APPENDIX 8 GLINT AND GLARE ANAYLYSIS, HOOD AERODROME

FORGESOLAR GLARE ANALYSIS

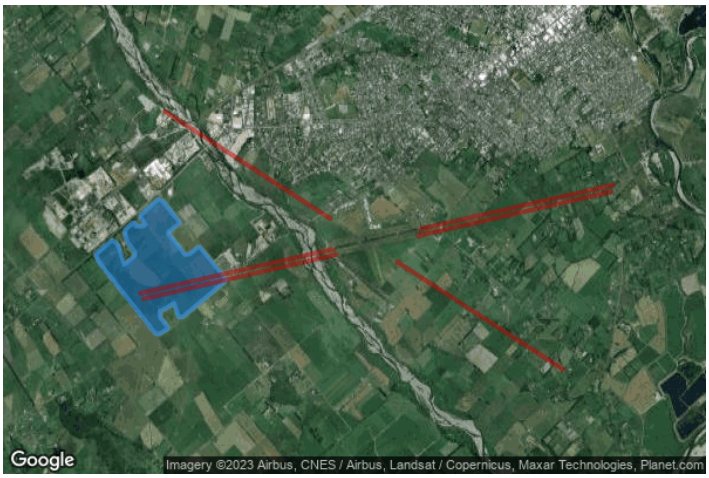
Project: **Masterton Solar**
Proposed 90MW Solar Farm SW of Masterton

Site configuration: **Masterton SAT 2939 Flightpaths**

Site description: Masterton SAT Config Oct R2

Created 02 Nov, 2023
Updated 02 Nov, 2023
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 104505.17313

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
Masterton	SA tracking	SA tracking	42,749	712.5	39,410	656.8	149,400.0	1,207,838

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
Runway 06 - Grass	21,392	356.5	19,074	317.9
Runway 06 - Sealed	21,357	355.9	20,336	338.9
Runway 10 - Crosswind	0	0.0	0	0.0
Runway 24 - Grass	0	0.0	0	0.0
Runway 24 - Sealed	0	0.0	0	0.0
Runway 28 - Crosswind	0	0.0	0	0.0

Component Data

PV Arrays

Name: Masterton
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 180.0°
Max tracking angle: 50.0°
Resting angle: 5.0°
Ground Coverage Ratio: 0.5
Rated power: 60.0 kW
Panel material: Light textured 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	-40.976347	175.592950	117.58	2.00	119.58
2	-40.974844	175.595268	118.80	2.00	120.80
3	-40.974844	175.595294	118.78	2.00	120.78
4	-40.975017	175.595538	118.79	2.00	120.79
5	-40.975191	175.595961	118.79	2.00	120.79
6	-40.975547	175.596272	118.49	2.00	120.49
7	-40.977559	175.597016	117.64	2.00	119.64
8	-40.976577	175.598604	118.66	2.00	120.66
9	-40.976219	175.598650	119.06	2.00	121.06
10	-40.975160	175.597598	120.77	2.00	122.77
11	-40.974440	175.597213	119.69	2.00	121.69
12	-40.973707	175.597184	120.08	2.00	122.08
13	-40.972957	175.598284	120.49	2.00	122.49
14	-40.972947	175.598725	120.14	2.00	122.14
15	-40.973315	175.598740	120.65	2.00	122.65
16	-40.973291	175.599808	120.01	2.00	122.01
17	-40.973105	175.600132	120.38	2.00	122.38
18	-40.972395	175.599450	120.95	2.00	122.95
19	-40.972206	175.599449	121.02	2.00	123.02
20	-40.972025	175.599554	121.08	2.00	123.08
21	-40.970340	175.601984	121.66	2.00	123.66
22	-40.970337	175.602128	121.64	2.00	123.64
23	-40.970503	175.602670	121.00	2.00	123.00
24	-40.972808	175.605137	118.95	2.00	120.95
25	-40.972992	175.605144	118.81	2.00	120.81
26	-40.973930	175.603636	118.84	2.00	120.84
27	-40.974111	175.603525	118.81	2.00	120.81
28	-40.976412	175.605933	117.02	2.00	119.02
29	-40.976396	175.606619	116.89	2.00	118.89
30	-40.975643	175.607837	116.80	2.00	118.80
31	-40.975636	175.608160	116.62	2.00	118.62
32	-40.979002	175.611799	114.60	2.00	116.60
33	-40.979183	175.611925	114.44	2.00	116.44
34	-40.979367	175.611932	114.25	2.00	116.25
35	-40.983314	175.605670	114.80	2.00	116.80
36	-40.983330	175.604991	115.24	2.00	117.24
37	-40.981822	175.604349	116.15	2.00	118.15
38	-40.982660	175.602541	115.65	2.00	117.65
39	-40.982665	175.602316	115.83	2.00	117.83
40	-40.983390	175.602345	114.71	2.00	116.71
41	-40.984447	175.603456	115.11	2.00	117.11
42	-40.984636	175.603463	114.85	2.00	116.85
43	-40.985211	175.602238	114.90	2.00	116.90
44	-40.985224	175.601678	114.93	2.00	116.93
45	-40.977429	175.593468	116.32	2.00	118.32
46	-40.976710	175.592964	117.22	2.00	119.22

