ATTACHMENT G: GLINT AND GLARE ANALYSIS

To: HOHI bn, LLC

From: Drew Timmis, Tetra Tech, Inc.

Date: October 24, 2022

Subject: Glint and Glare Analysis of the Hop Hill Solar Project in Benton County, Washington

At the request of HOHI bn LLC (HOHI), a subsidiary of BNC DEVCO, LLC, a joint venture between BrightNight LLC and Cordelio Power, Tetra Tech, Inc. (Tetra Tech) conducted a glint and glare analysis of the proposed Hop Hill Solar and Storage Project (Project). The analysis reviewed the Siting Area, which encompasses the boundary of the leased parcels for the Project and covers approximately 22,020 acres. The Project is located on rural land in unincorporated Benton County, approximately 11 miles north of the city of Prosser. The Project Siting Area includes the Solar Array Siting Area, which is approximately 11,179 acres consisting of rural rangeland and agricultural lands with limited residential or commercial development.

This memorandum provides a description of the glint and glare anticipated from use of the Project site as a solar energy generating facility. Included with this memo are the Sandia glare analysis reports (Attachment A).

1.0 GLARE ANALYSIS METHOD

With growing numbers of solar energy systems being proposed and installed throughout the United States, the potential impact of glint (a momentary flash of bright light) and glare (a continuous source of bright light) from solar photovoltaic modules has come under scrutiny by aviation authorities. The Federal Aviation Administration (FAA) issued an Interim Policy (78 *Federal Register* [FR] 63276) on October 23, 2013, describing methods for obtaining FAA review and approval of proposed solar arrays on airport property. These methods involved the use of the Sandia National Laboratories (Sandia) Solar Glare Hazard Analysis Tool (SGHAT), a modeling/compliance analysis tool now licensed for public use within the ForgeSolar GlareGauge cloud software application.

Sandia developed SGHAT v. 3.0, a web-based tool and methodology to evaluate potential glint/glare associated with solar energy installations. The validated tool provides a quantified assessment of when and where glare will occur, as well as information about potential ocular impacts. The calculations and methods are based on analyses, test data, a database of different photovoltaic module surfaces (e.g., anti-reflective coating, texturing), and models developed over several years at Sandia. The results are presented in a simple, easy-to-interpret plot that specifies when glare will occur throughout the year, with color indicating the potential ocular hazard (Sandia National Laboratories 2016).

Based on this background, Tetra Tech has utilized the SGHAT tool as licensed for use in ForgeSolar GlareGauge cloud software application for modeling and analysis. ForgeSolar GlareGauge with SGHAT modeling provides a quantified assessment of when and where glare will occur, as well as information about potential ocular impacts. The calculations and methods are based on analyses, test data, a database of different photovoltaic module surfaces (e.g., anti-reflective coating, texturing), and models developed over several years at Sandia National Laboratory. The results are presented in a simple easy-to-interpret plot that specifies when glare will occur throughout the year, with color indicating the potential ocular hazard.

As requested by HOHI, the SGHAT was utilized to evaluate the potential for glint and glare when driving along 1) proximal segments of nearby roads (Anderson Road, Holmason Road, N County Line Road, Sheller Road, and W Snipes Road); 2) seventeen nearby locations selected to represent observer views at neighboring properties; 3) the two-mile final approach paths for the Sunnyside Municipal Airport (1S5) and Prosser Airport (S40); and 4) representative Department of Defense (DoD) flight paths within the vicinity of the Project.

The panels to be used on the proposed Project are smooth glass surface material with an anti-reflection coating (ARC), which is noted in the glare analysis. Two analyses were performed to simulate panels with single-axis tracking (SAT) with a 60 degree maximum tracking range, no resting angle, and a panel height of 7 feet above ground surface (centroid height) with applicable panel specifications. The panel orientation, location, and specifications used in the analysis were provided by HOHI. The two analyses differed due to the receptors. The analysis includes calculations to predict potential glare minutes at the following specified receptors:

- Viewing height of observer in standard first floor building at 6 feet above ground surface (Analysis 1);
- Viewing height of observer in standard vehicle at 5 feet above ground surface (Analysis 1);
- 1S5 two-mile final approach path for Runway 07 (Analysis 2)
- 1S5 two-mile final approach path for Runway 25 (Analysis 2)
- S40 two-mile final approach path for Runway 08 (Analysis 2)
- S40 two-mile final approach path for Runway 26 (Analysis 2)
- DoD training flight paths at 200 feet above ground surface (Analysis 2)

2.0 GLINT VS. GLARE

As an industry standard, the term “glint and glare analysis” is typically used to describe an analysis of potential ocular impacts to defined receptors. As a point of clarification, ForgeSolar defines glint and glare in the following statement:

> *Glint is typically defined as a momentary flash of bright light, often caused by a reflection off a moving source. A typical example of glint is a momentary solar reflection from a moving car. Glare is defined as a continuous source of bright light. Glare is generally associated with stationary objects, which, due to the slow relative movement of the sun, reflect sunlight for a longer duration.* (Sandia National Laboratories 2016)

Based on the ForgeSolar definitions of glint and glare and that the Project’s photovoltaic panels will not likely rotate faster than the relative daily motion of the sun, the potential reflectance from the Project modeled throughout this memo will be referred to as glare.

Glare is categorized by the SGHAT online tool, GlareGauge, into three tiers of severity (ocular hazards) that are shown by different colors in the model output:

- Red glare: glare predicted with a potential for permanent eye damage (retinal burn)
- Yellow glare: glare predicted with a potential for temporary after-image
- Green glare: glare predicted with a low potential for temporary after-image

These categories of glare are calculated using a typical observer's blink response time, ocular transmission coefficient (the amount of radiation absorbed in the eye prior to reaching the retina), pupil diameter, and eye focal length (the distance between where rays intersect in the eye and the retina). As a point of comparison, direct viewing of the sun without a filter is considered to be on the border between yellow glare and red glare, while typical camera flashes are considered to be lower tier yellow glare (approximately three orders of magnitude less than direct viewing of the sun). Upon exposure to yellow glare, the observer may experience a temporary spot in their vision after the exposure. Upon exposure to green glare, the observer may experience a bright reflection but typically no spot lasting after exposure.

3.0 FAA NOTICE CRITERIA CONSULTATION

The FAA developed a *Technical Guidance for Evaluating Selected Solar Technologies on Airports* in 2010 (updated in 2018), in addition to FAA regulatory guidance under 78 FR 63276 Interim Policy, *FAA Review of Solar Energy System Projects on Federally Obligated Airports* (collectively referred to as FAA Guidance). The FAA Guidance recommends that glare analyses should be performed on a site-specific basis using the Sandia SGHAT. This guidance applies to solar facilities located on federally obligated airport property; it is not mandatory for a proposed solar installation that is not on an airport (and for which a Form 7460-1 is filed with FAA pursuant to Code of Federal Regulations [CFR] Title 14 Part 77.9, as discussed below), but is considered to be an industry best practice for solar facilities in general. The SGHAT is the standard for measuring potential ocular impact as a result of solar facilities (78 FR 63276).

According to 78 FR 63276, the FAA has determined that "glint and glare from solar energy systems could result in an ocular impact to pilots and/or air traffic control (ATC) facilities and compromise the safety of the air transportation system" (FAA 2013). The updated final FAA policy at 86 FR 25801 states that:

> *FAA has subsequently concluded that in most cases, the glint and glare from solar energy systems to pilots on final approach is similar to glint and glare pilots routinely experience from water bodies, glass facade buildings, parking lots, and similar features. However, FAA has continued to receive reports of potential glint and glare from on-airport solar energy systems on personnel working in Air Traffic Control Tower (ATCT) cabs. Therefore, FAA has determined the scope of agency policy should be focused on the impact of on-airport solar energy systems to federally-obligated towered airports, specifically the airport's ATCT cab* (FAA 2021).

The FAA has developed the following criteria for analysis of solar energy projects located on jurisdictional airports:

- No potential for glint or glare in the existing or planned ATC tower cab.
- Glint or glare along the final approach path for any existing landing threshold or future landing thresholds (including any planned interim phases of the landing thresholds) as shown on the current

FAA-approved Airport Layout Plan is allowed. The final approach path is defined as 2 miles from 50 feet above the landing threshold using a standard three-degree glidepath.

