MATAMATA SOUTHERN SOLAR FARM

Glint and Glare Assessment

DATE: 18TH October 2024

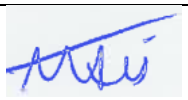
REVISION: 0

Contents

Quality Information

Document	Matamata Ashbourne Southern SF Glint and Glare Report
Ref	Documents\Land - potential sites\Matamata\Glint & Glare
Date	18th October 2024
Prepared by	DJ Unnikrishnan
Reviewed by	Glen Jacobsen

Revision History

Rev	Revision Date	Details	Authorised	
			Name/Position	Signature
0	18/10/2024	For Information	Matt Shanks / Development Manager	

1.0 Summary

Lightyears Solar Limited has conducted a thorough Glint and Glare Assessment for the proposed Southern Solar Farm located on the Southern end of 247 Station Road, Matamata, on behalf of Maven Associates. The assessment was undertaken utilising the advanced ForgeSolar Glare gauge tool and evaluated more than 40 receptors in the surrounding area.

The findings indicate that there are no impacts on most receptors, with the exception one route receptor. The route receptor on Station Road indicates that there will be annual green glare of 95 minutes (or 1.6 hours) and orange glare of 6 minutes (or 0.1 hour), which means there may be a potential for temporary after – image. The duration of the glare was estimated to be less than 5 minutes and would happen only in 3 months – March, September and November. The potential for temporary after image is expected to happen during the mornings between 5AM till 7AM. The after image could be mitigated by providing a secondary planting strip / barrier.

The overall impact on the receptors are minimal and this ensures that the solar farm will operate harmoniously within the region, providing clean energy without affecting the local environment.

2.0 Glint and Glare Overview

Glint and glare are optical phenomena related to the reflection of sunlight. Glint is characterised by brief, intermittent flashes of bright light resulting from sunlight reflecting off surfaces like solar panels or water bodies. Glare, on the other hand, involves sustained and uncomfortable brightness, often causing visual discomfort or impairment due to intense and uncontrolled light sources, such as direct sunlight or reflections. In the context of a glint and glare report, particularly for projects like solar farms, it is crucial to assess and manage these phenomena to ensure safety and environmental compatibility.

The GlareGauge tool is designed to detect potential glare emanating from solar PV arrays and categorises them based on their ocular impact. It's important to clarify that this software does not consider view shedding, which involves blocking glare sources through buildings, terrain, or vegetation. Consequently, it represents a worst-case scenario.

The tool quantifies the ocular impact of solar glare into three categories, reflecting the effects on afterimages as given in Figure 1:

- Green indicates a low potential for causing after-image (flash blindness).
- Yellow suggests potential for temporary after-image.
- Red signals the potential for causing retinal burn, which may result in permanent eye damage.

Note that retinal burn is generally not a concern with PV glare because PV modules do not focus reflected sunlight. As PV modules are constructed to absorb as much solar irradiation as possible to increase their efficiency, their reflectivity is very low compared to many other common materials such as grass and house rooftops.

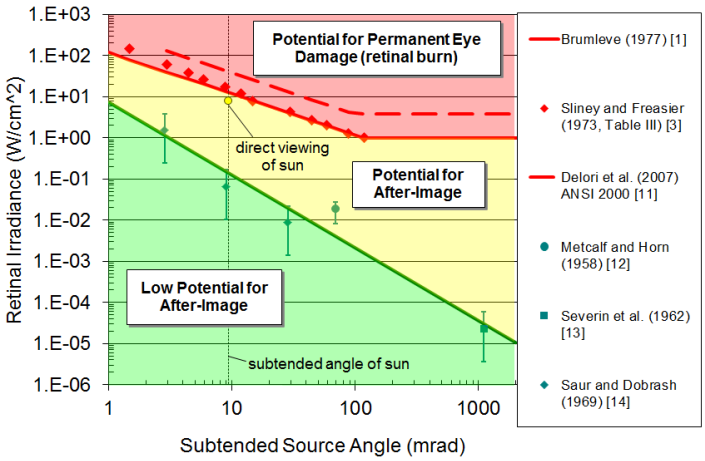


Figure 1-Glare hazard plot defines ocular impact as function of retinal irradiance and subtended source angle (https://www.forgesolar.com/help/#ref-ho-2011-method)

2.1 PV Arrays

The PV array was set-up in the model based on the boundaries given in Figure 2. The following parameters were used:

- Single axis trackers which follow the sun from East to West
- Tracker panel rows aligned in North – South configuration
- Maximum tracking angle 60°
- Ground Coverage Ratio: 0.48
- Module height above ground: 1.4m
- Modules made using smooth glass with anti-reflective coating.

Figure 2- PV Array site coverage on the Northern end of 247 Station Road.

2.2 Obstruction Components

There will be planting strip around the perimeter of the solar farm as shown in Figure 3. It will be grown and maintained to a height of 2.5m.

Figure 3- Planting strip defined around the perimeter of the solar farm

3.0 Receptors

3.1 Route Receptors

Five route receptors were identified around the proposed solar farm, each set at a height of 1.5 meters to simulate the view from a car. The names of the route receptors are provided below:

- Eldonwood Road
- Highgrove Avenue
- Hinuera Road
- Jellicoe Road and Peakedale Drive
- Station Road

An evaluation for all the receptors is given below in the following sections.

3.1.1 Eldonwood Road

Eldonwood Road is located on the North-East of the proposed solar farm and is a residential road, with a significant number residential properties as shown in Figure 4. This road was considered as the first route receptor and had the following parameters:

- Path type: One-way Road
- Observer view angle: 50^{o}

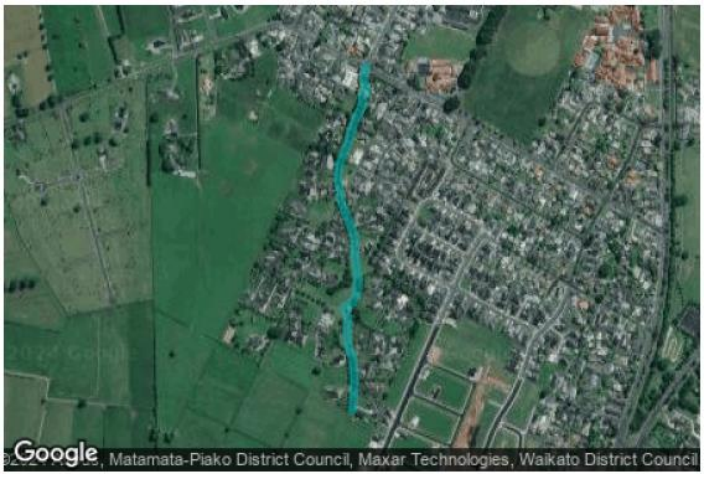


Figure 4- Route receptor 1 at Eldonwood Road on the North – East of the proposed solar farm.

3.1.2 Highgrove Avenue

Highgrove Avenue is one-way road with few residential properties located on the Northern side of the proposed solar farm as shown in Figure 5. The route had the following parameters:

- Path type: One way Road
- Observer view angle: 50°

Figure 5 - Route receptor 2 at Highgrove Road on the Northern side of the proposed solar farm.

3.1.3 Hinuera Road

Hinuera Road is primary road that connects to Matamata Township via SH27. There are few residential properties along the road and limited vegetation that could provide screening for the proposed solar farm, therefore, this road was considered in the assessment. The road is located on the Eastern side of the proposed solar farm as shown in Figure 6.The route had the following parameters:

- Path type: Two-way Road
- Observer view angle: 50°

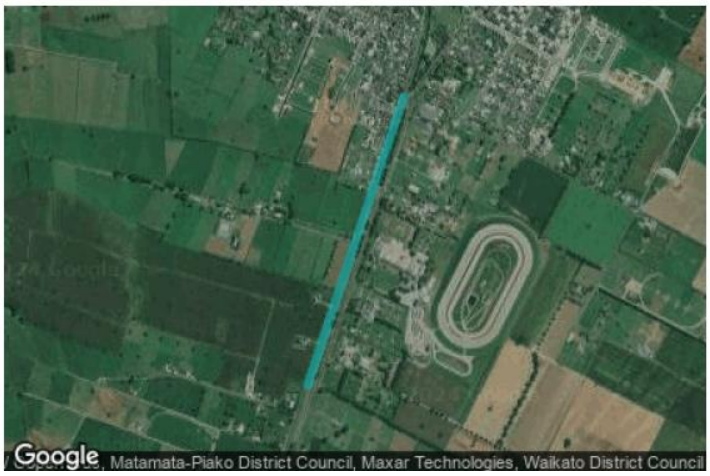


Figure 6- Route receptor 3 at Hinuera Road, located towards the East of the proposed solar farm.

3.1.4 Jellicoe Road and Peakedale Drive

Jellicoe Road and Peakedale Drive is part of a single no-exit road comprised of only residential properties in the area. The road is located on the Eastern side of the proposed solar farm as shown in Figure 7. The route had the following parameters:

- Path type: One – way road
- Observer view angle: 50°

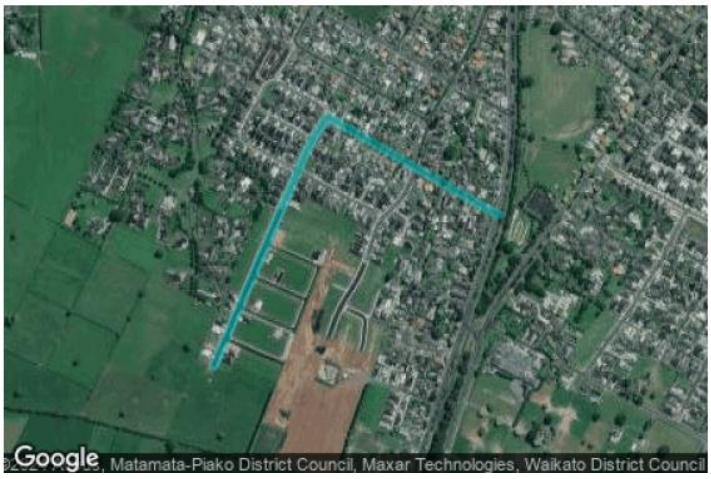


Figure 7- Route receptor 4 at Jellicoe Road and Peakedale Drive, located towards the East of the proposed solar farm.

