



Crawford & Associates Engineering & Land Surveying, PC

PRESIDENT
Jennifer Crawford P.E.

PRINCIPAL EMERITUS
David J. Crawford, P.E.

Hudson Office – One Hudson City Centre, Suite 300 • Hudson, NY 12534
Tel: (518) 828-2700 • Fax: (518) 828-2723 • www.crawfordandassociates.com

ASSOCIATES
Andrew P. Aubin, P.E., LEED
Daniel J. Russell, L.S.
Donna M. Verna, P.E.

E-Mail:

June 6, 2024

Attn: Chris Brand, Planning Board Chair
Town of Marlborough
Planning Board
21 Milton Turnpike, Suite 200
Milton, NY 12547

**RE: ELP MarlboroughSolar
Solar Glare Analysis
C&A #4996.26**

Dear Mr. Brand:

As requested, C&A has evaluated the potential for glare at the proposed solar facility to be located at 335 Bingham Road in the Town of Marlborough, NY. The facility is proposed as a south facing array with a fixed tilt of 25°. As explained in more detail below, our analysis shows that with existing/proposed screening to the east and west of the array, observers outside of the facility should not expect to observe glare from the proposed solar facility.

To analyze conditions for the specifics of this project, a ForgeSolar analysis was conducted focusing on observation point receptors for residences/businesses surrounding the proposed project. Locations of the observation point (OP) receptors can be seen in the attached ForgeSolar Glare Analysis and in Figure 1 below.



Figure 1: Locations of Observation Point (OP) receptors and PV Arrays

The elevations of the OP receptors are shown in the table below. All OP receptors are assumed to be 6 ft above ground elevation.

OP #	Ground Elevation (ft)
OP 1	554.8
OP 2	524.5
OP 3	563.1
OP 4	626.1
OP 5	687.4

Figure 2: Observation Point Receptor Ground Elevations

Based on the attached analysis, where the facility is visible from the east (OP 3), there is potential for yellow glare (glare with potential for after-image)¹ emanating from the west for less than 15 minutes during the evening in the spring and summer. Where the facility is visible from the west (OP 1 & 4) there is potential for green glare (glare with low potential for after-image)¹ emanating from the east for less than or about 20 minutes during the morning in the spring and summer. The remaining receptors (OP 2 & 5) are not predicted to have any glare potential, OP 2 due to it being located north of, and at a lower elevation than the facility, OP 5 due to it being located directly south the facility.

Although the potential impact to residences is likely to be similar to natural glare from a rising / setting sun or reflection over a glassy body of water, the Applicant is committed to minimizing impacts associated with the array. While the attached analysis does not account for vegetative screening, the actual project installation proposes robust landscape plantings with a mix of evergreen and deciduous species, which would provide year-round screening. This would be further enhanced by deciduous leaf-on conditions during non-winter months, during the times when glare could occur. It is anticipated that vegetative screening would either obscure or break up the reflected light into “glint” (a non-continuous light source), particularly when viewed by a moving subject, thereby minimizing any potential impacts.

Please feel free to contact me at (518) 828-2700 x 1128 or jcrawford@crawfordandassociates.com with any questions or comments.

Sincerely,
**Crawford & Associates Engineering and
Land Surveying, P.C.**



Jennifer Crawford, PE
President

¹ Ho, C. K., Ghanbari, C. M., and Diver, R. B., 2011, Methodology to Assess Potential Glint and Glare Hazards from Concentrating Solar Power Plants: Analytical Models and Experimental Validation, *ASME J. Sol. Energy Eng.*, 133.

FORGESOLAR GLARE ANALYSIS

Project: **ELP Marlborough**

5 MW-AC Project, Fixed Tilt

Site configuration: **ELP Marlborough**

Created 31 May, 2024

Updated 05 Jun, 2024

Time-step 1 minute

Timezone offset UTC-5

Minimum sun altitude 0.0 deg

DNI peaks at 1,000.0 W/m²

Category 5 MW to 10 MW

Site ID 120669.20482

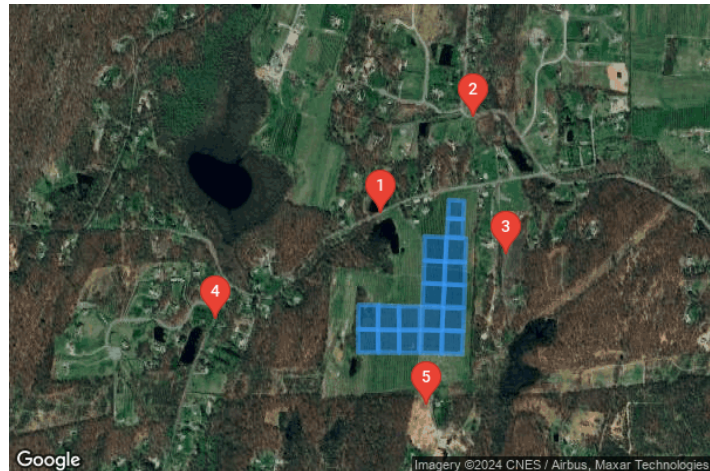
Ocular transmission coefficient 0.5

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 kWh
			min	hr	min	hr	
PV array 1	25.0	180.0	0	0.0	0	0.0	-
PV array 10	25.0	180.0	45	0.8	0	0.0	-
PV array 11	25.0	180.0	656	10.9	0	0.0	-
PV array 12	25.0	180.0	0	0.0	0	0.0	-
PV array 13	25.0	180.0	1,105	18.4	0	0.0	-
PV array 14	25.0	180.0	866	14.4	0	0.0	-
PV array 15	25.0	180.0	3,363	56.0	132	2.2	-
PV array 16	25.0	180.0	3,672	61.2	878	14.6	-
PV array 17	25.0	180.0	3,307	55.1	250	4.2	-
PV array 18	25.0	180.0	2,689	44.8	0	0.0	-
PV array 2	25.0	180.0	0	0.0	0	0.0	-
PV array 3	25.0	180.0	0	0.0	0	0.0	-
PV array 4	25.0	180.0	0	0.0	0	0.0	-
PV array 5	25.0	180.0	0	0.0	0	0.0	-
PV array 6	25.0	180.0	648	10.8	0	0.0	-
PV array 7	25.0	180.0	94	1.6	0	0.0	-
PV array 8	25.0	180.0	102	1.7	0	0.0	-
PV array 9	25.0	180.0	86	1.4	0	0.0	-

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

OP 1	1,145	19.1	0	0.0
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Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 2	0	0.0	0	0.0
OP 3	4,828	80.5	1,260	21.0
OP 4	10,660	177.7	0	0.0
OP 5	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array 1

Axis tracking: Fixed (no rotation)

Tilt: 25.0°

Orientation: 180.0°

Rated power: -

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	41.585519	-74.020288	633.00	4.20	637.20
2	41.585507	-74.019559	633.00	4.20	637.20
3	41.584887	-74.019545	633.00	4.20	637.20
4	41.584889	-74.020283	633.00	4.20	637.20

Name: PV array 10

Axis tracking: Fixed (no rotation)

Tilt: 25.0°

Orientation: 180.0°

Rated power: -

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	41.586104	-74.017166	645.00	4.20	649.20
2	41.586088	-74.016394	645.00	4.20	649.20
3	41.585474	-74.016421	645.00	4.20	649.20
4	41.585502	-74.017198	645.00	4.20	649.20

Name: PV array 11

Axis tracking: Fixed (no rotation)

Tilt: 25.0°

Orientation: 180.0°

Rated power: -

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	41.586780	-74.017888	620.00	4.20	624.20
2	41.586750	-74.017118	620.00	4.20	624.20
3	41.586140	-74.017177	620.00	4.20	624.20
4	41.586184	-74.017917	620.00	4.20	624.20

Name: PV array 12

Axis tracking: Fixed (no rotation)

Tilt: 25.0°

Orientation: 180.0°

Rated power: -

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	41.586748	-74.017105	628.00	4.20	632.20
2	41.586722	-74.016367	628.00	4.20	632.20
3	41.586124	-74.016394	628.00	4.20	632.20
4	41.586148	-74.017150	628.00	4.20	632.20

Name: PV array 13

Axis tracking: Fixed (no rotation)

Tilt: 25.0°

Orientation: 180.0°

Rated power: -

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	41.587400	-74.017853	597.00	4.20	601.20
2	41.587370	-74.017096	597.00	4.20	601.20
3	41.586762	-74.017126	597.00	4.20	601.20
4	41.586786	-74.017880	597.00	4.20	601.20

Name: PV array 14

Axis tracking: Fixed (no rotation)

Tilt: 25.0°

Orientation: 180.0°

Rated power: -

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	41.587368	-74.017088	603.00	4.20	607.20
2	41.587351	-74.016360	603.00	4.20	607.20
3	41.586730	-74.016364	603.00	4.20	607.20
4	41.586760	-74.017113	603.00	4.20	607.20

Name: PV array 15

Axis tracking: Fixed (no rotation)

Tilt: 25.0°

Orientation: 180.0°

Rated power: -

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	41.588065	-74.017849	580.00	4.20	584.20
2	41.588032	-74.017050	580.00	4.20	584.20
3	41.587373	-74.017087	580.00	4.20	584.20
4	41.587405	-74.017851	580.00	4.20	584.20

