“E”

Visual Assessment and Glare Impact Study

American Canyon Solar P18-00114-UP
Planning Commission Hearing October 17, 2018

American Canyon Solar Project

Permit #: P18-00114

Visual Assessment from American Canyon Road

May 2018

RENEWABLE PROPERTIES

Visual Assessment Summary

In response to Napa County Planning, Building, and Environmental Services' request to assess the visibility of the American Canyon Solar Project (the “Project”) at 2180 American Canyon Road, American Canyon, CA 94503 (the "Property") from American Canyon Road, the Renewable Properties team submits the following visual assessment of the Project. As presented below, the Project is naturally screened from the scenic roadway and not visible from American Canyon Road.

Napa County has designated American Canyon Road as a scenic roadway. The Napa County Code considers American Canyon Road an "Arterial County Road," requiring a 42-foot setback from project improvements. At its nearest point, the Project is over 600 feet from American Canyon Road. This distance significantly exceeds the minimum setback requirements and minimizes the overall appearance and optics of the Property itself, let alone the Project.

The Property has a natural vegetative barrier surrounding the periphery of the Project area. The elevation of the Project's solar panels are approximately 6’ to 8’ in height, but the natural vegetative barrier runs continuously parallel to American Canyon Road, ranging anywhere from 20’ to 50’ high from elevations along the roadway. Due to the distance from the Project site to American Canyon Road and the vegetative buffer surrounding the Property, the Project is not visible from American Canyon Road.

Exhibit A: Project site aerial with Natural Vegetative Buffer

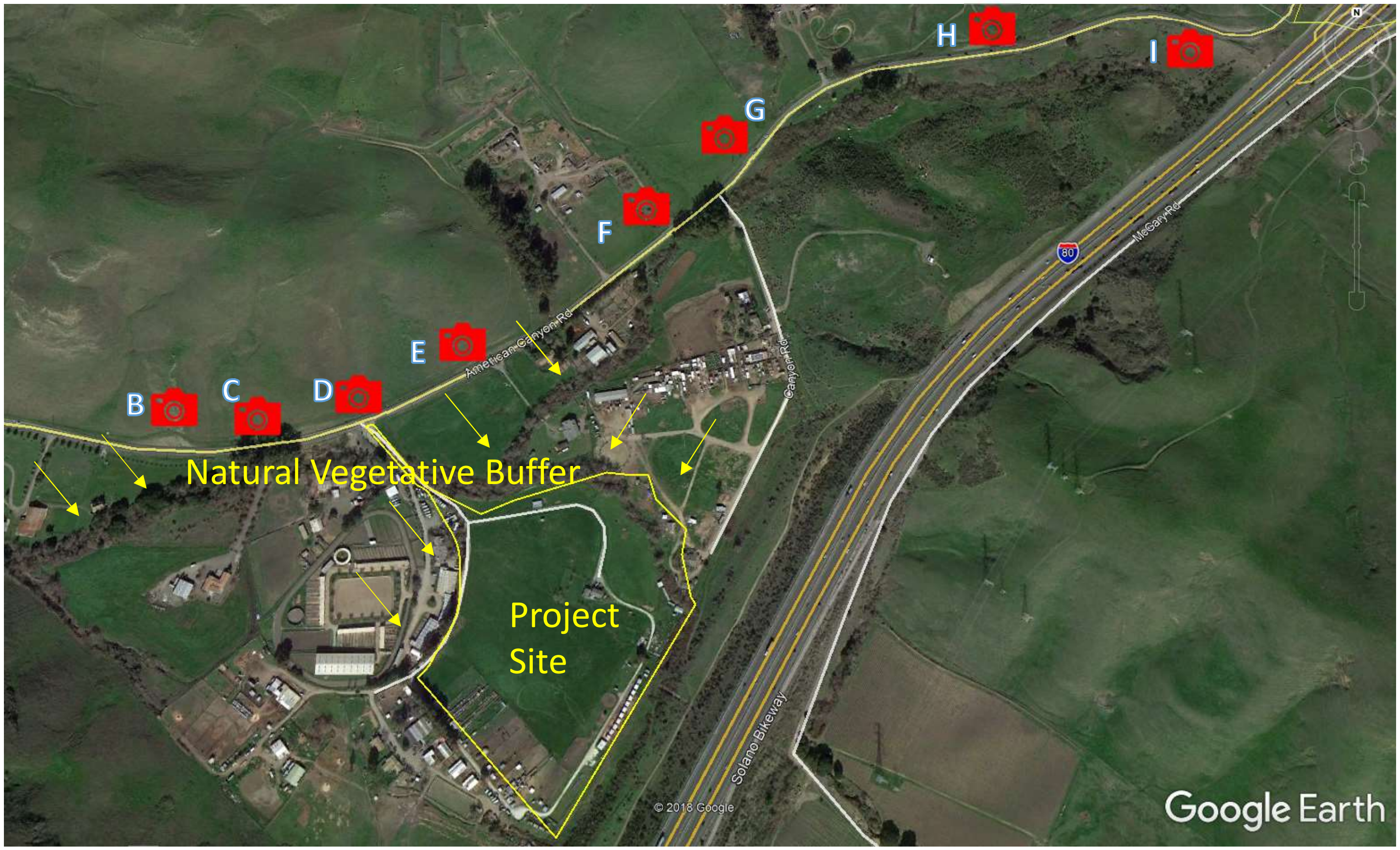


Exhibit B: Approaching the project from the west heading east along American Canyon Road

