APPENDIX 5.1 BIG-2

SOLAR FARM GLARE STUDY

Date: February 9, 2024
To: BNSF
From: Anna Jordan
Subject: BIG – Glare Study Memorandum

BNSF Railway (BNSF) ("Client") retained 1898 & Co., a division of Burns & McDonnell, Inc., ("1898 & Co.") to conduct a glare study for the proposed Barstow International Gateway (the "Project"), a solar energy facility proposed in San Bernardino County, California. The purpose of the study is to identify the potential for solar glare directed onto nearby properties or roadways.

Background

The Barstow International Gateway is in San Bernardino County, California. The site was modeled with typical parameters of a utility-scale photovoltaic system utilizing a single-axis tracking racking solution which is expected for the Project.

Thirty-nine (39) observation points ("OPs"), representing stationary observers at nearby properties, and twelve (12) path receptor routes ("Routes"), representing eleven (11) nearby roadway observers and one (1) nearby railway observer, were reviewed and studied for the potential for glare from the Project. No public or private airports were identified within 5 miles of the Project.

The solar glare study analyzing the potential for glare from the Project was performed to comply with the San Bernardino Zoning Ordinance, which states the following requirements:

> **Section 84.29.040.b:** *Glare. Solar energy facilities shall be designed to preclude daytime glare on any abutting residential land use zoning district, residential parcel, or public right-of-way.*

Sandia National Laboratories developed the Solar Glare Hazard Analysis Tool, which determines the risk of glare potential from solar energy systems (Sandia National Laboratories, 2019) and is available for commercial use from ForgeSolar. The Solar Glare Hazard Analysis Tool determines if there is a potential for glare by performing a geometric analysis that considers the position of the sun, the PV array, and specified observers and was used to evaluate if glare could be directed onto nearby properties and roadways for the Project.

The Solar Glare Hazard Analysis Tool does not account for changes in topography, vegetation, or structures that would partially or completely obstruct the view and reduce or mitigate the impact of the glare on an observer, unless that object is specifically modeled as an obstruction component in ForgeSolar. The obstruction components modeled in ForgeSolar were limited to areas with substantial amounts of existing and mature vegetation for the first evaluation of existing visual obstructions. Accordingly, a second line-of-sight (LOS) analysis is performed following the glare analysis for ground-level observers that were noted to have the potential to experience glare in areas where there may only be partial visual obstructions existing.

Glare Analysis

To perform the glare analysis, the Solar Glare Hazard Analysis Tool licensed for commercial use to ForgeSolar was utilized (Sandia National Laboratories, 2019). The Solar Glare Hazard Analysis Tool allows the user to specify a site location, draw an outline of the proposed photovoltaic array, and specify observer locations. Once these parameters are given, the properties of the arrays such as the tracking type, tilt, module surface type, and orientation can be specified for each array. Latitude, longitude, and elevation for each receptor and array vertex are tracked and used for sun position and vector calculations to determine glare for the observation points for every minute in a calendar year (ForgeSolar, 2019).

The Solar output indicates if there is potential for glare at the identified receptors. If glare exists, the Solar Glare Hazard Analysis Tool creates the Solar Glare Ocular Hazard Plot (SGOHP), which identifies the degree of the hazard, the location on the array it is from, and the time it occurs. The Solar Glare Hazard Analysis Tool evaluated the potential glare at the receptors for every minute in a full calendar year, considers the sun's path through the sky throughout a calendar year, and conservatively considers clear and sunny conditions for every day in a calendar year.

The glare determined by the Solar Glare Hazard Analysis Tool is assigned a color value of "green", "yellow", or "red" based on the intensity of the light that reaches an observer's retina and the size of the glare in the observer's field of view in increasing severity. "Green" glare is glare that is bright and large enough to affect some observers in ideal conditions, "yellow" glare is glare bright and large enough to affect most observers when occurring, and "red" glare is bright and large enough to cause retinal burn in most observers. It should be noted that no receptors in this study were given a determination of "red" glare by the Solar Glare Hazard Analysis Tool, i.e., the glare did not have the potential to cause retinal burn, and "red" glare is typically only possible for concentrated solar-thermal projects.

The analysis in ForgeSolar assumed no visual obstructions between the source of glare and an observer unless an obstruction was specifically defined as an "obstruction component" in ForgeSolar. Areas near the Project with substantial amounts of existing and mature vegetation, which would accordingly block glare from reflected and refracted light, were the only visual obstructions considered in the ForgeSolar analysis step of the study as obstruction components. The obstruction components considered in the ForgeSolar study was the first of two evaluations of existing visual obstructions and was limited to areas of substantial existing and mature vegetation.

From 1898 & Co.'s experience on similar large solar energy systems, an appropriate threshold for glare to be consequential determined by ForgeSolar is "yellow" glare and not "green" glare due to the overall conservative nature of the ForgeSolar modeling assumptions, the low potential for afterimage in a typical observer described by "green" glare in ideal conditions in the original studies performed by Ho, C.K., and the allowable thresholds used by the Federal Aviation Administration in previous and current policies.

Line-of-Sight (LOS) Analysis

The obstruction components utilized in the ForgeSolar analysis were limited to areas with substantial amounts of existing and mature vegetation for the first evaluation of existing visual obstructions. For the second evaluation of existing visual obstructions, the instances of "yellow" glare identified by ForgeSolar were further reviewed for potential visual obstructions. The line of sight from the observers to the arrays were categorized as "Visible", "Marginally Visible", or "Not Visible" due to geography, vegetation, structures, or other existing objects. These results were then combined with the Solar Glare Hazard Analysis Tool output to determine if glare could affect an observer with an unobstructed line of sight (LOS). If no potential for "yellow" glare was noted from the Solar Glare Hazard Analysis Tool, then the LOS was not evaluated as there was no potential for glare noted that may need further mitigation with visual obstructions to the LOS.

