



FORGESOLAR GLARE ANALYSIS

Project: **Babacomari**

Site configuration: **Site Config 1-temp-3**

Analysis conducted by Joshua Gunderson (joshua.gunderson@clenera.com) at 18:44 on 07 Dec, 2020.

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
2-mile flight path(s)	PASS	Flight path receptor(s) do not receive yellow glare
ATCT(s)	PASS	Receptor(s) marked as ATCT do not receive glare

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

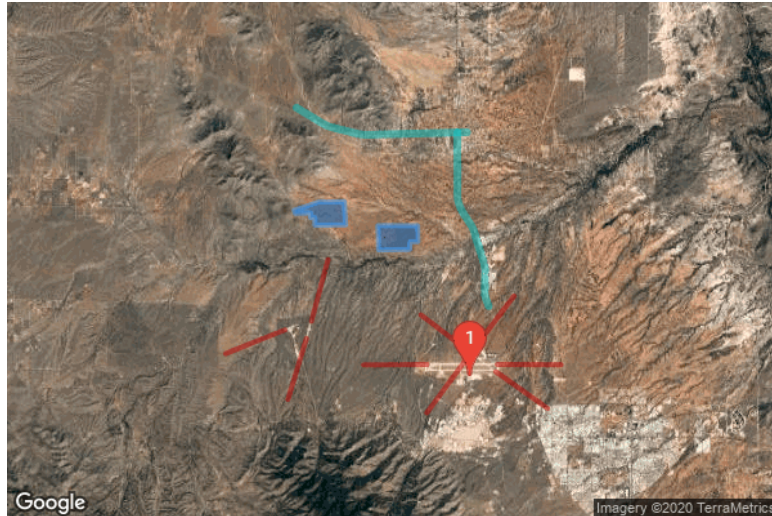
- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

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

SITE CONFIGURATION

Analysis Parameters

DNI: peaks at 1,000.0 W/m²
 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: 46713.8359



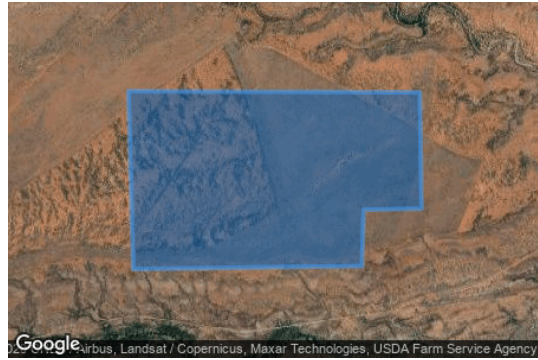
PV Array(s)

Name: Babacomari North
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: 5.0°
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	31.661411	-110.410782	4579.20	6.00	4585.20
2	31.661192	-110.424386	4664.78	6.00	4670.78
3	31.657466	-110.437433	4752.20	6.00	4758.20
4	31.656151	-110.436918	4746.88	6.00	4752.88
5	31.656297	-110.428807	4677.15	6.00	4683.15
6	31.654178	-110.428721	4666.66	6.00	4672.66
7	31.654178	-110.426489	4653.53	6.00	4659.53
8	31.650781	-110.426403	4615.94	6.00	4621.94
9	31.650854	-110.410096	4550.53	6.00	4556.53

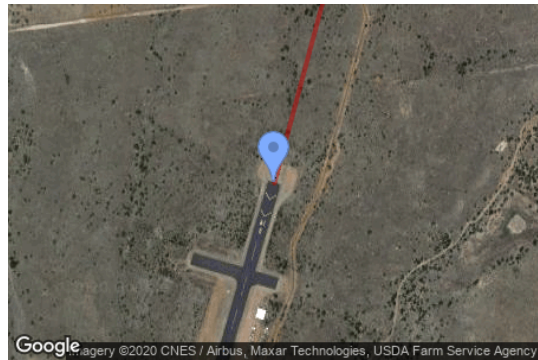
Name: Babacomari South
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0°
Tracking axis tilt: 0.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 60.0°
Resting angle: 5.0°
Rated power: -
Panel material: Smooth glass without AR coating
Reflectivity: Vary with sun
Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	31.650563	-110.392824	4495.10	6.00	4501.10
2	31.639602	-110.392480	4478.96	6.00	4484.97
3	31.639785	-110.375872	4433.90	6.00	4439.90
4	31.643256	-110.375743	4455.88	6.00	4461.88
5	31.643329	-110.371538	4438.96	6.00	4444.96
6	31.650490	-110.371666	4442.83	6.00	4448.83

Flight Path Receptor(s)