The online FAA Notice Criteria Tool (NCT) reports whether a proposed structure is in proximity to a jurisdictional air navigation facility and if formal submission to the FAA Obstruction Evaluation Group under 14 CFR Part 77.9 (Safe, Efficient Use, and Preservation of the Navigable Airspace) is recommended. The NCT also identifies final approach flight paths that may be considered vulnerable to a proposed structure's impact on navigation signal reception. The NCT was utilized to determine if the proposed Project is located within an FAA-identified impact area based on the Project boundaries and height above ground surface. The FAA NCT Report stated that the Project does not exceed notice criteria and a formal filing with the FAA Obstruction Evaluation Group is not required.

4.0 GLARE ANALYSIS RESULTS

The SGHAT GlareGauge modeled the results for the Project. The simulation found that there is predicted green glare at Observation Point (OP) 2 and sections of Anderson Road in Analysis 1, and predicted green glare for the representative DoD Flight Path 1. A summary of the amount of predicted glare for analyses is presented in Table 1, showing only the receptors that received glare.

Table 1. Analysis of Predicted Glare Summary

Analysis	Receptor	Annual Green Glare		Annual Yellow Glare	
		minutes	hours	minutes	hours
Analysis 1	OP 2 - residential home	262,683	2,218.6	0	0
	Anderson Road	133114	4,378.1	0	0
Analysis 2 - FAA	DoD Flight Path 1	345,015	5,750.2	0	0

No instances of red glare are predicted for any OP or route segment.

5.0 SUMMARY

The Project site layout was modeled on SGHAT GlareGauge in order to evaluate the potential extent of any glint and glare the proposed Project may have upon nearby points of observation and vehicle route. Two analyses were performed: Analysis 1 represented the point of view from an average first floor residential/commercial structure and typical commuter car (6 feet and 5 feet, respectively); Analysis 2 represented the 2-mile final approach paths for nearby airports and representative flight paths through the vicinity. Both analyses used panel specifications of smooth glass with ARC. Based on the results, there is green glare predicted for specific receptors.

The analyses considered the photovoltaic array areas as the entire Siting Area, and not just the location of the panels. Panel placement is likely to be more restrained due to zoning setbacks and geographical constraints. With the panels moved away from the modeled siting boundary, it is likely that the predicted glare to Anderson Road will be zero because the analysis modeled only the adjacent edge of the Project to cause the glare. Similarly, OP 2 is for a residential home located within the Siting Area and glare is predicted due to the overlap of the modeled Project Area and close proximity. The glare predicted for OP 2 will likely be reduced once modeled with more accurate array layouts.

For Analysis 2, it is likely that the green glare predicted for the DoD flight path will not be an issue. The FAA policy pertaining to solar projects on federally obligated airport property (86 FR 25801) concludes that the glint and glare from a solar energy system pilots experience on final approach is similar to glint and glare pilots routinely experience from water bodies, glass façade buildings, parking lots, and similar features. For the Project, the glare predicted to aircraft along the modeled DoD test flight path at 200 feet is believed to have a similar impact as that of flying over a water body. Though the panels have a smoother surface than a water body, they will include an ARC that will drastically reduce their reflectivity. In addition, the actual exposure time to glare experienced by aircraft operating on those flight paths is dependent on aircraft speed while operating on the route. Military aircraft operating on routes typically fly at ground speeds ranging from 300 to 480 knots. The amount of exposure time to the predicted glare would be down to seconds.

The GlareGauge model does not account for varying ambient conditions (i.e., cloudy days, precipitation), atmospheric attenuation, screening due to existing topography not located within the defined array layouts, or existing vegetation or structures (including fences or walls), nor does the tool allow proposed landscaping to be included. As such, the predicted results are considered to be conservative.

6.0 REFERENCES

FAA (Federal Aviation Administration). 2018. Technical Guidance for Evaluating Selected Solar Technologies on Airports. Available online at: https://www.faa.gov/sites/faa.gov/files/airports/environmental/FAA-Airport-Solar-Guide-2018.pdf

FAA. 2021. FAA Policy: Review of Solar Energy System Projects on Federally-Obligated Airports. 86 FR 25801. May 11, 2021.

Sandia Solar Glare Hazard Analysis Tool, GlareGauge hosted by ForgeSolar. Accessed online https://www.forgesolar.com/.

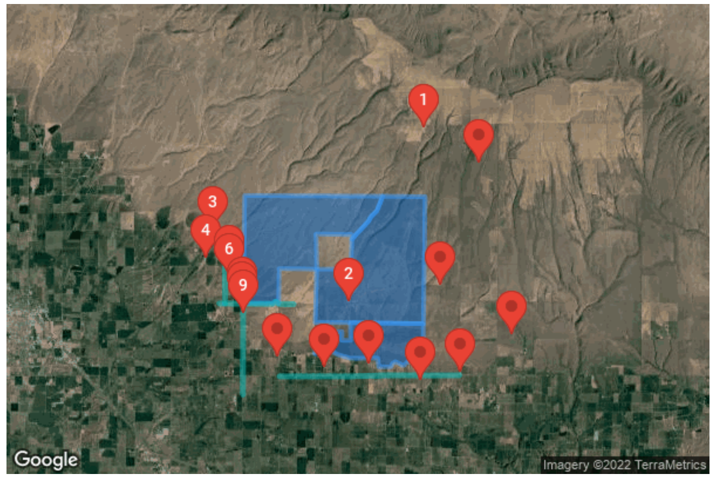
Sandia (Sandia National Laboratories). 2016. Solar Glare Hazard Analysis Tool (SGHAT) User’s Manual v. 3.0. December 6, 2016.

ATTACHMENT A: GLARE ANALYSIS REPORTS

FORGESOLAR GLARE ANALYSIS

Project: **Hop Hill**
Site configuration: **Hop Hill Solar_Analysis 1**

Created 04 Oct, 2022
Updated 05 Oct, 2022
Time-step 1 minute
Timezone offset UTC-8
Site ID 77050.13633
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
Methodology V2



Summary of Results Glare with low potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	SA tracking	SA tracking	133,114	2,218.6	0	0.0	-
PV array 2	SA tracking	SA tracking	262,683	4,378.1	0	0.0	-
PV array 3	SA tracking	SA tracking	0	0.0	0	0.0	-

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

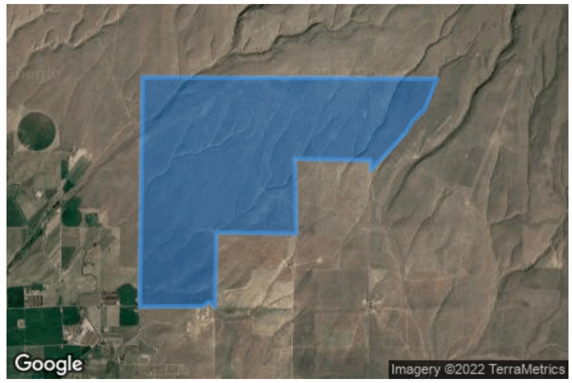
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Anderson Road	133,114	2,218.6	0	0.0
Holmason Road	0	0.0	0	0.0
N Country Line Road	0	0.0	0	0.0
Sheller Road	0	0.0	0	0.0
W Snipes Road	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	262,683	4,378.1	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
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

Component Data

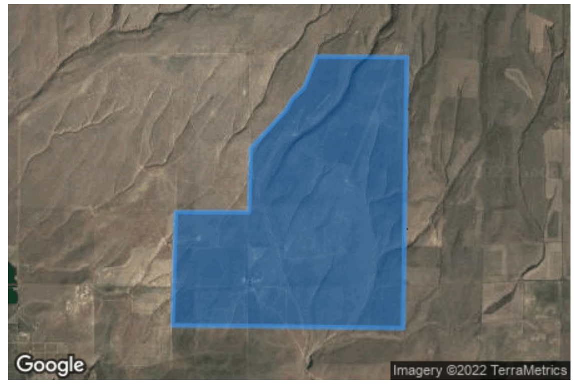
PV Arrays

Name: PV array 1
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 180.0°
Max tracking angle: 60.0°
Resting angle: 60.0°
Ground Coverage Ratio: 0.5
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material



