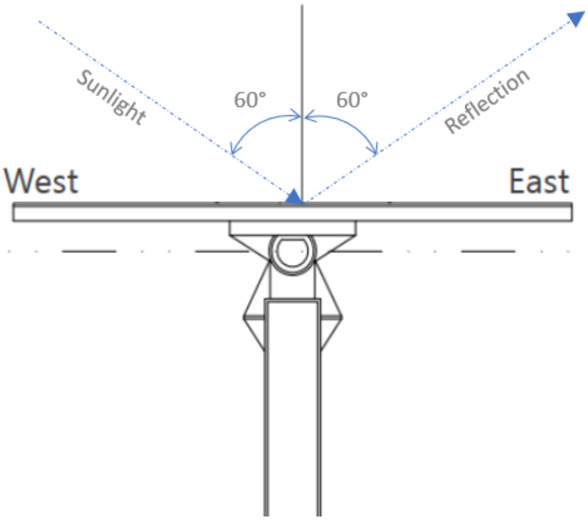


Figure 4: Typical sunlight reflection off the surface of a solar module

The two most common PV mounting structures are fixed tilt and single axis tracking. Fixed-tilt arrays are stationary, while single-axis tracking arrays rotate the receiving surface of the modules from east to west throughout the day as the sun moves across the sky.

In a fixed-tilt PV array, since the sun is moving but the modules are stationary, the angle of incidence varies as the sun moves across the sky. It is smallest around noon when the sun is overhead and largest in the early morning and late afternoon when the sun is near the horizon. There is therefore a higher potential for glare at these times.

The angle of incidence for a single axis tracking system varies less as the reflective surface of the modules rotates on a horizontal axis to follow the sun. Single axis tracking arrays therefore generate less glare than fixed tilt arrays. The tracking varies throughout the year to match seasonal changes in the sun's path (see Figure 5).

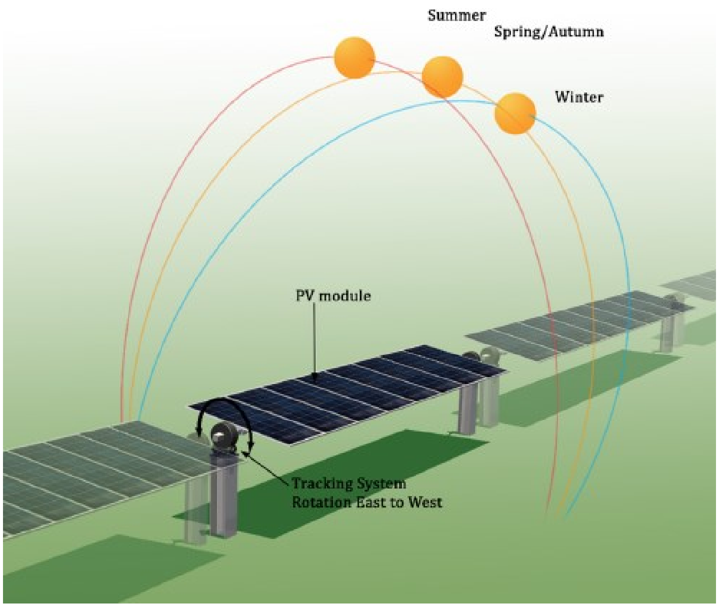


Figure 5: Sun position relative to PV module mounted on a horizontal single axis tracking system

2 PROJECT DESCRIPTION

2.1 Site Overview

ITP Development is proposing a solar farm at the location described in Table 1. The site is located approximately 5 km northeast of the town of Quirindi, within the Liverpool Plains Shire Council area, NSW. Figure 6 displays the proposed site and surrounding lots.

Table 1. Site Information

Parameter	Description
Lot/DP(s)	130 and 134 / DP751009
Street address	Borah Creek Road, Quirindi NSW 2343
Council	Liverpool Plains Shire Council
Project area	141.75 ha (total), 11.09 ha (development area)
Current land use	Cropping