3.1.5 Station Road

Station Road is the primary road running along the front of the proposed solar farm as shown in Figure 8. The route had the following parameters:

- Path type: Two – way road
- Observer view angle: 50°

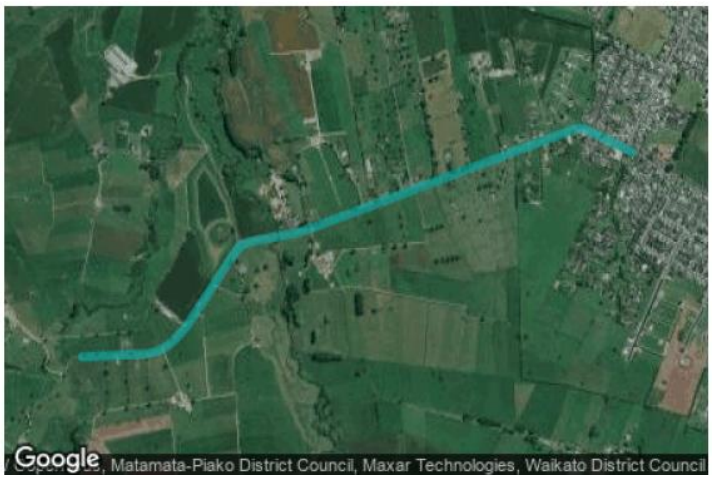


Figure 8- Route receptor 5 at Station Road, located in front of the proposed solar farm.

3.2 Flight Path Receptors

To identify the flight paths necessary for the glint and glare assessment, a benchmark radius of 25 km around the proposed solar farm was established. The assessment found Matamata Aerodrome to be the only aerodrome in close proximity to the solar farm. Two regional airports—Hamilton (HZL) and Tauranga (TRG)—were noted, but their flight paths were not included in the analysis due to their locations being outside the benchmark radius, making them less relevant to potential impacts.

At Matamata Aerodrome, two flight paths were identified: FP1 and FP2 (refer to Figure 9 and Figure 10), each extending 2 miles on either side of the runway. Notably, the aerodrome does not have an Air Traffic Control Tower. The assessment concluded that there would be no significant glint or glare effects from the solar farm on Matamata Aerodrome.

Figure 9- Flight Path 1 identified at Matamata Aerodrome.

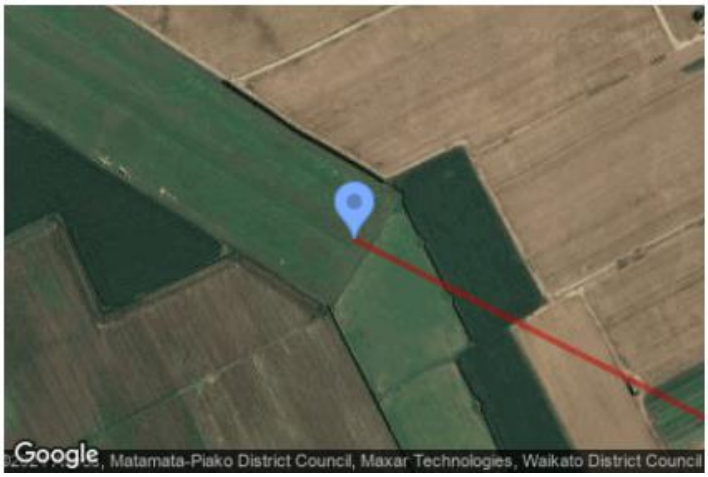


Figure 10- Flight Path 2 identified at Matamata Aerodrome.

3.3 Discrete Observation Points

Forty discrete observation point receptors were identified, all of them represented residential properties within the surrounding areas of the proposed solar farm. Each of these points have a height set at 1.7m to simulate a view from an average person. These points are identified in Figure 11.

Figure 11- *All identified discrete observation points around the proposed solar farm.*

4.0 Glare Analysis Results

The glint and glare analysis provided results for all 40 and above receptors included in the simulation. Notably, there were no glares recorded at any of the receptors, except on route receptor 8 which is Station Road.

Station Road route receptor showed an annual green glare of 95 minutes (or 1.6 hours) and orange glare of 6 minutes (or 0.1 hour), as shown in Figure 12, which means there will be a potential for temporary after – image . All the other receptors register an annual green and yellow glare exposures as zero.

While this indicates a minimal risk of after-images, it confirms that mitigation measures may be required to eliminate the risk of after-images on the northwestern side of the solar farm.

Results from every receptor showing the annual green and orange glare is given in Figure 12 and Figure 13 .

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Station Road	95	1.6	6	0.1
Eldonwood Road	0	0.0	0	0.0
Highgrove Ave	0	0.0	0	0.0
Hinuera Road	0	0.0	0	0.0
Jellicoe Rd - Peakedale Drive	0	0.0	0	0.0
FP 1	0	0.0	0	0.0
FP 2	0	0.0	0	0.0
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	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0
OP 14	0	0.0	0	0.0
OP 15	0	0.0	0	0.0
OP 16	0	0.0	0	0.0
OP 17	0	0.0	0	0.0
OP 18	0	0.0	0	0.0
OP 19	0	0.0	0	0.0
OP 20	0	0.0	0	0.0
OP 21	0	0.0	0	0.0
OP 22	0	0.0	0	0.0
OP 23	0	0.0	0	0.0
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 26	0	0.0	0	0.0
OP 27	0	0.0	0	0.0
OP 28	0	0.0	0	0.0
OP 29	0	0.0	0	0.0
OP 30	0	0.0	0	0.0

Figure 12 - Glint and Glare results – 37 Receptors.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 31	0	0.0	0	0.0
OP 32	0	0.0	0	0.0
OP 33	0	0.0	0	0.0
OP 34	0	0.0	0	0.0
OP 35	0	0.0	0	0.0
OP 36	0	0.0	0	0.0
OP 37	0	0.0	0	0.0
OP 38	0	0.0	0	0.0
OP 39	0	0.0	0	0.0
OP 40	0	0.0	0	0.0

Figure 13- Glint and Glare results – 10 Receptors.

4.1 Route Receptor: Station Road Results

The results from route receptor Station Road stated the following:

- Green glare or Low potential for temporary after image: 95 minutes
- Yellow glare or Potential for temporary after image: 6 minutes

Predicted glare occurrence and duration: The predicted instances of green glare are anticipated to occur between November and early February, again in mid-March, and from mid-September to early October, as illustrated in Figure 14. In contrast, yellow glare is expected to occur only three times a year: late September, late November, and mid-March. All predicted exposures to temporary afterimages are projected to last less than 5 minutes each day and will occur exclusively between 5 AM and 7 AM Figure 15.

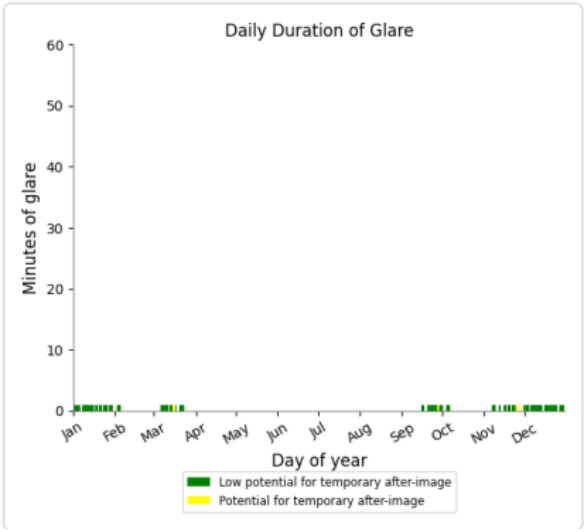


Figure 14- Daily duration of glare.

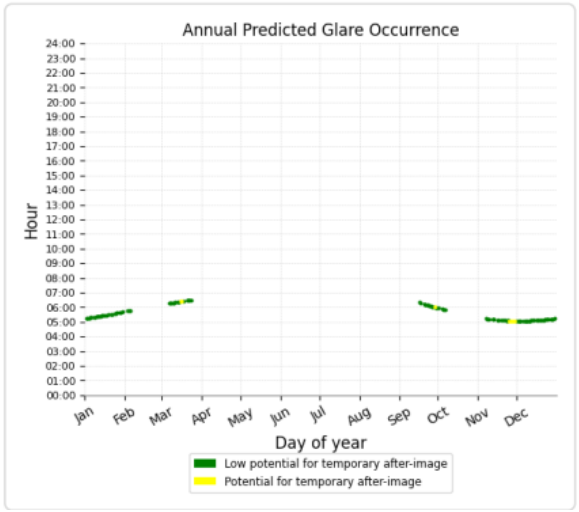


Figure 15- Annual predicted glare occurrence

Hazard Plot: The hazard plot uses orange plot points to represent the intensity of the glare. The results show they are mainly in green zone except a couple of them in yellow zone as shown in Figure 16 .