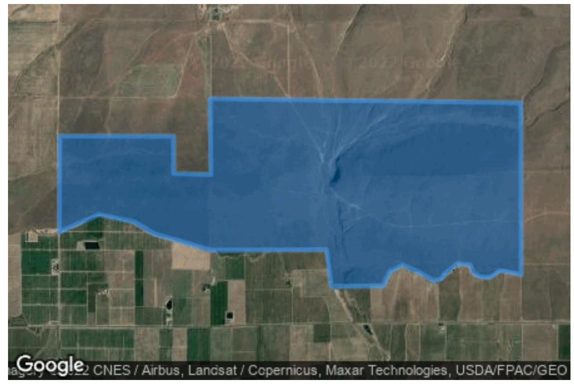
Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	46.331590	-119.873510	1209.18	7.00	1216.18
2	46.331679	-119.856001	1347.89	7.00	1354.89
3	46.332479	-119.854606	1336.12	7.00	1343.12
4	46.332308	-119.853845	1324.48	0.00	1324.48
5	46.332308	-119.853845	1324.48	0.00	1324.48
6	46.332308	-119.853845	1324.48	0.00	1324.48
7	46.332308	-119.853845	1324.48	0.00	1324.48
8	46.332308	-119.853845	1324.48	0.00	1324.48
9	46.332308	-119.853845	1324.48	0.00	1324.48
10	46.331515	-119.852761	1287.19	7.00	1294.19
11	46.345663	-119.852396	1353.66	7.00	1360.66
12	46.345456	-119.830423	1525.41	7.00	1532.41
13	46.359617	-119.830782	1717.13	7.00	1724.13
14	46.359365	-119.809904	1874.81	7.00	1881.81
15	46.357529	-119.809947	1844.98	7.00	1851.98
16	46.357499	-119.809904	1843.98	7.00	1850.98
17	46.364595	-119.800290	1944.39	7.00	1951.39
18	46.366846	-119.798316	1972.69	7.00	1979.69
19	46.368889	-119.795183	2017.57	7.00	2024.57
20	46.374367	-119.791965	2101.69	7.00	2108.69
21	46.374841	-119.791707	2115.43	7.00	2122.43
22	46.375099	-119.872650	1596.66	7.00	1603.66

Name: PV array 2
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 180.0°
Max tracking angle: 60.0°
Resting angle: 60.0°
Ground Coverage Ratio: 0.5
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	46.374844	-119.791753	2117.70	7.00	2124.70
2	46.374311	-119.792011	2103.25	7.00	2110.25
3	46.368862	-119.795187	2015.30	7.00	2022.30
4	46.366849	-119.798319	1972.69	7.00	1979.69
5	46.364568	-119.800293	1942.66	7.00	1949.66
6	46.357460	-119.809864	1843.14	7.00	1850.14
7	46.345404	-119.810336	1688.68	7.00	1695.68
8	46.345404	-119.830463	1525.41	7.00	1532.41
9	46.323933	-119.831314	1372.13	7.00	1379.13
10	46.323813	-119.810658	1444.83	7.00	1451.83
11	46.323427	-119.767907	1534.81	7.00	1541.81
12	46.374654	-119.766860	2292.77	7.00	2299.77

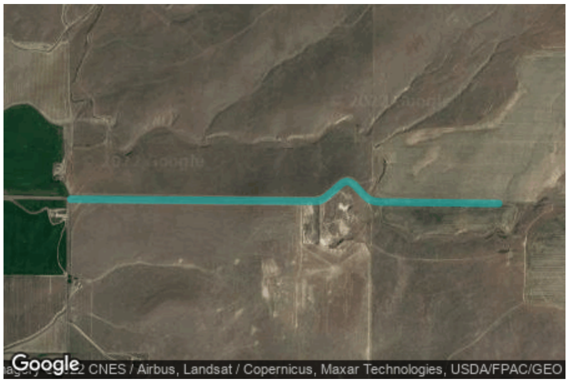
Name: PV array 3
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 180.0°
Max tracking angle: 60.0°
Resting angle: 60.0°
Ground Coverage Ratio: 0.5
Rated power: -
Panel material: Smooth glass without AR coating
Reflectivity: Vary with sun
Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	46.323826	-119.810710	1436.22	7.00	1443.22
2	46.316647	-119.810571	1450.46	7.00	1457.46
3	46.316727	-119.815688	1433.51	7.00	1440.51
4	46.320265	-119.815680	1395.89	7.00	1402.89
5	46.320287	-119.831365	1336.42	7.00	1343.42
6	46.311200	-119.831395	1325.23	7.00	1332.23
7	46.312860	-119.825945	1325.83	7.00	1332.83
8	46.312148	-119.821138	1321.89	7.00	1328.89
9	46.311037	-119.818378	1321.59	7.00	1328.59
10	46.309466	-119.810611	1319.44	7.00	1326.44
11	46.309525	-119.794714	1263.68	7.00	1270.68
12	46.306042	-119.794027	1251.36	7.00	1258.36
13	46.306101	-119.786903	1316.09	7.00	1323.09
14	46.307421	-119.786024	1318.41	7.00	1325.41
15	46.308088	-119.784286	1324.60	7.00	1331.60
16	46.307287	-119.781754	1327.17	7.00	1334.17
17	46.306561	-119.779973	1327.74	7.00	1334.74
18	46.306783	-119.778900	1329.85	7.00	1336.85
19	46.307243	-119.778449	1329.83	7.00	1336.83
20	46.308221	-119.776690	1331.98	7.00	1338.98
21	46.308073	-119.774973	1335.24	7.00	1342.24
22	46.307332	-119.774522	1336.98	7.00	1343.98
23	46.306961	-119.773621	1333.02	7.00	1340.02
24	46.306887	-119.772226	1333.05	7.00	1340.05
25	46.307554	-119.770896	1332.00	7.00	1339.00
26	46.307184	-119.767951	1335.97	7.00	1342.97
27	46.323430	-119.767982	1514.86	7.00	1521.86

Route Receptors

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



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	46.331275	-119.844020	1355.94	5.00	1360.94
2	46.331348	-119.852107	1293.43	5.00	1298.43
3	46.331374	-119.852504	1292.92	5.00	1297.92
4	46.331466	-119.852922	1296.47	5.00	1301.47
5	46.331666	-119.853265	1304.95	5.00	1309.95
6	46.332137	-119.853898	1326.49	5.00	1331.49
7	46.332281	-119.854220	1334.56	5.00	1339.56
8	46.332322	-119.854472	1338.55	5.00	1343.55
9	46.332244	-119.854778	1343.16	5.00	1348.16
10	46.331896	-119.855347	1346.46	5.00	1351.46
11	46.331522	-119.856001	1347.99	5.00	1352.99
12	46.331414	-119.856291	1346.59	5.00	1351.59
13	46.331387	-119.856631	1344.14	5.00	1349.14
14	46.331482	-119.873426	1208.67	5.00	1213.67

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	46.331618	-119.884099	1159.48	5.00	1164.48
2	46.335678	-119.884084	1097.03	5.00	1102.03
3	46.339438	-119.884160	1150.11	5.00	1155.11
4	46.341949	-119.884181	1169.83	5.00	1174.83
5	46.344826	-119.884151	1153.12	5.00	1158.12
6	46.346289	-119.884204	1164.44	5.00	1169.44

Name: N Country Line Road
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	46.294847	-119.873716	988.47	5.00	993.47
2	46.301704	-119.873694	1041.21	5.00	1046.21
3	46.310058	-119.873655	1135.57	5.00	1140.57
4	46.316951	-119.873608	1236.33	5.00	1241.33
5	46.321501	-119.873578	1258.90	5.00	1263.90
6	46.327889	-119.873568	1197.25	5.00	1202.25
7	46.331228	-119.873523	1203.23	5.00	1208.23

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	46.331475	-119.873576	1207.62	5.00	1212.62
2	46.331497	-119.875931	1199.57	5.00	1204.57
3	46.331522	-119.878343	1186.21	5.00	1191.21
4	46.331545	-119.881084	1173.42	5.00	1178.42
5	46.331563	-119.885328	1153.35	5.00	1158.35
6	46.331585	-119.887532	1135.28	5.00	1140.28

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

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	46.302605	-119.746974	1282.80	5.00	1287.80
2	46.302524	-119.760144	1278.75	5.00	1283.75
3	46.302554	-119.771685	1283.08	5.00	1288.08
4	46.302554	-119.786844	1258.98	5.00	1263.98
5	46.302584	-119.788601	1236.26	5.00	1241.26
6	46.302495	-119.794073	1253.89	5.00	1258.89
7	46.302287	-119.804495	1247.40	5.00	1252.40
8	46.302162	-119.811205	1259.99	5.00	1264.99
9	46.302162	-119.830317	1195.85	5.00	1200.85
10	46.302156	-119.852150	1120.17	5.00	1125.17