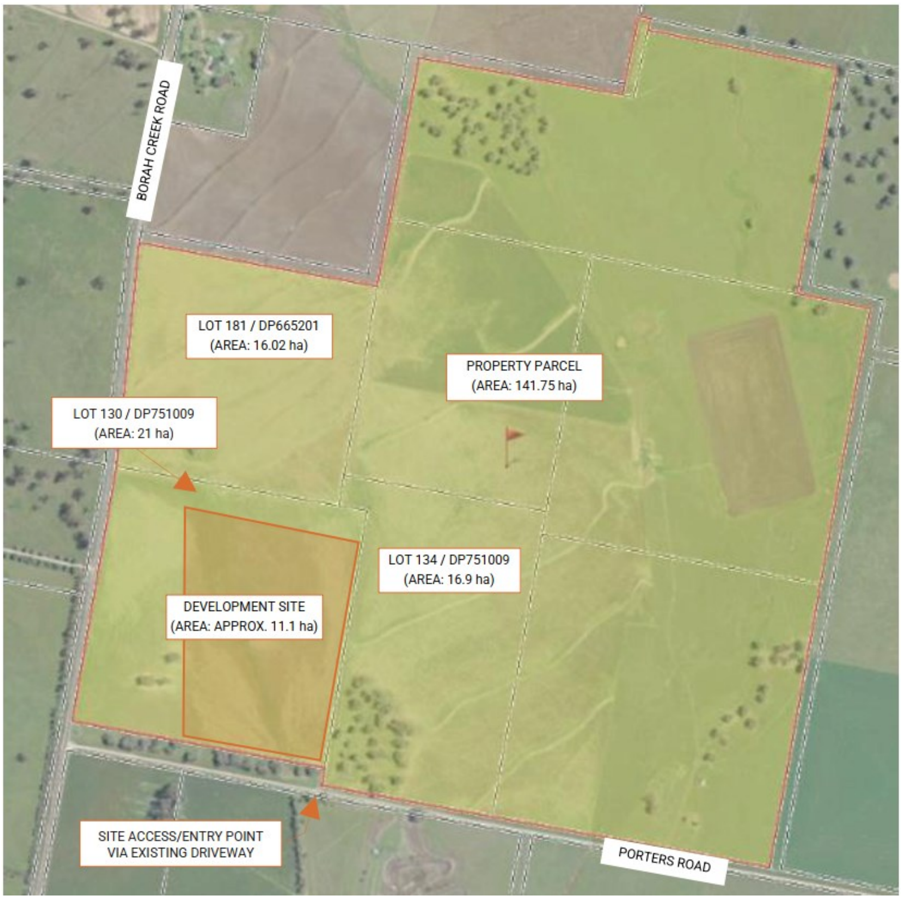


Figure 6. Proposed 11 ha solar farm site and surrounding area

2.2 Solar Farm Details

Table 2 summarises the details of the proposed solar farm.

Table 2. Solar farm information

Parameter	Description
Solar farm name	Quirindi 1B Solar Farm
Site reference	Quirindi 1B (QDI1B)
AC capacity	5 MW
Mounting system	Single-axis tracking

ITPD is proposing to construct a solar farm with an AC output of 5.0 MW on an approximately 11.09 ha site that is currently used for cropping.

There are to be approximately 10,750 solar modules installed in 128 tracker tables (each one approximately 92 m long) running north to south. There is approximately 6.0 m spacing between each row. The mounting system is constructed on piles that are driven into the ground. Each row of solar photovoltaic (PV) modules will rotate to track the sun across the sky from east to west each day.

The solar farm will also consist of an inverter station, which incorporates the high/medium voltage switchgear and transformers and two 3.4 MW inverters. The inverter station is ground mounted and incorporated on a 12.19 m skid. Allowance is made for a 2.9 m high battery energy storage system (BESS) on a 12.1 m skid alongside the inverter stations.

The construction is expected to take approximately 3 months. Once operational the site will be unmanned. Quarterly maintenance is expected to be carried out by a crew of 2 – 3 people.

Solar panels and related infrastructure will be decommissioned and removed upon cessation of operations. This is likely to occur within two years of the end of the project. The site can then be returned to the pre-development land use.

3 ANALYSIS

3.1 Overview

The Solar Glare Hazard Analysis Tool (SGHAT) was developed by Sandia National Laboratories to evaluate glare resulting from solar farms at different viewpoints, based on the location, orientation, and specifications of the PV modules. This tool is required by the United States FAA for glare hazard analysis near airports and is also recognised by the Australian Government Civil Aviation Safety Authority (CASA).

The GlareGauge software uses SGHAT to provide an indication of the type of glare expected at each potential receptor. It runs with a simulation timestep of one minute. Glint lasting for less than one minute is unlikely to occur from the sun on PV modules due to their slow movement.

3.2 Assumptions

The visual impact of solar farms depends on the scale and type of infrastructure, the prominence and topography of the site relative to the surrounding environment, and any proposed screening measures to reduce visibility of the site. Our model includes selected obstructions[2] (OBs) as described in Section 3.3.1.

Atmospheric conditions such as cloud cover influence light reflection and the resulting impact on visual receptors. GlareGauge does not model varying atmospheric conditions; instead, the model assumes clear sky conditions, with a peak direct normal irradiance (DNI) of 1,000 W/m^2 which varies throughout the day.

Table 3 details the parameters used in the SGHAT model. GlareGauge default settings were adopted for the analysis time interval, direct normal irradiance, observer eye characteristics and slope error. The height of the observation points was assumed to be 1.5 m for a road user sitting in a car and 1.65 m for a person (i.e., standing).

Table 3. SGHAT specification inputs

Parameters	Input
Time zone	UTC+10:00
Module tracking	Single axis
Module surface material	Smooth glass with ARC (anti-reflective coating)
Tracking axis orientation	0°

[2] In the GlareGauge model, obstructions are opaque barriers that block the transmission of incident and reflected light.

Maximum tracking angle	60°
Resting angle	0°
Height of modules above ground	1.70m (height from the ground to the PV panel centroid)

3.3 Model construction

3.3.1 Study area

This assessment considers potential visual receptors (e.g., residences and road users) within 2 km of the site. There is no formal guidance on the maximum distance for glint and glare assessments; however, the significance of a reflection decreases with distance for two main reasons:

1. The solar farm appears smaller (smaller subtended angle), and glare has less impact
2. Visual obstructions (e.g., terrain, vegetation) may block the view of the solar farm

Glint and glare impacts beyond 2 km are highly unlikely. This choice of distance is conservative and is based on existing studies and assessment experience.

3.3.2 Model components

The model (see Figure 7) was constructed as follows:

- The array was modelled as a single PV object, given it is small and the site does not feature any major changes in elevation.
- Receptors were placed at 11 observation points and 2 road routes.