Name: PV array 16

Axis tracking: Fixed (no rotation)

Tilt: 25.0°

Orientation: 180.0°

Rated power: -

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	41.588032	-74.017034	580.00	4.20	584.20
2	41.588000	-74.016320	580.00	4.20	584.20
3	41.587361	-74.016357	580.00	4.20	584.20
4	41.587373	-74.017077	580.00	4.20	584.20

Name: PV array 17

Axis tracking: Fixed (no rotation)

Tilt: 25.0°

Orientation: 180.0°

Rated power: -

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	41.588548	-74.016994	560.00	4.20	564.20
2	41.588526	-74.016420	560.00	4.20	564.20
3	41.588026	-74.016444	560.00	4.20	564.20
4	41.588047	-74.017042	560.00	4.20	564.20

Name: PV array 18

Axis tracking: Fixed (no rotation)

Tilt: 25.0°

Orientation: 180.0°

Rated power: -

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	41.589058	-74.016959	547.00	4.20	551.20
2	41.589030	-74.016390	547.00	4.20	551.20
3	41.588534	-74.016422	547.00	4.20	551.20
4	41.588556	-74.016994	547.00	4.20	551.20

Name: PV array 2

Axis tracking: Fixed (no rotation)

Tilt: 25.0°

Orientation: 180.0°

Rated power: -

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	41.585505	-74.019543	653.00	4.20	657.20
2	41.585499	-74.018784	653.00	4.20	657.20
3	41.584883	-74.018781	653.00	4.20	657.20
4	41.584885	-74.019532	653.00	4.20	657.20

Name: PV array 3

Axis tracking: Fixed (no rotation)

Tilt: 25.0°

Orientation: 180.0°

Rated power: -

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	41.585494	-74.018773	660.00	4.20	664.20
2	41.585494	-74.018030	660.00	4.20	664.20
3	41.584880	-74.018051	660.00	4.20	664.20
4	41.584882	-74.018770	660.00	4.20	664.20

Name: PV array 4

Axis tracking: Fixed (no rotation)

Tilt: 25.0°

Orientation: 180.0°

Rated power: -

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	41.585506	-74.017949	659.00	4.20	663.20
2	41.585482	-74.017198	659.00	4.20	663.20
3	41.584860	-74.017220	659.00	4.20	663.20
4	41.584876	-74.017987	659.00	4.20	663.20

Name: PV array 5

Axis tracking: Fixed (no rotation)

Tilt: 25.0°

Orientation: 180.0°

Rated power: -

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	41.585486	-74.017198	655.00	4.20	659.20
2	41.585462	-74.016426	655.00	4.20	659.20
3	41.584844	-74.016463	655.00	4.20	659.20
4	41.584860	-74.017220	655.00	4.20	659.20

Name: PV array 6

Axis tracking: Fixed (no rotation)

Tilt: 25.0°

Orientation: 180.0°

Rated power: -

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	41.586188	-74.020262	616.00	4.20	620.20
2	41.585526	-74.020283	616.00	4.20	620.20
3	41.585515	-74.019560	616.00	4.20	620.20
4	41.586178	-74.019543	616.00	4.20	620.20

Name: PV array 7

Axis tracking: Fixed (no rotation)

Tilt: 25.0°

Orientation: 180.0°

Rated power: -

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	41.586178	-74.019535	632.00	4.20	636.20
2	41.586148	-74.018789	632.00	4.20	636.20
3	41.585506	-74.018784	632.00	4.20	636.20
4	41.585514	-74.019545	632.00	4.20	636.20

Name: PV array 8

Axis tracking: Fixed (no rotation)

Tilt: 25.0°

Orientation: 180.0°

Rated power: -

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	41.586150	-74.018784	640.00	4.20	644.20
2	41.586144	-74.018019	640.00	4.20	644.20
3	41.585510	-74.018019	640.00	4.20	644.20
4	41.585512	-74.018773	640.00	4.20	644.20

Name: PV array 9

Axis tracking: Fixed (no rotation)

Tilt: 25.0°

Orientation: 180.0°

Rated power: -

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	41.586132	-74.017923	640.00	4.20	644.20
2	41.586108	-74.017172	640.00	4.20	644.20
3	41.585494	-74.017209	640.00	4.20	644.20
4	41.585506	-74.017944	640.00	4.20	644.20

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (ft)	Height (ft)
OP 1	1	41.588690	-74.019450	554.80	6.00
OP 2	2	41.591323	-74.016051	524.48	6.00
OP 3	3	41.587546	-74.014859	563.10	6.00
OP 4	4	41.585776	-74.025488	626.05	6.00
OP 5	5	41.583435	-74.017759	687.35	6.00

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	25.0	180.0	0	0.0	0	0.0	-
PV array 10	25.0	180.0	45	0.8	0	0.0	-
PV array 11	25.0	180.0	656	10.9	0	0.0	-
PV array 12	25.0	180.0	0	0.0	0	0.0	-
PV array 13	25.0	180.0	1,105	18.4	0	0.0	-
PV array 14	25.0	180.0	866	14.4	0	0.0	-
PV array 15	25.0	180.0	3,363	56.0	132	2.2	-
PV array 16	25.0	180.0	3,672	61.2	878	14.6	-
PV array 17	25.0	180.0	3,307	55.1	250	4.2	-
PV array 18	25.0	180.0	2,689	44.8	0	0.0	-
PV array 2	25.0	180.0	0	0.0	0	0.0	-
PV array 3	25.0	180.0	0	0.0	0	0.0	-
PV array 4	25.0	180.0	0	0.0	0	0.0	-
PV array 5	25.0	180.0	0	0.0	0	0.0	-
PV array 6	25.0	180.0	648	10.8	0	0.0	-
PV array 7	25.0	180.0	94	1.6	0	0.0	-
PV array 8	25.0	180.0	102	1.7	0	0.0	-
PV array 9	25.0	180.0	86	1.4	0	0.0	-

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
OP 1	1,145	19.1	0	0.0
OP 2	0	0.0	0	0.0
OP 3	4,828	80.5	1,260	21.0
OP 4	10,660	177.7	0	0.0
OP 5	0	0.0	0	0.0

PV: PV array 1 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
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

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: PV array 10 low potential for temporary after-image

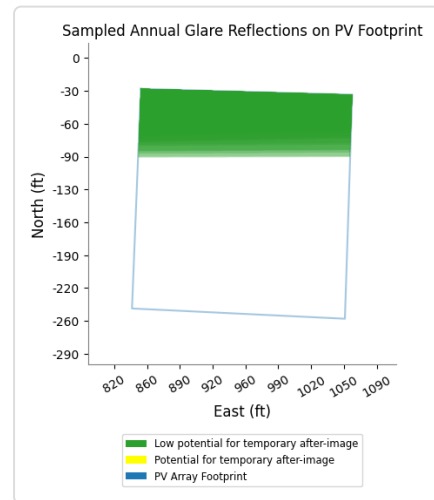
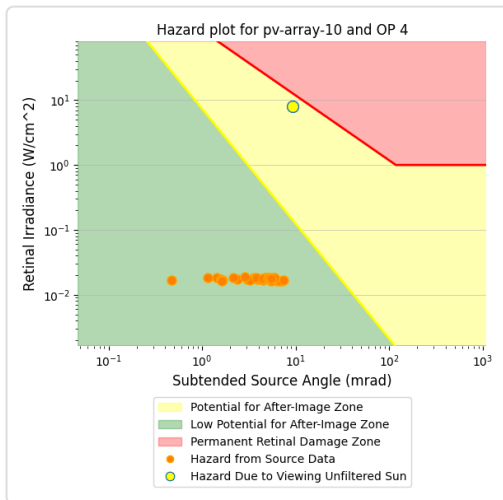
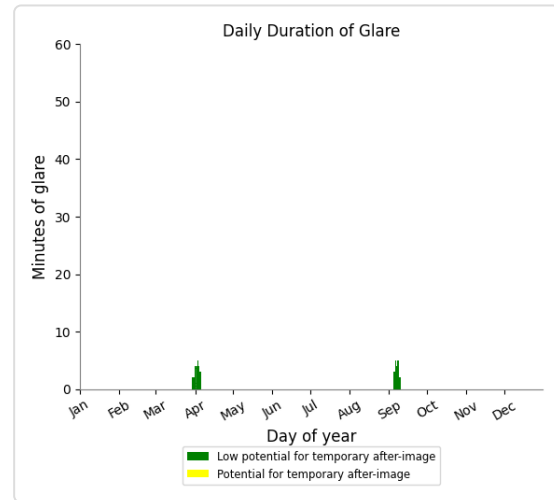
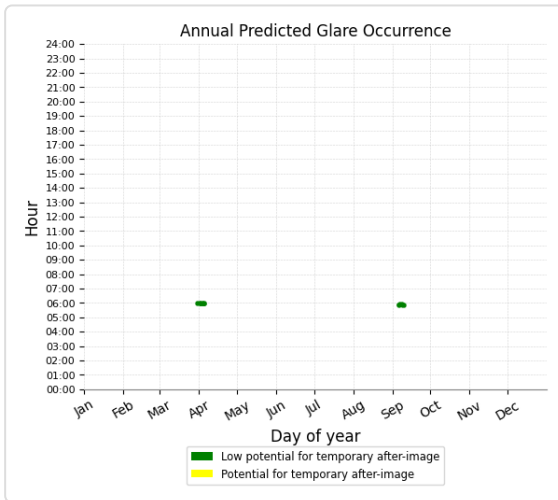
Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 4	45	0.8	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 5	0	0.0	0	0.0

PV array 10 and OP 4

Yellow glare: none

Green glare: 45 min.