Any visual obstructions between the source of glare and the observer such as geography, vegetation, or structures will serve to reduce the intensity of the light that reaches an observer's retina and the size of the glare in the observer's field of view by blocking the light. Accordingly, the instances of glare identified in this study may over-represent actual glare experienced by an observer when the Project is operating. Any added visual screening such as fencing, vegetation buffers, or berms required to meet other permitting requirements should reduce or eliminate the potential for an observer to experience glare when the screening is acting as a visual obstruction to the line of sight.

Determinations of "Marginal" and "Not Visible" line of sight when glare instances were identified were required to have multiple visual obstructions to address the uncertainty of individual visual obstructions being removed. Accordingly, the results of the LOS analysis may under-report the existing visual screening to address uncertainties in the long-term placement and provide more conservative mitigation recommendations.

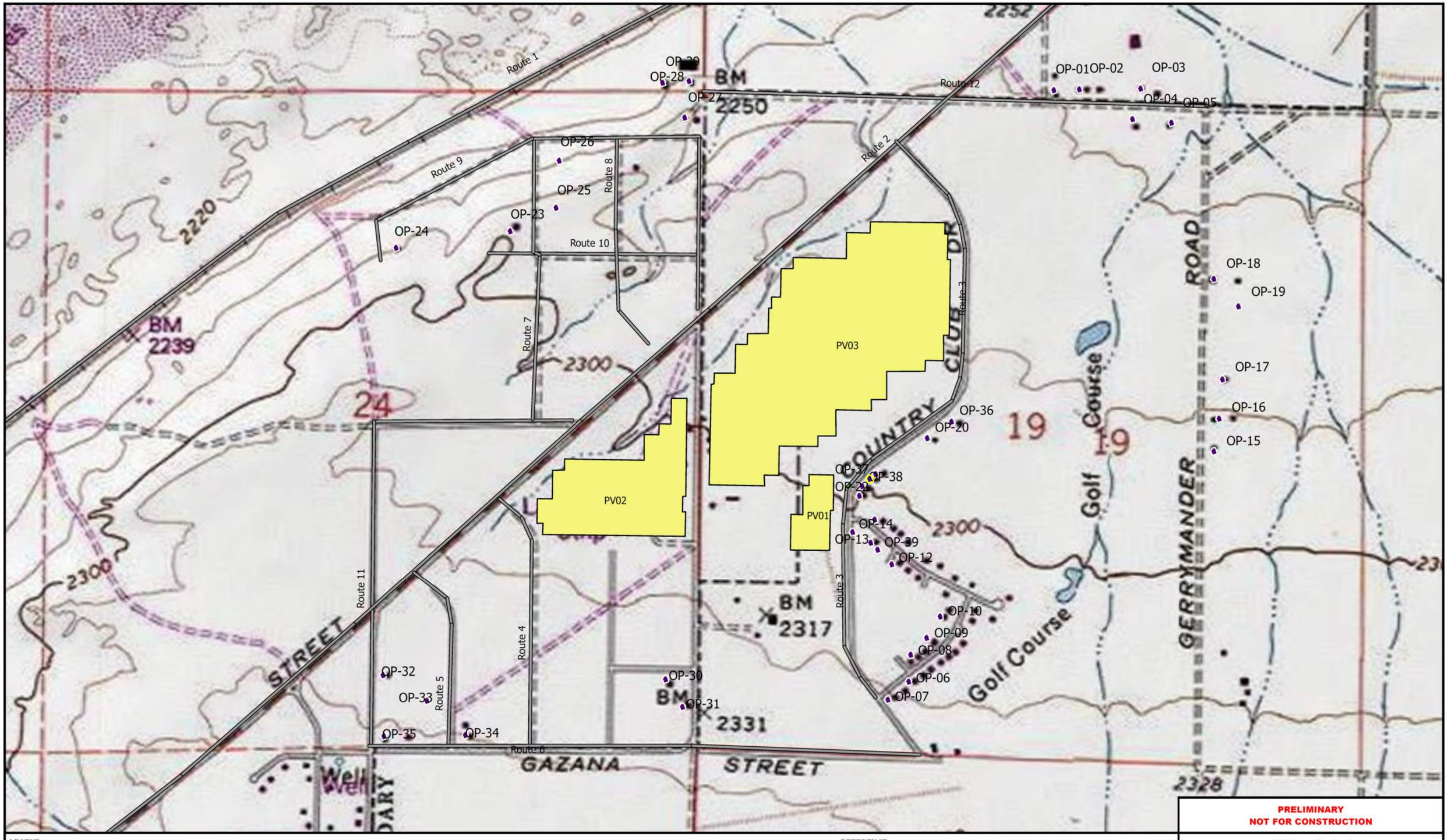
Results

After evaluating the LOS from the latest available satellite imagery and for the location of the sun from the perspective of the observer during instances of glare, the following conclusions were noted:

1. For the thirty-nine (39) observation points assessed representing nearby residences, one (1) instance of "yellow" glare was noted:
    a. One (1) instance of glare occurring for a residence identified as OP37 was determined to have minimal or no existing visual obstructions to reduce or mitigate the glare.
2. For the twelve (12) path receptor routes assessed, representing eleven (11) nearby roadways and one (1 nearby railways, one (1) instance of "yellow" glare was noted:
    a. One (1) instance of glare occurring for southbound traffic on Country Club Drive was determined to have minimal or no existing visual obstructions to reduce or mitigate the glare.