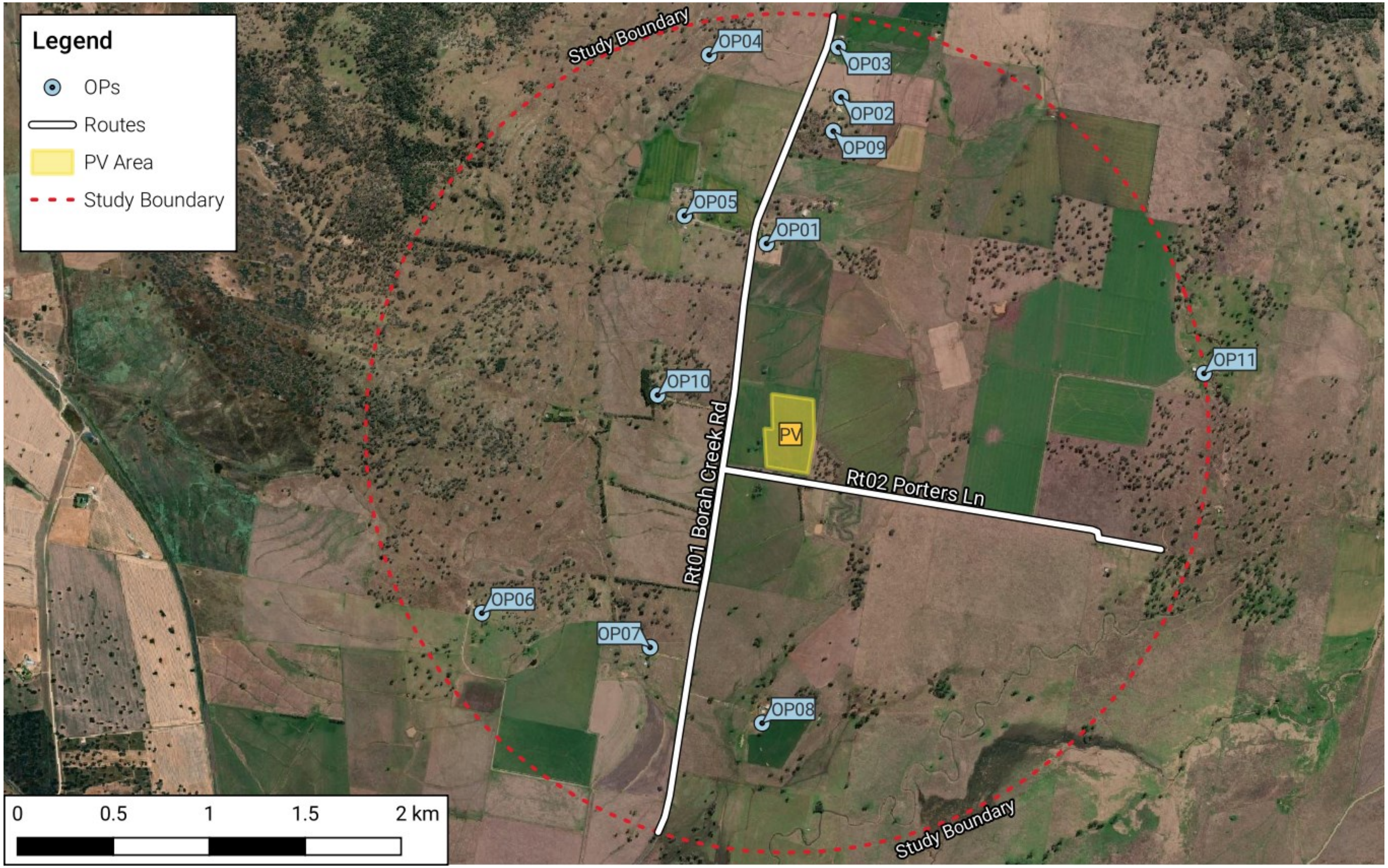


Figure 7. Model showing study area, PV array, and receptors

3.4 Results

The results of the GlareGauge analysis (attached in Appendix A) at each of the observation points are summarised in Table 4. The analysis identified 124 minutes (~2 hours) of yellow glare and 346 minutes (~6 hours) of cumulative green glare spread across multiple points and routes.

The glare received each day varied across the year. For observation points where some glare occurred, the impact is described qualitatively. No observation points or routes received more than seven minutes of glare in any single day (see Appendix A for full results). The time of day at which glare was observed varied between observation points and across the year. In general, most glare occurred in the early mornings or late evenings, when the array is backtracking.

Table 4. Glare potential at each receptor

Receptor	Location	'Green' glare (min/yr)	'Yellow' glare (min/yr)	Daily glare potential
OP01	-31.456, 150.7122	0	0	None
OP02	-31.4492, 150.7165	0	0	None
OP03	-31.4468, 150.7164	0	0	None
OP04	-31.4471, 150.7093	0	0	None
OP05	-31.4546, 150.7078	0	0	None
OP06	-31.4731, 150.6962	0	0	None
OP07	-31.4749, 150.7054	0	0	None
OP08	-31.4785, 150.7114	0	0	None
OP09	-31.4508, 150.716	0	0	None
OP10	-31.463, 150.7061	45	0	Up to 7 minutes of green glare between 5:00 am and 6:15 am, from 1-2 January, 20-27 March, and 16-21 September.
OP11	-31.4625, 150.7361	105	0	Up to 4 minutes of green glare between 5:45 pm and 6:30 pm, from 19 September to 27 October.
RT01	Borah Creek Rd	28	37	Up to 2 minutes of yellow glare between 6:45 am and 7:15 am, from 7 June to 6 July.