PV array 10 and OP 1

No glare found

PV array 10 and OP 2

No glare found

PV array 10 and OP 3

No glare found

PV array 10 and OP 5

No glare found

PV: PV array 11 low potential for temporary after-image

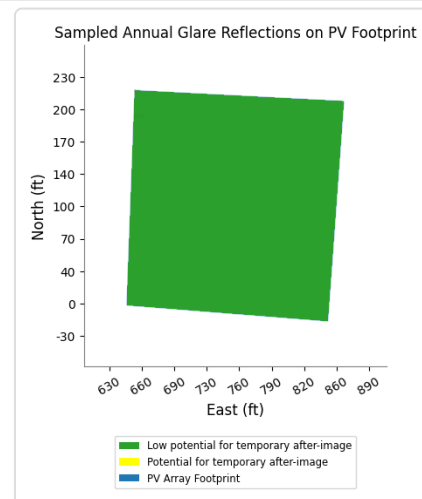
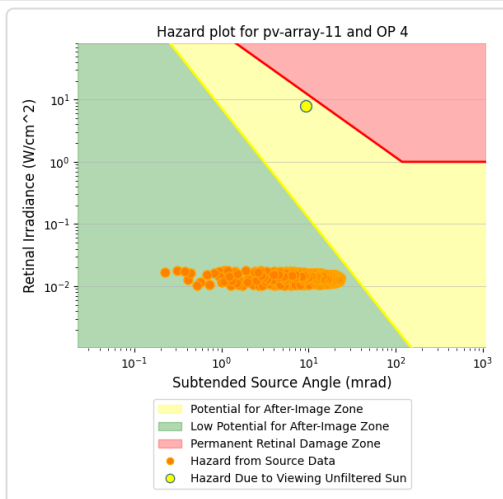
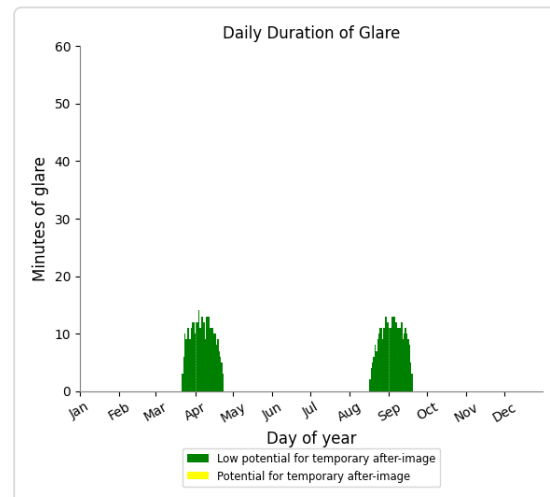
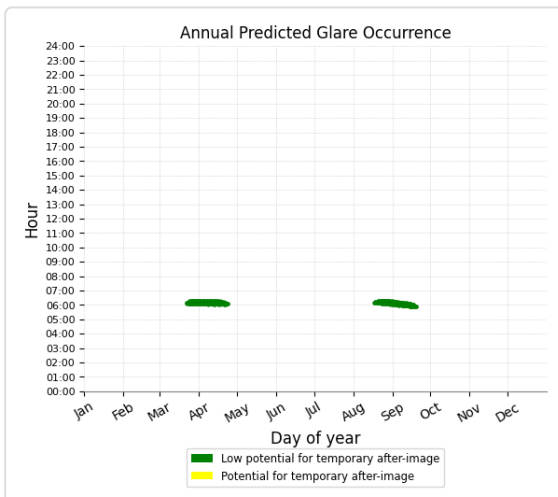
Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 4	656	10.9	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 5	0	0.0	0	0.0

PV array 11 and OP 4

Yellow glare: none

Green glare: 656 min.



PV array 11 and OP 1

No glare found

PV array 11 and OP 2

No glare found

PV array 11 and OP 3

No glare found

PV array 11 and OP 5

No glare found

PV: PV array 12 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
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

PV array 12 and OP 1

No glare found

PV array 12 and OP 2

No glare found

PV array 12 and OP 3

No glare found

PV array 12 and OP 4

No glare found

PV array 12 and OP 5

No glare found

PV: PV array 13 low potential for temporary after-image

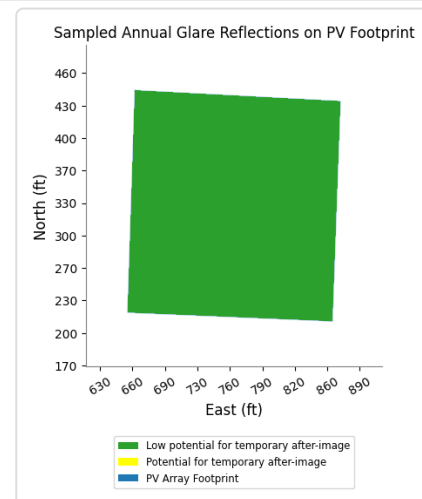
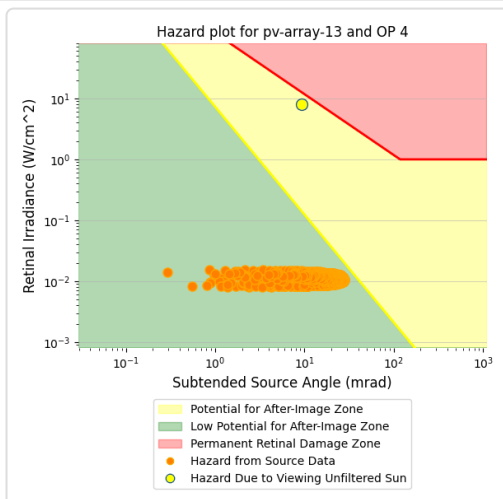
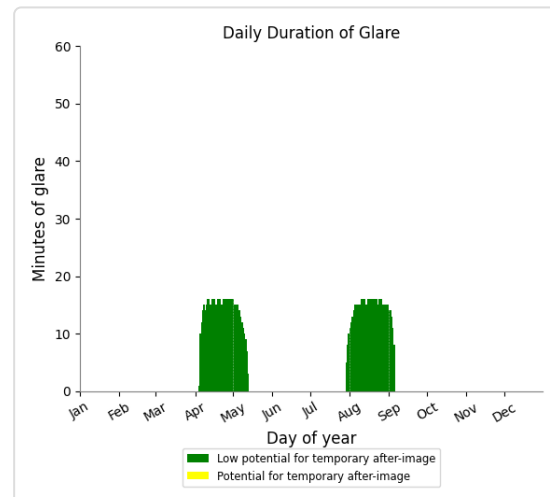
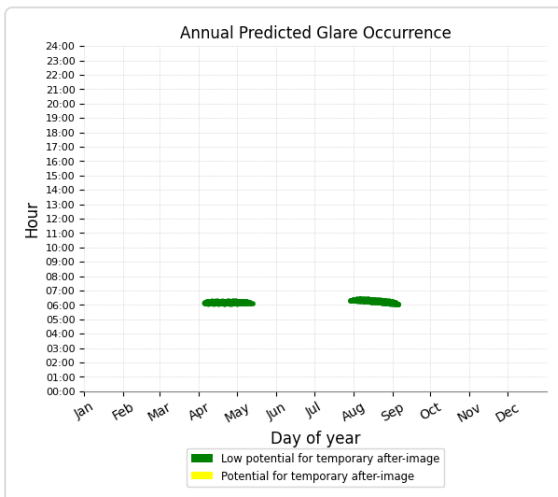
Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 4	1,105	18.4	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 5	0	0.0	0	0.0

PV array 13 and OP 4

Yellow glare: none

Green glare: 1,105 min.