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (ft)	Height (ft)
OP 1	1	46.402155	-119.767164	2703.71	6.00
OP 2	2	46.332127	-119.811383	1511.94	6.00
OP 3	3	46.360961	-119.891323	1308.76	6.00
OP 4	4	46.349706	-119.895185	1161.02	6.00
OP 5	5	46.345603	-119.881173	1178.55	6.00
OP 6	6	46.342403	-119.881131	1192.89	6.00
OP 7	7	46.332639	-119.873979	1216.85	6.00
OP 8	8	46.330635	-119.874022	1198.87	6.00
OP 9	9	46.327482	-119.873175	1192.30	6.00
OP 10	10	46.309916	-119.853522	1188.09	6.00
OP 11	11	46.305493	-119.825713	1250.03	6.00
OP 12	12	46.306931	-119.799678	1316.14	6.00
OP 13	13	46.300498	-119.769565	1255.65	6.00
OP 14	14	46.303556	-119.746081	1304.16	6.00
OP 15	15	46.318757	-119.716063	1620.58	6.00
OP 16	16	46.339080	-119.757640	1796.46	6.00
OP 17	17	46.388257	-119.735165	2610.14	6.00

Glare Analysis Results

Summary of Results

Glare with low potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	SA tracking	SA tracking	133,114	2,218.6	0	0.0	-
PV array 2	SA tracking	SA tracking	262,683	4,378.1	0	0.0	-
PV array 3	SA tracking	SA tracking	0	0.0	0	0.0	-

Total annual 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
Anderson Road	133,114	2,218.6	0	0.0
Holmason Road	0	0.0	0	0.0
N Country Line Road	0	0.0	0	0.0
Sheller Road	0	0.0	0	0.0
W Snipes Road	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	262,683	4,378.1	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

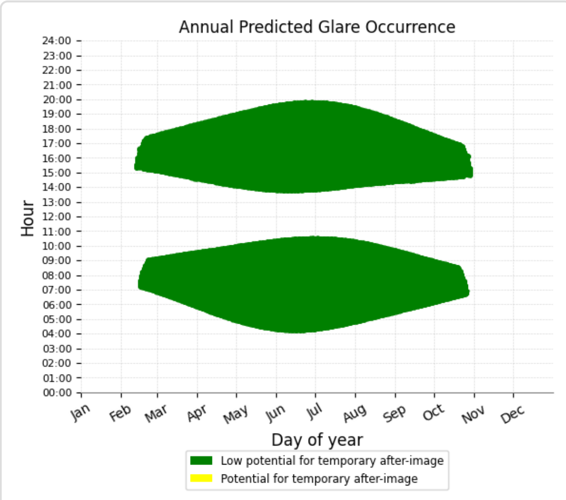
PV: PV array 1 low potential for temporary after-image

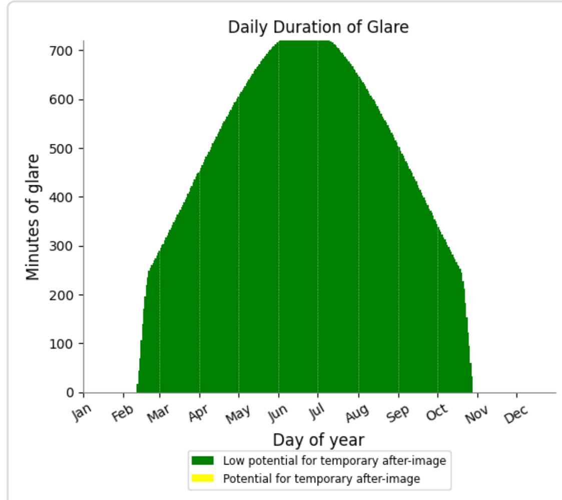
Receptor results ordered by category of glare

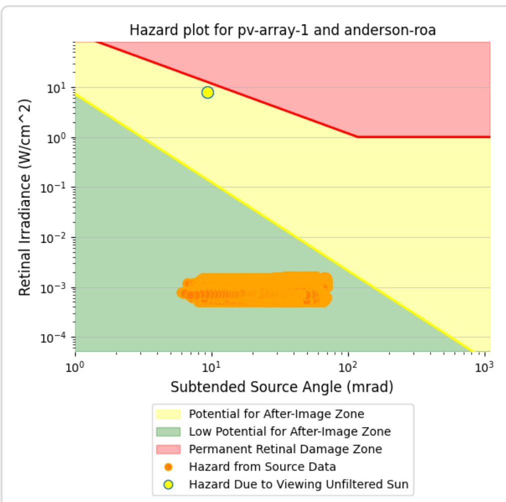
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Anderson Road	133,114	2,218.6	0	0.0
Holmason Road	0	0.0	0	0.0
N Country Line Road	0	0.0	0	0.0
Sheller Road	0	0.0	0	0.0
W Snipes Road	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	0	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

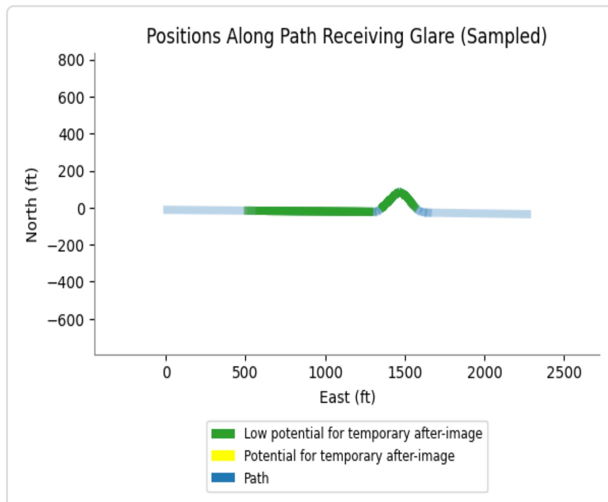
PV array 1 and Anderson Road

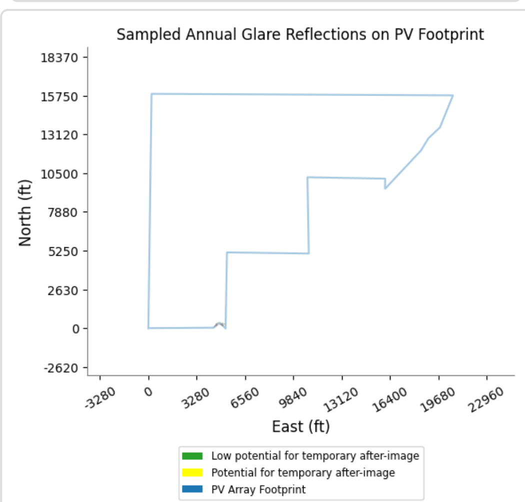
Receptor type: Route
0 minutes of yellow glare
133,114 minutes of green glare











PV array 1 and Holmason Road

Receptor type: Route
No glare found

PV array 1 and N Country Line Road

Receptor type: Route
No glare found

PV array 1 and Sheller Road

Receptor type: Route
No glare found

PV array 1 and W Snipes Road

Receptor type: Route
No glare found

PV array 1 and OP 1

Receptor type: Observation Point
No glare found

PV array 1 and OP 2

Receptor type: Observation Point
No glare found

PV array 1 and OP 3

Receptor type: Observation Point
No glare found

PV array 1 and OP 4

Receptor type: Observation Point
No glare found

PV array 1 and OP 5

Receptor type: Observation Point
No glare found

PV array 1 and OP 6

Receptor type: Observation Point
No glare found

PV array 1 and OP 7

Receptor type: Observation Point
No glare found

PV array 1 and OP 8

Receptor type: Observation Point
No glare found

PV array 1 and OP 9

Receptor type: Observation Point
No glare found

PV array 1 and OP 10

Receptor type: Observation Point
No glare found

PV array 1 and OP 11

Receptor type: Observation Point
No glare found

PV array 1 and OP 12

Receptor type: Observation Point
No glare found

PV array 1 and OP 13

Receptor type: Observation Point
No glare found

PV array 1 and OP 14

Receptor type: Observation Point
No glare found

PV array 1 and OP 15

Receptor type: Observation Point
No glare found

PV array 1 and OP 16

Receptor type: Observation Point
No glare found

PV array 1 and OP 17

Receptor type: Observation Point

No glare found

PV: PV array 2 low potential for temporary after-image

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Anderson Road	0	0.0	0	0.0
Holmason Road	0	0.0	0	0.0
N Country Line Road	0	0.0	0	0.0
Sheller Road	0	0.0	0	0.0
W Snipes Road	0	0.0	0	0.0
OP 2	262,683	4,378.1	0	0.0
OP 1	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