Flight Path Receptors

Name: Runway 06 - Grass
Description: None
Threshold height: 0 m
Direction: 257.0°
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	-40.976467	175.628108	109.20	0.00	109.20
Two-mile	-40.981336	175.599922	109.20	168.70	277.90

Name: Runway 06 - Sealed
Description: None
Threshold height: 0 m
Direction: 257.0°
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	-40.975853	175.627621	110.50	0.00	110.50
Two-mile	-40.980722	175.599436	110.50	168.70	279.20

Name: Runway 10 - Crosswind
Description: None
Threshold height: 0 m
Direction: 302.0°
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	-40.972492	175.627274	110.60	0.00	110.60
Two-mile	-40.960624	175.603005	110.60	168.70	279.30

Name: Runway 24 - Grass
Description: None
Threshold height: 0 m
Direction: 77.0°
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	-40.974378	175.640197	103.70	0.00	103.70
Two-mile	-40.969509	175.668382	103.70	168.70	272.40

Name: Runway 24 - Sealed
Description: None
Threshold height: 0 m
Direction: 77.0°
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	-40.973627	175.640504	104.40	0.00	104.40
Two-mile	-40.968754	175.668707	104.40	168.70	273.10

Name: Runway 28 - Crosswind
Description: None
Threshold height: 0 m
Direction: 122.0°
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	-40.977277	175.637062	104.30	0.00	104.30
Two-mile	-40.989142	175.661331	104.30	168.70	273.00

Glare Analysis Results

Summary of Results

Glare with potential for temporary after-image predicted

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	°	°	min	hr	min	hr	kWh	cd/m^2
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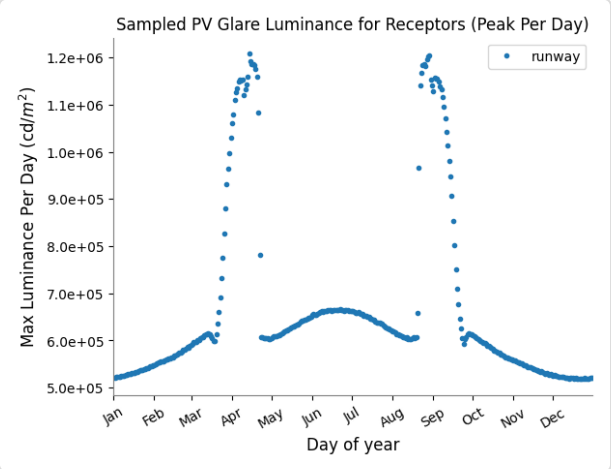
Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Runway 06 - Grass	21,392	356.5	19,074	317.9
Runway 06 - Sealed	21,357	355.9	20,336	338.9
Runway 10 - Crosswind	0	0.0	0	0.0
Runway 24 - Grass	0	0.0	0	0.0
Runway 24 - Sealed	0	0.0	0	0.0
Runway 28 - Crosswind	0	0.0	0	0.0