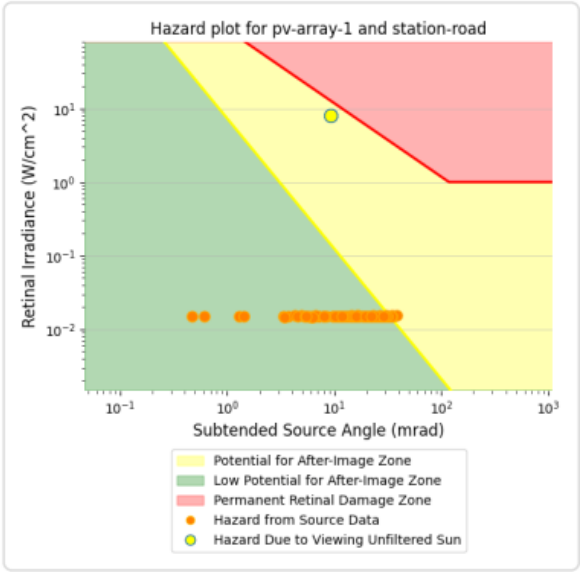


Figure 16- Hazard Plot for PV Array and Station Road.

Position along path receiving glare: Figure 17 shows the position along the path that receives the glares.

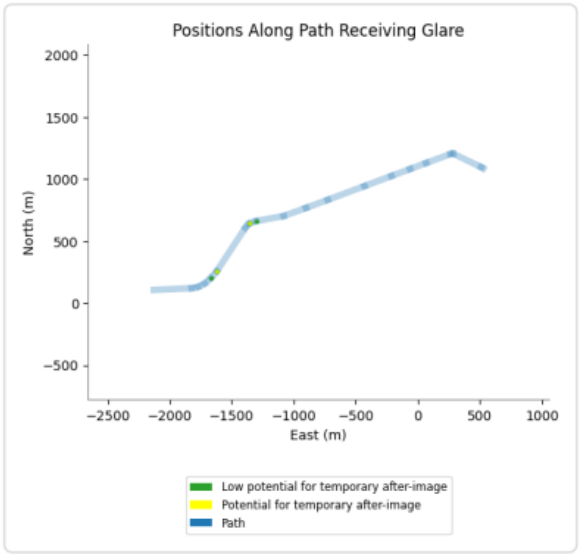


Figure 17- Positions along the path receiving glare

Annual glare reflections on the PV footprint: Figure 18 examines the annual pattern of glare reflections on the area covered by photovoltaic panels. The Southern and Eastern sides are predicted to create a mix of green and yellow glares.

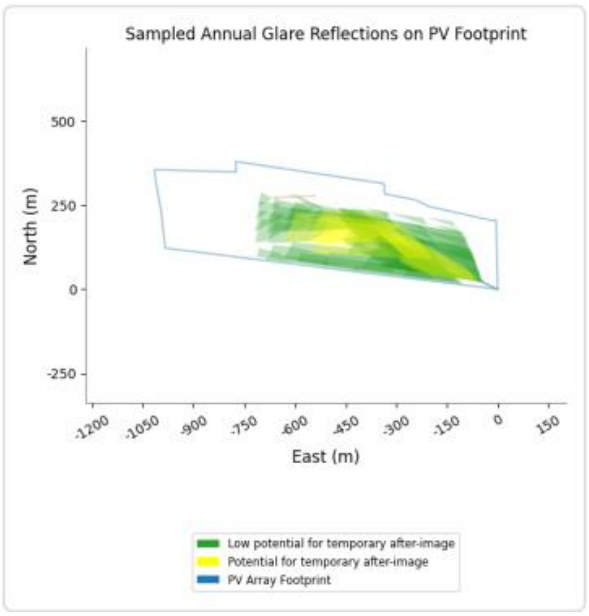


Figure 18- Sampled annual glare reflections on PV Array

Estimated glare per month: In Figure 19, the monthly estimates for green and yellow glare are presented. Notably, during December and January, the green glare exceeds 20 minutes each month. Meanwhile, in March, September, and November, the yellow glare is minimal, lasting less than 3 minutes throughout the entire month.

Distinct glare per month

PV	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
pv-array-1 (green)	24	3	13	0	0	0	0	0	12	4	12	27
pv-array-1 (yellow)	0	0	2	0	0	0	0	0	1	0	3	0

Figure 19 - Estimated glare per month from the proposed solar farm.

5.0 Potential Solution

To mitigate the issue of after images caused by yellow glare, a secondary planting strip / barrier 5-meters high, offset by 5-meters from the northern and western boundaries of the proposed solar farm could be established, as illustrated in Figure 20. This approach aims to eliminate the impact of yellow glare and its associated after images entirely, while also reducing green glare to 27 minutes (or 0.5 hours). Furthermore, this measure would decrease the duration of glare from 7 months a year to just 3 months (March, September, and October), as shown in Figure 21.

Figure 20 - Secondary planting strip barrier along the North and West side of the proposed solar farm.

Distinct glare per month

PV	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
pv-array-1 (green)	0	0	13	0	0	0	0	0	10	4	0	0
pv-array-1 (yellow)	0	0	0	0	0	0	0	0	0	0	0	0

Figure 21 - Estimated glare per month from the proposed solar farm after 5m barrier is placed

Predicted glare occurrence and duration: The predicted instances of green glare are anticipated to occur between mid-September and early October, again in mid-March as illustrated in Figure 22. In contrast, yellow glare is not expected to occur at all. All predicted exposures to low potential for temporary afterimages are projected to last less than 5 minutes each day and will occur exclusively between 5 AM and 7 AM Figure 23.

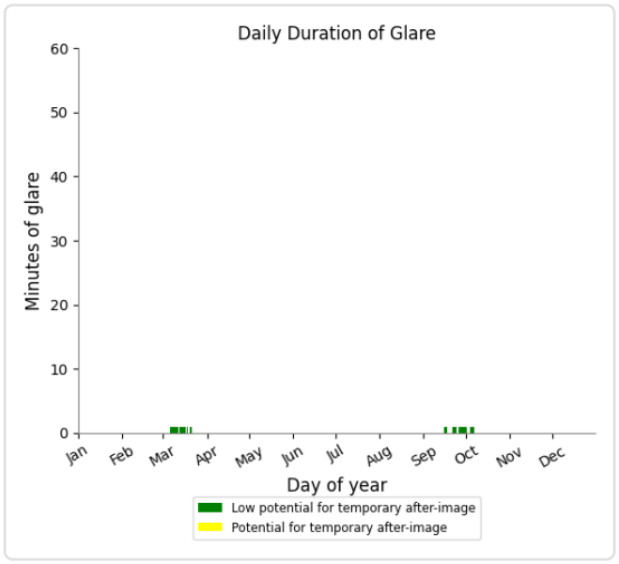


Figure 22 - Daily duration of glare.

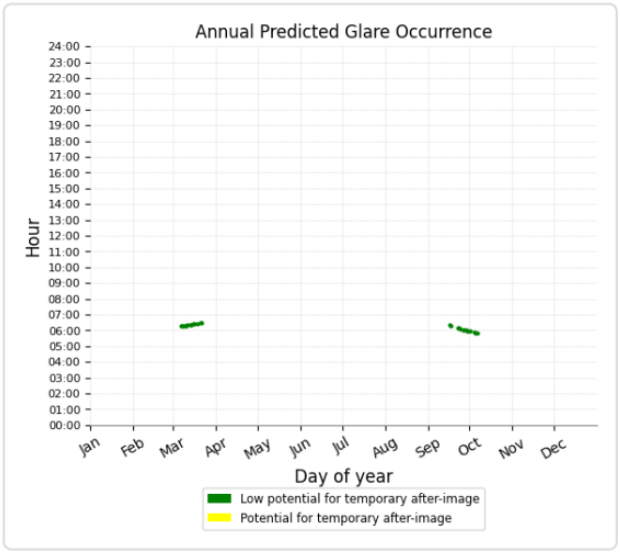


Figure 23- Annual predicted glare occurrence

Hazard Plot: The hazard plot uses orange plot points to represent the intensity of the glare. The results show they are only in green zone as shown in Figure 24.

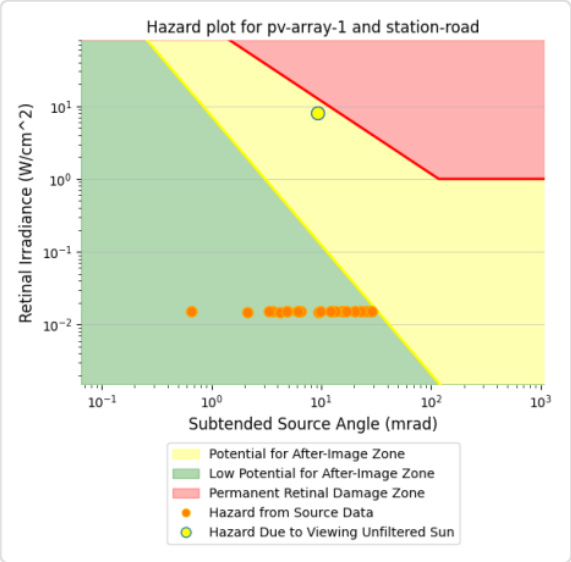


Figure 24- Hazard Plot for PV Array and Station Road.

Position along path receiving glare: Figure 25 shows the position along the path that receives the glares.

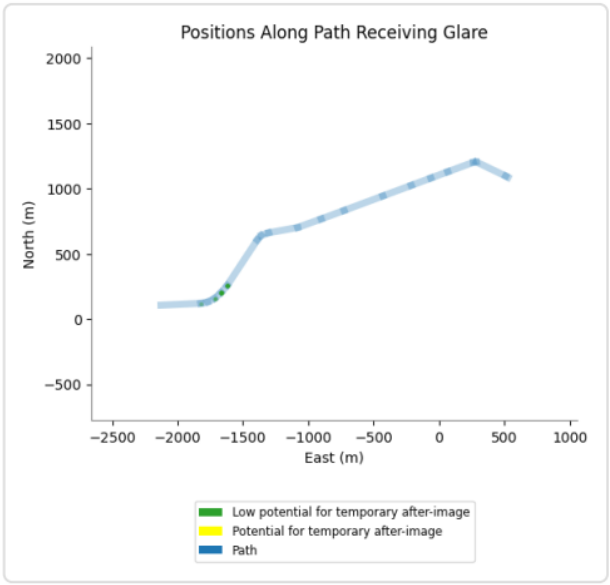


Figure 25- Positions along the path receiving glare

Annual glare reflections on the PV footprint: Figure 26 examines the annual pattern of glare reflections on the area covered by photovoltaic panels. The Southern and Eastern sides are predicted to create minimal green glares.