PV array 2 and Anderson Road

Receptor type: Route

No glare found

PV array 2 and Holmason Road

Receptor type: Route

No glare found

PV array 2 and N Country Line Road

Receptor type: Route

No glare found

PV array 2 and Sheller Road

Receptor type: Route

No glare found

PV array 2 and W Snipes Road

Receptor type: Route

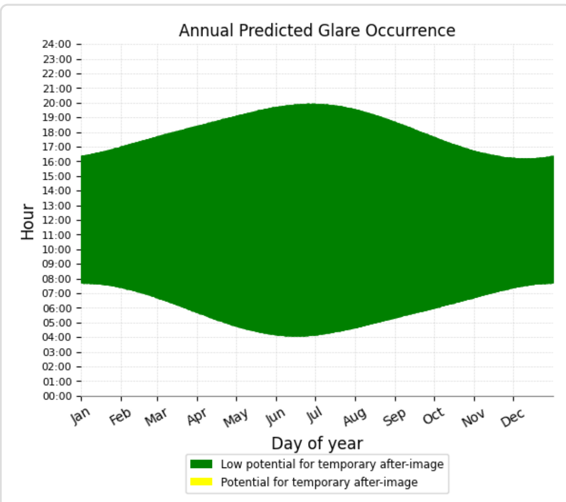
No glare found

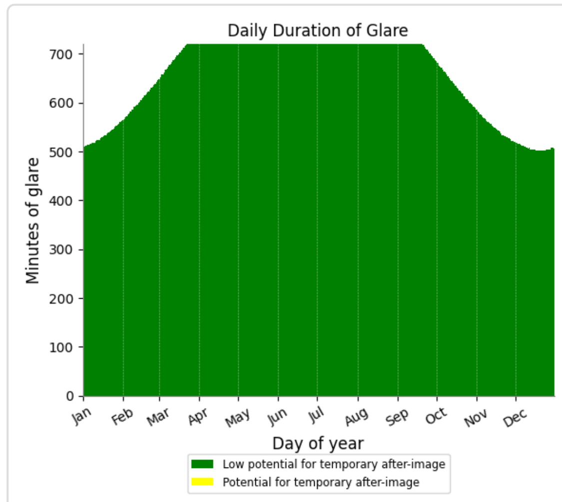
PV array 2 and OP 2

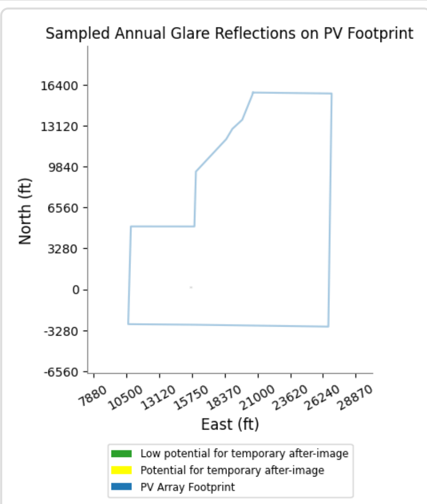
Receptor type: Observation Point

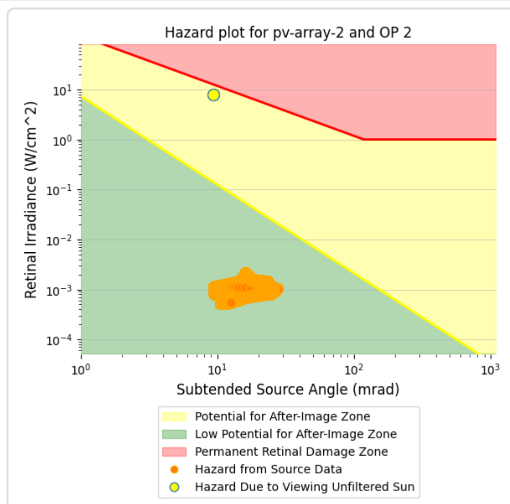
0 minutes of yellow glare

262,683 minutes of green glare









PV array 2 and OP 1

Receptor type: Observation Point

No glare found

PV array 2 and OP 3

Receptor type: Observation Point

No glare found

PV array 2 and OP 4

Receptor type: Observation Point

No glare found

PV array 2 and OP 5

Receptor type: Observation Point

No glare found

PV array 2 and OP 6

Receptor type: Observation Point

No glare found

PV array 2 and OP 7

Receptor type: Observation Point

No glare found

PV array 2 and OP 8

Receptor type: Observation Point

No glare found

PV array 2 and OP 9

Receptor type: Observation Point

No glare found

PV array 2 and OP 10

Receptor type: Observation Point

No glare found

PV array 2 and OP 11

Receptor type: Observation Point

No glare found

PV array 2 and OP 12

Receptor type: Observation Point

No glare found

PV array 2 and OP 13

Receptor type: Observation Point

No glare found

PV array 2 and OP 14

Receptor type: Observation Point

No glare found

PV array 2 and OP 15

Receptor type: Observation Point

No glare found

PV array 2 and OP 16

Receptor type: Observation Point

No glare found

PV array 2 and OP 17

Receptor type: Observation Point

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
Anderson Road	0	0.0	0	0.0
Holmason Road	0	0.0	0	0.0
N Country Line Road	0	0.0	0	0.0
Sheller Road	0	0.0	0	0.0
W Snipes Road	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

PV array 3 and Anderson Road

Receptor type: Route

No glare found

PV array 3 and N Country Line Road

Receptor type: Route

No glare found

PV array 3 and Holmason Road

Receptor type: Route

No glare found

PV array 3 and Sheller Road

Receptor type: Route

No glare found

PV array 3 and W Snipes Road

Receptor type: Route

No glare found

PV array 3 and OP 1

Receptor type: Observation Point
No glare found

PV array 3 and OP 2

Receptor type: Observation Point
No glare found

PV array 3 and OP 3

Receptor type: Observation Point
No glare found

PV array 3 and OP 4

Receptor type: Observation Point
No glare found

PV array 3 and OP 5

Receptor type: Observation Point
No glare found

PV array 3 and OP 6

Receptor type: Observation Point
No glare found

PV array 3 and OP 7

Receptor type: Observation Point
No glare found

PV array 3 and OP 8

Receptor type: Observation Point
No glare found

PV array 3 and OP 9

Receptor type: Observation Point
No glare found

PV array 3 and OP 10

Receptor type: Observation Point
No glare found

PV array 3 and OP 11

Receptor type: Observation Point
No glare found

PV array 3 and OP 12

Receptor type: Observation Point
No glare found

PV array 3 and OP 13

Receptor type: Observation Point
No glare found

PV array 3 and OP 14

Receptor type: Observation Point
No glare found

PV array 3 and OP 15

Receptor type: Observation Point
No glare found

PV array 3 and OP 16

Receptor type: Observation Point
No glare found

PV array 3 and OP 17

Receptor type: Observation Point
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.

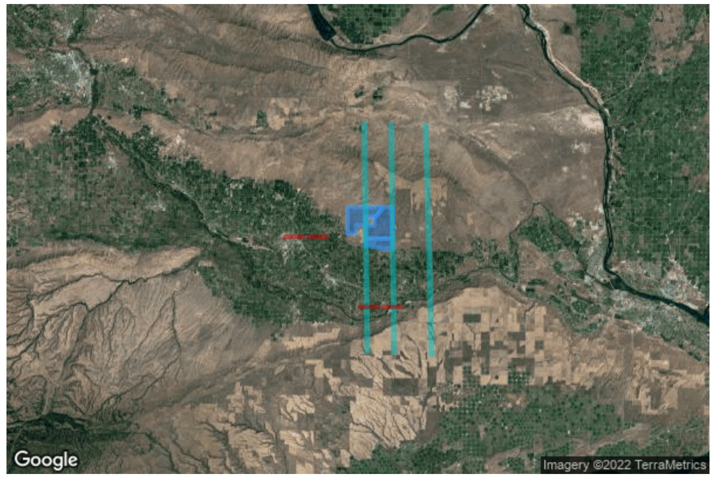
Default glare analysis parameters and observer eye characteristics (for reference only):

- 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

FORGESOLAR GLARE ANALYSIS

Project: **Hop Hill**
Site configuration: **Hop Hill Solar_Analysis 2**

Created 05 Oct, 2022
Updated 05 Oct, 2022
Time-step 1 minute
Timezone offset UTC-8
Site ID 77086.13633
Category 100 MW to 1 GW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
Methodology V2