PV: Masterton potential temporary after-image

Receptor results ordered by category of glare

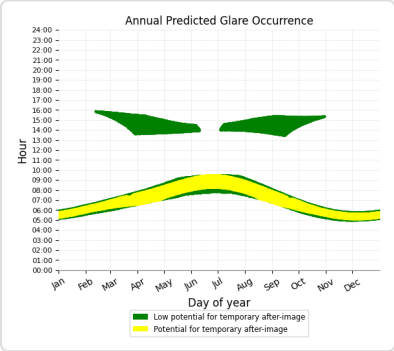
Receptor	Annual Green Glare		Annual Yellow Glare		Peak Luminance
	min	hr	min	hr	cd/m^2
Runway 06 - Grass	21,392	356.5	19,074	317.9	1,199,721
Runway 06 - Sealed	21,357	355.9	20,336	338.9	1,207,838
Runway 10 - Crosswind	0	0.0	0	0.0	0
Runway 24 - Grass	0	0.0	0	0.0	0
Runway 24 - Sealed	0	0.0	0	0.0	0
Runway 28 - Crosswind	0	0.0	0	0.0	0

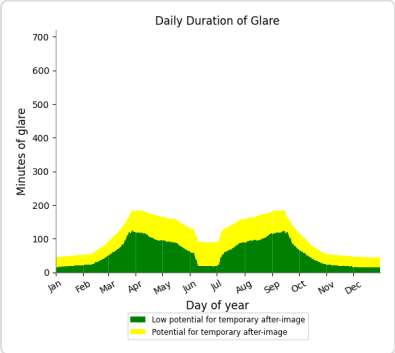


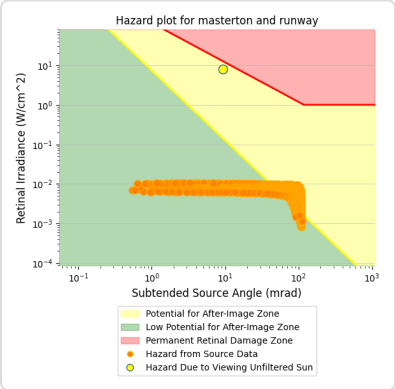
Masterton and FP: Runway 06 - Grass

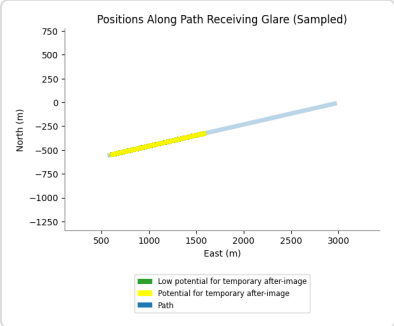
Yellow glare: 19,074 min.

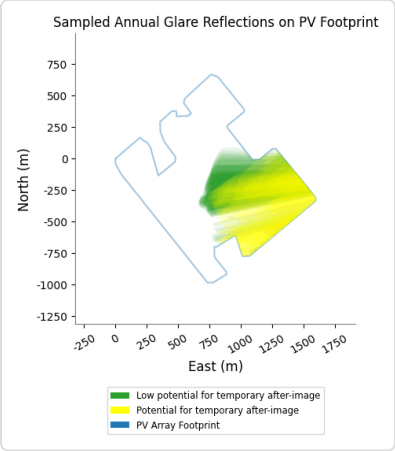
Green glare: 21,392 min.