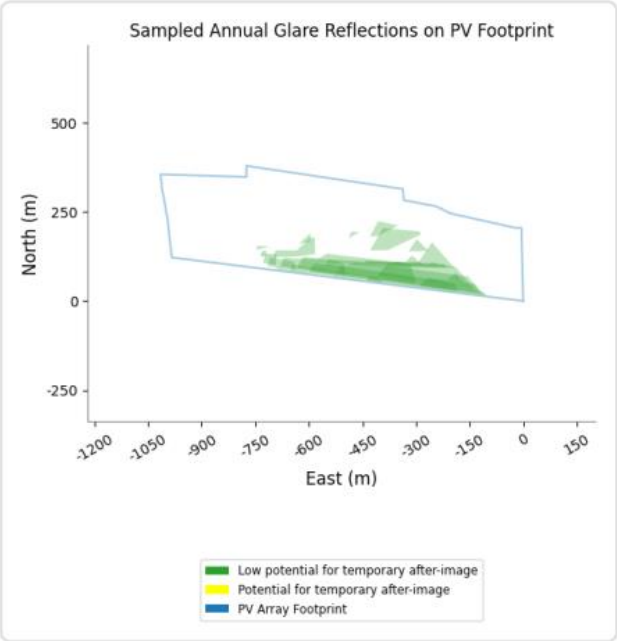


Figure 26- Sampled annual glare reflections on PV Array

6.0 Conclusions and Observations

The results show that all receptors, apart from one, experience no risk of glare. The potential for a temporary after image (yellow glare) is estimated at 6 minutes. Additionally, the low potential for afterimages is expected to last less than 5 minutes. The results are shown in **Appendix A.**

To mitigate the issue of after images caused by yellow glare, a secondary planting strip / barrier 5-meters high, offset by 5-meters from the northern and western boundaries of the proposed solar farm could be established. This enhancement would eliminate the risk of yellow glare and reduce green glare to just 27 minutes per year. Detailed results of this additional barrier's impact are presented in **Appendix B**.

It should be noted the software simulation uses clear sky weather data where glint and glare is not reduced due to atmospheric conditions or clouds, which provides a worst-case scenario. In reality, clouds, fog and other atmospheric conditions will result in less glare than simulated in this report.

Appendix A: ForgeSolar Glare Analysis Results

FORGESOLAR GLARE ANALYSIS

Project: **Matamata Stage - 2**

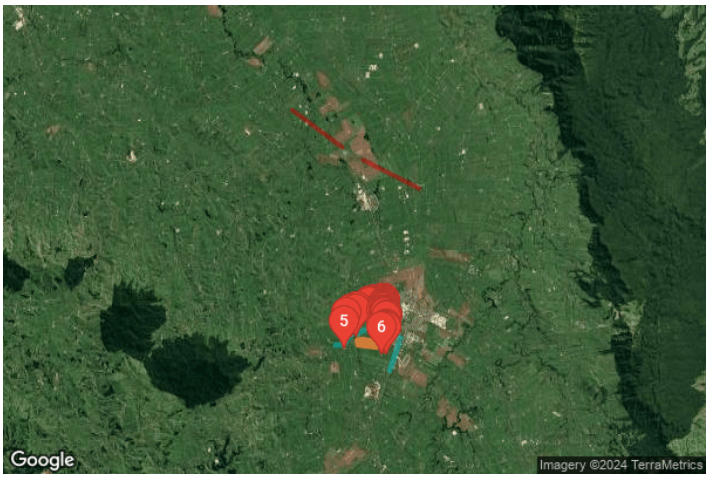
High-level Glint & Glare analysis for Stage - 2 Solar Farm for Maven Associates

Site configuration: **Matamata Stage - 2**

Client: Maven Associates

Created 15 Oct, 2024
Updated 17 Oct, 2024
Time-step 1 minute
Timezone offset UTC12
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Category 10 MW to 100 MW
Site ID 131335.22403

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
	°	°	min	hr	min	hr	kWh
PV array 1	SA tracking	SA tracking	95	1.6	6	0.1	56,990,000.0

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
Eldonwood Road	0	0.0	0	0.0
Highgrove Ave	0	0.0	0	0.0
Hinuera Road	0	0.0	0	0.0
Jellicoe Rd - Peakedale Drive	0	0.0	0	0.0
Station Road	95	1.6	6	0.1
FP 1	0	0.0	0	0.0
FP 2	0	0.0	0	0.0
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

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
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	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0
OP 14	0	0.0	0	0.0
OP 15	0	0.0	0	0.0
OP 16	0	0.0	0	0.0
OP 17	0	0.0	0	0.0
OP 18	0	0.0	0	0.0
OP 19	0	0.0	0	0.0
OP 20	0	0.0	0	0.0
OP 21	0	0.0	0	0.0
OP 22	0	0.0	0	0.0
OP 23	0	0.0	0	0.0
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 26	0	0.0	0	0.0
OP 27	0	0.0	0	0.0
OP 28	0	0.0	0	0.0
OP 29	0	0.0	0	0.0
OP 30	0	0.0	0	0.0
OP 31	0	0.0	0	0.0
OP 32	0	0.0	0	0.0
OP 33	0	0.0	0	0.0
OP 34	0	0.0	0	0.0
OP 35	0	0.0	0	0.0
OP 36	0	0.0	0	0.0
OP 37	0	0.0	0	0.0
OP 38	0	0.0	0	0.0
OP 39	0	0.0	0	0.0
OP 40	0	0.0	0	0.0

Component Data

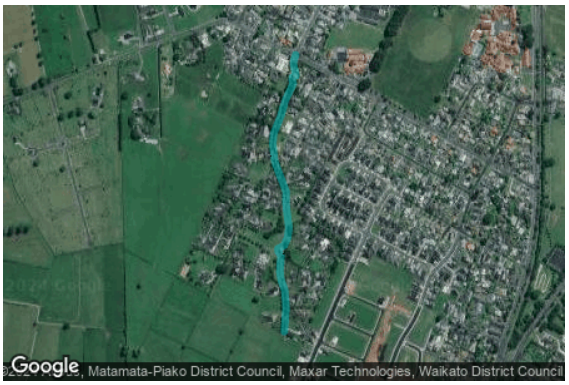
PV Arrays

Name: PV array 1
Description: Solar Farm Stage - 2
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.48
Rated power: 20863.0 kW
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	-37.827269	175.757125	65.00	1.40	66.40
2	-37.825417	175.757071	64.00	1.40	65.40
3	-37.825430	175.756921	64.00	1.40	65.40
4	-37.825057	175.754813	63.00	1.40	64.40
5	-37.824879	175.754351	63.00	1.40	64.40
6	-37.824722	175.753327	62.00	1.40	63.40
7	-37.824442	175.753300	62.00	1.40	63.40
8	-37.823856	175.748324	60.00	1.40	61.40
9	-37.824136	175.748330	61.00	1.40	62.40
10	-37.824072	175.745594	61.00	1.40	62.40
11	-37.824382	175.745631	61.00	1.40	62.40
12	-37.825191	175.745814	62.00	1.40	63.40
13	-37.826170	175.745949	63.00	1.40	64.40

Route Receptors

Name: Eldonwood Road
Path type: One-way (toward increasing index)
Observer view angle: 50.0°

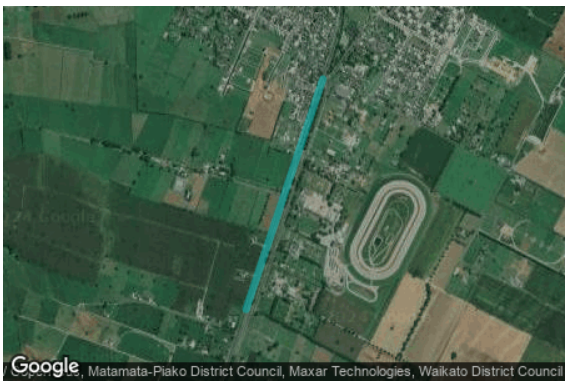


Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.817355	175.762833	64.00	1.50	65.50
2	-37.817578	175.762750	64.00	1.50	65.50
3	-37.817922	175.762844	64.00	1.50	65.50
4	-37.817964	175.762718	64.00	1.50	65.50
5	-37.818046	175.762715	64.00	1.50	65.50
6	-37.818129	175.762750	64.00	1.50	65.50
7	-37.818572	175.762484	64.00	1.50	65.50
8	-37.819006	175.762323	64.00	1.50	65.50
9	-37.819494	175.762074	64.00	1.50	65.50
10	-37.819765	175.762047	64.00	1.50	65.50
11	-37.820218	175.762109	64.00	1.50	65.50
12	-37.820483	175.762227	64.00	1.50	65.50
13	-37.821049	175.762503	64.62	1.50	66.12
14	-37.821383	175.762500	65.00	1.50	66.50
15	-37.821873	175.762575	65.00	1.50	66.50
16	-37.822021	175.762600	65.00	1.50	66.50
17	-37.822288	175.762562	65.00	1.50	66.50
18	-37.822509	175.762444	65.00	1.50	66.50
19	-37.822595	175.762227	65.00	1.50	66.50
20	-37.822680	175.762235	65.00	1.50	66.50
21	-37.822788	175.762331	65.00	1.50	66.50
22	-37.823203	175.762288	65.00	1.50	66.50
23	-37.823449	175.762334	65.00	1.50	66.50
24	-37.823714	175.762457	65.00	1.50	66.50
25	-37.824207	175.762502	66.00	1.50	67.50
26	-37.824838	175.762443	66.00	1.50	67.50