The project site is shielded from view by a natural vegetative barrier

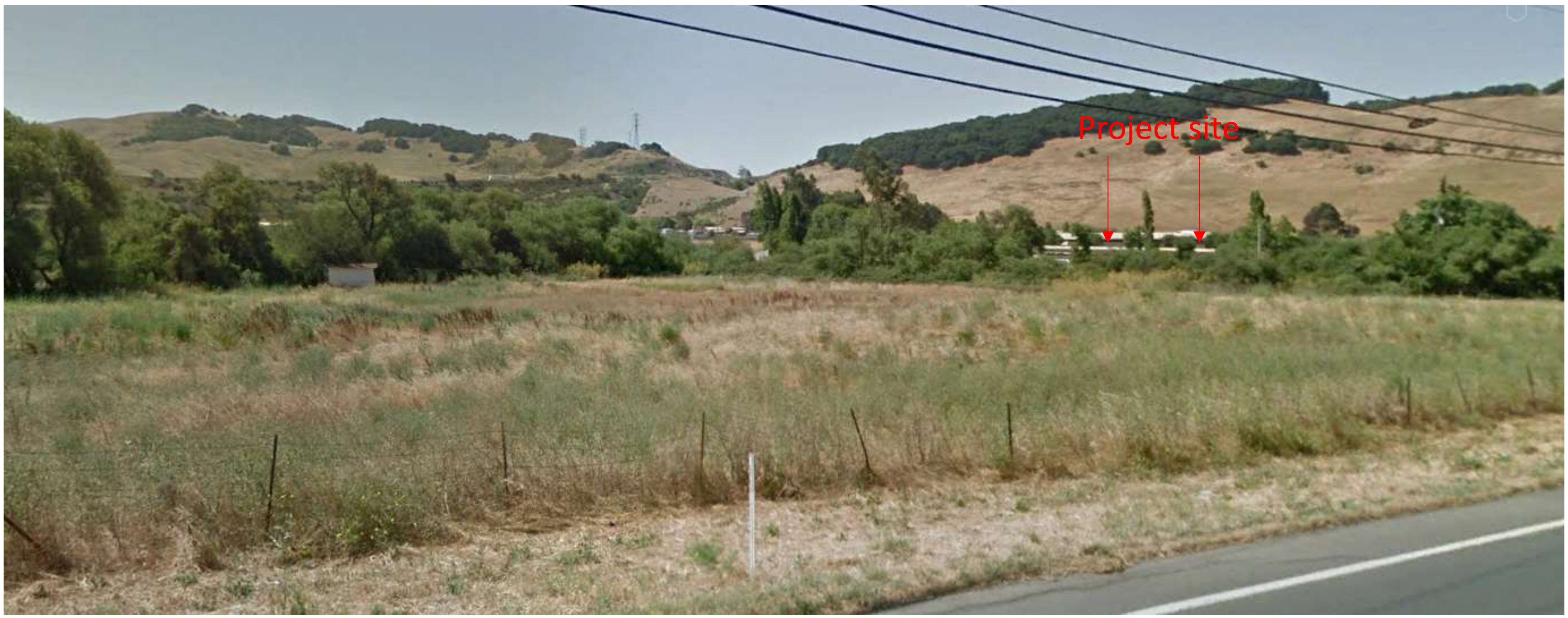
Exhibit C: Approaching the project from the west heading east along American Canyon Road

The project site is shielded from view by a natural vegetative barrier

Exhibit D: Approaching the project entrance from the west

The project site is shielded by a natural vegetative barrier and not visible from the road approach

Exhibit E: Approaching the project from the east heading west on American Canyon Road



The project site is shielded from view by a natural vegetative barrier

Exhibit F: Approaching the project from the east heading west on American Canyon Road

The project site is significantly shielded from view by structures and vegetation

Exhibit G: Approaching the project from the east heading west on American Canyon Road

The project site is significantly shielded from view by topography and a vegetative barrier

Exhibit H: Approaching the project from the east heading west on American Canyon Road

The project site is significantly shielded from view by topography, distance and a vegetative barrier

Exhibit I: Approaching the project from the east heading west on American Canyon Road