Summary of Results Glare with low potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	SA tracking	SA tracking	104,451	1,740.8	0	0.0	-
PV array 2	SA tracking	SA tracking	120,509	2,008.5	0	0.0	-
PV array 3	SA tracking	SA tracking	120,055	2,000.9	0	0.0	-

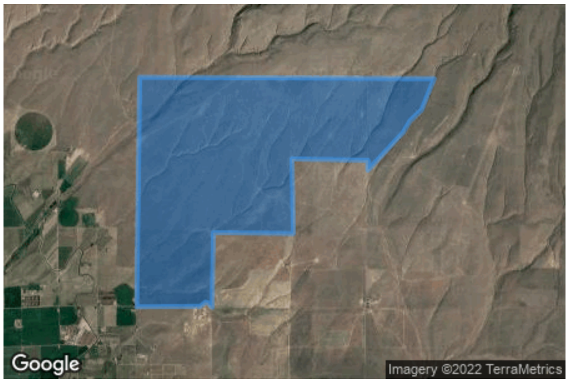
Total annual glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
DoD Flight Path 1	345,015	5,750.2	0	0.0
DoD Flight Path 2	0	0.0	0	0.0
DoD Flight Path 3	0	0.0	0	0.0
1S5 RWY 07	0	0.0	0	0.0
1S5 RWY 25	0	0.0	0	0.0
S40 RWY 26	0	0.0	0	0.0
S40 RWY 8	0	0.0	0	0.0

Component Data

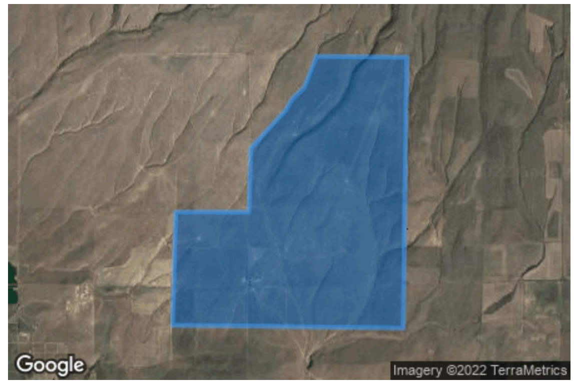
PV Arrays

Name: PV array 1
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 180.0°
Max tracking angle: 60.0°
Resting angle: 60.0°
Ground Coverage Ratio: 0.5
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material



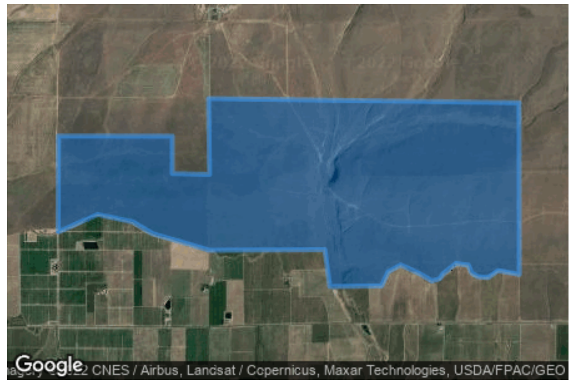
Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	46.331590	-119.873510	1209.18	7.00	1216.18
2	46.331679	-119.856001	1347.89	7.00	1354.89
3	46.332479	-119.854606	1336.12	7.00	1343.12
4	46.332308	-119.853845	1324.48	0.00	1324.48
5	46.331515	-119.852761	1287.19	7.00	1294.19
6	46.345663	-119.852396	1353.66	7.00	1360.66
7	46.345456	-119.830423	1525.41	7.00	1532.41
8	46.359617	-119.830782	1717.13	7.00	1724.13
9	46.359365	-119.809904	1874.81	7.00	1881.81
10	46.357529	-119.809947	1844.98	7.00	1851.98
11	46.357499	-119.809904	1843.98	7.00	1850.98
12	46.364595	-119.800290	1944.39	7.00	1951.39
13	46.366846	-119.798316	1972.69	7.00	1979.69
14	46.368889	-119.795183	2017.57	7.00	2024.57
15	46.374367	-119.791965	2101.69	7.00	2108.69
16	46.374841	-119.791707	2115.43	7.00	2122.43
17	46.375099	-119.872650	1596.66	7.00	1603.66

Name: PV array 2
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 180.0°
Max tracking angle: 60.0°
Resting angle: 60.0°
Ground Coverage Ratio: 0.5
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	46.374844	-119.791753	2117.70	7.00	2124.70
2	46.374311	-119.792011	2103.25	7.00	2110.25
3	46.368862	-119.795187	2015.30	7.00	2022.30
4	46.366849	-119.798319	1972.69	7.00	1979.69
5	46.364568	-119.800293	1942.66	7.00	1949.66
6	46.357460	-119.809864	1843.14	7.00	1850.14
7	46.345404	-119.810336	1688.68	7.00	1695.68
8	46.345404	-119.830463	1525.41	7.00	1532.41
9	46.323933	-119.831314	1372.13	7.00	1379.13
10	46.323813	-119.810658	1444.83	7.00	1451.83
11	46.323427	-119.767907	1534.81	7.00	1541.81
12	46.374654	-119.766860	2292.77	7.00	2299.77

Name: PV array 3
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 180.0°
Max tracking angle: 60.0°
Resting angle: 60.0°
Ground Coverage Ratio: 0.5
Rated power: -
Panel material: Smooth glass without 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	46.323826	-119.810710	1436.22	7.00	1443.22
2	46.316647	-119.810571	1450.46	7.00	1457.46
3	46.316727	-119.815688	1433.51	7.00	1440.51
4	46.320265	-119.815680	1395.89	7.00	1402.89
5	46.320287	-119.831365	1336.42	7.00	1343.42
6	46.311200	-119.831395	1325.23	7.00	1332.23
7	46.312860	-119.825945	1325.83	7.00	1332.83
8	46.312148	-119.821138	1321.89	7.00	1328.89
9	46.311037	-119.818378	1321.59	7.00	1328.59
10	46.309466	-119.810611	1319.44	7.00	1326.44
11	46.309525	-119.794714	1263.68	7.00	1270.68
12	46.306042	-119.794027	1251.36	7.00	1258.36
13	46.306101	-119.786903	1316.09	7.00	1323.09
14	46.307421	-119.786024	1318.41	7.00	1325.41
15	46.308088	-119.784286	1324.60	7.00	1331.60
16	46.307287	-119.781754	1327.17	7.00	1334.17
17	46.306561	-119.779973	1327.74	7.00	1334.74
18	46.306783	-119.778900	1329.85	7.00	1336.85
19	46.307243	-119.778449	1329.83	7.00	1336.83
20	46.308221	-119.776690	1331.98	7.00	1338.98
21	46.308073	-119.774973	1335.24	7.00	1342.24
22	46.307332	-119.774522	1336.98	7.00	1343.98
23	46.306961	-119.773621	1333.02	7.00	1340.02
24	46.306887	-119.772226	1333.05	7.00	1340.05
25	46.307554	-119.770896	1332.00	7.00	1339.00
26	46.307184	-119.767951	1335.97	7.00	1342.97
27	46.323430	-119.767982	1514.86	7.00	1521.86

Route Receptors

Name: DoD Flight Path 1
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	46.508427	-119.833504	1006.29	200.00	1206.29
2	46.141417	-119.826638	1639.10	200.00	1839.10

Name: DoD Flight Path 2
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	46.506536	-119.770333	845.92	200.00	1045.92
2	46.139514	-119.763467	1332.35	200.00	1532.35

Name: DoD Flight Path 3
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	46.505591	-119.689309	652.56	200.00	852.56
2	46.135707	-119.675576	1098.31	200.00	1298.31

Flight Path Receptors

Name: 1S5 RWY 07
Description:
Threshold height: 50 ft
Direction: 90.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	46.326762	-119.977144	737.66	50.00	787.66
Two-mile	46.326762	-120.019062	740.29	600.80	1341.09

Name: 1S5 RWY 25
Description:
Threshold height: 50 ft
Direction: 270.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	46.326700	-119.963735	761.35	50.00	811.35
Two-mile	46.326700	-119.921817	897.68	467.10	1364.78

Name: S40 RWY 26
Description:
Threshold height: 50 ft
Direction: 270.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	46.213351	-119.788731	679.42	50.00	729.42
Two-mile	46.213351	-119.746899	697.59	585.26	1282.85