Name: Highgrove Ave
Path type: One-way (toward increasing index)
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.818141	175.754360	60.00	1.50	61.50
2	-37.819654	175.754851	60.00	1.50	61.50
3	-37.819720	175.755072	61.00	1.50	62.50
4	-37.819906	175.754939	61.00	1.50	62.50
5	-37.822470	175.755806	62.00	1.50	63.50

Name: Hinuera Road
Path type: Two-way
Observer view angle: 50.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.825577	175.769801	67.00	1.50	68.50
2	-37.837445	175.764788	68.00	1.50	69.50
3	-37.838072	175.764525	68.00	1.50	69.50

Name: Jellicoe Rd - Peakedale Drive
Path type: One-way (toward increasing index)
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.826398	175.762982	66.57	1.50	68.07
2	-37.821690	175.765546	66.00	1.50	67.50
3	-37.821071	175.766050	66.00	1.50	67.50
4	-37.821078	175.766199	66.00	1.50	67.50
5	-37.823123	175.770719	67.00	1.50	68.50
6	-37.823136	175.770794	67.00	1.50	68.50

Name: Station Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.826315	175.732966	76.00	1.50	77.50
2	-37.826186	175.736431	73.00	1.50	74.50
3	-37.826087	175.737032	72.00	1.50	73.50
4	-37.825837	175.737636	71.00	1.50	72.50
5	-37.825439	175.738194	70.00	1.50	71.50
6	-37.824958	175.738719	70.00	1.50	71.50
7	-37.821801	175.741342	64.00	1.50	65.50
8	-37.821494	175.741690	63.00	1.50	64.50
9	-37.821312	175.742323	62.00	1.50	63.50
10	-37.820947	175.744850	59.00	1.50	60.50
11	-37.820356	175.746897	58.00	1.50	59.50
12	-37.819772	175.748884	58.00	1.50	59.50
13	-37.818769	175.752256	59.00	1.50	60.50
14	-37.818037	175.754723	60.00	1.50	61.50
15	-37.817531	175.756426	61.00	1.50	62.50
16	-37.817096	175.757895	61.00	1.50	62.50
17	-37.816446	175.760118	63.00	1.50	64.50
18	-37.816421	175.760384	63.00	1.50	64.50
19	-37.817394	175.762930	64.00	1.50	65.50
20	-37.817481	175.763126	64.00	1.50	65.50

Flight Path Receptors

Name: FP 1
Description:
Threshold height: 15 m
Direction: 126.6°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-37.734826	175.736655	49.00	15.24	64.24
Two-mile	-37.717584	175.707274	43.00	189.92	232.92

Name: FP 2
Description:
Threshold height: 15 m
Direction: 296.9°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-37.740754	175.748994	50.00	15.24	65.24
Two-mile	-37.753853	175.781626	50.00	183.92	233.92

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-37.821506	175.745846	59.00	1.70
OP 2	2	-37.822769	175.744894	60.00	1.70
OP 3	3	-37.822562	175.741806	64.00	1.70
OP 4	4	-37.824595	175.739427	68.00	1.70
OP 5	5	-37.828128	175.738313	71.00	1.70
OP 6	6	-37.830802	175.760130	67.00	1.70
OP 7	7	-37.830744	175.762974	68.00	1.70
OP 8	8	-37.829795	175.762964	68.00	1.70
OP 9	9	-37.830395	175.761841	68.00	1.70
OP 10	10	-37.818901	175.753203	60.00	1.70
OP 11	11	-37.819646	175.753225	60.00	1.70
OP 12	12	-37.819278	175.755655	61.00	1.70
OP 13	13	-37.818340	175.756083	61.00	1.70
OP 14	14	-37.819182	175.757474	62.00	1.70
OP 15	15	-37.824534	175.761959	65.79	1.70
OP 16	16	-37.823805	175.762050	65.00	1.70
OP 17	17	-37.823517	175.761616	65.00	1.70
OP 18	18	-37.823190	175.761627	65.00	1.70
OP 19	19	-37.823339	175.761015	65.00	1.70
OP 20	20	-37.823250	175.760682	65.00	1.70
OP 21	21	-37.823330	175.759733	64.00	1.70
OP 22	22	-37.822436	175.760441	64.00	1.70
OP 23	23	-37.822411	175.760071	64.00	1.70
OP 24	24	-37.822262	175.759556	64.00	1.70
OP 25	25	-37.821572	175.760171	64.00	1.70
OP 26	26	-37.820964	175.760718	64.00	1.70
OP 27	27	-37.820438	175.760997	64.00	1.70
OP 28	28	-37.820027	175.761072	64.00	1.70
OP 29	29	-37.819667	175.761281	64.00	1.70
OP 30	30	-37.819315	175.761399	64.00	1.70
OP 31	31	-37.818845	175.761705	64.00	1.70
OP 32	32	-37.818421	175.761817	64.00	1.70
OP 33	33	-37.818196	175.761614	64.00	1.70
OP 34	34	-37.818074	175.761426	63.00	1.70
OP 35	35	-37.817993	175.761270	63.00	1.70
OP 36	36	-37.817896	175.761034	63.00	1.70
OP 37	37	-37.817840	175.760911	63.00	1.70
OP 38	38	-37.817768	175.760712	63.00	1.70
OP 39	39	-37.826116	175.762772	66.00	1.70
OP 40	40	-37.825505	175.763115	66.00	1.70

Obstruction Components

Name: Planting Strip
Top height: 2.5 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-37.824072	175.745586	61.00
2	-37.826181	175.745933	63.00
3	-37.827281	175.757140	65.00
4	-37.825405	175.757079	64.00
5	-37.824855	175.754360	63.00
6	-37.824703	175.753347	62.00
7	-37.824419	175.753309	62.00
8	-37.823850	175.748314	60.00
9	-37.824131	175.748322	61.00
10	-37.824067	175.745582	61.00

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
	°	°	min	hr	min	hr	kWh
PV array 1	SA tracking	SA tracking	95	1.6	6	0.1	56,990,000.0

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
Eldonwood Road	0	0.0	0	0.0
Highgrove Ave	0	0.0	0	0.0
Hinuera Road	0	0.0	0	0.0
Jellicoe Rd - Peakedale Drive	0	0.0	0	0.0
Station Road	95	1.6	6	0.1
FP 1	0	0.0	0	0.0
FP 2	0	0.0	0	0.0
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	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0
OP 14	0	0.0	0	0.0
OP 15	0	0.0	0	0.0
OP 16	0	0.0	0	0.0
OP 17	0	0.0	0	0.0
OP 18	0	0.0	0	0.0
OP 19	0	0.0	0	0.0
OP 20	0	0.0	0	0.0
OP 21	0	0.0	0	0.0
OP 22	0	0.0	0	0.0
OP 23	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 26	0	0.0	0	0.0
OP 27	0	0.0	0	0.0
OP 28	0	0.0	0	0.0
OP 29	0	0.0	0	0.0
OP 30	0	0.0	0	0.0
OP 31	0	0.0	0	0.0
OP 32	0	0.0	0	0.0
OP 33	0	0.0	0	0.0
OP 34	0	0.0	0	0.0
OP 35	0	0.0	0	0.0
OP 36	0	0.0	0	0.0
OP 37	0	0.0	0	0.0
OP 38	0	0.0	0	0.0
OP 39	0	0.0	0	0.0
OP 40	0	0.0	0	0.0

PV: PV array 1 potential temporary after-image

Receptor results ordered by category of glare

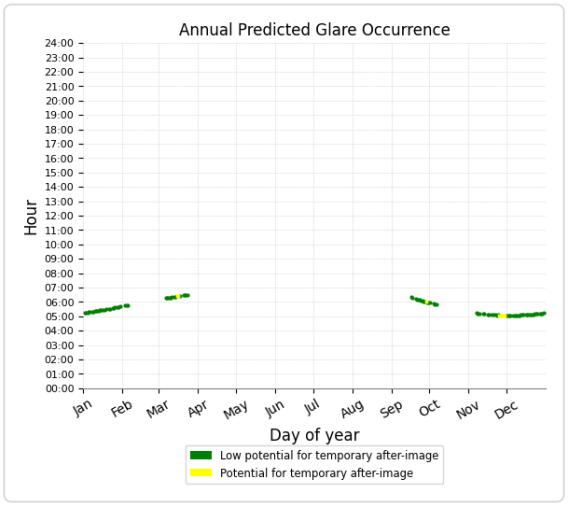
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Station Road	95	1.6	6	0.1
Eldonwood Road	0	0.0	0	0.0
Highgrove Ave	0	0.0	0	0.0
Hinuera Road	0	0.0	0	0.0
Jellicoe Rd - Peakedale Drive	0	0.0	0	0.0
FP 1	0	0.0	0	0.0
FP 2	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	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	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0
OP 14	0	0.0	0	0.0
OP 15	0	0.0	0	0.0
OP 16	0	0.0	0	0.0
OP 17	0	0.0	0	0.0
OP 18	0	0.0	0	0.0
OP 19	0	0.0	0	0.0
OP 20	0	0.0	0	0.0
OP 21	0	0.0	0	0.0
OP 22	0	0.0	0	0.0
OP 23	0	0.0	0	0.0
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 26	0	0.0	0	0.0
OP 27	0	0.0	0	0.0
OP 28	0	0.0	0	0.0
OP 29	0	0.0	0	0.0
OP 30	0	0.0	0	0.0