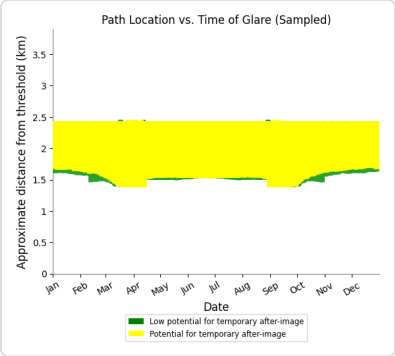


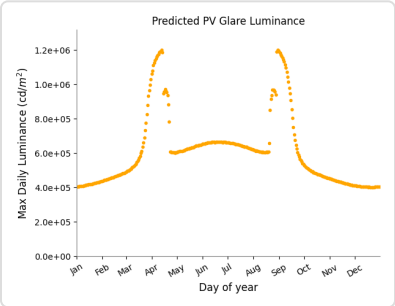






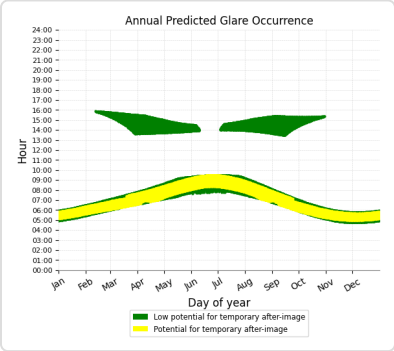


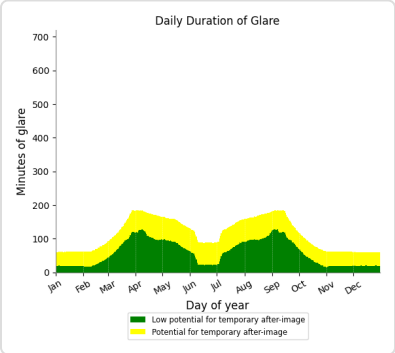


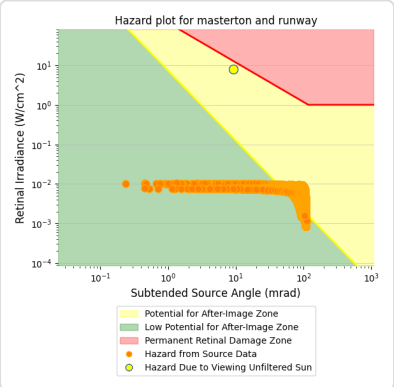


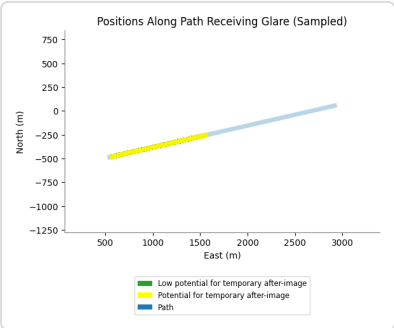
Masterton and FP: Runway 06 - Sealed

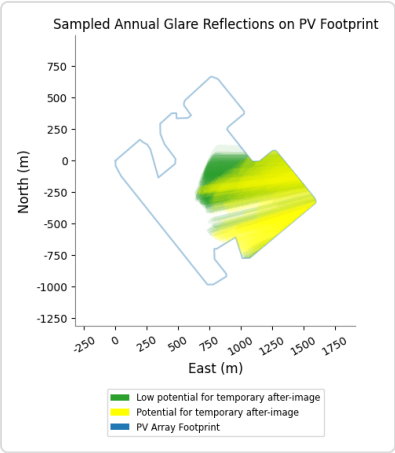
Yellow glare: 20,336 min.
Green glare: 21,357 min.

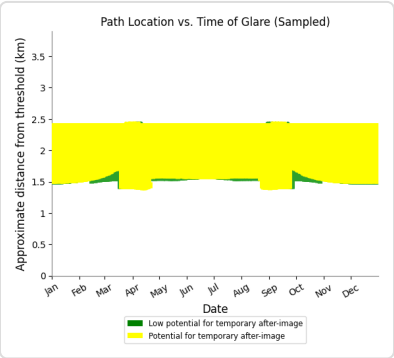


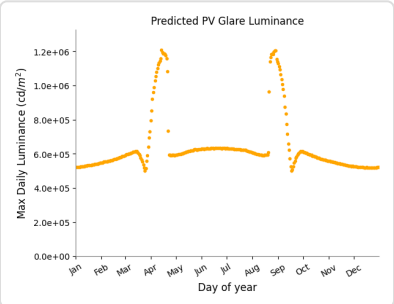












Masterton and FP: Runway 10 - Crosswind

No glare found

Masterton and FP: Runway 24 - Grass

No glare found

Masterton and FP: Runway 24 - Sealed

No glare found

Masterton and FP: Runway 28 - Crosswind

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

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