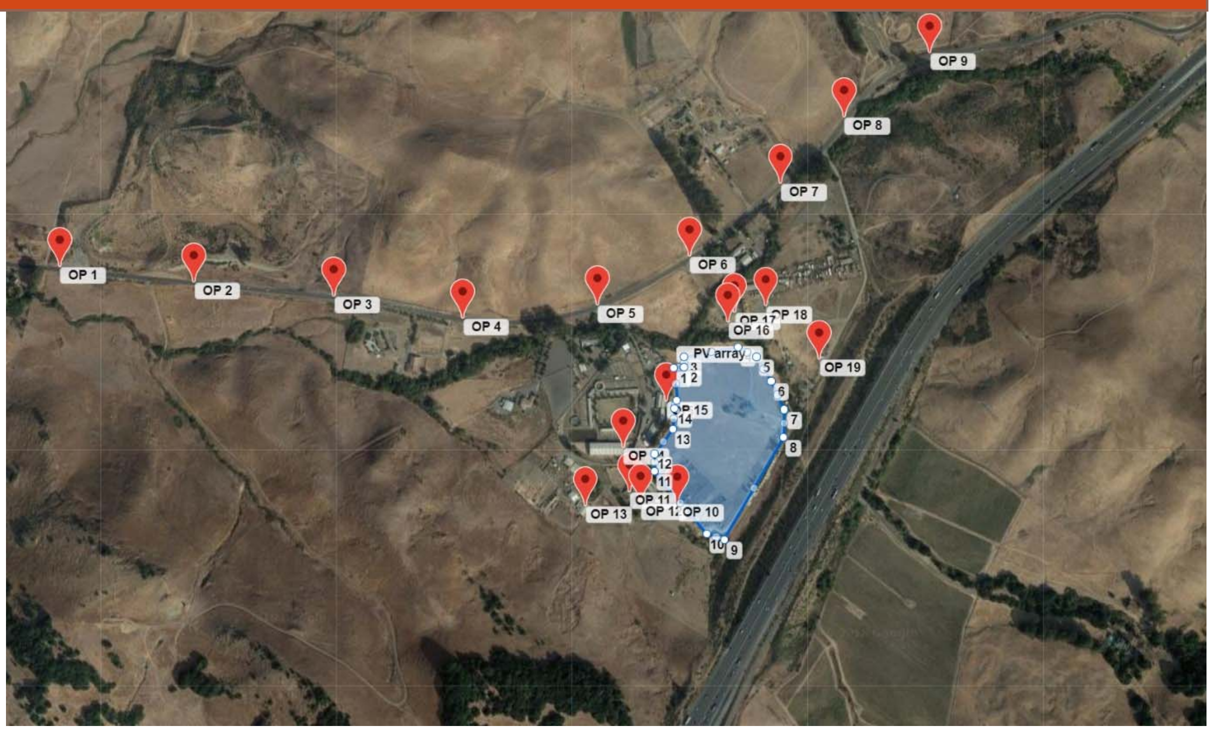
The project site is significantly shielded from view by topography, distance and a vegetative barrier

Conclusion

In conclusion, the Project is naturally shielded and buffered by various plants, bushes and trees from American Canyon Road. This, in addition to the significant distance from American Canyon Road to the Project area, provides that there are no visual impacts from American Canyon Road.

RENEWABLE PROPERTIES

Glare Impact Study of American Canyon Solar Facility



Thomas Cleveland, PE
Raleigh, NC
June 1, 2018
thcleveland@gmail.com

Contents

Executive Summary....................2

Background....................3

Glare Impact Analysis....................3

Modeling the American Canyon Solar Facility....................3

Analysis of Potential Glare Impacts to Nearby Motorists....................4

Analysis of Residential and Commercial Neighbors....................7

Analysis of Napa County Airport....................9

SGHAT Results....................10

Conclusion....................11

Appendix A: SGHAT/ForgeSolar Results Report....................12

Appendix B: Thomas Cleveland's CV....................22

Executive Summary

Photovoltaic modules (aka solar panels) are designed to absorb, and thus not reflect, close to 100% of the solar energy that strikes them. However, when sunlight strikes the glass front of a solar panel at a glancing angle a significant portion of the solar radiation is reflected, which can potentially lead to solar glare impacting a person, including pilots of landing aircraft. Thankfully, the conditions required for a PV project to create hazardous glare rarely occurs.

In order to avoid construction of solar PV projects that could create a solar glare hazard for aircraft, the Federal Aviation Administration (FAA) and Sandia National Laboratories partnered to develop a software to calculate the potential for a PV project to create glare intense enough to be a hazard to nearby airports. The software, called Solar Glare Hazard Analysis Tool (SGHAT), may also be used to assess the potential for a PV project to cause solar glare for other viewers, such as vehicle drivers on nearby roads and neighbors looking out of their windows.

The analysis presented in this report used a privately licensed version of the SGHAT software, called ForgeSolar, to conduct a detailed site-specific PV solar glare analysis of the American Canyon Solar project. The software from ForgeSolar has been validated as effective for this type of solar glare analysis. The software analysis checks for the potential for low or high intensity solar glare at every minute of the year, at many user-defined observation points. Specifically, the analysis of the American Canyon Solar project included nine observation points along American Canyon road, six observation points along Interstate-80, nine observation points at nearby residential and non-residential buildings, and the final two miles of the approach flight paths for the four runways at Napa County Airport (see figure to the right).

Observation Points Analyzed in ForgeSolar, in Addition to the Flight Paths at Napa County Airport (Not Shown, approximately 4 miles to the NW); OP1 to OP9 on American Canyon Road and OP20 to OP25 on Interstate-80

The software analysis found no glare of any intensity at any time during the year at any of the analyzed locations. Furthermore, the software does not take into account obstructions between the solar array and the observation location that block the line of sight between the PV array and the observation location. At this site, several bands of thick, tall vegetation and some hills largely or fully obstruct view of the proposed solar array for many of the analyzed locations. For example, view of the proposed solar array appears to be totally blocked from American Canyon Road. This result of no glare is to be expected because the project will use a single axis tracking system to support the solar panels, which will keep the panels facing generally toward the sun which dramatically minimizes any solar reflection and directs what little reflection there is upward.

Background

At the request of Renewable Properties, LLC, I conducted an analysis of the potential for solar glare impacts by the proposed 3 MW_{AC} American Canyon solar facility. The study analyzed the potential for glare impacts to nearby drivers, neighbors, and pilots approaching the Napa County Airport (KAPC).