Name: S40 RWY 8
Description:
Threshold height: 50 ft
Direction: 90.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	46.213396	-119.802390	702.54	50.00	752.54
Two-mile	46.213396	-119.844222	763.72	542.25	1305.97

Glare Analysis Results

Summary of Results Glare with low potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	SA tracking	SA tracking	104,451	1,740.8	0	0.0	-
PV array 2	SA tracking	SA tracking	120,509	2,008.5	0	0.0	-
PV array 3	SA tracking	SA tracking	120,055	2,000.9	0	0.0	-

Total annual 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
DoD Flight Path 1	345,015	5,750.2	0	0.0
DoD Flight Path 2	0	0.0	0	0.0
DoD Flight Path 3	0	0.0	0	0.0
1S5 RWY 07	0	0.0	0	0.0
1S5 RWY 25	0	0.0	0	0.0
S40 RWY 26	0	0.0	0	0.0
S40 RWY 8	0	0.0	0	0.0

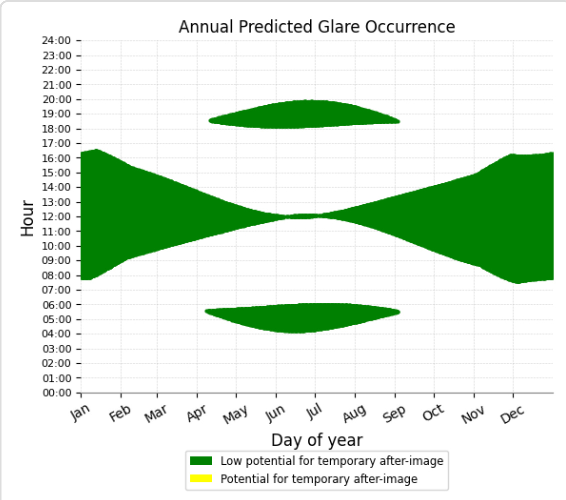
PV: PV array 1 low potential for temporary after-image

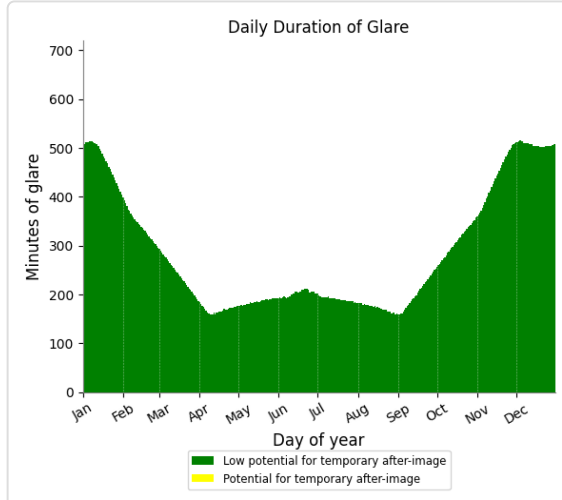
Receptor results ordered by category of glare

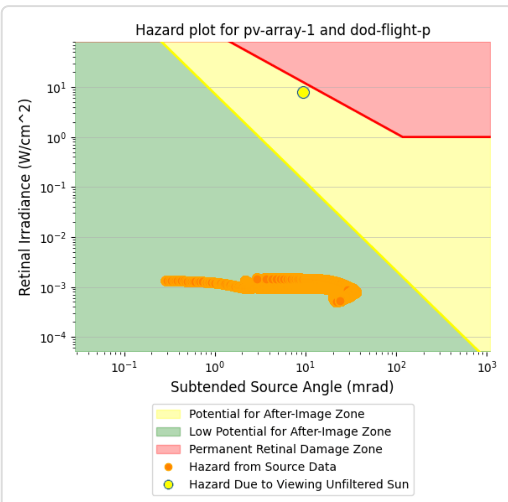
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
DoD Flight Path 1	104,451	1,740.8	0	0.0
DoD Flight Path 2	0	0.0	0	0.0
DoD Flight Path 3	0	0.0	0	0.0
1S5 RWY 07	0	0.0	0	0.0
1S5 RWY 25	0	0.0	0	0.0
S40 RWY 26	0	0.0	0	0.0
S40 RWY 8	0	0.0	0	0.0

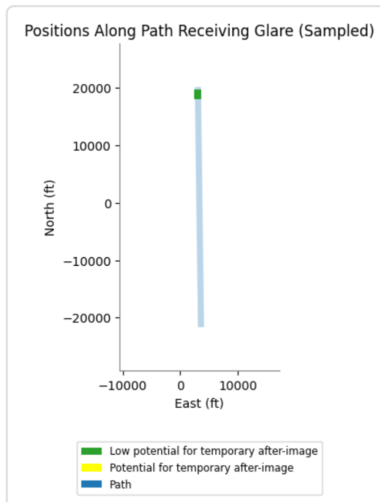
PV array 1 and DoD Flight Path 1

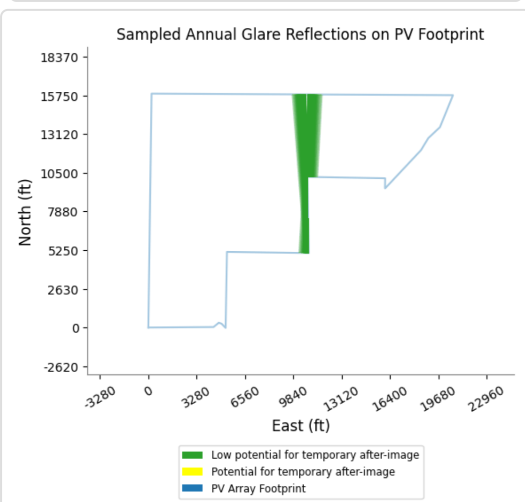
Receptor type: Route
0 minutes of yellow glare
104,451 minutes of green glare











PV array 1 and DoD Flight Path 2

Receptor type: Route

No glare found

PV array 1 and DoD Flight Path 3

Receptor type: Route

No glare found

PV array 1 and 1S5 RWY 07

Receptor type: 2-mile Flight Path

No glare found

PV array 1 and 1S5 RWY 25

Receptor type: 2-mile Flight Path

No glare found

PV array 1 and S40 RWY 26

Receptor type: 2-mile Flight Path

No glare found

PV array 1 and S40 RWY 8

Receptor type: 2-mile Flight Path

No glare found

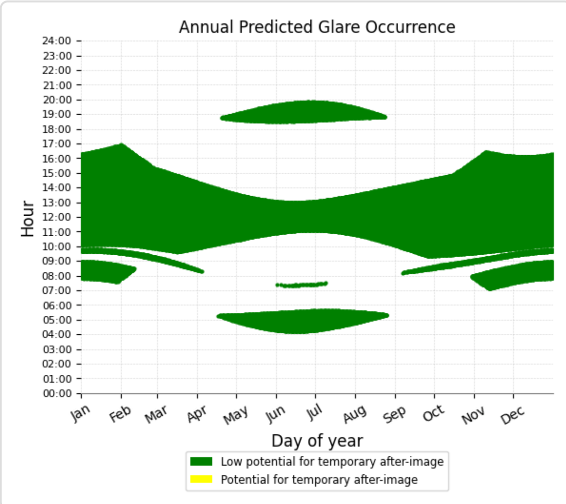
PV: PV array 2 low potential for temporary after-image

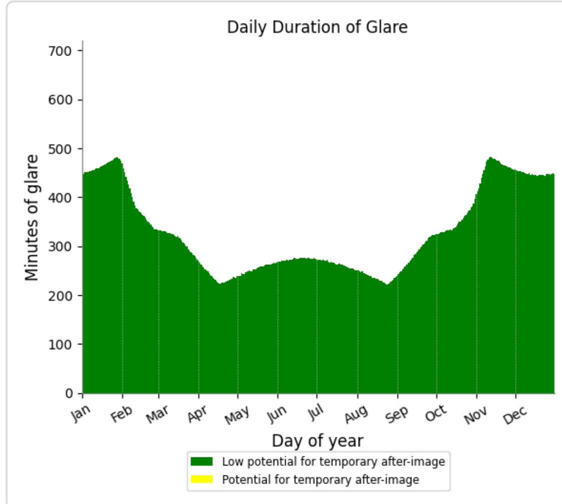
Receptor results ordered by category of glare