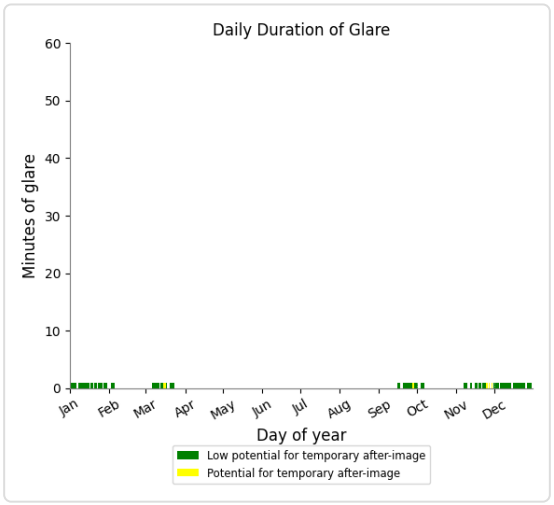
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 31	0	0.0	0	0.0
OP 32	0	0.0	0	0.0
OP 33	0	0.0	0	0.0
OP 34	0	0.0	0	0.0
OP 35	0	0.0	0	0.0
OP 36	0	0.0	0	0.0
OP 37	0	0.0	0	0.0
OP 38	0	0.0	0	0.0
OP 39	0	0.0	0	0.0
OP 40	0	0.0	0	0.0

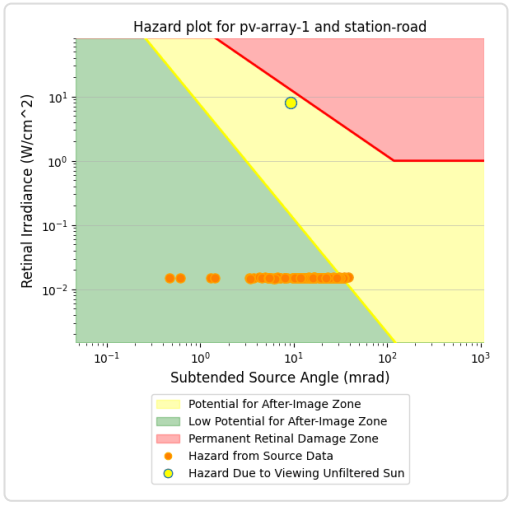
PV array 1 and Route: Station Road

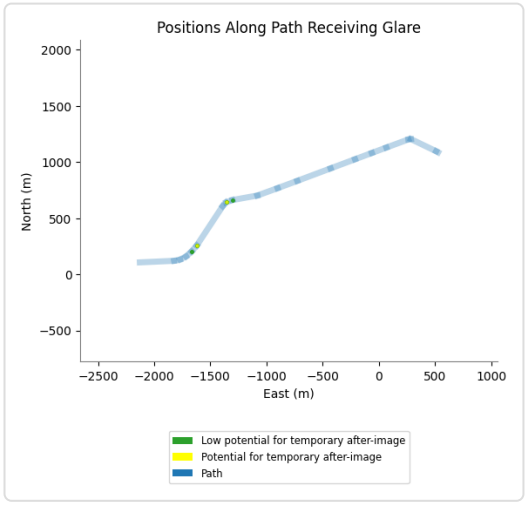
Yellow glare: 6 min.

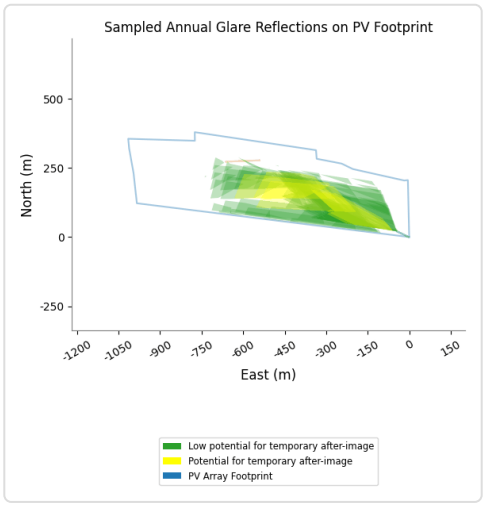
Green glare: 95 min.











PV array 1 and Route: Eldonwood Road

No glare found

PV array 1 and Route: Highgrove Ave

No glare found

PV array 1 and Route: Hinuera Road

No glare found

PV array 1 and Route: Jellicoe Rd - Peakedale Drive

No glare found

PV array 1 and FP: FP 1

No glare found

PV array 1 and FP: FP 2

No glare found

PV array 1 and OP 1

No glare found

PV array 1 and OP 2

No glare found

PV array 1 and OP 3

No glare found

PV array 1 and OP 4

No glare found

PV array 1 and OP 5

No glare found

PV array 1 and OP 6

No glare found

PV array 1 and OP 7

No glare found

PV array 1 and OP 8

No glare found

PV array 1 and OP 9

No glare found

PV array 1 and OP 10

No glare found

PV array 1 and OP 11

No glare found

PV array 1 and OP 12

No glare found

PV array 1 and OP 13

No glare found

PV array 1 and OP 14

No glare found

PV array 1 and OP 15

No glare found

PV array 1 and OP 16

No glare found

PV array 1 and OP 17

No glare found

PV array 1 and OP 18

No glare found

PV array 1 and OP 19

No glare found

PV array 1 and OP 20

No glare found

PV array 1 and OP 21

No glare found

PV array 1 and OP 22

No glare found

PV array 1 and OP 23

No glare found

PV array 1 and OP 24

No glare found

PV array 1 and OP 25

No glare found

PV array 1 and OP 26

No glare found

PV array 1 and OP 27

No glare found

PV array 1 and OP 28

No glare found

PV array 1 and OP 29

No glare found

PV array 1 and OP 30

No glare found

PV array 1 and OP 31

No glare found

PV array 1 and OP 32

No glare found

PV array 1 and OP 33

No glare found

PV array 1 and OP 34

No glare found

PV array 1 and OP 35

No glare found

PV array 1 and OP 36

No glare found

PV array 1 and OP 37

No glare found

PV array 1 and OP 38

No glare found

PV array 1 and OP 39

No glare found

PV array 1 and OP 40

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

Appendix B: ForgeSolar Glare Analysis Results with Planting Barrier

FORGESOLAR GLARE ANALYSIS

Project: **Matamata Stage - 2**

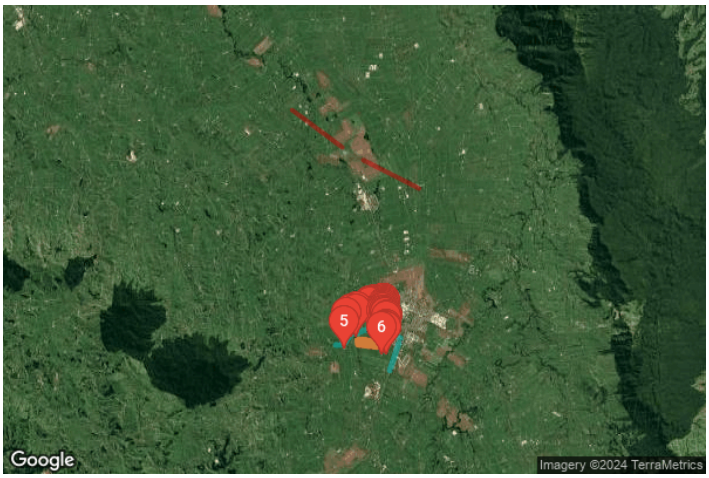
High-level Glint & Glare analysis for Stage - 2 Solar Farm for Maven Associates

Site configuration: **Matamata Stage - 2**

Client: Maven Associates

Created 15 Oct, 2024
Updated 17 Oct, 2024
Time-step 1 minute
Timezone offset UTC12
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Category 10 MW to 100 MW
Site ID 131577.22403

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 low potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	SA tracking	SA tracking	27	0.5	0	0.0	56,990,000.0

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
Eldonwood Road	0	0.0	0	0.0
Highgrove Ave	0	0.0	0	0.0
Hinuera Road	0	0.0	0	0.0
Jellicoe Rd - Peakedale Drive	0	0.0	0	0.0
Station Road	27	0.5	0	0.0
FP 1	0	0.0	0	0.0
FP 2	0	0.0	0	0.0
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

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
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	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0
OP 14	0	0.0	0	0.0
OP 15	0	0.0	0	0.0
OP 16	0	0.0	0	0.0
OP 17	0	0.0	0	0.0
OP 18	0	0.0	0	0.0
OP 19	0	0.0	0	0.0
OP 20	0	0.0	0	0.0
OP 21	0	0.0	0	0.0
OP 22	0	0.0	0	0.0
OP 23	0	0.0	0	0.0
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 26	0	0.0	0	0.0
OP 27	0	0.0	0	0.0
OP 28	0	0.0	0	0.0
OP 29	0	0.0	0	0.0
OP 30	0	0.0	0	0.0
OP 31	0	0.0	0	0.0
OP 32	0	0.0	0	0.0
OP 33	0	0.0	0	0.0
OP 34	0	0.0	0	0.0
OP 35	0	0.0	0	0.0
OP 36	0	0.0	0	0.0
OP 37	0	0.0	0	0.0
OP 38	0	0.0	0	0.0
OP 39	0	0.0	0	0.0
OP 40	0	0.0	0	0.0