Glare Impact Analysis

Figure 1: Glare coming directly from the Sun

Intense glare can create a visual hazard. Every driver is familiar with the type of glare shown in the photo to the right of the view of an auto driver heading directly into the rising or setting sun. Pilots often fly in the direction of the sun and thus experience very intense glare from the sun itself. Pilots also experience distracting glare from a variety of objects on the ground such as metal structures, bodies of water, and bright lights. Consequently, pilots fly with sunglasses and tinted visors to minimize this hazard. The reflected glare produced by these objects is not nearly as intense as direct sunlight. Reflections off of solar panels (aka PV modules) can also cause glare visible to pilots. Due to the potential for this hazard, the Federal Aviation Administration (FAA) and Sandia National Laboratories collaborated to create an online software tool, known as the Solar Glare Hazard Analysis Tool, or SGHAT, to analyze solar photovoltaic projects for their potential to create hazardous solar glare. After multiple years of free public availability access to the SGHAT tool was ended and the SGHAT technology was licensed to a private company, ForgeSolar. ForgeSolar improved upon the original SGHAT technology and offers a private solar glare hazard analysis tool. The analysis presented in this report used the current professional ForgeSolar software.

Modeling the American Canyon Solar Facility

The models presented in this report used the default values for model variables that are not site specific, such as PV modules with smooth glass without an exterior anti-reflective coating (ARC) and sun subtended angle of 9.3 milliradians. These default values are generally conservative, such as assuming the modules will not have an ARC. This conservative approach means the results produced by the SGHAT presents a worst-case scenario. All of the model variables are visible in the ForgeSolar results reports included in the Appendix A of this report.

Below are images of the American Canyon Solar site plan (Figure 2) and the American Canyon Solar array as modeled in the SGHAT (Figure 3). The whole array consists of single axis trackers that tilt the solar panels toward the east early in the morning and then slowly rotate the long north-south rows of solar panels to follow the sun's path across the sky. The panels are totally horizontal (facing directly upwards) when the sun reaches its highest point around the middle of the day and rotate as far as 60 degrees from horizontal at the start and end of the day. This tracking feature not only boosts electricity production compared to a fixed-tilt system, but it also dramatically reduces the potential for solar glare impacts. Because the tracker keeps the panels facing in the general direction of the sun there is very little reflection from the panels and any reflection is directed upward, away for potential viewers of the reflected sunlight.

Figure 2: Site Plan over an Aerial Photo

Figure 3: Solar Array location in SGHAT model

For all SGHAT models in this report, the solar array is modeled at a height of 5 feet, representing a typical height for the surface of PV modules. Models were also run with array heights of 2 feet and 8 feet, representing the bottom and top of the array when tilted, as recommended in the SGHAT user manual. The results of the 2-ft and 8-ft height models were exactly the same as the model with a 5-foot array height, so for simplicity only the 5-foot array data is presented in this report.

It is vital to realize that while the software does take into account the topography of the site and the actual land elevation of each observation point analyzed, the software does *not* take into account visual obstructions between the solar array and the observer. This includes both topographical barriers, such as a hill, and living or man-made barriers such as a forest or building. Detailed analysis of the visibility of the solar array from each observation point is not included in this report, although a quick examination of the aerial 3-D surface models reveals that most of the observation points analyzed have their view of the solar array, and thus any glare it may produce, fully blocked by thick and tall vegetation. A comprehensive line-of-sight study was not conducted as a part of this glare study because the SGHAT found zero glare at every observation point analyzed.

Analysis of Potential Glare Impacts to Nearby Motorists

There are two roadways near this proposed project, American Canyon Road to the north of the project and Interstate 80 to the east and south of the site. Interstate 80 is about 100 feet higher than the solar site and has hills and barrier walls that limit west/south-bound motorist's views of the site and nearly block all views of the array for an east/north-bound motorist. American Canyon Road is at about the same elevation as the solar site. The views from American Canyon Road in the vicinity of the proposed site are obstructed by heavy vegetation between the roadway and the solar site. The following four images from a 3-D model of the site in Google Earth provide a sense of the views of the site from each roadway. The four modeled views are from an elevated vantage point providing a much better view of the solar site than a motorist would have.

Figure 4. View From Directly South of the Site From Above I-80. Green Area is a Simple, Elevated 3-D Model of the Array

Figure 5. View from Directly East of the Array on I-80, View of 3-D Model of Array and Terrain from a Slightly Elevated Location

Figure 6. Elevated View from directly North of the Site, across American Canyon Road, Showing Heavy Vegetation Obstructing the View of the Proposed Solar Array From the Roadway

Figure 7. Elevated View from Directly West of the Site, Showing Heavy Vegetation Blocking the View of the Proposed Solar Array from American Canyon Road

Numerous observation points along each of these two nearby roadways (Figure 8) were analyzed for glare from the proposed solar array. Each observation point was modeled as 5 feet from the ground, to represent the height of a driver. The software checks for glare from 360 degrees around each observation point, regardless of the direction of travel. Studies of pilots have shown that glare from beyond 45 degrees from their direction of travel does not present any glare hazard, and it is reasonable to assume that the same holds true for motor vehicle drivers as well.

The SGHAT results found no glare of any intensity during any minute of the year for any of the observation points located on roadways.

Figure 8. Observation Points Analyzed in ForgeSolar; OP1 to OP9 on American Canyon Road and OP20 to OP25 on Interstate-80

Analysis of Residential and Commercial Neighbors

There are numerous buildings around the proposed solar array. Most of the buildings are non-residential, but there are a few homes nearby as well. Many of the closest buildings with the least obstructed views of the proposed solar array were chosen for SGHAT analysis. The modeled locations are shown in Figure 9 and Figure 10. Each observation point is modeled at 8 feet from grade to represent floor level of 2 to 3 feet above grade plus a person’s eyes about 5 to 6 feet above the floor.