Receptor	Location	'Green' glare (min/yr)	'Yellow' glare (min/yr)	Daily glare potential
RT02	Porters Ln	168	87	Up to 2 minutes of yellow glare between 5:00 pm and 5:45 pm, on 13 April, from 24 April to 18 August, and on 29 August. Up to 2 minutes of yellow glare between 6:30 am and 7:15 am, from 11 May to 1 August.
Total		**346**	**124**	

4 SUMMARY

The results of the GlareGauge analysis indicated that both road routes (Borah Creek Road and Porters Lane) received yellow glare, while both road routes and two observation points received green glare. Yellow glare has the potential to cause after image to observers, while green glare has low potential to cause after image. In general, most of the glare occurred during early mornings and late evenings when backtracking is active. No observation points or routes received more than seven minutes of glare in any single day.

The existing roadside vegetation and terrain are expected to provide a physical obstruction between the solar farm many receptors. This will reduce the visual impact of the project. The glare impact from the project is low and further mitigation is not required.

5 REFERENCES

Federal Aviation Administration (FAA), 2018. Solar Guide: Technical Guidance for Evaluating Selected Solar Technologies on Airports. Retrieved from the FAA website: https://www.faa.gov/airports/environmental/

Thompson, R., Ave, I., Anne, D., Jan, M., David, S. and Robert, C., 2013. Interim policy, FAA review of solar energy system projects on federally obligated airports.

Barrett, S., Devita, P., Ho, C. and Miller, B., 2014. Energy technologies' compatibility with airports and airspace: Guidance for aviation and energy planners. Journal of Airport Management, 8(4), pp.318-326.

Lorenzo, E., L. Narvarte and J. Munoz, 2011, "Tracking and back-tracking." Madrid, Spain. Progress in Photovoltaics: Research and Applications 19: 747-753.

APPENDIX A. FORGESOLAR GLARE ANALYSIS

FORGESOLAR GLARE ANALYSIS

Project: **23073 - Quirindi Solar Farm**

A 5MW AC solar farm near Quirindi, New South Wales

Site configuration: **Quirindi v1**

Client: ITP Development

Site description: 5MW AC Solar farm near Quirindi NSW

Created 07 Dec, 2023
Updated 07 Dec, 2023
Time-step 1 minute
Timezone offset UTC10
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Category 1 MW to 5 MW
Site ID 107316.18632

Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
PV analysis methodology V2

Summary of Results

Glare with potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy	Peak Luminance
	°	°	min	hr	min	hr	kWh	cd/m^2
PV Area	SA tracking	SA tracking	346	5.8	124	2.1	-	1,295,000

Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
RT01 Borah Creek Rd	28	0.5	37	0.6
RT02 Porters Ln	168	2.8	87	1.4
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0
OP 8	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 9	0	0.0	0	0.0
OP 10	45	0.8	0	0.0
OP 11	105	1.8	0	0.0

Component Data

PV Arrays

Name: PV Area
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.35
Rated power: -
Panel material: Smooth glass with 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	-31.466483	150.711972	430.22	1.70	431.92
2	-31.464674	150.711897	433.35	1.70	435.05
3	-31.464724	150.712357	430.97	1.70	432.67
4	-31.463061	150.712346	435.33	1.70	437.03
5	-31.463381	150.714631	434.04	1.70	435.74
6	-31.465025	150.714640	430.03	1.70	431.73
7	-31.466847	150.714238	428.56	1.70	430.26
8	-31.466483	150.711972	430.22	1.70	431.92

Route Receptors

Name: RT01 Borah Creek Rd
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-31.445365	150.716185	471.95	1.50	473.45
2	-31.446174	150.716004	473.53	1.50	475.03
3	-31.446878	150.715757	475.15	1.50	476.65
4	-31.454884	150.711766	460.34	1.50	461.84
5	-31.455471	150.711583	462.11	1.50	463.61
6	-31.458748	150.710932	451.61	1.50	453.11
7	-31.462912	150.710311	442.22	1.50	443.72
8	-31.471225	150.708613	418.84	1.50	420.34
9	-31.474318	150.707851	412.59	1.50	414.09
10	-31.481854	150.706302	404.29	1.50	405.79
11	-31.482845	150.706004	401.86	1.50	403.36
12	-31.483554	150.705620	402.05	1.50	403.55

Name: RT02 Porters Ln
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-31.466561	150.709570	430.22	1.50	431.72
2	-31.469759	150.729759	423.59	1.50	425.09
3	-31.469874	150.730067	422.53	1.50	424.03
4	-31.470175	150.730114	421.98	1.50	423.48
5	-31.470756	150.733508	421.77	1.50	423.27

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-31.455996	150.712240	459.30	1.65
OP 2	2	-31.449187	150.716492	477.97	1.65
OP 3	3	-31.446844	150.716403	475.19	1.65
OP 4	4	-31.447076	150.709311	487.57	1.65
OP 5	5	-31.454603	150.707769	477.98	1.65
OP 6	6	-31.473082	150.696204	445.75	1.65
OP 7	7	-31.474857	150.705391	413.45	1.65
OP 8	8	-31.478528	150.711448	407.95	1.65
OP 9	9	-31.450783	150.716027	476.16	1.65
OP 10	10	-31.463008	150.706091	449.99	1.65
OP 11	11	-31.462526	150.736080	429.37	1.65

Glare Analysis Results

Summary of Results

Glare with potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy	Peak Luminance
	°	°	min	hr	min	hr	kWh	cd/m^2
PV Area	SA tracking	SA tracking	346	5.8	124	2.1	-	1,295,000