PV array 13 and OP 1

No glare found

PV array 13 and OP 2

No glare found

PV array 13 and OP 3

No glare found

PV array 13 and OP 5

No glare found

PV: PV array 14 low potential for temporary after-image

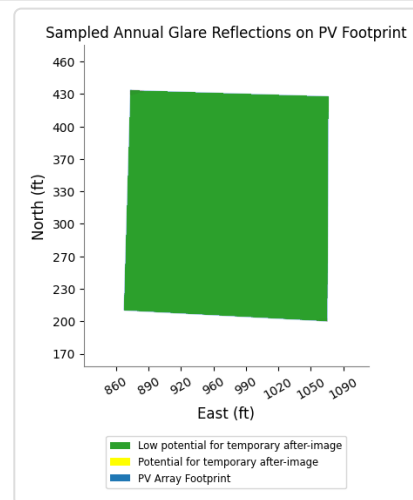
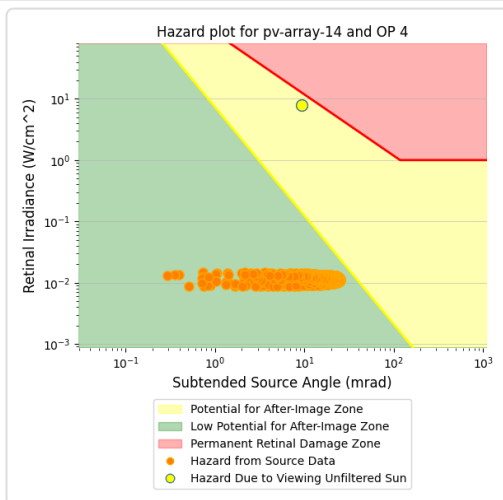
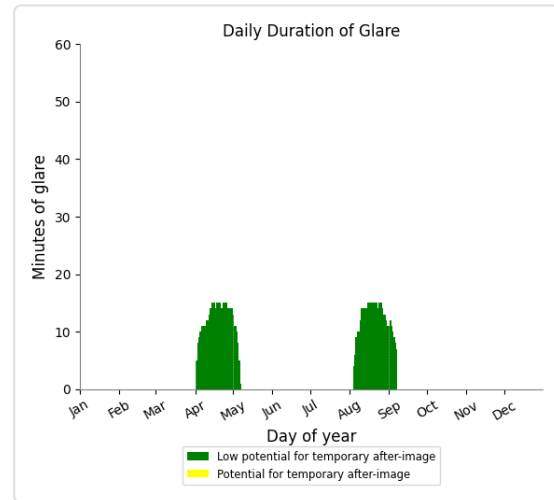
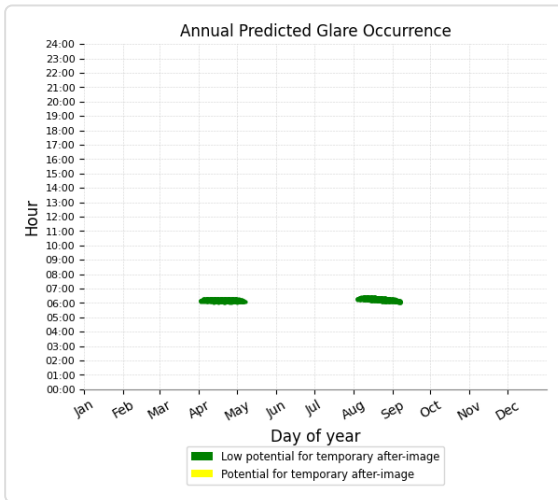
Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 4	866	14.4	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 5	0	0.0	0	0.0

PV array 14 and OP 4

Yellow glare: none

Green glare: 866 min.



PV array 14 and OP 1

No glare found

PV array 14 and OP 2

No glare found

PV array 14 and OP 3

No glare found

PV array 14 and OP 5

No glare found

PV: PV array 15 potential temporary after-image

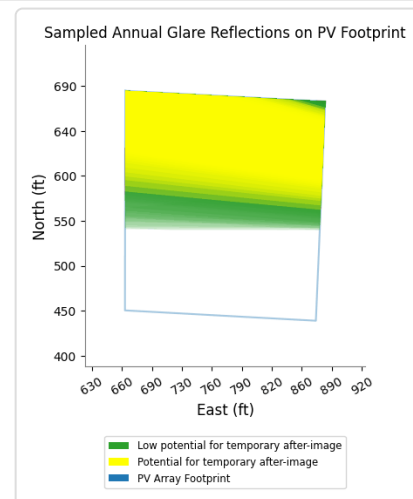
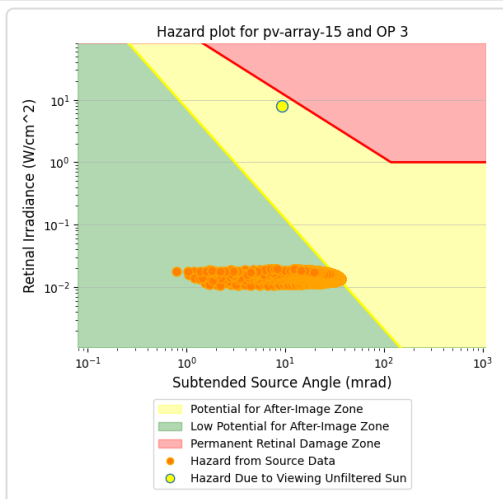
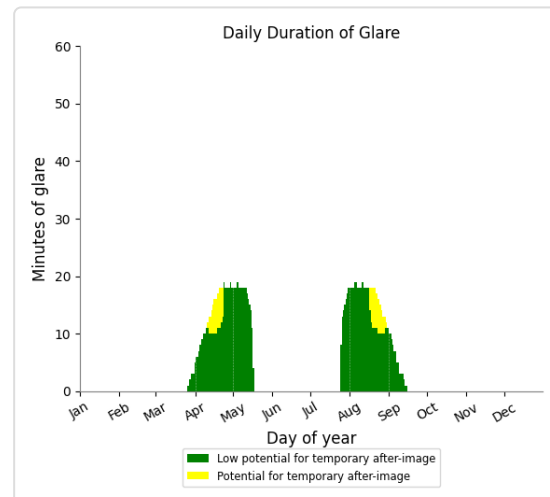
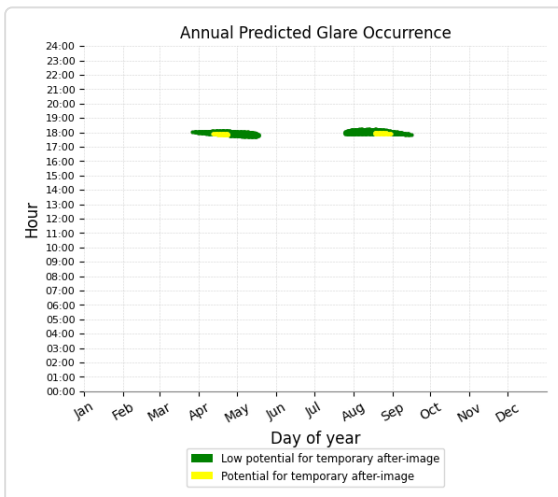
Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 3	1,270	21.2	132	2.2
OP 4	2,093	34.9	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 5	0	0.0	0	0.0

PV array 15 and OP 3

Yellow glare: 132 min.

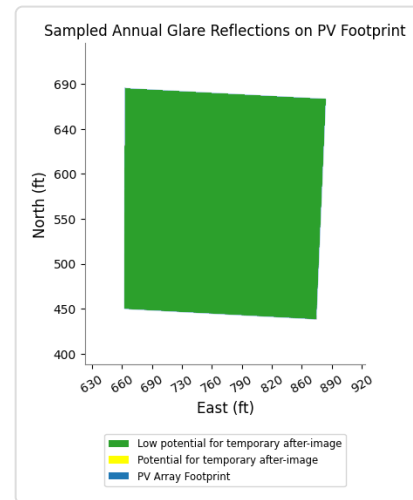
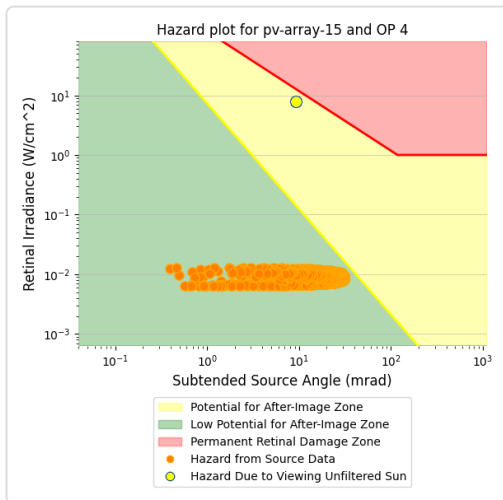
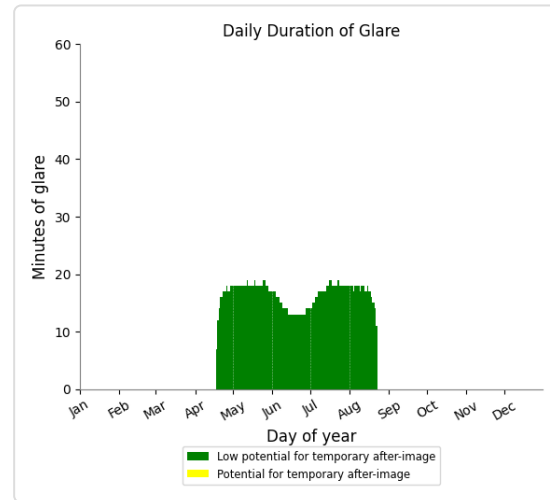
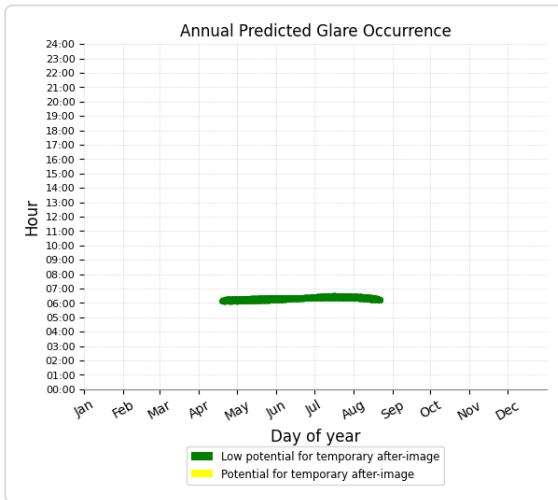
Green glare: 1,270 min.