The SGHAT results found no glare of any intensity during any minute of the year for any of the observation points located at buildings. The buildings that were not specifically analyzed either have a fully obstructed view of the proposed solar array, or are located between modeled observation points such that it is safe to assume that no glare will occur at these sites because glare would not occur at these sites without also occurring to some degree at one of the modeled observation points.

Figure 9. Residential and Non-Residential Observation Points to the South and West of the Array (OP10 to OP15)

Figure 10. Residential and Non-Residential Observation Points to the North and West of the Array (OP16 to OP19)

Analysis of Napa County Airport

While FAA does not have jurisdiction to limit development outside of airport property and airspace, they have provided guidance that they recommend that solar projects within 5 nautical miles of an airport conduct a SGHAT analysis[1].

This analysis modeled the potential for glare hazards for pilots on final approach to the Napa County Airport, located about 4.6 miles (4.0 nautical miles) northwest of the proposed solar site (Figure 11). Napa County Airport has four primary runways, Runway 18, 24, 36, and 9. The SGHAT examines the last two miles of the landing approach to each runway. The analysis is limited to this portion of the flight path because severe glare during the final approach has the potential to create a hazard for the pilot, whereas severe glare earlier in the flight is not generally a significant hazard.

The SGHAT results found no glare of any intensity during any minute of the year for any of the four runway flight paths.

---

[1] FAA proposed this 5 nautical mile threshold in the stakeholder development process for the Template Solar Development Ordinance for North Carolina in 2013. The 5 nautical mile threshold was included in the consensus template ordinance and has been adopted by jurisdictions across North Carolina (http://go.ncsu.edu/template-solar-ordinance)

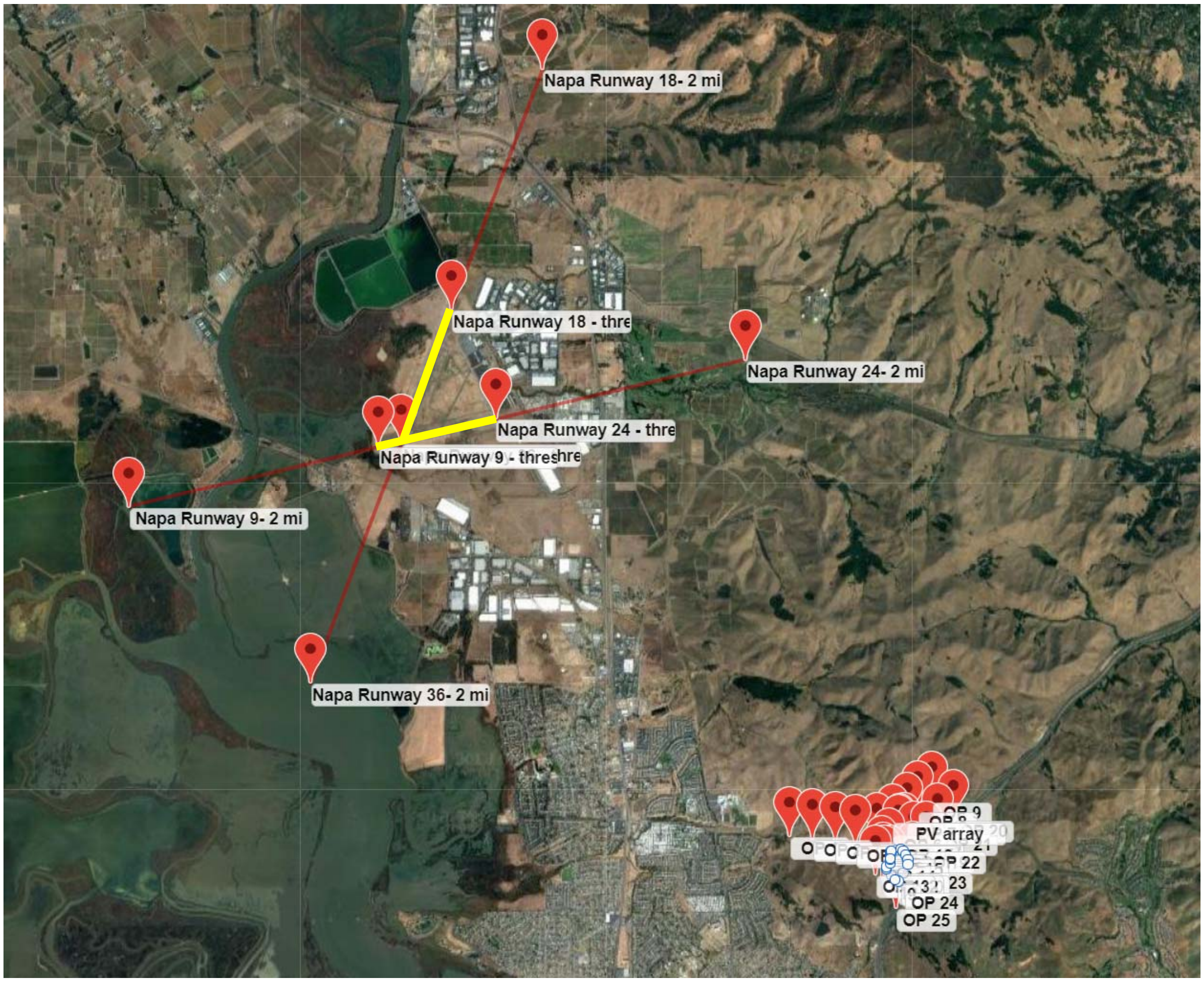


Figure 11. Location of Napa County Airport Runways (yellow lines) and Approach Flight Paths in Relation to the American Canyon Project Site (lower right)

SGHAT Results

A glare analysis was performed for all of the observation points and flight paths described above. A summary of results is presented in this section of the report and the full ForgeSolar-generated report in provided in Appendix A.