A six-foot privacy fence is planned around the arrays at the Project Site. This visual screening will further reduce or eliminate glare identified by acting as a visual obstruction. It is not anticipated that the Project will require any additional mitigation measures. The study also contained several assumptions to address uncertainties in the information provided, including but not limited to: (1) sunny conditions year-round, (2) a completely free horizon that does not affect localized sunset and sunrise times, and (3) complete coverage of modules in the modeled regions with no full or partial visual obstructions from the site equipment itself. As such, the modeling tools likely overestimate the instances of glare reported.

ATTACHMENT A - ARRAY, RECEPTOR, AND OBSTRUCTION COMPONENT LOCATIONS



LEGEND

- Arrays
- Routes
- Instances of "Green" Glare
- Instances of "Yellow" Glare
- Residences

REFERENCE

0 — 1 Miles

0 — 1 Kilometers

PRELIMINARY
NOT FOR CONSTRUCTION

BIG Solar Project
Solar Glare Study

LOCATION:	San Bernardino, California
CLIENT:	BNSF Railroad
PROJ. NO.:	156211
CREATED:	2/9/2024

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ATTACHMENT B – FORGESOLAR ANALYSIS RESULTS

FORGESOLAR GLARE ANALYSIS

Project: **156211 - BNSF - BIG Solar Project**
Site configuration: **BNSF - Single Axis - v2_Arrays**

Created 30 Jan, 2024
Updated 30 Jan, 2024
Time-step 1 minute
Timezone offset UTC-8
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Category 500 kW to 1 MW
Site ID 110836.16357

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
PV01	SA tracking	SA tracking	248	4.1	14	0.2	-
PV02	SA tracking	SA tracking	0	0.0	0	0.0	-
PV03	SA tracking	SA tracking	0	0.0	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
Route 1	0	0.0	0	0.0
Route 10	0	0.0	0	0.0
Route 11	0	0.0	0	0.0
Route 12	0	0.0	0	0.0
Route 2	0	0.0	0	0.0
Route 3	225	3.8	14	0.2
Route 4	0	0.0	0	0.0
Route 5	0	0.0	0	0.0
Route 6	0	0.0	0	0.0
Route 7	0	0.0	0	0.0
Route 8	0	0.0	0	0.0
Route 9	0	0.0	0	0.0

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
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	23	0.4	0	0.0
OP 38	0	0.0	0	0.0
OP 39	0	0.0	0	0.0

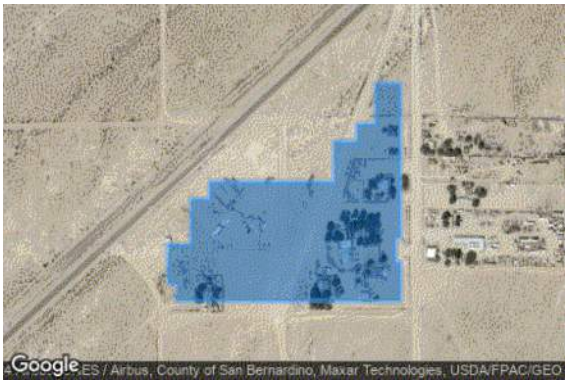
Component Data

PV Arrays

Name: PV01
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 180.0°
Max tracking angle: 55.0°
Resting angle: 5.0°
Ground Coverage Ratio: 0.34
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	34.854746	-117.132464	2304.10	4.50	2308.60
2	34.853862	-117.132464	2309.70	4.50	2314.20
3	34.853860	-117.132993	2309.80	4.50	2314.30
4	34.853862	-117.133522	2310.00	4.50	2314.50
5	34.854268	-117.133519	2307.00	4.50	2311.50
6	34.854651	-117.133522	2306.20	4.50	2310.70
7	34.854650	-117.133204	2305.70	4.50	2310.20
8	34.854973	-117.133205	2302.80	4.50	2307.30
9	34.855292	-117.133205	2301.60	4.50	2306.10
10	34.855293	-117.133046	2301.40	4.50	2305.90
11	34.855537	-117.133046	2300.80	4.50	2305.30
12	34.855537	-117.132385	2300.80	4.50	2305.30
13	34.855140	-117.132388	2303.50	4.50	2308.00
14	34.854748	-117.132385	2305.40	4.50	2309.90
15	34.854746	-117.132422	2305.00	4.50	2309.50

Name: PV02
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 180.0°
Max tracking angle: 55.0°
Resting angle: 5.0°
Ground Coverage Ratio: 0.34
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	34.855803	-117.137481	2304.50	4.50	2309.00
2	34.856369	-117.137481	2301.30	4.50	2305.80
3	34.856371	-117.137085	2301.20	4.50	2305.70
4	34.856615	-117.137084	2301.10	4.50	2305.60
5	34.856615	-117.136768	2301.10	4.50	2305.60
6	34.857181	-117.136767	2297.30	4.50	2301.80
7	34.857181	-117.136344	2297.20	4.50	2301.70
8	34.855013	-117.136344	2308.90	4.50	2313.40
9	34.855013	-117.136422	2308.80	4.50	2313.30
10	34.854672	-117.136423	2309.80	4.50	2314.30
11	34.854672	-117.136344	2310.30	4.50	2314.80
12	34.854393	-117.136341	2312.40	4.50	2316.90
13	34.854128	-117.136344	2313.00	4.50	2317.50
14	34.854128	-117.140178	2315.90	4.50	2320.40
15	34.854373	-117.140179	2315.50	4.50	2320.00
16	34.854373	-117.140336	2315.50	4.50	2320.00
17	34.854917	-117.140336	2314.40	4.50	2318.90
18	34.854918	-117.139940	2311.40	4.50	2315.90
19	34.855557	-117.139940	2306.80	4.50	2311.30
20	34.855559	-117.139623	2307.60	4.50	2312.10
21	34.855803	-117.139622	2307.80	4.50	2312.30
22	34.855804	-117.137639	2304.50	4.50	2309.00