PV array 15 and OP 4

Yellow glare: none

Green glare: 2,093 min.



PV array 15 and OP 1

No glare found

PV array 15 and OP 2

No glare found

PV array 15 and OP 5

No glare found

PV: PV array 16 potential temporary after-image

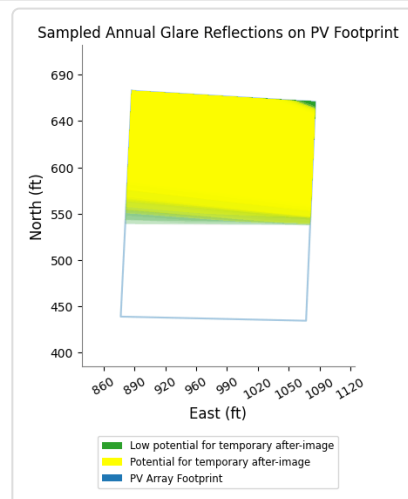
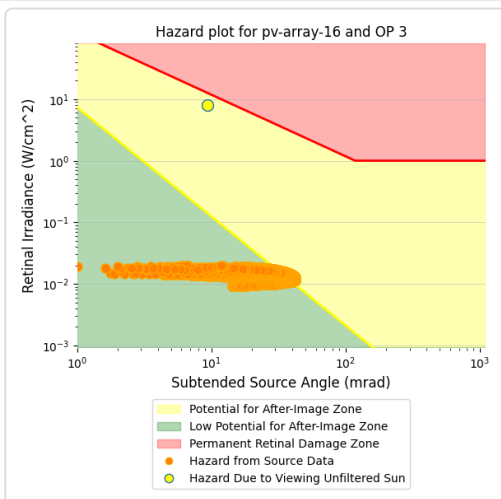
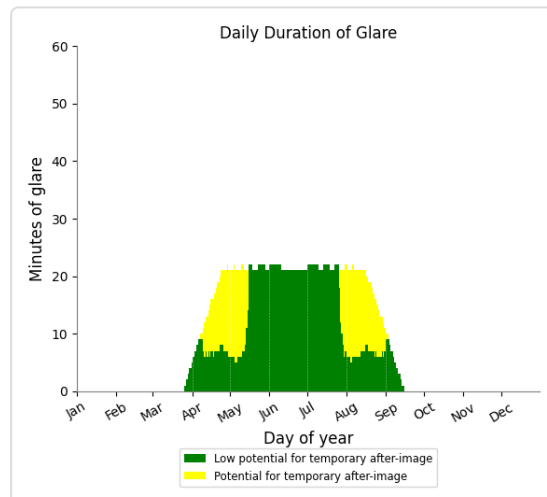
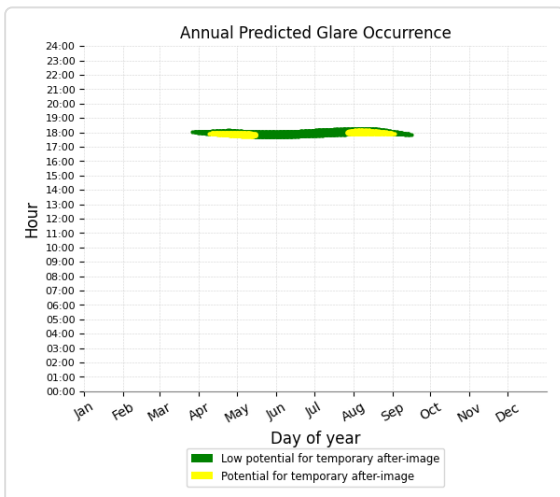
Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 3	2,200	36.7	878	14.6
OP 4	1,472	24.5	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 5	0	0.0	0	0.0

PV array 16 and OP 3

Yellow glare: 878 min.

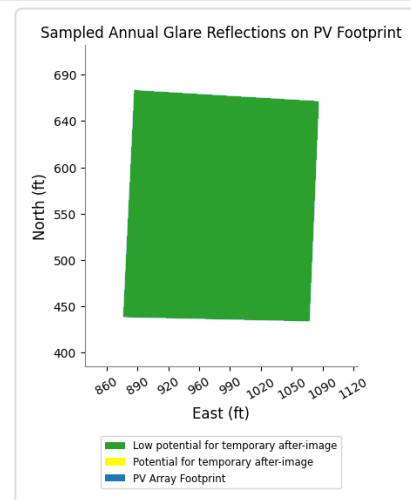
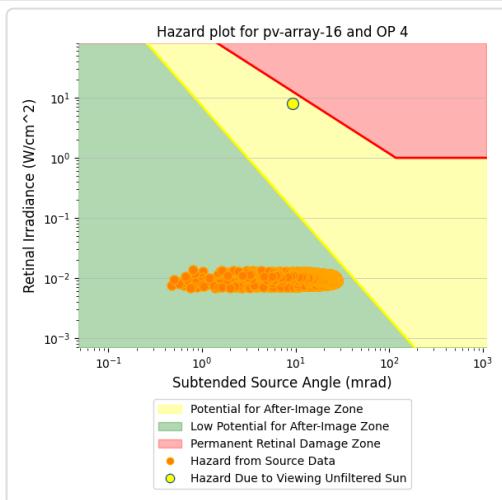
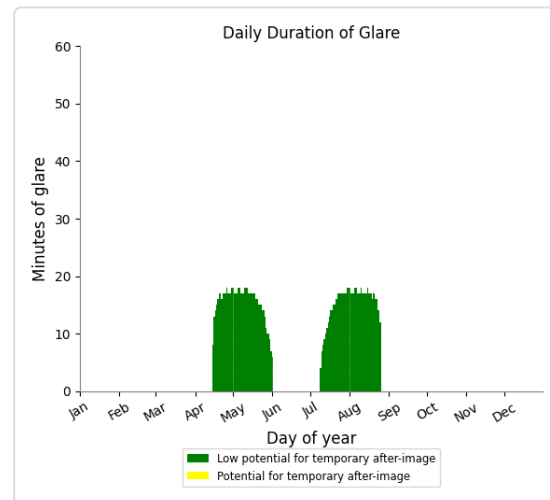
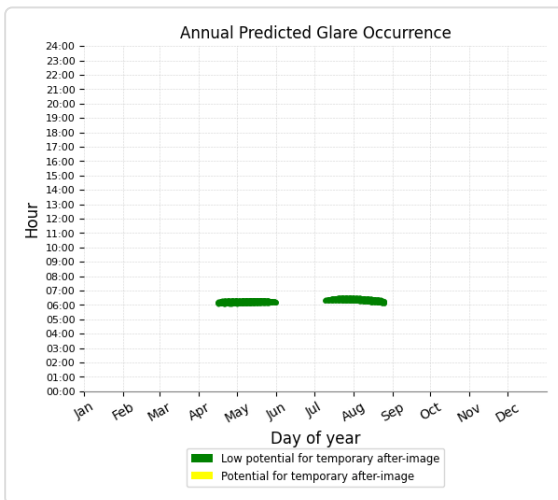
Green glare: 2,200 min.



PV array 16 and OP 4

Yellow glare: none

Green glare: 1,472 min.



PV array 16 and OP 1

No glare found

PV array 16 and OP 2

No glare found

PV array 16 and OP 5

No glare found

PV: PV array 17 potential temporary after-image

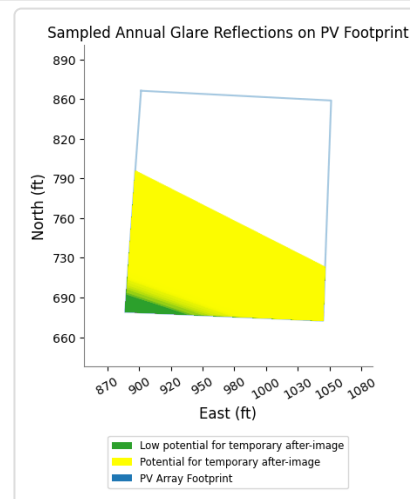
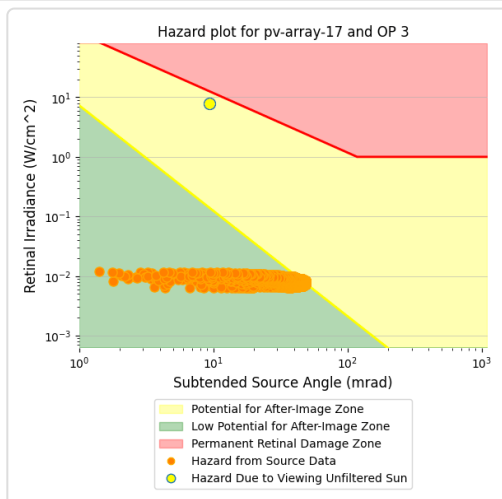
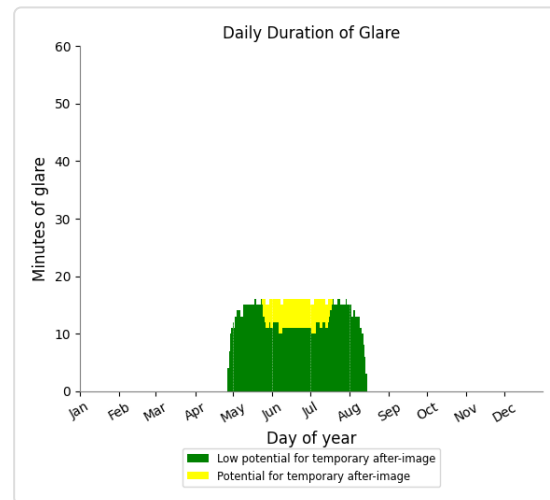
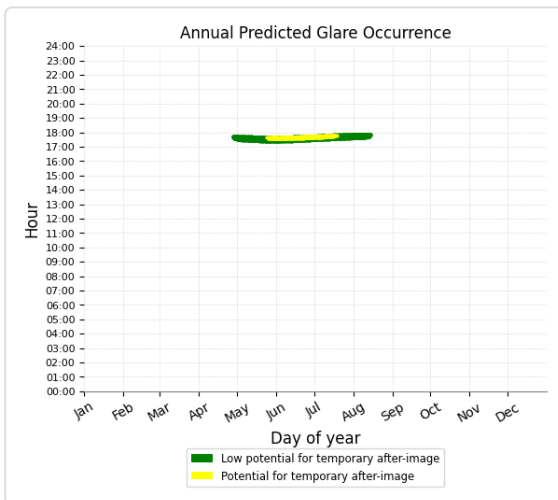
Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 3	1,358	22.6	250	4.2
OP 4	1,949	32.5	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 5	0	0.0	0	0.0