The SGHAT defines two intensities of glare, "green" and "yellow". Green glare represents a "Low Potential for Temporary After-Image" and is about 1/1000th the intensity of looking directly into the sun (based on Hazards Plot in the SGHAT User's Manual[2]. According to the FAA Interim solar policy[3], which defines the requirements for solar projects constructed on airport property, glare classified in this green range that is visible to pilots on their final approach is acceptable. In other words, any amount of green glare is considered non-hazardous. Yellow glare has a "Potential for Temporary After-

---

[2] https://share.sandia.gov/phlux/static/references/glint-glare/SGHAT_Users_Manual_v2-0_final.pdf

[3] "Interim Policy for the FAA Review of Solar Energy System Projects on Federally Obligated Airports.", http://www.gpo.gov/fdsys/pkg/FR-2013-10-23/pdf/2013-24729.pdf

Image"; such glare could affect the pilot's ability so see clearly even after looking away from the glare. The FAA Interim solar policy (only has authority for solar built on airports) does not allow solar arrays that produce yellow glare visible to pilots on final approach to be built on airport property.

The SGHAT results found no glare of any intensity during any minute of the year for any of the four runway flight paths or any of the 25 land-based observation points.

Conclusion

The proposed American Canyon solar facility will not produce any glare impacts. ForgeSolar, a detailed, proven solar glare hazard analysis software, was used to model the potential for the proposed solar array to cause glare to approaching motorists, people at nearby buildings, and pilots landing at a nearby airport. The software analysis found no glare of any intensity at any time during the year at any of the analyzed locations. The proposed project will use a single axis tracking system to support the solar panels, which will keep the panels facing generally toward the sun which dramatically minimizes any solar reflection and directs what little reflection there is upward. Furthermore, the software does not take into account obstructions between the solar array and each observation location analyzed. At this site several bands of thick, tall vegetation obstruct view of the proposed solar array for many of the analyzed locations. For example, view of the proposed solar array from American Canyon Road appears to be fully obstructed and views from Interstate 80 are partially obstructed.

Appendix A: SGHAT/ForgeSolar Results Report

ForgeSolar Glare Analysis Report – Page 1 of 10

ForgeSolar
PV planning & glare analysis

FORGESOLAR GLARE ANALYSIS

Project: **American Canyon**
proposed American Canyon 3MW solar facility in American Canyon, CA

Site configuration: **American Canyon**
Analysis conducted by Tommy Cleveland (thcleveland@gmail.com) at 03:43 on 31 May, 2018.

U.S. FAA 2013 Policy Adherence

The following table summarizes the policy adherence of the glare analysis based on the 2013 U.S. Federal Aviation Administration Interim Policy 78 FR 63276. This policy requires the following criteria be met for solar energy systems on airport property:

- No "yellow" glare (potential for after-image) for any flight path from threshold to 2 miles
- No glare of any kind for Air Traffic Control Tower(s) ("ATCT") at cab height.
- Default analysis and observer characteristics (see list below)

ForgeSolar does not represent or speak officially for the FAA and cannot approve or deny projects. Results are informational only.

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
Flight path(s)	PASS	Flight path receptor(s) do not receive yellow glare
ATCT(s)	N/A	No ATCT receptors designated

Default glare analysis and observer eye characteristics are as follows:

- 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

FAA Policy 78 FR 63276 can be read at https://www.federalregister.gov/d/2013-24729

ForgeSolar Glare Analysis Report – Page 2 of 10

SITE CONFIGURATION

Analysis Parameters

DNI: peaks at 1,000.0 W/m^2
Time interval: 1 min
Ocular transmission coefficient: 0.5
Pupil diameter: 0.002 m
Eye focal length: 0.017 m
Sun subtended angle: 9.3 mrad
Site Config ID: 18498.2978

PV Array(s)

Name: PV array
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0°
Tracking axis tilt: 0.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 60.0°
Resting angle: 60.0°
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	38.161971	-122.215011	233.17	5.00	238.17
2	38.161975	-122.214786	234.00	5.00	239.00
3	38.162165	-122.214775	233.26	5.00	238.27
4	38.162355	-122.213520	242.65	5.00	247.65
5	38.162161	-122.213080	244.73	5.00	249.73
6	38.161730	-122.212753	249.82	5.00	254.82
7	38.161203	-122.212445	254.59	5.00	259.59
8	38.160705	-122.212456	259.01	5.00	264.01
9	38.158833	-122.213835	261.04	5.00	266.04
10	38.158925	-122.214248	255.53	5.00	260.53
11	38.160077	-122.215473	240.24	5.00	245.24
12	38.160393	-122.215462	238.78	5.00	243.78
13	38.160845	-122.215044	239.96	5.00	244.96
14	38.161224	-122.215006	238.85	5.00	243.85
15	38.161368	-122.214947	237.87	5.00	242.87

ForgeSolar Glare Analysis Report – Page 3 of 10

Flight Path Receptor(s)

Name: Napa Runway 18
Description:
Threshold height: 50 ft
Direction: °
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	38.223173	-122.278021	29.05	50.00	79.06
Two-mile	38.250219	-122.264997	129.64	502.87	632.51

Name: Napa Runway 24
Description:
Threshold height: 50 ft
Direction: °
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	38.210869	-122.271614	35.68	50.00	85.69
Two-mile	38.217521	-122.235762	158.84	480.30	639.14