Name: PV03
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 180.0°
Max tracking angle: 55.0°
Resting angle: 5.0°
Ground Coverage Ratio: 0.34
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	34.861153	-117.129492	2270.20	4.50	2274.70
2	34.860909	-117.129492	2270.90	4.50	2275.40
3	34.860908	-117.129413	2271.00	4.50	2275.50
4	34.860341	-117.129413	2273.30	4.50	2277.80
5	34.860342	-117.129333	2273.30	4.50	2277.80
6	34.858667	-117.129333	2282.10	4.50	2286.60
7	34.858666	-117.129492	2282.50	4.50	2287.00
8	34.858100	-117.129492	2283.90	4.50	2288.40
9	34.858100	-117.129968	2285.60	4.50	2290.10
10	34.857855	-117.129968	2286.40	4.50	2290.90
11	34.857854	-117.130999	2286.20	4.50	2290.70
12	34.857215	-117.130999	2290.40	4.50	2294.90
13	34.857215	-117.131395	2290.70	4.50	2295.20
14	34.856969	-117.131396	2291.20	4.50	2295.70
15	34.856969	-117.132348	2293.10	4.50	2297.60
16	34.856403	-117.132347	2295.30	4.50	2299.80
17	34.856403	-117.132823	2296.50	4.50	2301.00
18	34.856158	-117.132823	2297.80	4.50	2302.30
19	34.856157	-117.133856	2299.40	4.50	2303.90
20	34.855518	-117.133854	2301.60	4.50	2306.10
21	34.855517	-117.134249	2301.40	4.50	2305.90
22	34.855272	-117.134251	2304.50	4.50	2309.00
23	34.855272	-117.135706	2306.50	4.50	2311.00
24	34.857513	-117.135706	2297.20	4.50	2301.70
25	34.857515	-117.135626	2297.10	4.50	2301.60
26	34.857759	-117.135626	2296.20	4.50	2300.70
27	34.857760	-117.135071	2293.40	4.50	2297.90
28	34.858399	-117.135071	2289.90	4.50	2294.40
29	34.858399	-117.134755	2289.90	4.50	2294.40
30	34.858644	-117.134754	2289.80	4.50	2294.30
31	34.858644	-117.134198	2289.50	4.50	2294.00
32	34.859211	-117.134199	2287.10	4.50	2291.60
33	34.859211	-117.134119	2287.50	4.50	2292.00
34	34.859456	-117.134119	2287.00	4.50	2291.50
35	34.859456	-117.133880	2285.80	4.50	2290.30
36	34.860096	-117.133881	2283.90	4.50	2288.40
37	34.860097	-117.133565	2283.20	4.50	2287.70
38	34.860342	-117.133564	2281.90	4.50	2286.40
39	34.860341	-117.132136	2279.70	4.50	2284.20
40	34.860908	-117.132136	2277.30	4.50	2281.80
41	34.860909	-117.131502	2276.20	4.50	2280.70
42	34.861154	-117.131502	2274.50	4.50	2279.00
43	34.861153	-117.130492	2273.20	4.50	2277.70

Route Receptors

Name: Route 1
Path type: Two-way
Observer view angle: 25.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	34.874455	-117.118302	2242.71	14.00	2256.71
2	34.868504	-117.131177	2232.57	14.00	2246.57
3	34.864349	-117.140447	2225.45	14.00	2239.45
4	34.862765	-117.143966	2233.39	14.00	2247.39
5	34.861145	-117.147442	2242.65	14.00	2256.65
6	34.859067	-117.150704	2237.49	14.00	2251.49
7	34.854278	-117.157999	2246.99	14.00	2260.99
8	34.851883	-117.161475	2249.91	14.00	2263.91

Name: Route 10
Path type: Two-way
Observer view angle: 25.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	34.860373	-117.136182	2289.77	4.00	2293.77
2	34.860338	-117.141739	2302.18	4.00	2306.18

Name: Route 11
Path type: Two-way
Observer view angle: 25.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	34.856664	-117.139428	2310.92	4.00	2314.92
2	34.856576	-117.144749	2319.73	4.00	2323.73
3	34.849382	-117.144706	2349.55	4.00	2353.55

Name: Route 12
Path type: Two-way
Observer view angle: 25.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	34.863991	-117.136028	2252.86	4.00	2256.86
2	34.863817	-117.122462	2255.52	4.00	2259.52

Name: Route 2
Path type: Two-way
Observer view angle: 25.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	34.845412	-117.154738	2330.13	4.00	2334.13
2	34.848699	-117.149749	2352.28	4.00	2356.28
3	34.852115	-117.145158	2334.42	4.00	2338.42
4	34.856693	-117.139149	2308.03	4.00	2312.03
5	34.859193	-117.135759	2289.69	4.00	2293.69
6	34.872468	-117.118086	2246.63	4.00	2250.63