PV array 17 and OP 3

Yellow glare: 250 min.

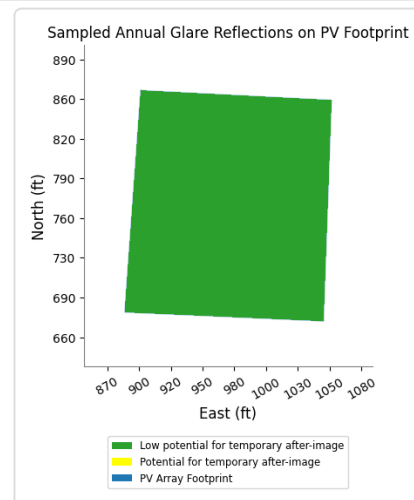
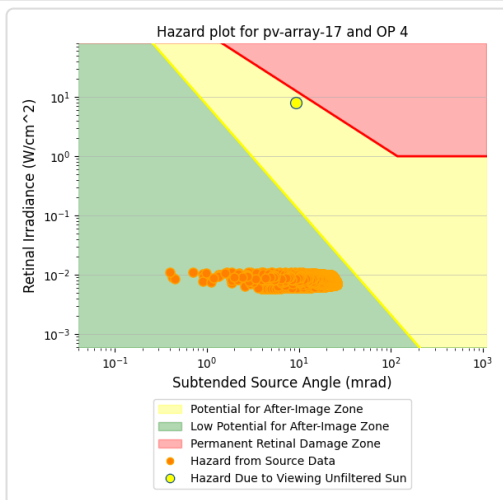
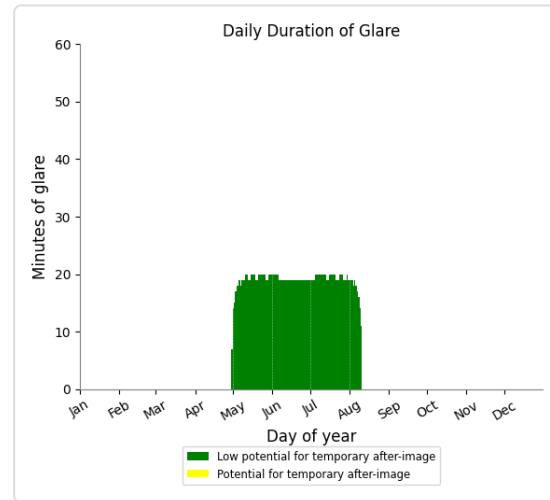
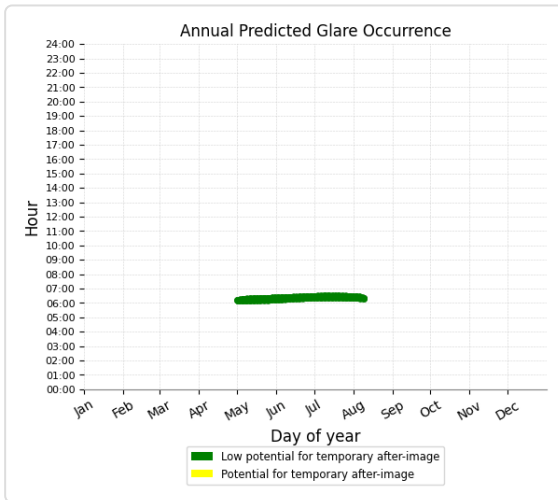
Green glare: 1,358 min.



PV array 17 and OP 4

Yellow glare: none

Green glare: 1,949 min.



PV array 17 and OP 1

No glare found

PV array 17 and OP 2

No glare found

PV array 17 and OP 5

No glare found

PV: PV array 18 low potential for temporary after-image

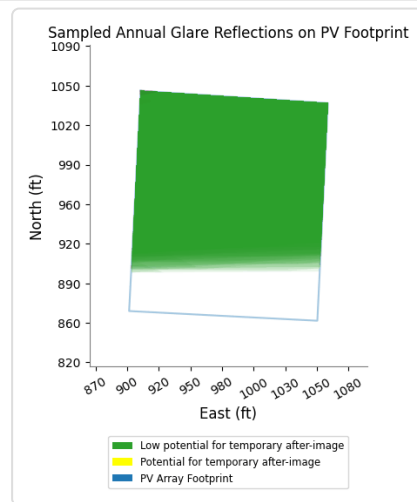
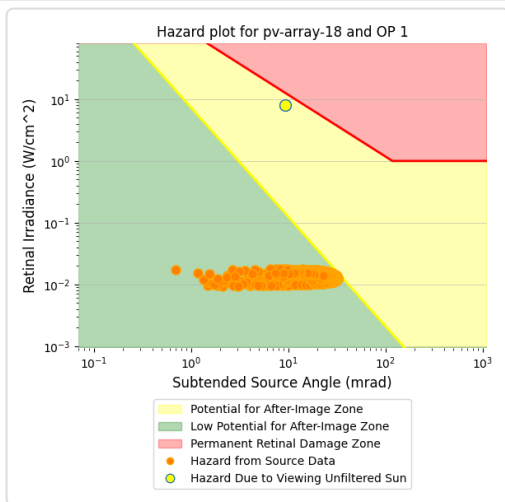
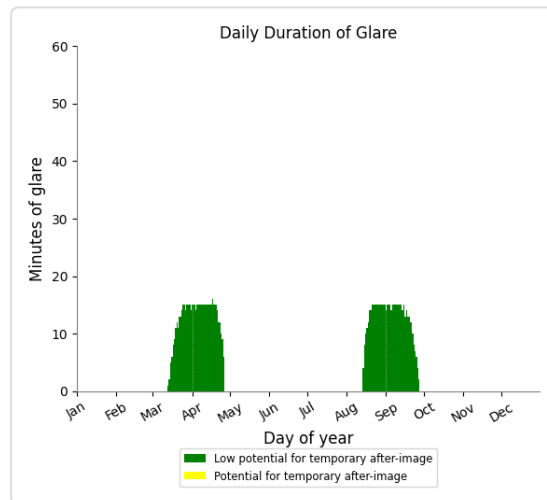
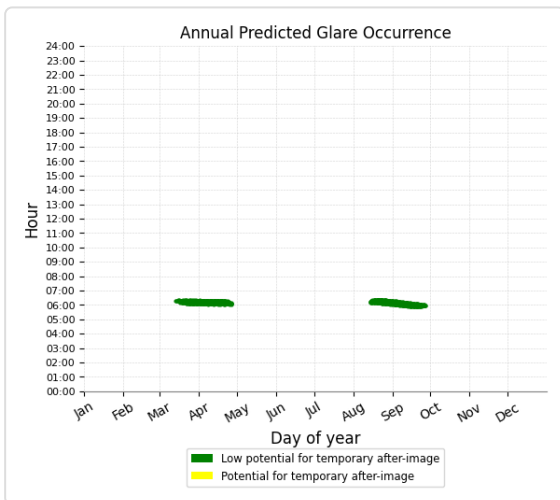
Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 1	1,145	19.1	0	0.0
OP 4	1,544	25.7	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 5	0	0.0	0	0.0