ForgeSolar Glare Analysis Report – Page 4 of 10

Name: Napa Runway 36
Description:
Threshold height: 50 ft
Direction: °
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	38.208045	-122.285270	14.26	50.00	64.26
Two-mile	38.180981	-122.298231	2.17	615.55	617.72

Name: Napa Runway 9
Description:
Threshold height: 50 ft
Direction: °
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	38.207732	-122.288454	13.90	50.00	63.90
Two-mile	38.200933	-122.324260	6.64	610.72	617.36

ForgeSolar Glare Analysis Report – Page 5 of 10

Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (ft)	Height (ft)
OP 1	1	38.163836	-122.229326	134.94	4.00
OP 2	2	38.163550	-122.226193	170.33	4.00
OP 3	3	38.163296	-122.222932	200.15	4.00
OP 4	4	38.162892	-122.219928	223.72	4.00
OP 5	5	38.163128	-122.216795	233.26	4.00
OP 6	6	38.164022	-122.214649	250.83	4.00
OP 7	7	38.165355	-122.212525	267.07	4.00
OP 8	8	38.166569	-122.211044	289.32	4.00
OP 9	9	38.167750	-122.209049	323.64	4.00
OP 10	10	38.159477	-122.214938	248.23	8.00
OP 11	11	38.159707	-122.216039	237.21	8.00
OP 12	12	38.159494	-122.215789	240.61	8.00
OP 13	13	38.159453	-122.217074	234.89	8.00
OP 14	14	38.160508	-122.216202	229.16	8.00
OP 15	15	38.161359	-122.215186	235.67	8.00
OP 16	16	38.162820	-122.213753	237.94	8.00
OP 17	17	38.162990	-122.213609	239.69	8.00
OP 18	18	38.163111	-122.212881	243.86	8.00
OP 19	19	38.162133	-122.211630	257.83	8.00
OP 20	20	38.165663	-122.205832	453.09	5.00
OP 21	21	38.164161	-122.208042	427.95	5.00
OP 22	22	38.162204	-122.209866	381.92	5.00
OP 23	23	38.159801	-122.211645	348.01	5.00
OP 24	24	38.157507	-122.212933	379.78	5.00
OP 25	25	38.155718	-122.214134	410.64	5.00

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
PV array	SA tracking	SA tracking	0	0	-

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
Napa Runway 18	0	0
Napa Runway 24	0	0

ForgeSolar Glare Analysis Report – Page 6 of 10

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
Napa Runway 36	0	0
Napa Runway 9	0	0
OP 1	0	0
OP 2	0	0
OP 3	0	0
OP 4	0	0
OP 5	0	0
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	0	0
OP 14	0	0
OP 15	0	0
OP 16	0	0
OP 17	0	0
OP 18	0	0
OP 19	0	0
OP 20	0	0
OP 21	0	0
OP 22	0	0
OP 23	0	0
OP 24	0	0
OP 25	0	0

Results for: PV array

Receptor	Green Glare (min)	Yellow Glare (min)
Napa Runway 18	0	0
Napa Runway 24	0	0
Napa Runway 36	0	0
Napa Runway 9	0	0
OP 1	0	0
OP 2	0	0
OP 3	0	0
OP 4	0	0
OP 5	0	0

ForgeSolar Glare Analysis Report – Page 7 of 10

Receptor	Green Glare (min)	Yellow Glare (min)
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	0	0
OP 14	0	0
OP 15	0	0
OP 16	0	0
OP 17	0	0
OP 18	0	0
OP 19	0	0
OP 20	0	0
OP 21	0	0
OP 22	0	0
OP 23	0	0
OP 24	0	0
OP 25	0	0

Flight Path: Napa Runway 18

0 minutes of yellow glare
0 minutes of green glare

Flight Path: Napa Runway 24

0 minutes of yellow glare
0 minutes of green glare

Flight Path: Napa Runway 36

0 minutes of yellow glare
0 minutes of green glare

Flight Path: Napa Runway 9

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 1

0 minutes of yellow glare

ForgeSolar Glare Analysis Report – Page 8 of 10

0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 5

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 6

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 7

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 8

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 9

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 10

0 minutes of yellow glare
0 minutes of green glare

ForgeSolar Glare Analysis Report – Page 9 of 10

Point Receptor: OP 11

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 12

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 13

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 14

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 15

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 16

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 17

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 18

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 19

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 20

0 minutes of yellow glare

ForgeSolar Glare Analysis Report – Page 10 of 10

0 minutes of green glare

Point Receptor: OP 21

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 22

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 23

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 24

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 25

0 minutes of yellow glare
0 minutes of green glare

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.
Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values may differ.
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.

Appendix B: Thomas Cleveland's CV

Thomas (Tommy) H. Cleveland, P.E.