Name: Route 3
Path type: Two-way
Observer view angle: 25.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	34.862946	-117.130834	2271.87	4.00	2275.87
2	34.861767	-117.129397	2271.47	4.00	2275.47
3	34.861097	-117.129075	2269.85	4.00	2273.85
4	34.860569	-117.128946	2272.34	4.00	2276.34
5	34.858245	-117.128968	2283.88	4.00	2287.88
6	34.857717	-117.129032	2285.73	4.00	2289.73
7	34.857211	-117.129242	2284.52	4.00	2288.52
8	34.855873	-117.131409	2300.75	4.00	2304.75
9	34.855239	-117.132032	2304.76	4.00	2308.76
10	34.854429	-117.132117	2305.74	4.00	2309.74
11	34.851722	-117.132032	2318.52	4.00	2322.52
12	34.851036	-117.131581	2318.67	4.00	2322.67
13	34.850613	-117.131173	2321.56	4.00	2325.56

Name: Route 4
Path type: Two-way
Observer view angle: 25.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	34.854898	-117.141351	2316.83	4.00	2320.83
2	34.854493	-117.140751	2315.31	4.00	2319.31
3	34.854000	-117.140472	2315.95	4.00	2319.95
4	34.849383	-117.140444	2344.94	4.00	2348.94

Name: Route 5
Path type: Two-way
Observer view angle: 25.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	34.853239	-117.143619	2326.55	4.00	2330.55
2	34.852676	-117.142718	2327.61	4.00	2331.61
3	34.852095	-117.142589	2329.56	4.00	2333.56
4	34.849383	-117.142632	2345.89	4.00	2349.89

Name: Route 6
Path type: Two-way
Observer view angle: 25.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	34.849383	-117.144757	2348.81	4.00	2352.81
2	34.849489	-117.136066	2339.19	4.00	2343.19
3	34.849362	-117.129964	2328.88	4.00	2332.88

Name: Route 7
Path type: Two-way
Observer view angle: 25.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	34.856675	-117.140495	2313.10	4.00	2317.10
2	34.860320	-117.140366	2293.01	4.00	2297.01
3	34.860373	-117.140538	2293.09	4.00	2297.09
4	34.862891	-117.140559	2245.18	4.00	2249.18

Name: Route 8
Path type: Two-way
Observer view angle: 25.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	34.858383	-117.137405	2296.97	4.00	2300.97
2	34.859123	-117.138220	2296.11	4.00	2300.11
3	34.860936	-117.138327	2283.01	4.00	2287.01
4	34.862944	-117.138327	2258.13	4.00	2262.13

Name: Route 9
Path type: Two-way
Observer view angle: 25.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	34.859176	-117.136096	2289.69	4.00	2293.69
2	34.862988	-117.136117	2259.05	4.00	2263.05
3	34.862886	-117.140613	2245.16	4.00	2249.16
4	34.861022	-117.144770	2264.03	4.00	2268.03
5	34.860144	-117.144636	2283.82	4.00	2287.82

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (ft)	Height (ft)
OP 1	1	34.864143	-117.126629	2261.76	6.00
OP 2	2	34.864168	-117.125941	2262.83	6.00
OP 3	3	34.864174	-117.124275	2256.23	6.00
OP 4	4	34.863521	-117.124502	2261.02	6.00
OP 5	5	34.863440	-117.123478	2264.38	6.00
OP 6	6	34.851006	-117.130290	2324.30	6.00
OP 7	7	34.850581	-117.130837	2325.14	6.00
OP 8	8	34.851592	-117.130246	2320.55	6.00
OP 9	9	34.851955	-117.129835	2318.11	6.00
OP 10	10	34.852423	-117.129478	2315.82	6.00
OP 11	11	34.854566	-117.131265	2308.48	6.00
OP 12	12	34.853582	-117.130793	2308.75	6.00
OP 13	13	34.854056	-117.131358	2313.77	6.00
OP 14	14	34.854277	-117.131862	2307.06	6.00
OP 15	15	34.856177	-117.122184	2293.98	6.00
OP 16	16	34.856920	-117.122047	2289.82	6.00
OP 17	17	34.857771	-117.121966	2283.62	6.00
OP 18	18	34.860000	-117.122250	2274.31	6.00
OP 19	19	34.859399	-117.121581	2272.53	6.00
OP 20	20	34.856372	-117.129879	2300.22	6.00
OP 21	21	34.855583	-117.131260	2302.91	6.00
OP 22	22	34.855085	-117.131691	2306.05	6.00
OP 23	23	34.860835	-117.141176	2302.90	6.00
OP 24	24	34.860432	-117.144233	2283.37	6.00
OP 25	25	34.861357	-117.139974	2296.27	6.00
OP 26	26	34.862412	-117.139880	2262.74	6.00
OP 27	27	34.863402	-117.136519	2266.96	6.00
OP 28	28	34.864226	-117.136427	2250.34	6.00
OP 29	29	34.864175	-117.137119	2244.67	6.00
OP 30	30	34.850961	-117.136816	2333.57	6.00
OP 31	31	34.850347	-117.136355	2336.13	6.00
OP 32	32	34.850960	-117.144410	2339.25	6.00
OP 33	33	34.850413	-117.143224	2345.28	6.00
OP 34	34	34.849657	-117.142184	2347.12	6.00
OP 35	35	34.849619	-117.144371	2354.31	6.00
OP 36	36	34.856756	-117.129243	2297.26	6.00
OP 37	37	34.855465	-117.131423	2306.31	6.00
OP 38	38	34.855300	-117.131616	2304.87	6.00
OP 39	39	34.853903	-117.131179	2308.10	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
PV01	SA tracking	SA tracking	248	4.1	14	0.2	-
PV02	SA tracking	SA tracking	0	0.0	0	0.0	-
PV03	SA tracking	SA tracking	0	0.0	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
Route 1	0	0.0	0	0.0
Route 10	0	0.0	0	0.0
Route 11	0	0.0	0	0.0
Route 12	0	0.0	0	0.0
Route 2	0	0.0	0	0.0
Route 3	225	3.8	14	0.2
Route 4	0	0.0	0	0.0
Route 5	0	0.0	0	0.0
Route 6	0	0.0	0	0.0
Route 7	0	0.0	0	0.0
Route 8	0	0.0	0	0.0
Route 9	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