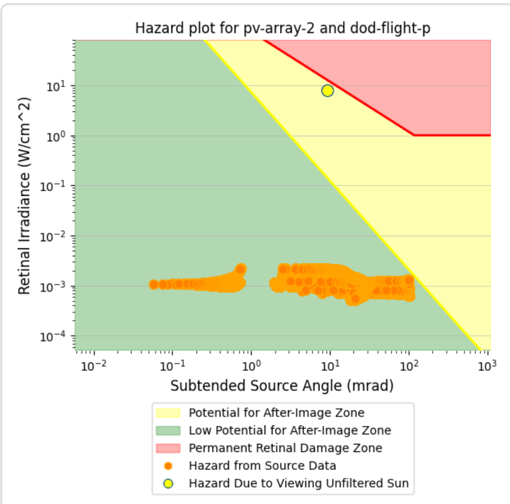
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
DoD Flight Path 1	120,509	2,008.5	0	0.0
DoD Flight Path 2	0	0.0	0	0.0
DoD Flight Path 3	0	0.0	0	0.0
1S5 RWY 07	0	0.0	0	0.0
1S5 RWY 25	0	0.0	0	0.0
S40 RWY 26	0	0.0	0	0.0
S40 RWY 8	0	0.0	0	0.0

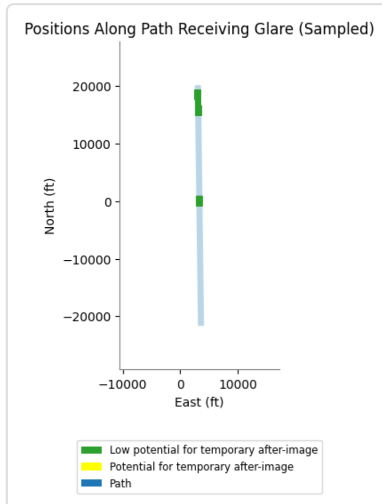
PV array 2 and DoD Flight Path 1

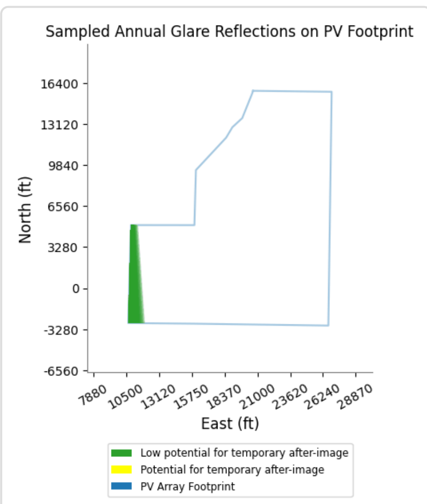
Receptor type: Route
0 minutes of yellow glare
120,509 minutes of green glare











PV array 2 and DoD Flight Path 2

Receptor type: Route

No glare found

PV array 2 and DoD Flight Path 3

Receptor type: Route

No glare found

PV array 2 and 1S5 RWY 07

Receptor type: 2-mile Flight Path

No glare found

PV array 2 and 1S5 RWY 25

Receptor type: 2-mile Flight Path

No glare found

PV array 2 and S40 RWY 26

Receptor type: 2-mile Flight Path

No glare found

PV array 2 and S40 RWY 8

Receptor type: 2-mile Flight Path

No glare found

PV: PV array 3 low potential for temporary after-image

Receptor results ordered by category of glare

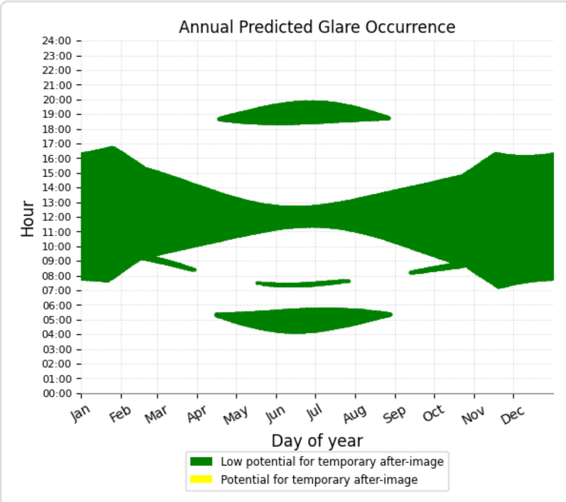
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
DoD Flight Path 1	120,055	2,000.9	0	0.0
DoD Flight Path 2	0	0.0	0	0.0
DoD Flight Path 3	0	0.0	0	0.0
1S5 RWY 07	0	0.0	0	0.0
1S5 RWY 25	0	0.0	0	0.0
S40 RWY 26	0	0.0	0	0.0
S40 RWY 8	0	0.0	0	0.0

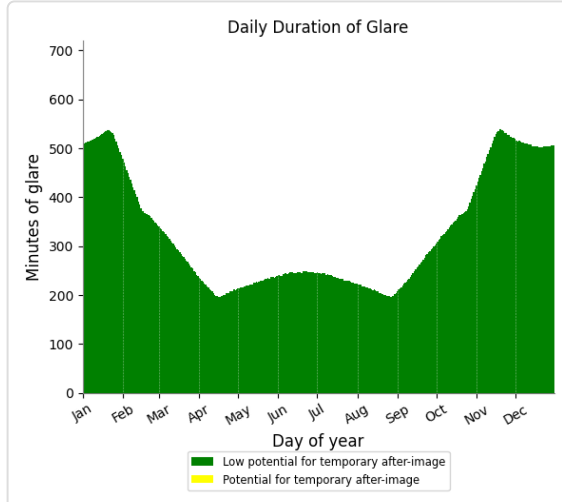
PV array 3 and DoD Flight Path 1

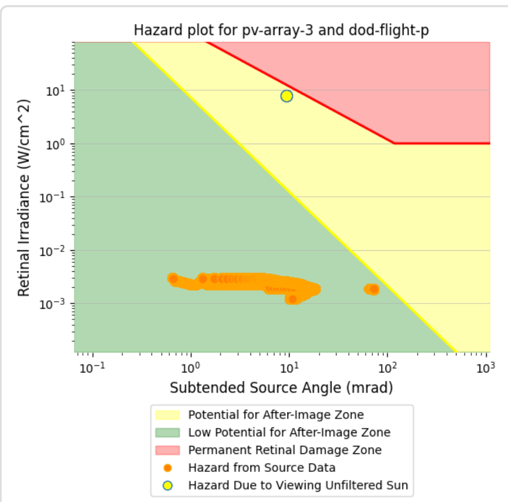
Receptor type: Route

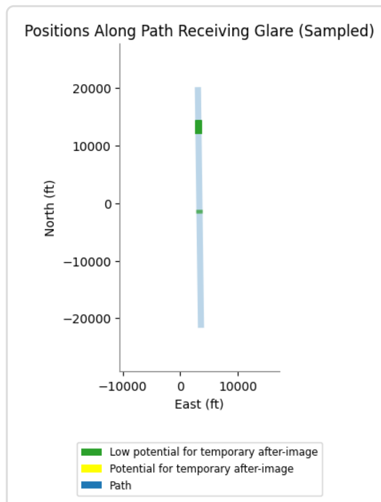
0 minutes of yellow glare

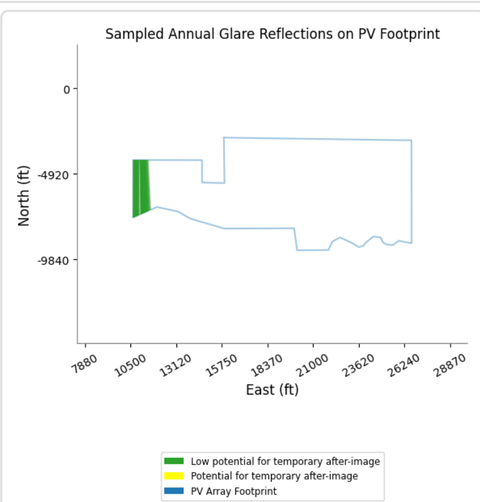
120,055 minutes of green glare











PV array 3 and DoD Flight Path 2

Receptor type: Route
No glare found

PV array 3 and DoD Flight Path 3

Receptor type: Route
No glare found

PV array 3 and 1S5 RWY 07

Receptor type: 2-mile Flight Path
No glare found

PV array 3 and 1S5 RWY 25

Receptor type: 2-mile Flight Path
No glare found

PV array 3 and S40 RWY 26

Receptor type: 2-mile Flight Path
No glare found

PV array 3 and S40 RWY 8

Receptor type: 2-mile Flight Path
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