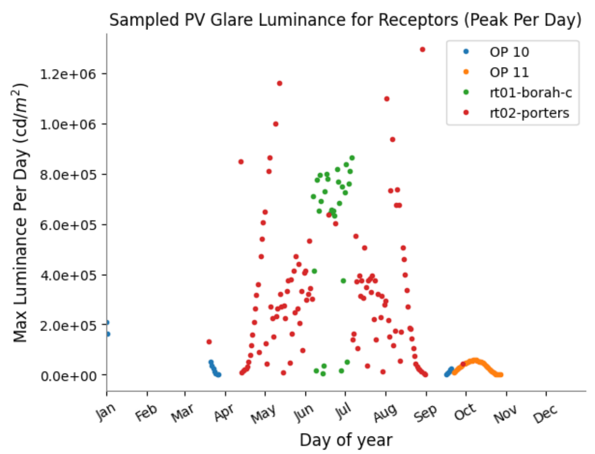
Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
RT01 Borah Creek Rd	28	0.5	37	0.6
RT02 Porters Ln	168	2.8	87	1.4
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0
OP 8	0	0.0	0	0.0
OP 9	0	0.0	0	0.0
OP 10	45	0.8	0	0.0
OP 11	105	1.8	0	0.0

PV: PV Area potential temporary after-image

Receptor results ordered by category of glare

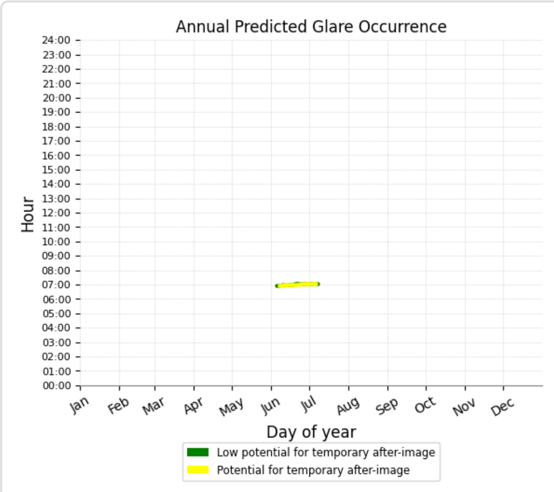
Receptor	Annual Green Glare		Annual Yellow Glare		Peak Luminance
	min	hr	min	hr	cd/m^2
RT01 Borah Creek Rd	28	0.5	37	0.6	865,533
RT02 Porters Ln	168	2.8	87	1.4	1,295,000
OP 10	45	0.8	0	0.0	210,555
OP 11	105	1.8	0	0.0	57,580
OP 1	0	0.0	0	0.0	0
OP 2	0	0.0	0	0.0	0
OP 3	0	0.0	0	0.0	0
OP 4	0	0.0	0	0.0	0
OP 5	0	0.0	0	0.0	0
OP 6	0	0.0	0	0.0	0
OP 7	0	0.0	0	0.0	0
OP 8	0	0.0	0	0.0	0
OP 9	0	0.0	0	0.0	0

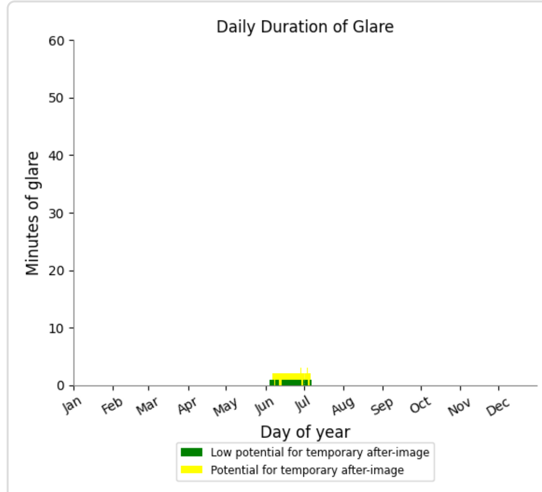


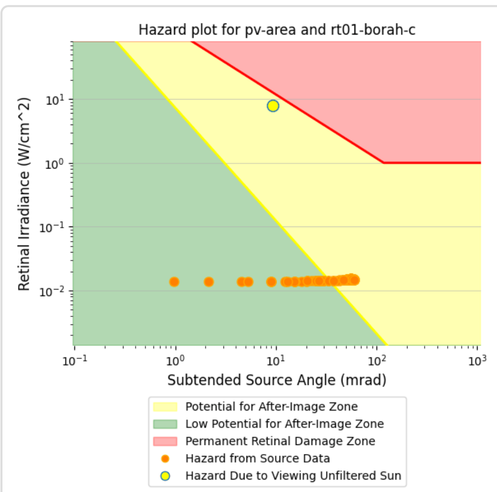
PV Area and Route: RT01 Borah Creek Rd

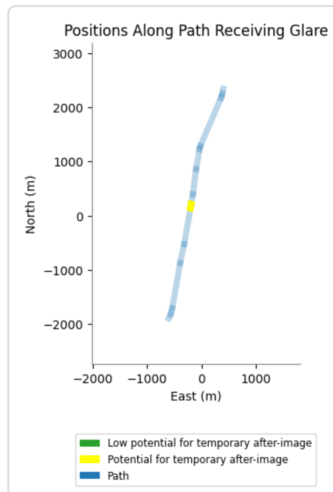
Yellow glare: 37 min.