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
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	23	0.4	0	0.0
OP 38	0	0.0	0	0.0
OP 39	0	0.0	0	0.0

PV: PV01 potential temporary after-image

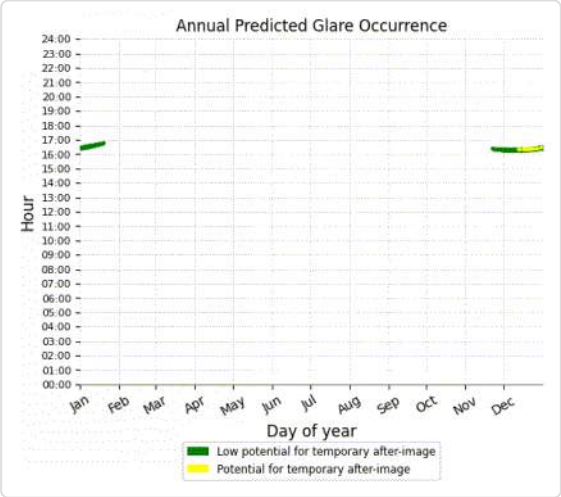
Receptor results ordered by category of glare

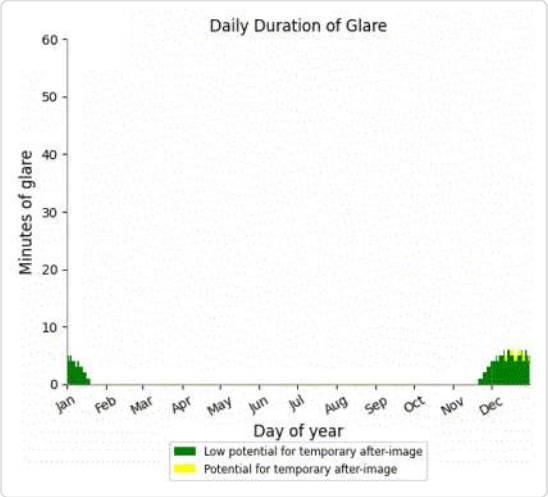
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Route 3	225	3.8	14	0.2
Route 1	0	0.0	0	0.0
Route 10	0	0.0	0	0.0
Route 11	0	0.0	0	0.0
Route 12	0	0.0	0	0.0
Route 2	0	0.0	0	0.0
Route 4	0	0.0	0	0.0
Route 5	0	0.0	0	0.0
Route 6	0	0.0	0	0.0
Route 7	0	0.0	0	0.0
Route 8	0	0.0	0	0.0
Route 9	0	0.0	0	0.0
OP 37	23	0.4	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 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

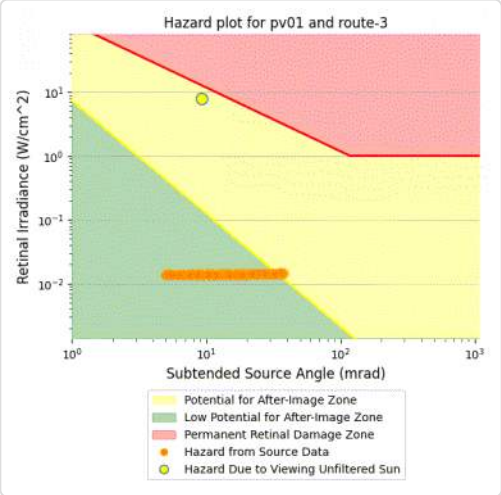
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 25	0	0.0	0	0.0
OP 26	0	0.0	0	0.0
OP 27	0	0.0	0	0.0
OP 28	0	0.0	0	0.0
OP 29	0	0.0	0	0.0
OP 30	0	0.0	0	0.0
OP 31	0	0.0	0	0.0
OP 32	0	0.0	0	0.0
OP 33	0	0.0	0	0.0
OP 34	0	0.0	0	0.0
OP 35	0	0.0	0	0.0
OP 36	0	0.0	0	0.0
OP 38	0	0.0	0	0.0
OP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

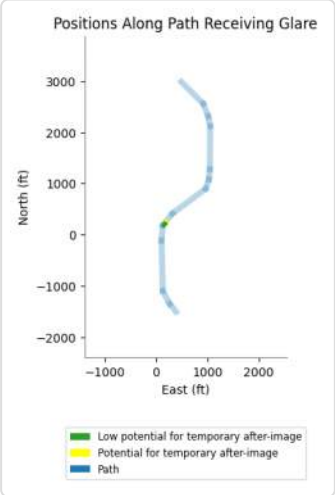
PV01 and Route: Route 3

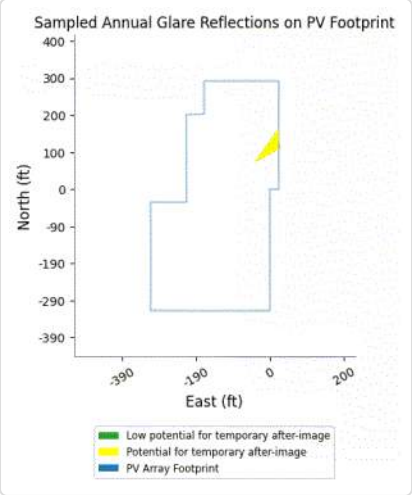
Yellow glare: 14 min.
Green glare: 225 min.