Name: FP 1
Description:
Threshold height: 50 ft
Direction: 195.0°
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	31.607225	-110.428285	4750.23	50.00	4800.23
Two-mile	31.635152	-110.419483	4460.68	893.01	5353.69

Name: FP 2

Description:

Threshold height: 50 ft

Direction: 16.9°

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	31.599473	-110.430955	4790.42	50.00	4840.42
Two-mile	31.571805	-110.440818	5022.01	371.86	5393.87

Name: FP 3

Description:

Threshold height: 50 ft

Direction: 68.2°

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	31.603282	-110.442466	4764.72	50.00	4814.72
Two-mile	31.592531	-110.474016	4853.41	514.77	5368.18

Name: FP 4

Description:

Threshold height: 50 ft

Direction: 89.6°

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	31.587572	-110.366521	4717.72	50.00	4767.72
Two-mile	31.587375	-110.400501	4783.77	537.40	5321.18

Name: FP 5

Description:

Threshold height: 50 ft

Direction: 270.3°

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	31.587623	-110.329090	4602.07	50.00	4652.07
Two-mile	31.587472	-110.295110	4503.85	701.67	5205.52

Name: FP 6

Description:

Threshold height: 50 ft

Direction: 127.3°

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	31.592574	-110.342820	4606.82	50.00	4656.82
Two-mile	31.610079	-110.369867	4475.30	734.98	5210.28

Name: FP 7

Description:

Threshold height: 50 ft

Direction: 305.3°

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	31.584348	-110.329940	4615.56	50.00	4665.56
Two-mile	31.567628	-110.302218	4576.99	642.03	5219.02

Name: FP 8

Description:

Threshold height: 50 ft

Direction: 217.2°

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	31.595606	-110.340766	4581.53	50.00	4631.53
Two-mile	31.618629	-110.320210	4398.39	786.59	5184.98

Name: FP 9

Description:

Threshold height: 50 ft

Direction: 36.4°

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	31.588926	-110.346576	4644.46	50.00	4694.46
Two-mile	31.565655	-110.366742	4886.36	361.56	5247.91

Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (ft)	Height (ft)
1-ATCT	1	31.582038	-110.343817	4687.33	75.00

Map image of 1-ATCT



Route Receptor(s)

Name: Hwy 82

Path type: Two-way

Observer view angle: 50.0°

Note: Route receptors are excluded from this FAA policy review. Use the 2-mile flight path receptor to simulate flight paths according to FAA guidelines.



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	31.703976	-110.436276	4765.33	6.00	4771.33
2	31.702191	-110.432789	4751.98	6.00	4757.98
3	31.700238	-110.428932	4731.97	6.00	4737.97
4	31.697919	-110.424404	4709.61	6.00	4715.61
5	31.696340	-110.421271	4690.89	6.00	4696.89
6	31.695578	-110.419287	4679.19	6.00	4685.19
7	31.695012	-110.417125	4668.81	6.00	4674.81
8	31.694492	-110.414759	4658.60	6.00	4664.60
9	31.693784	-110.411369	4653.41	6.00	4659.41
10	31.693109	-110.408236	4654.15	6.00	4660.15
11	31.692145	-110.403757	4631.50	6.00	4637.50
12	31.691707	-110.400598	4631.25	6.00	4637.25
13	31.691679	-110.399439	4629.68	6.00	4635.68
14	31.691697	-110.397518	4625.97	6.00	4631.97
15	31.691771	-110.394396	4612.16	6.00	4618.16
16	31.691907	-110.388179	4573.88	6.00	4579.88
17	31.692054	-110.381736	4506.40	6.00	4512.40
18	31.692184	-110.375928	4476.15	6.00	4482.15
19	31.692280	-110.370998	4457.53	6.00	4463.54
20	31.692389	-110.366572	4444.47	6.00	4450.47
21	31.692526	-110.360317	4420.67	6.00	4426.67
22	31.692668	-110.353880	4398.07	6.00	4404.07
23	31.692777	-110.348714	4383.15	6.00	4389.15
24	31.692849	-110.345243	4369.28	6.00	4375.28

Name: Hwy 90
Path type: Two-way
Observer view angle: 50.0°

Note: Route receptors are excluded from this FAA policy review. Use the 2-mile flight path receptor to simulate flight paths according to FAA guidelines.