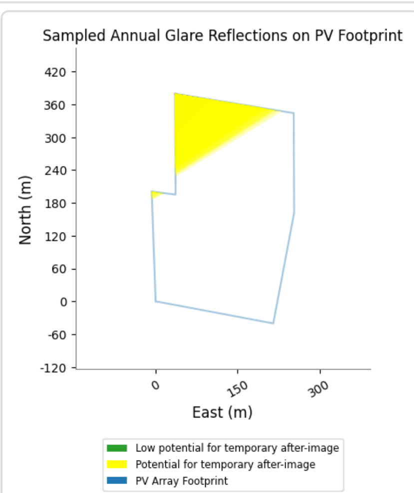
Green glare: 28 min.

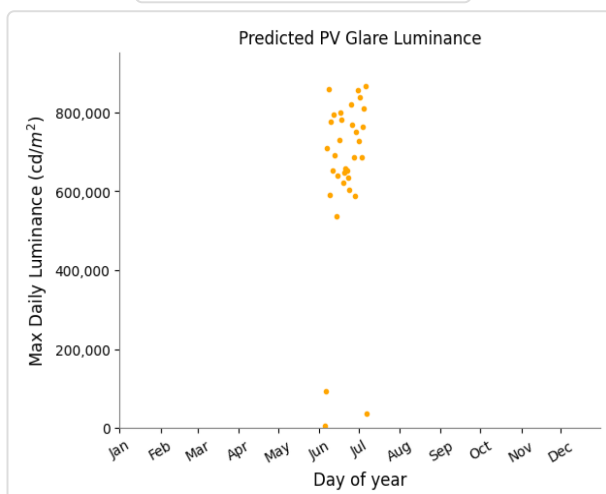








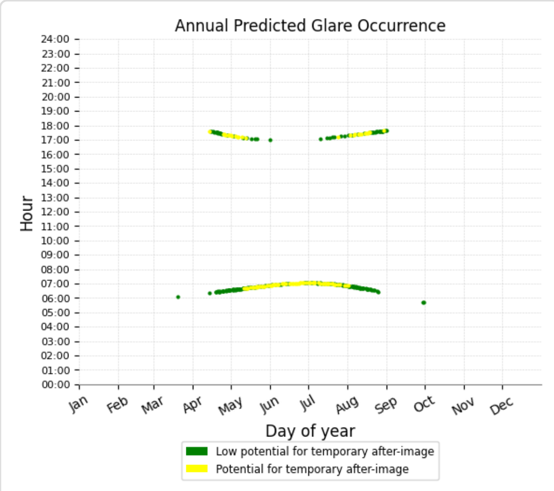


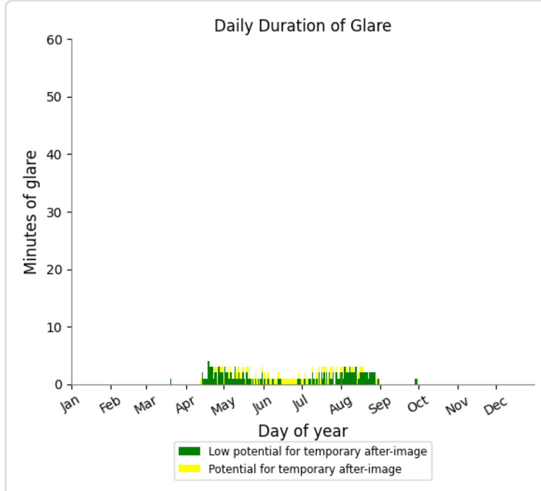


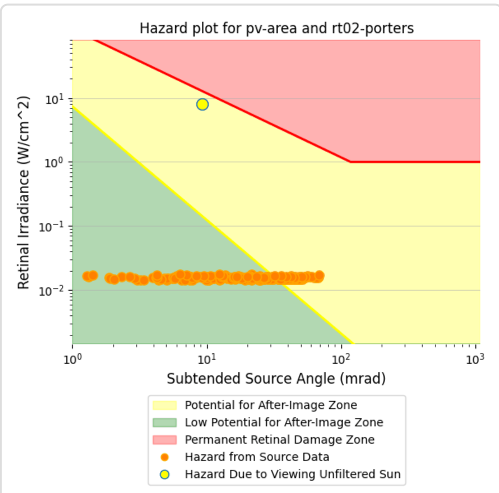
PV Area and Route: RT02 Porters Ln

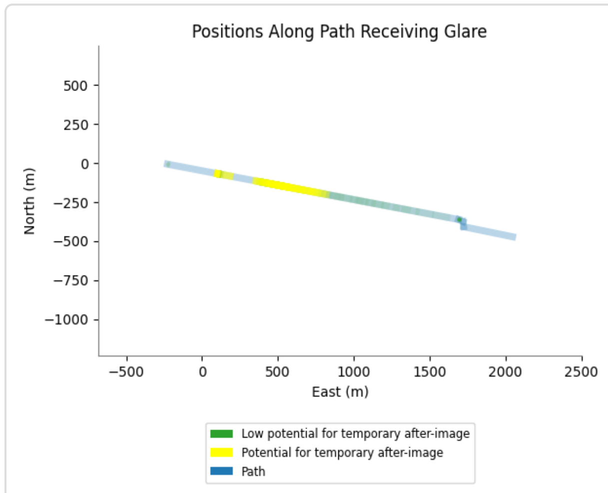
Yellow glare: 87 min.