PV01 and Route: Route 1

No glare found

PV01 and Route: Route 10

No glare found

PV01 and Route: Route 11

No glare found

PV01 and Route: Route 12

No glare found

PV01 and Route: Route 2

No glare found

PV01 and Route: Route 4

No glare found

PV01 and Route: Route 5

No glare found

PV01 and Route: Route 6

No glare found

PV01 and Route: Route 7

No glare found

PV01 and Route: Route 8

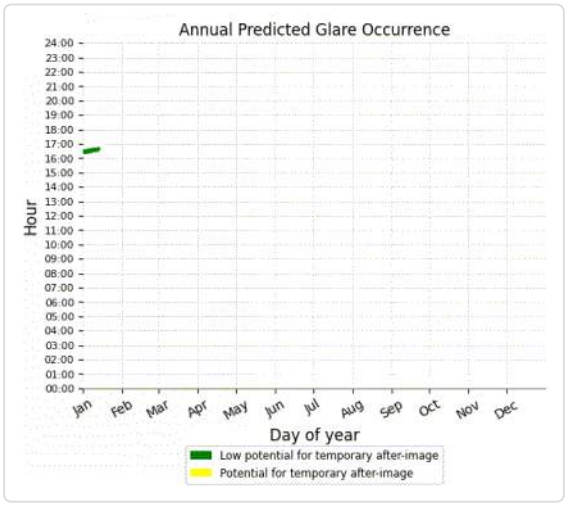
No glare found

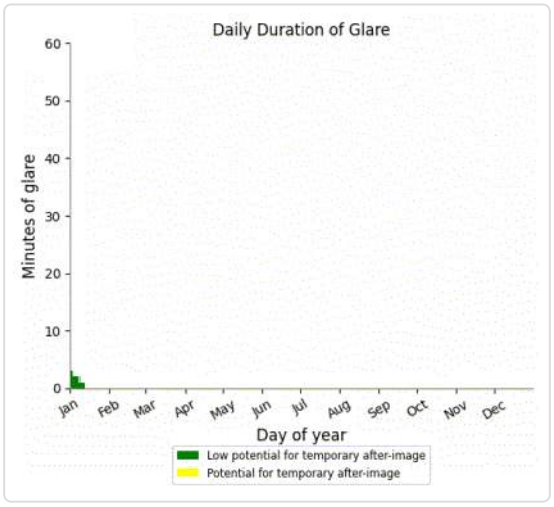
PV01 and Route: Route 9

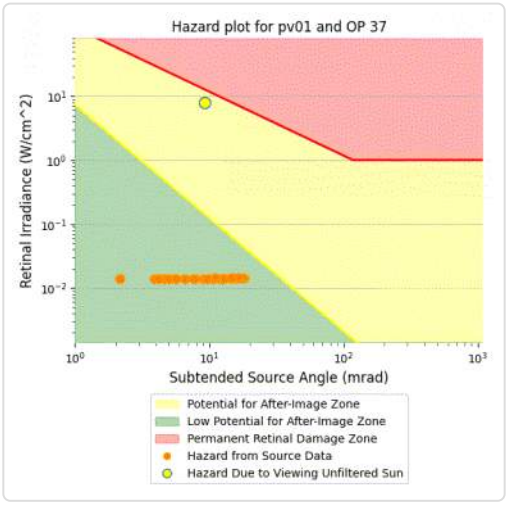
No glare found

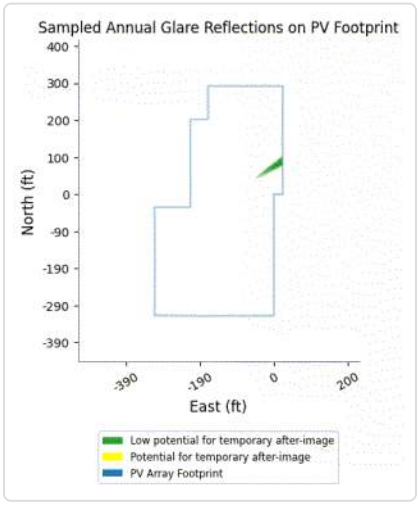
PV01 and OP 37

Yellow glare: none
Green glare: 23 min.