PV array 18 and OP 1

Yellow glare: none

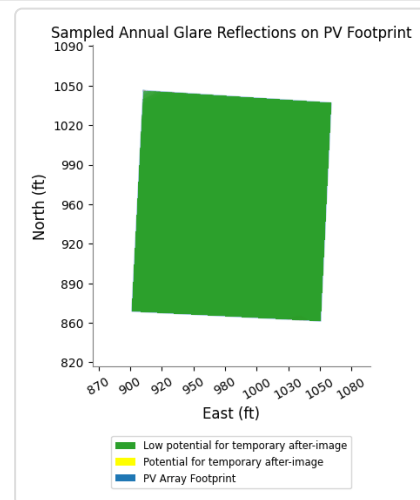
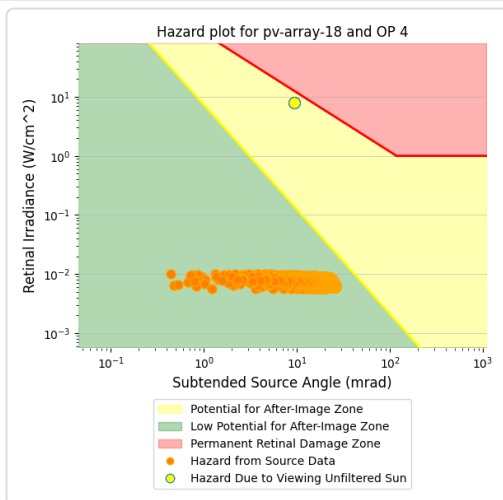
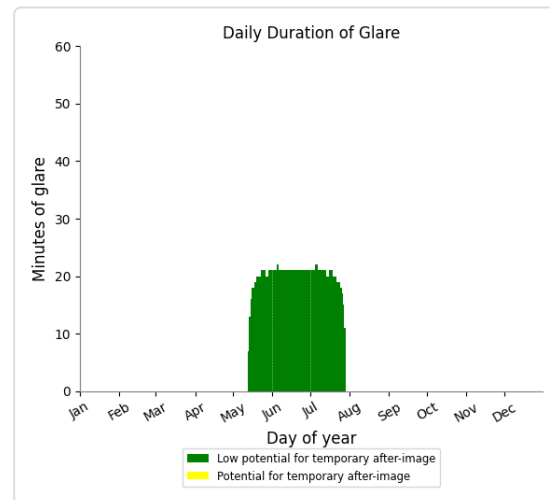
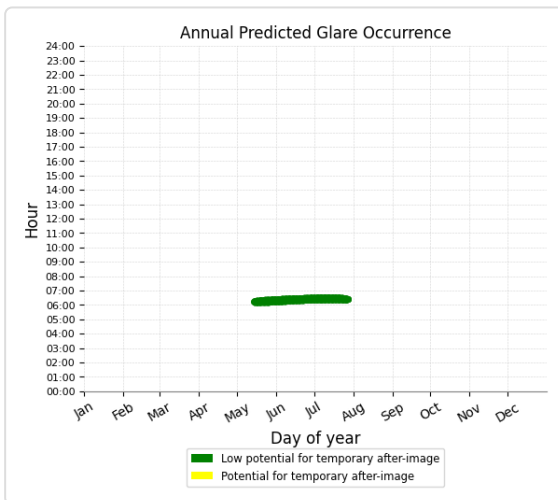
Green glare: 1,145 min.



PV array 18 and OP 4

Yellow glare: none

Green glare: 1,544 min.



PV array 18 and OP 2

No glare found

PV array 18 and OP 3

No glare found

PV array 18 and OP 5

No glare found

PV: PV array 2 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
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

PV array 2 and OP 1

No glare found

PV array 2 and OP 2

No glare found

PV array 2 and OP 3

No glare found

PV array 2 and OP 4

No glare found

PV array 2 and OP 5

No glare found

PV: PV array 3 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
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

PV array 3 and OP 1

No glare found

PV array 3 and OP 2

No glare found

PV array 3 and OP 3

No glare found

PV array 3 and OP 4

No glare found

PV array 3 and OP 5

No glare found

PV: PV array 4 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
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

PV array 4 and OP 1

No glare found

PV array 4 and OP 2

No glare found

PV array 4 and OP 3

No glare found

PV array 4 and OP 4

No glare found

PV array 4 and OP 5

No glare found

PV: PV array 5 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
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

PV array 5 and OP 1

No glare found

PV array 5 and OP 2

No glare found

PV array 5 and OP 3

No glare found

PV array 5 and OP 4

No glare found

PV array 5 and OP 5

No glare found

PV: PV array 6 low potential for temporary after-image

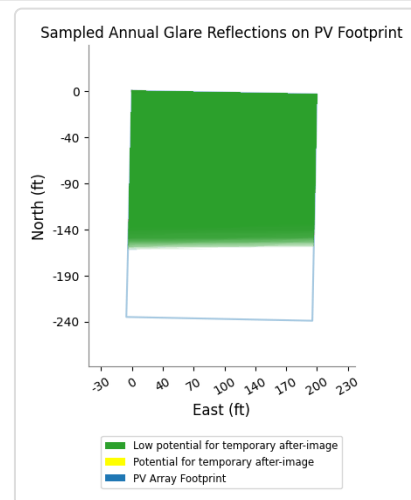
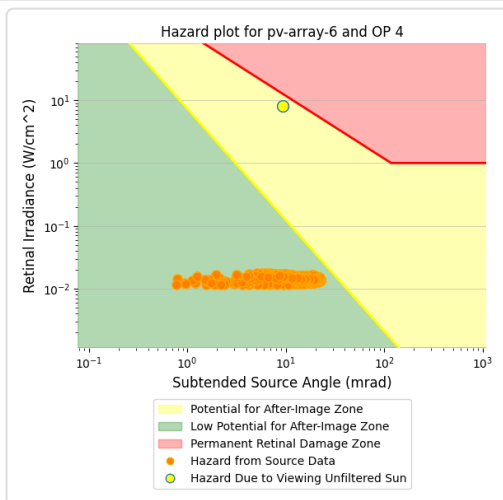
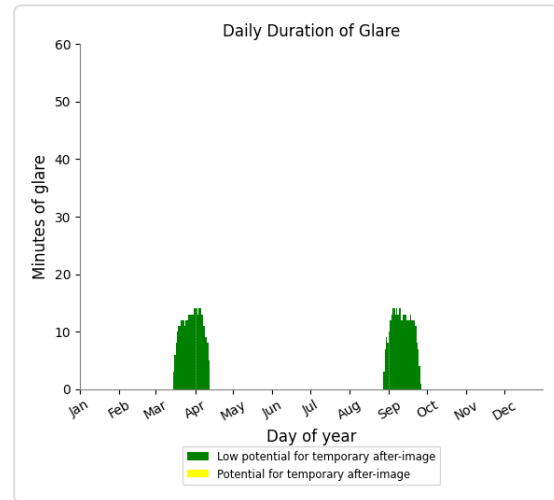
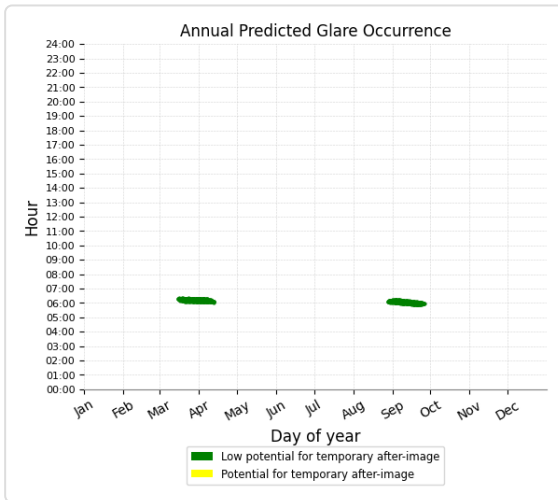
Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 4	648	10.8	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 5	0	0.0	0	0.0

PV array 6 and OP 4

Yellow glare: none

Green glare: 648 min.



PV array 6 and OP 1

No glare found

PV array 6 and OP 2

No glare found

PV array 6 and OP 3

No glare found

PV array 6 and OP 5

No glare found

PV: PV array 7 low potential for temporary after-image

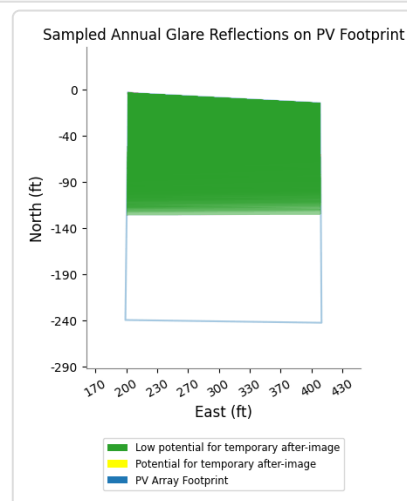
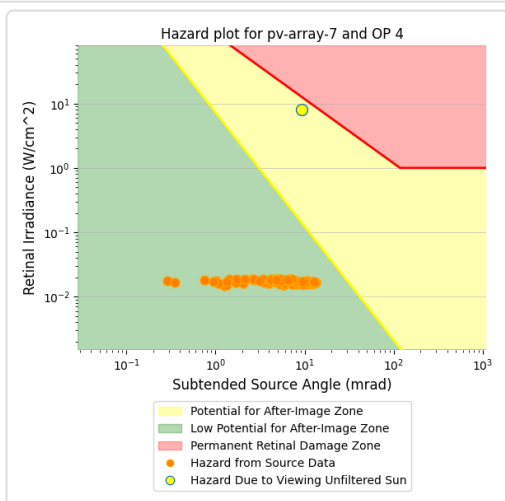
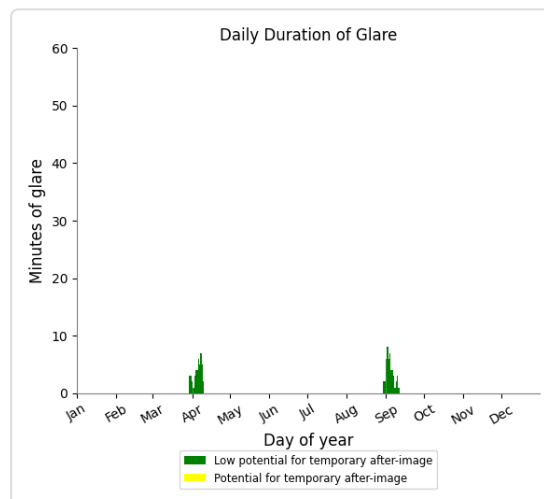
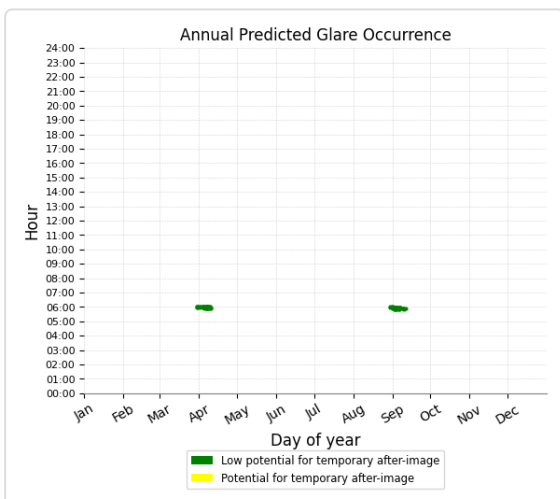
Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 4	94	1.6	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 5	0	0.0	0	0.0