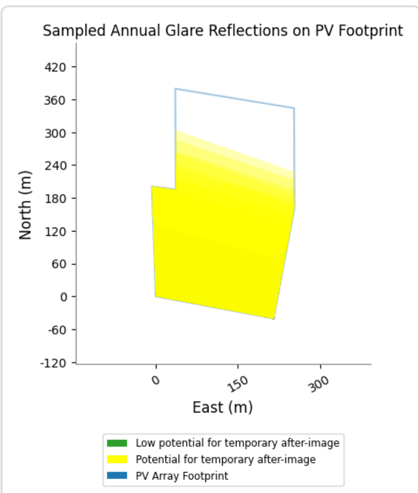
Green glare: 168 min.

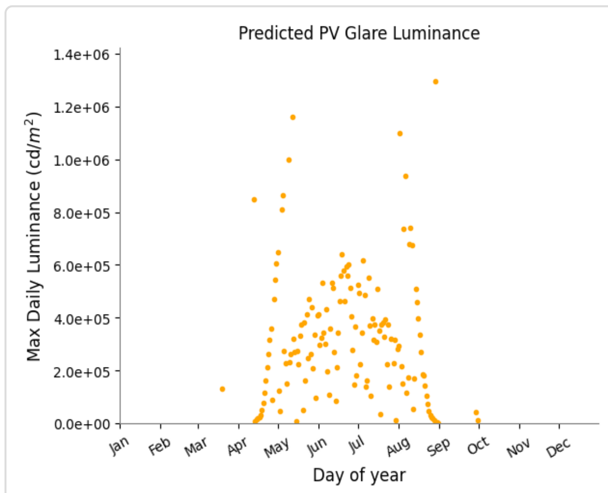








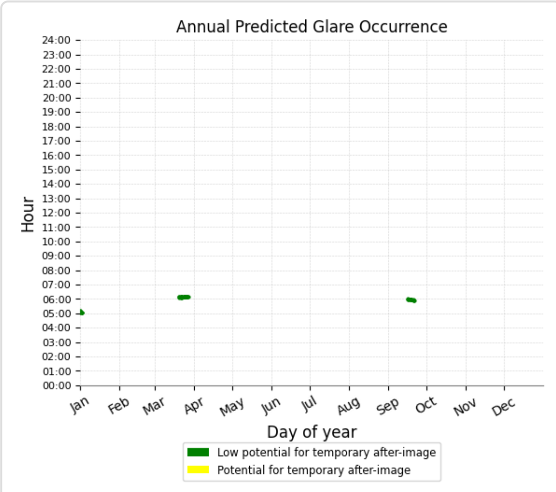


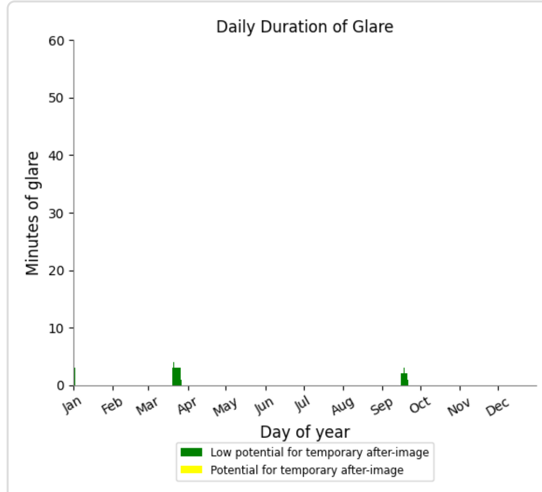


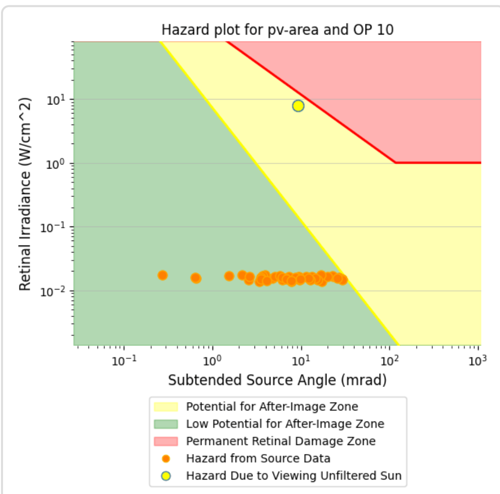
PV Area and OP 10

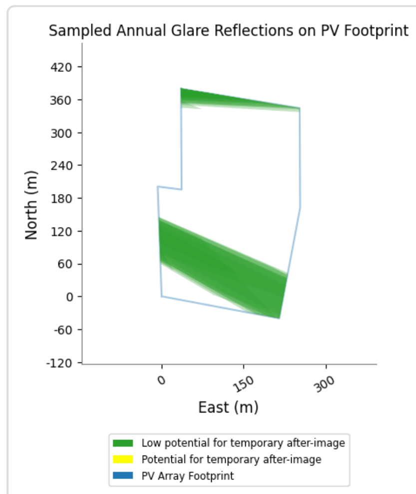
Yellow glare: none

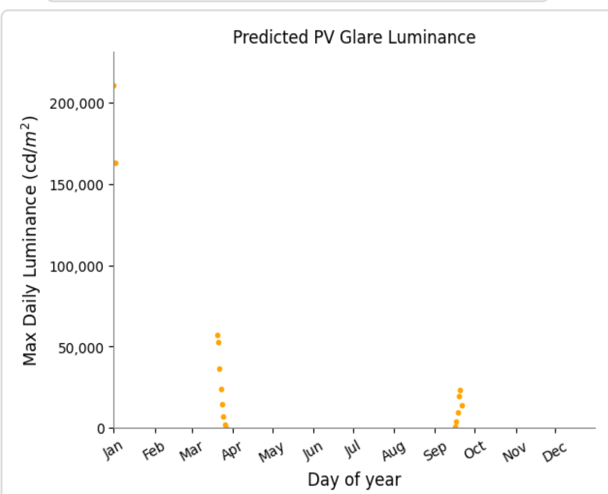
Green glare: 45 min.