PV01 and OP 1

No glare found

PV01 and OP 2

No glare found

PV01 and OP 3

No glare found

PV01 and OP 4

No glare found

PV01 and OP 5

No glare found

PV01 and OP 6

No glare found

PV01 and OP 7

No glare found

PV01 and OP 8

No glare found

PV01 and OP 9

No glare found

PV01 and OP 10

No glare found

PV01 and OP 11

No glare found

PV01 and OP 12

No glare found

PV01 and OP 13

No glare found

PV01 and OP 14

No glare found

PV01 and OP 15

No glare found

PV01 and OP 16

No glare found

PV01 and OP 17

No glare found

PV01 and OP 18

No glare found

PV01 and OP 19

No glare found

PV01 and OP 20

No glare found

PV01 and OP 21

No glare found

PV01 and OP 22

No glare found

PV01 and OP 23

No glare found

PV01 and OP 24

No glare found

PV01 and OP 25

No glare found

PV01 and OP 26

No glare found

PV01 and OP 27

No glare found

PV01 and OP 28

No glare found

PV01 and OP 29

No glare found

PV01 and OP 30

No glare found

PV01 and OP 31

No glare found

PV01 and OP 32

No glare found

PV01 and OP 33

No glare found

PV01 and OP 34

No glare found

PV01 and OP 35

No glare found

PV01 and OP 36

No glare found

PV01 and OP 38

No glare found

PV01 and OP 39

No glare found

PV: PV02 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Route 1	0	0.0	0	0.0
Route 10	0	0.0	0	0.0
Route 11	0	0.0	0	0.0
Route 12	0	0.0	0	0.0
Route 2	0	0.0	0	0.0
Route 3	0	0.0	0	0.0
Route 4	0	0.0	0	0.0
Route 5	0	0.0	0	0.0
Route 6	0	0.0	0	0.0
Route 7	0	0.0	0	0.0
Route 8	0	0.0	0	0.0
Route 9	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

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
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

PV02 and Route: Route 1

No glare found

PV02 and Route: Route 10

No glare found

PV02 and Route: Route 11

No glare found

PV02 and Route: Route 12

No glare found

PV02 and Route: Route 2

No glare found

PV02 and Route: Route 3

No glare found

PV02 and Route: Route 4

No glare found

PV02 and Route: Route 5

No glare found

PV02 and Route: Route 6

No glare found

PV02 and Route: Route 7

No glare found

PV02 and Route: Route 8

No glare found

PV02 and Route: Route 9

No glare found

PV02 and OP 1

No glare found

PV02 and OP 2

No glare found

PV02 and OP 3

No glare found

PV02 and OP 4

No glare found

PV02 and OP 5

No glare found

PV02 and OP 6

No glare found

PV02 and OP 7

No glare found

PV02 and OP 8

No glare found

PV02 and OP 9

No glare found

PV02 and OP 10

No glare found

PV02 and OP 11

No glare found

PV02 and OP 12

No glare found

PV02 and OP 13

No glare found

PV02 and OP 14

No glare found

PV02 and OP 15

No glare found

PV02 and OP 16

No glare found

PV02 and OP 17

No glare found

PV02 and OP 18

No glare found

PV02 and OP 19

No glare found

PV02 and OP 20

No glare found

PV02 and OP 21

No glare found

PV02 and OP 22

No glare found

PV02 and OP 23

No glare found

PV02 and OP 24

No glare found

PV02 and OP 25

No glare found

PV02 and OP 26

No glare found

PV02 and OP 27

No glare found

PV02 and OP 28

No glare found

PV02 and OP 29

No glare found

PV02 and OP 30

No glare found

PV02 and OP 31

No glare found

PV02 and OP 32

No glare found

PV02 and OP 33

No glare found

PV02 and OP 34

No glare found

PV02 and OP 35

No glare found

PV02 and OP 36

No glare found

PV02 and OP 37

No glare found

PV02 and OP 38

No glare found

PV02 and OP 39

No glare found

PV: PV03 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Route 1	0	0.0	0	0.0
Route 10	0	0.0	0	0.0
Route 11	0	0.0	0	0.0
Route 12	0	0.0	0	0.0
Route 2	0	0.0	0	0.0
Route 3	0	0.0	0	0.0
Route 4	0	0.0	0	0.0
Route 5	0	0.0	0	0.0
Route 6	0	0.0	0	0.0
Route 7	0	0.0	0	0.0
Route 8	0	0.0	0	0.0
Route 9	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

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
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

PV03 and Route: Route 1

No glare found

PV03 and Route: Route 10

No glare found

PV03 and Route: Route 11

No glare found

PV03 and Route: Route 12

No glare found

PV03 and Route: Route 2

No glare found

PV03 and Route: Route 3

No glare found

PV03 and Route: Route 4

No glare found

PV03 and Route: Route 5

No glare found

PV03 and Route: Route 6

No glare found

PV03 and Route: Route 7

No glare found

PV03 and Route: Route 8

No glare found

PV03 and Route: Route 9

No glare found

PV03 and OP 1

No glare found

PV03 and OP 2

No glare found

PV03 and OP 3

No glare found

PV03 and OP 4

No glare found

PV03 and OP 5

No glare found

PV03 and OP 6

No glare found

PV03 and OP 7

No glare found

PV03 and OP 8

No glare found

PV03 and OP 9

No glare found

PV03 and OP 10

No glare found

PV03 and OP 11

No glare found

PV03 and OP 12

No glare found

PV03 and OP 13

No glare found

PV03 and OP 14

No glare found

PV03 and OP 15

No glare found

PV03 and OP 16

No glare found

PV03 and OP 17

No glare found

PV03 and OP 18

No glare found

PV03 and OP 19

No glare found

PV03 and OP 20

No glare found

PV03 and OP 21

No glare found

PV03 and OP 22

No glare found

PV03 and OP 23

No glare found

PV03 and OP 24

No glare found

PV03 and OP 25

No glare found

PV03 and OP 26

No glare found

PV03 and OP 27

No glare found

PV03 and OP 28

No glare found

PV03 and OP 29

No glare found

PV03 and OP 30

No glare found

PV03 and OP 31

No glare found

PV03 and OP 32

No glare found

PV03 and OP 33

No glare found

PV03 and OP 34

No glare found

PV03 and OP 35

No glare found

PV03 and OP 36

No glare found

PV03 and OP 37

No glare found

PV03 and OP 38

No glare found

PV03 and OP 39

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