PV array 7 and OP 4

Yellow glare: none

Green glare: 94 min.



PV array 7 and OP 1

No glare found

PV array 7 and OP 2

No glare found

PV array 7 and OP 3

No glare found

PV array 7 and OP 5

No glare found

PV: PV array 8 low potential for temporary after-image

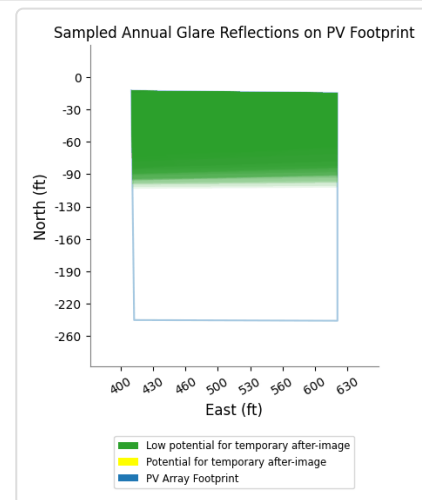
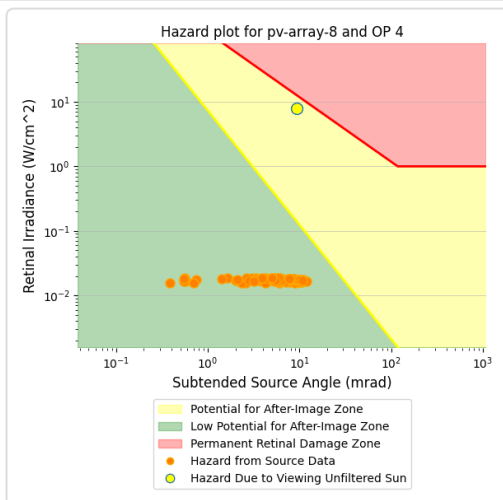
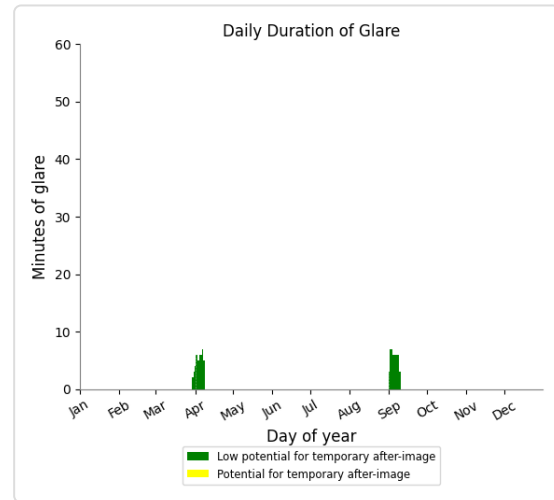
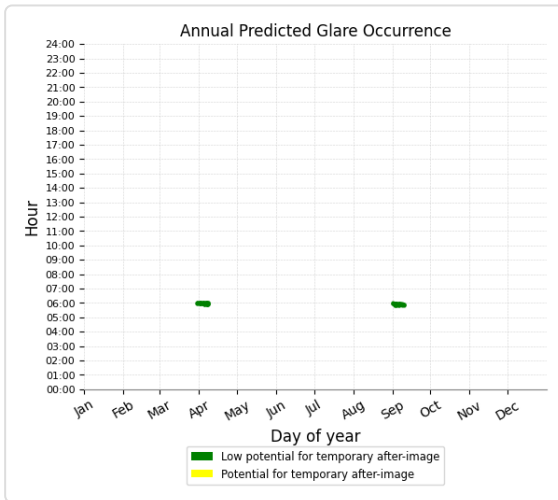
Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 4	102	1.7	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 5	0	0.0	0	0.0

PV array 8 and OP 4

Yellow glare: none

Green glare: 102 min.



PV array 8 and OP 1

No glare found

PV array 8 and OP 2

No glare found

PV array 8 and OP 3

No glare found

PV array 8 and OP 5

No glare found

PV: PV array 9 low potential for temporary after-image

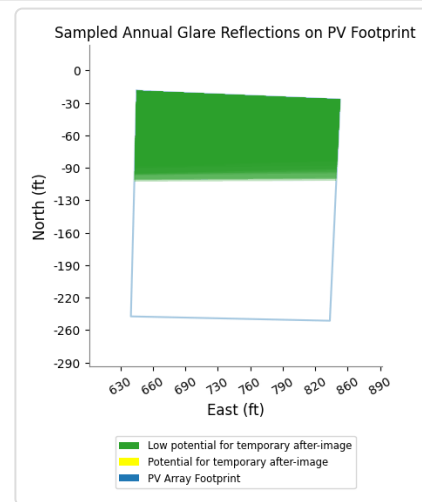
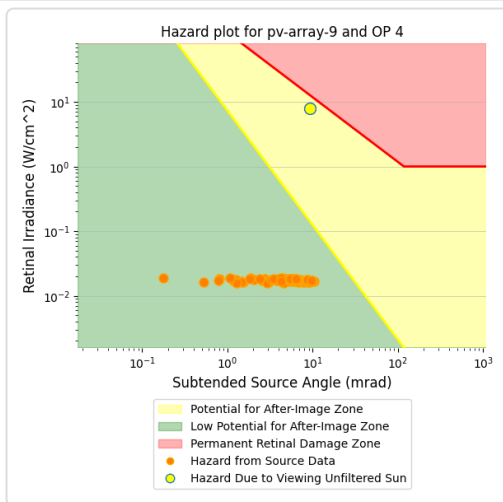
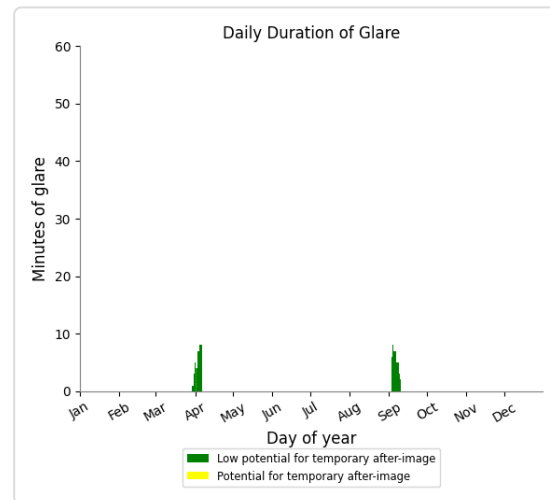
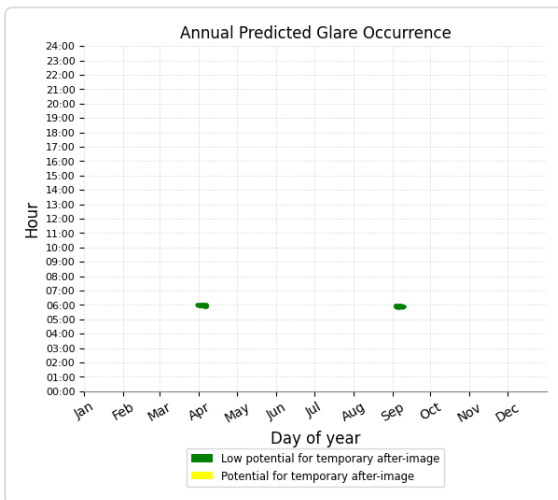
Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 4	86	1.4	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 5	0	0.0	0	0.0

PV array 9 and OP 4

Yellow glare: none

Green glare: 86 min.



PV array 9 and OP 1

No glare found

PV array 9 and OP 2

No glare found

PV array 9 and OP 3

No glare found

PV array 9 and OP 5

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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