Component Data

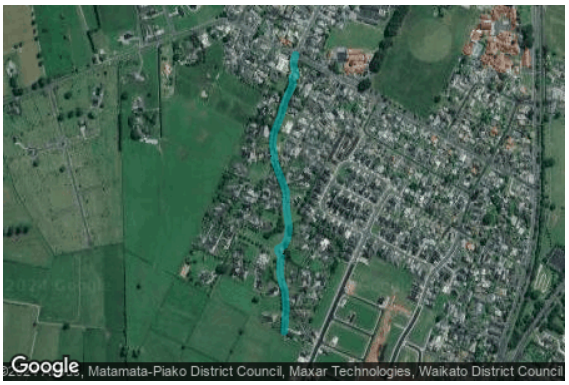
PV Arrays

Name: PV array 1
Description: Solar Farm Stage - 2
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 0.0°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.48
Rated power: 20863.0 kW
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	-37.827269	175.757125	65.00	1.40	66.40
2	-37.825417	175.757071	64.00	1.40	65.40
3	-37.825430	175.756921	64.00	1.40	65.40
4	-37.825057	175.754813	63.00	1.40	64.40
5	-37.824879	175.754351	63.00	1.40	64.40
6	-37.824722	175.753327	62.00	1.40	63.40
7	-37.824442	175.753300	62.00	1.40	63.40
8	-37.823856	175.748324	60.00	1.40	61.40
9	-37.824136	175.748330	61.00	1.40	62.40
10	-37.824072	175.745594	61.00	1.40	62.40
11	-37.824382	175.745631	61.00	1.40	62.40
12	-37.825191	175.745814	62.00	1.40	63.40
13	-37.826170	175.745949	63.00	1.40	64.40

Route Receptors

Name: Eldonwood Road
Path type: One-way (toward increasing index)
Observer view angle: 50.0°

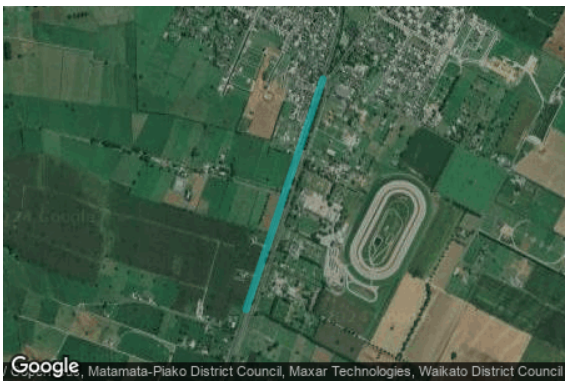


Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.817355	175.762833	64.00	1.50	65.50
2	-37.817578	175.762750	64.00	1.50	65.50
3	-37.817922	175.762844	64.00	1.50	65.50
4	-37.817964	175.762718	64.00	1.50	65.50
5	-37.818046	175.762715	64.00	1.50	65.50
6	-37.818129	175.762750	64.00	1.50	65.50
7	-37.818572	175.762484	64.00	1.50	65.50
8	-37.819006	175.762323	64.00	1.50	65.50
9	-37.819494	175.762074	64.00	1.50	65.50
10	-37.819765	175.762047	64.00	1.50	65.50
11	-37.820218	175.762109	64.00	1.50	65.50
12	-37.820483	175.762227	64.00	1.50	65.50
13	-37.821049	175.762503	64.62	1.50	66.12
14	-37.821383	175.762500	65.00	1.50	66.50
15	-37.821873	175.762575	65.00	1.50	66.50
16	-37.822021	175.762600	65.00	1.50	66.50
17	-37.822288	175.762562	65.00	1.50	66.50
18	-37.822509	175.762444	65.00	1.50	66.50
19	-37.822595	175.762227	65.00	1.50	66.50
20	-37.822680	175.762235	65.00	1.50	66.50
21	-37.822788	175.762331	65.00	1.50	66.50
22	-37.823203	175.762288	65.00	1.50	66.50
23	-37.823449	175.762334	65.00	1.50	66.50
24	-37.823714	175.762457	65.00	1.50	66.50
25	-37.824207	175.762502	66.00	1.50	67.50
26	-37.824838	175.762443	66.00	1.50	67.50

Name: Highgrove Ave
Path type: One-way (toward increasing index)
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.818141	175.754360	60.00	1.50	61.50
2	-37.819654	175.754851	60.00	1.50	61.50
3	-37.819720	175.755072	61.00	1.50	62.50
4	-37.819906	175.754939	61.00	1.50	62.50
5	-37.822470	175.755806	62.00	1.50	63.50

Name: Hinuera Road
Path type: Two-way
Observer view angle: 50.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.825577	175.769801	67.00	1.50	68.50
2	-37.837445	175.764788	68.00	1.50	69.50
3	-37.838072	175.764525	68.00	1.50	69.50

Name: Jellicoe Rd - Peakedale Drive
Path type: One-way (toward increasing index)
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.826398	175.762982	66.57	1.50	68.07
2	-37.821690	175.765546	66.00	1.50	67.50
3	-37.821071	175.766050	66.00	1.50	67.50
4	-37.821078	175.766199	66.00	1.50	67.50
5	-37.823123	175.770719	67.00	1.50	68.50
6	-37.823136	175.770794	67.00	1.50	68.50

Name: Station Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-37.826315	175.732966	76.00	1.50	77.50
2	-37.826186	175.736431	73.00	1.50	74.50
3	-37.826087	175.737032	72.00	1.50	73.50
4	-37.825837	175.737636	71.00	1.50	72.50
5	-37.825439	175.738194	70.00	1.50	71.50
6	-37.824958	175.738719	70.00	1.50	71.50
7	-37.821801	175.741342	64.00	1.50	65.50
8	-37.821494	175.741690	63.00	1.50	64.50
9	-37.821312	175.742323	62.00	1.50	63.50
10	-37.820947	175.744850	59.00	1.50	60.50
11	-37.820356	175.746897	58.00	1.50	59.50
12	-37.819772	175.748884	58.00	1.50	59.50
13	-37.818769	175.752256	59.00	1.50	60.50
14	-37.818037	175.754723	60.00	1.50	61.50
15	-37.817531	175.756426	61.00	1.50	62.50
16	-37.817096	175.757895	61.00	1.50	62.50
17	-37.816446	175.760118	63.00	1.50	64.50
18	-37.816421	175.760384	63.00	1.50	64.50
19	-37.817394	175.762930	64.00	1.50	65.50
20	-37.817481	175.763126	64.00	1.50	65.50

Flight Path Receptors

Name: FP 1
Description:
Threshold height: 15 m
Direction: 126.6°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-37.734826	175.736655	49.00	15.24	64.24
Two-mile	-37.717584	175.707274	43.00	189.92	232.92

Name: FP 2
Description:
Threshold height: 15 m
Direction: 296.9°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-37.740754	175.748994	50.00	15.24	65.24
Two-mile	-37.753853	175.781626	50.00	183.92	233.92

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-37.821506	175.745846	59.00	1.70
OP 2	2	-37.822769	175.744894	60.00	1.70
OP 3	3	-37.822562	175.741806	64.00	1.70
OP 4	4	-37.824595	175.739427	68.00	1.70
OP 5	5	-37.828128	175.738313	71.00	1.70
OP 6	6	-37.830802	175.760130	67.00	1.70
OP 7	7	-37.830744	175.762974	68.00	1.70
OP 8	8	-37.829795	175.762964	68.00	1.70
OP 9	9	-37.830395	175.761841	68.00	1.70
OP 10	10	-37.818901	175.753203	60.00	1.70
OP 11	11	-37.819646	175.753225	60.00	1.70
OP 12	12	-37.819278	175.755655	61.00	1.70
OP 13	13	-37.818340	175.756083	61.00	1.70
OP 14	14	-37.819182	175.757474	62.00	1.70
OP 15	15	-37.824534	175.761959	65.79	1.70
OP 16	16	-37.823805	175.762050	65.00	1.70
OP 17	17	-37.823517	175.761616	65.00	1.70
OP 18	18	-37.823190	175.761627	65.00	1.70
OP 19	19	-37.823339	175.761015	65.00	1.70
OP 20	20	-37.823250	175.760682	65.00	1.70
OP 21	21	-37.823330	175.759733	64.00	1.70
OP 22	22	-37.822436	175.760441	64.00	1.70
OP 23	23	-37.822411	175.760071	64.00	1.70
OP 24	24	-37.822262	175.759556	64.00	1.70
OP 25	25	-37.821572	175.760171	64.00	1.70
OP 26	26	-37.820964	175.760718	64.00	1.70
OP 27	27	-37.820438	175.760997	64.00	1.70
OP 28	28	-37.820027	175.761072	64.00	1.70
OP 29	29	-37.819667	175.761281	64.00	1.70
OP 30	30	-37.819315	175.761399	64.00	1.70
OP 31	31	-37.818845	175.761705	64.00	1.70
OP 32	32	-37.818421	175.761817	64.00	1.70
OP 33	33	-37.818196	175.761614	64.00	1.70
OP 34	34	-37.818074	175.761426	63.00	1.70
OP 35	35	-37.817993	175.761270	63.00	1.70
OP 36	36	-37.817896	175.761034	63.00	1.70
OP 37	37	-37.817840	175.760911	63.00	1.70
OP 38	38	-37.817768	175.760712	63.00	1.70
OP 39	39	-37.826116	175.762772	66.00	1.70
OP 40	40	-37.825505	175.763115	66.00	1.70

Obstruction Components

Name: Planting Strip
Top height: 2.5 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-37.824072	175.745586	61.00
2	-37.826181	175.745933	63.00
3	-37.827281	175.757140	65.00
4	-37.825405	175.757079	64.00
5	-37.824855	175.754360	63.00
6	-37.824703	175.753347	62.00
7	-37.824419	175.753309	62.00
8	-37.823850	175.748314	60.00
9	-37.824131	175.748322	61.00
10	-37.824067	175.745582	61.00

Name: Planting Strip - Barrier
Top height: 5.0 m

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)
1	-37.824105	175.750862	61.00
2	-37.823806	175.748283	60.00
3	-37.824100	175.748291	61.00
4	-37.824038	175.745531	61.00
5	-37.825854	175.745826	62.06