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	31.692707	-110.350392	4390.15	6.00	4396.15
2	31.689007	-110.350535	4395.05	6.00	4401.05
3	31.675664	-110.350348	4391.96	6.00	4397.96
4	31.664450	-110.350398	4386.72	6.00	4392.72
5	31.662048	-110.350108	4381.51	6.00	4387.51
6	31.660513	-110.349648	4375.36	6.00	4381.36
7	31.658211	-110.348575	4358.29	6.00	4364.29
8	31.656451	-110.347480	4364.98	6.00	4370.98
9	31.653465	-110.345206	4363.00	6.00	4369.00
10	31.652133	-110.344186	4352.23	6.00	4358.23
11	31.650032	-110.342641	4318.11	6.00	4324.11
12	31.648407	-110.341729	4305.43	6.00	4311.43
13	31.639889	-110.338567	4303.90	6.00	4309.90
14	31.634640	-110.336625	4344.80	6.00	4350.80
15	31.632585	-110.335949	4375.22	6.00	4381.22
16	31.631050	-110.335638	4395.45	6.00	4401.45
17	31.629223	-110.335552	4406.11	6.00	4412.11
18	31.625199	-110.335664	4422.99	6.00	4428.99
19	31.620549	-110.335778	4445.06	6.00	4451.06
20	31.619594	-110.335767	4446.67	6.00	4452.67
21	31.618671	-110.335622	4451.29	6.00	4457.29
22	31.617666	-110.335327	4457.74	6.00	4463.74
23	31.616004	-110.334608	4464.05	6.00	4470.06
24	31.614030	-110.333685	4460.91	6.00	4466.91

GLARE ANALYSIS RESULTS

Summary of Glare

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

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
FP 1	0	0
FP 2	0	0
FP 3	0	0
FP 4	0	0
FP 5	0	0
FP 6	0	0
FP 7	0	0
FP 8	0	0
FP 9	0	0
1-ATCT	0	0
Hwy 82	0	0
Hwy 90	0	0

Results for: Babacomari North

Receptor	Green Glare (min)	Yellow Glare (min)
FP 1	0	0
FP 2	0	0
FP 3	0	0
FP 4	0	0
FP 5	0	0
FP 6	0	0
FP 7	0	0
FP 8	0	0

Receptor	Green Glare (min)	Yellow Glare (min)
FP 9	0	0
1-ATCT	0	0
Hwy 82	0	0
Hwy 90	0	0

Flight Path: FP 1

0 minutes of yellow glare

0 minutes of green glare

Flight Path: FP 2

0 minutes of yellow glare

0 minutes of green glare

Flight Path: FP 3

0 minutes of yellow glare

0 minutes of green glare

Flight Path: FP 4

0 minutes of yellow glare

0 minutes of green glare

Flight Path: FP 5

0 minutes of yellow glare

0 minutes of green glare

Flight Path: FP 6

0 minutes of yellow glare

0 minutes of green glare

Flight Path: FP 7

0 minutes of yellow glare

0 minutes of green glare

Flight Path: FP 8

0 minutes of yellow glare

0 minutes of green glare

Flight Path: FP 9

0 minutes of yellow glare

0 minutes of green glare

Point Receptor: 1-ATCT

0 minutes of yellow glare

0 minutes of green glare

Route: Hwy 82

0 minutes of yellow glare

0 minutes of green glare

Route: Hwy 90

0 minutes of yellow glare

0 minutes of green glare

Results for: Babacomari South

Receptor	Green Glare (min)	Yellow Glare (min)
FP 1	0	0
FP 2	0	0
FP 3	0	0
FP 4	0	0
FP 5	0	0
FP 6	0	0
FP 7	0	0
FP 8	0	0
FP 9	0	0
1-ATCT	0	0
Hwy 82	0	0
Hwy 90	0	0

Flight Path: FP 1

0 minutes of yellow glare

0 minutes of green glare

Flight Path: FP 2

0 minutes of yellow glare

0 minutes of green glare

Flight Path: FP 3

0 minutes of yellow glare

0 minutes of green glare

Flight Path: FP 4

0 minutes of yellow glare

0 minutes of green glare

Flight Path: FP 5

0 minutes of yellow glare

0 minutes of green glare

Flight Path: FP 6

0 minutes of yellow glare

0 minutes of green glare

Flight Path: FP 7

0 minutes of yellow glare

0 minutes of green glare

Flight Path: FP 8

0 minutes of yellow glare

0 minutes of green glare

Flight Path: FP 9

0 minutes of yellow glare

0 minutes of green glare

Point Receptor: 1-ATCT

0 minutes of yellow glare

0 minutes of green glare

Route: Hwy 82

0 minutes of yellow glare

0 minutes of green glare

Route: Hwy 90

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.

Several 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.

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.)

Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.

Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.

The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual results and glare occurrence 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.

Refer to the Help page at www.forgesolar.com/help/ for assumptions and limitations not listed here.