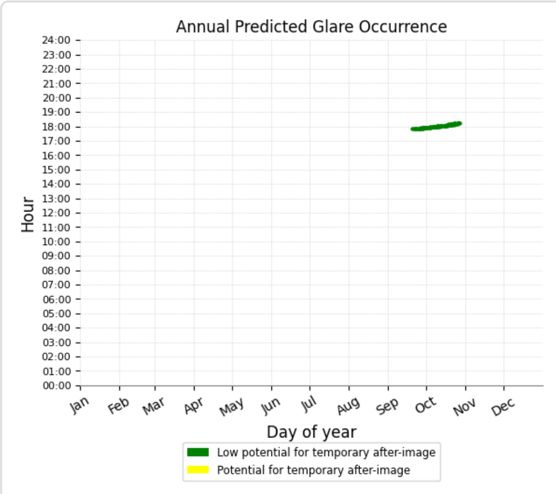


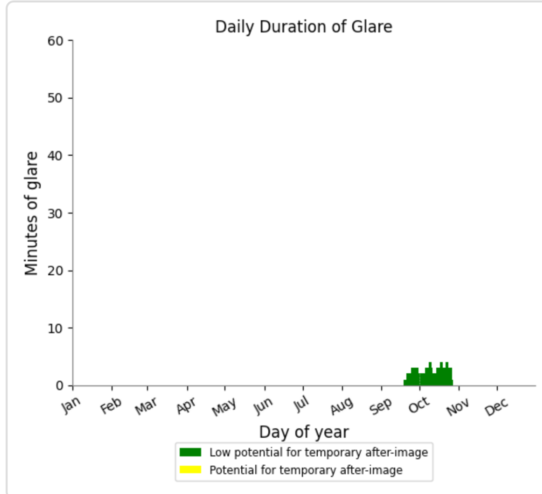


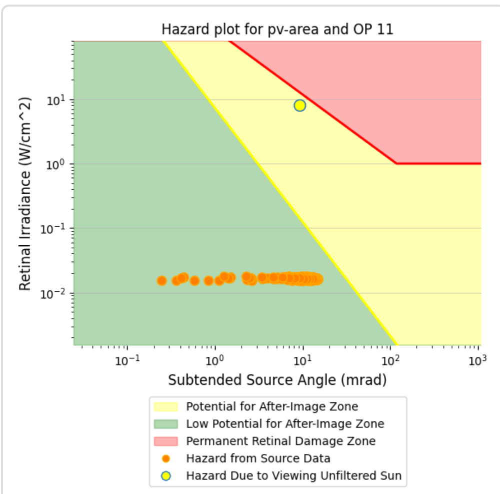


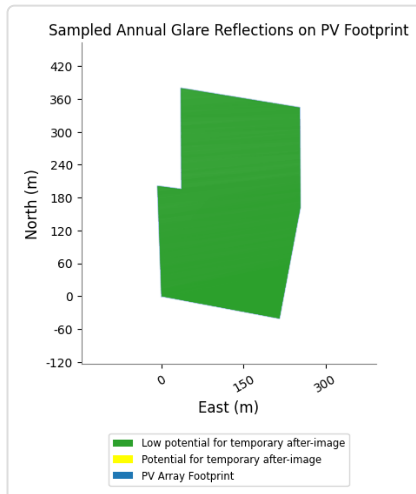
PV Area and OP 11

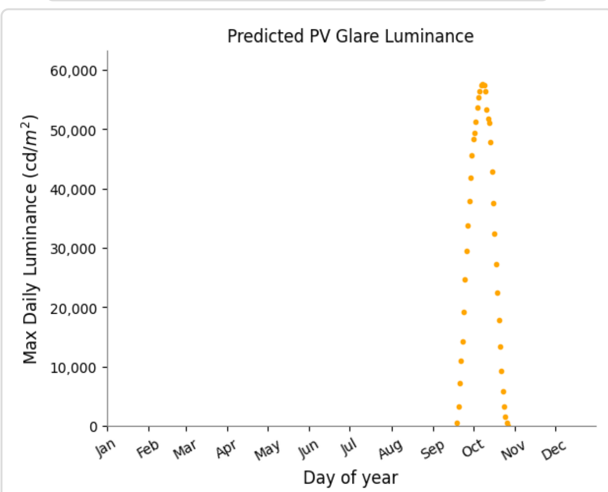
Yellow glare: none
Green glare: 105 min.











PV Area and OP 1

No glare found

PV Area and OP 2

No glare found

PV Area and OP 3

No glare found

PV Area and OP 4

No glare found

PV Area and OP 5

No glare found

PV Area and OP 6

No glare found

PV Area and OP 7

No glare found

PV Area and OP 8

No glare found

PV Area and OP 9

No glare found

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.
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.
Several V1 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 V1 analyses of path receptors.
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.
The analysis does not automatically consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
The 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.)
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.
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.
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.
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.
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.

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

ITP Renewables

Office: Level 1, 19-23 Moore St
Turner ACT 2612

Postal: PO Box 6127
O'Connor ACT 2602
Australia

Email: info@itpau.com.au
Phone: +61 (0) 2 6257 3511

itpau.com.au