Glare Analysis Results

Summary of Results

Glare with low potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	SA tracking	SA tracking	27	0.5	0	0.0	56,990,000.0

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
Eldonwood Road	0	0.0	0	0.0
Highgrove Ave	0	0.0	0	0.0
Hinuera Road	0	0.0	0	0.0
Jellicoe Rd - Peakedale Drive	0	0.0	0	0.0
Station Road	27	0.5	0	0.0
FP 1	0	0.0	0	0.0
FP 2	0	0.0	0	0.0
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	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0
OP 14	0	0.0	0	0.0
OP 15	0	0.0	0	0.0
OP 16	0	0.0	0	0.0
OP 17	0	0.0	0	0.0
OP 18	0	0.0	0	0.0
OP 19	0	0.0	0	0.0
OP 20	0	0.0	0	0.0
OP 21	0	0.0	0	0.0
OP 22	0	0.0	0	0.0
OP 23	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 26	0	0.0	0	0.0
OP 27	0	0.0	0	0.0
OP 28	0	0.0	0	0.0
OP 29	0	0.0	0	0.0
OP 30	0	0.0	0	0.0
OP 31	0	0.0	0	0.0
OP 32	0	0.0	0	0.0
OP 33	0	0.0	0	0.0
OP 34	0	0.0	0	0.0
OP 35	0	0.0	0	0.0
OP 36	0	0.0	0	0.0
OP 37	0	0.0	0	0.0
OP 38	0	0.0	0	0.0
OP 39	0	0.0	0	0.0
OP 40	0	0.0	0	0.0

PV: PV array 1 low potential for temporary after-image

Receptor results ordered by category of glare

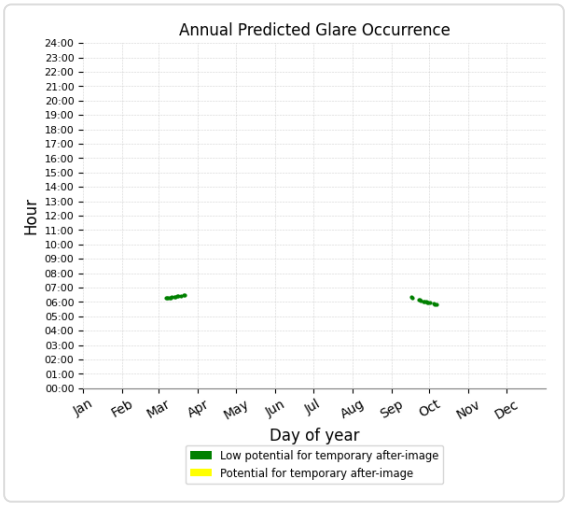
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Station Road	27	0.5	0	0.0
Eldonwood Road	0	0.0	0	0.0
Highgrove Ave	0	0.0	0	0.0
Hinuera Road	0	0.0	0	0.0
Jellicoe Rd - Peakedale Drive	0	0.0	0	0.0
FP 1	0	0.0	0	0.0
FP 2	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	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	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0
OP 14	0	0.0	0	0.0
OP 15	0	0.0	0	0.0
OP 16	0	0.0	0	0.0
OP 17	0	0.0	0	0.0
OP 18	0	0.0	0	0.0
OP 19	0	0.0	0	0.0
OP 20	0	0.0	0	0.0
OP 21	0	0.0	0	0.0
OP 22	0	0.0	0	0.0
OP 23	0	0.0	0	0.0
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 26	0	0.0	0	0.0
OP 27	0	0.0	0	0.0
OP 28	0	0.0	0	0.0
OP 29	0	0.0	0	0.0
OP 30	0	0.0	0	0.0

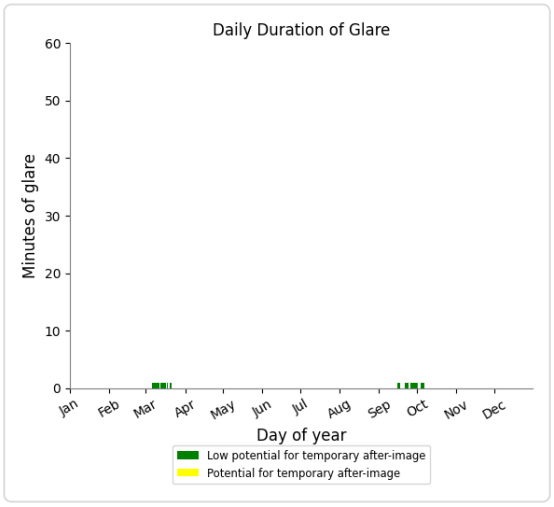
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 31	0	0.0	0	0.0
OP 32	0	0.0	0	0.0
OP 33	0	0.0	0	0.0
OP 34	0	0.0	0	0.0
OP 35	0	0.0	0	0.0
OP 36	0	0.0	0	0.0
OP 37	0	0.0	0	0.0
OP 38	0	0.0	0	0.0
OP 39	0	0.0	0	0.0
OP 40	0	0.0	0	0.0

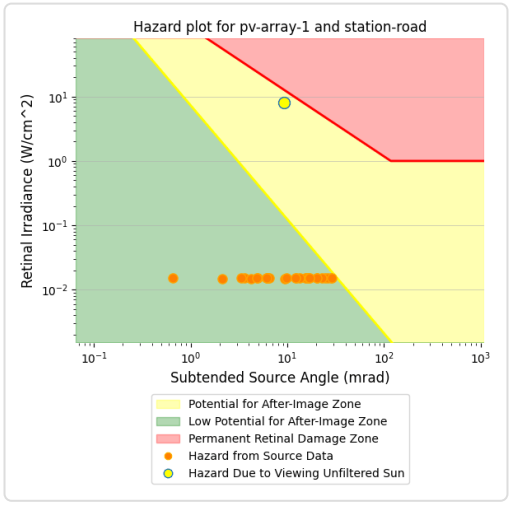
PV array 1 and Route: Station Road

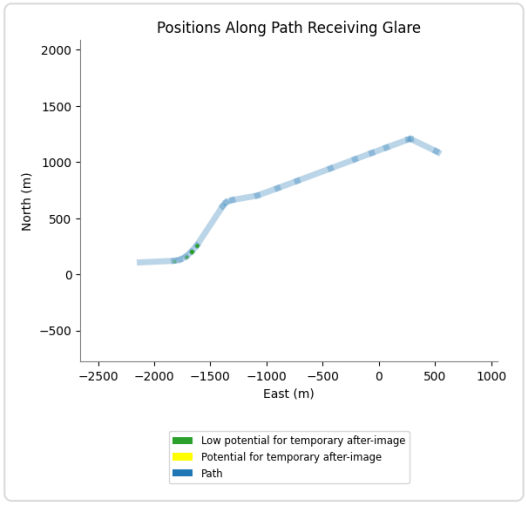
Yellow glare: none

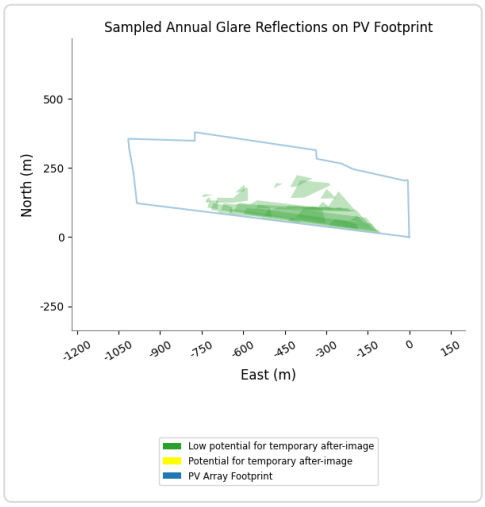
Green glare: 27 min.











PV array 1 and Route: Eldonwood Road

No glare found

PV array 1 and Route: Highgrove Ave

No glare found

PV array 1 and Route: Hinuera Road

No glare found

PV array 1 and Route: Jellicoe Rd - Peakedale Drive

No glare found

PV array 1 and FP: FP 1

No glare found

PV array 1 and FP: FP 2

No glare found

PV array 1 and OP 1

No glare found

PV array 1 and OP 2

No glare found

PV array 1 and OP 3

No glare found

PV array 1 and OP 4

No glare found

PV array 1 and OP 5

No glare found

PV array 1 and OP 6

No glare found

PV array 1 and OP 7

No glare found

PV array 1 and OP 8

No glare found

PV array 1 and OP 9

No glare found

PV array 1 and OP 10

No glare found

PV array 1 and OP 11

No glare found

PV array 1 and OP 12

No glare found

PV array 1 and OP 13

No glare found

PV array 1 and OP 14

No glare found

PV array 1 and OP 15

No glare found

PV array 1 and OP 16

No glare found

PV array 1 and OP 17

No glare found

PV array 1 and OP 18

No glare found

PV array 1 and OP 19

No glare found

PV array 1 and OP 20

No glare found

PV array 1 and OP 21

No glare found

PV array 1 and OP 22

No glare found

PV array 1 and OP 23

No glare found

PV array 1 and OP 24

No glare found

PV array 1 and OP 25

No glare found

PV array 1 and OP 26

No glare found

PV array 1 and OP 27

No glare found

PV array 1 and OP 28

No glare found

PV array 1 and OP 29

No glare found

PV array 1 and OP 30

No glare found

PV array 1 and OP 31

No glare found

PV array 1 and OP 32

No glare found

PV array 1 and OP 33

No glare found

PV array 1 and OP 34

No glare found

PV array 1 and OP 35

No glare found

PV array 1 and OP 36

No glare found

PV array 1 and OP 37

No glare found

PV array 1 and OP 38

No glare found

PV array 1 and OP 39

No glare found

PV array 1 and OP 40

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