4141 Laurel Hills Rd. Raleigh, NC thcleveland@gmail.com 919-923-5490

Education & Training

North Carolina State University, Mechanical Engineering M.S. 2004
North Carolina State University, Mechanical Engineering B.S., Business Mgmt. minor 2001 - Summa Cum Laude
Lumberton Sr. High School, Lumberton, NC, 1997 – Valedictorian

Professional Engineer, licensed in North Carolina (#033711), 2008 - Present

Professional Experience

Solar PV Engineer, Advanced Energy, Raleigh, NC, April 2017–Present

- Evaluation of commercial and utility scale solar PV facilities to assess the quality of design, construction, and operation
- Engineering analysis and concise presentation of results to customers

Solar Energy Engineer (various progressive titles), North Carolina Solar Center/NC Clean Energy Technology Center, North Carolina State University, 2005–April, 2017

- Lead solar engineer at the Center (2008-2017)
- Conducted detailed PV + storage feasibility study for community solar project for a NC municipal utility
- Provided quality assurance and technical support to development of in-house training program of every stage of solar farm construction for a leading regional utility-scale photovoltaic EPC firm
- Guided design of prototype residential Plug and Play PV system and collected AHJ feedback (Department of Energy SunShot project)
- Co-led stakeholder process to develop Template Solar Development Ordinance for North Carolina
- Led design and development of ISO-17025 accredited solar thermal collector testing lab
- Designed and installed PV field performance monitoring system, conducted performance analysis
- Conducted renewable energy site assessments for commercial, industrial, and institutional clients
- Presented to local government officials, community leaders, and general public on solar energy
- Provided technical support to a wide variety of energy consumers and stakeholders across North Carolina

Consultant/Expert Witness, Private consultant for over 15 solar developer clients, 2012-Present

- Provides expert witness testimony at special/conditional use and re-zoning public hearings regarding the health, safety, and environmental impact of utility-scale solar photovoltaic systems. Experience in NC, SC, VA, and FL (over 60 projects to date)
- Provides respectful clear answers to sometimes ill-informed and/or hostile questions
- Conduct site-specific studies of EMF, sound, and solar glare hazard for several projects

Instructor of ET 220 Solar Photovoltaic Assessment, Department of Forestry and Environmental Resources, North Carolina State University, 2014-Present

- Developed all course content for this new three credit hour online course
- Course covers all aspects of photovoltaic site assessment including energy use, solar resource, system design, utility tariffs, estimating, economics, and more
- Course is optional course for an Environmental Technology and Management degree
- Course is required for a Renewable Energy Assessment minor

Instructor of MAE 421 Design of Solar Energy Systems, Mechanical and Aerospace Engineering Department of North Carolina State University, 2009-2014

- Instructor of the solar energy engineering course, MAE 421, in the NC State University Mechanical and Aerospace Engineering department
- The course was offered during the spring semester and typically had 30 to 50 undergraduate and up to twelve graduate engineering students
- Previously co-instructor of the course for two years (2007, 2009)

Research Assistant, North Carolina Solar Center, North Carolina State University, 2003–2005

- Developed and validated a TRNSYS simulation model of a unique solar thermal concentrating collector
- Assisted with the installation of photovoltaic systems ranging in capacity from 1 kW to 5 kW

Selected Publications

"Balancing Agricultural Productivity with Ground-Based Photovoltaic Development", NCCETC/NCSU white paper, August 2017, https://nccleantech.ncsu.edu/wp-content/uploads/Balancing-Ag-and-Solar-final-version-update.pdf

"Health and Safety Impacts of Photovoltaics", NCCETC/NCSU white paper, May 2017, https://nccleantech.ncsu.edu/wp-content/uploads/Health-and-Safety-Impacts-of-Solar-Photovoltaics-2017_white-paper-1.pdf

"Community Solar (+ Storage) Program Design for Fayetteville Public Works Commission", NCSU/NCCETC report, March 2017, (Public version) https://nccleantech.ncsu.edu/wp-content/uploads/FPWC_CommunitySolar_Public_Version.pdf

T. Cleveland, H. Tsai, "Charlotte-Mecklenburg Schools Roadmap to 100% Renewable Electricity" & "Durham Public Schools Roadmap to 100% Renewable Electricity", NCCETC, February 2016

T. Cleveland, et al, "Template Solar Energy Development Ordinance for North Carolina", NCCETC & NCSEA, December 2013, www. go.ncsu.edu/template-solar-ordinance

M. Sheehan, T. Cleveland, "*Updated Recommendations for Federal Energy Regulatory Commission Small Generator Interconnection Procedures Screens*", Solar America Board for Codes and Standards Study Report, 64 p., July 2010, www.solarabcs.org/about/publications/reports/ferc-screens/pdfs/ABCS-FERC_studyreport.pdf

T. Cleveland, et al, "*Optimizing Solar Thermal Resource Use at Commercial Buildings*", Solar 2010 – ASES National Solar Energy Conference 2010, 6 p., May 2010, www.ases.org/papers/101.pdf

T. Cleveland, "*Description and Performance of a TRNSYS Model of the Solargenix Tracking Power Roof$_{TM}$*", Solar 2005 – ASES National Solar Energy Conference, 6 p.

T. Cleveland, K. Creamer, & Dr. R. Johnson, "*Energy Metering of Solar Domestic Hot Water Systems for Inclusion in Green Power and Renewable Portfolio Standards Programs*", Solar 2004 – ASES National Solar Energy Conference 2004, 6 p.

T. Cleveland, "*Effective Energy Metering of Solar Domestic Hot Water Systems for Inclusion in Green Power and Renewable Portfolio Standards*", Master's Thesis, North Carolina State University, Raleigh, 191 p., April 2004, http://repository.lib.ncsu.edu/ir/handle/1840.16/1152

Selected Recent Presentations

T. Cleveland, A. Huang, "Plug and Play Residential PV System Innovation and Demonstration", Solar Power International Conference 2015

T. Cleveland, "*Make Solar Energy Economical*", recorded video lecture for E102: Grand Challenges of Engineering course at NC State University, January 2015

T. Cleveland, M. Clark, "*Template Solar Ordinance for North Carolina*", Solar Power International Conference 2014