



## MEMO

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FROM	Mat Carson, Project Manager Duncan Quinn, Senior Consultant Ian Todd, Partner-in-Charge Ben Sussman, Technical Consulting Director
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REFERENCE	0739207
SUBJECT	Bear Valley Solar Energy Project - Glare Analysis Memorandum

### 1. INTRODUCTION

Bear Valley Electric Service, Inc. (BVES), proposes to construct the Bear Valley Solar Energy Project (Project), a photovoltaic (PV) solar facility in unincorporated San Bernardino County, California. The Project is being designed, permitted, and developed by EDF Renewables Distribution-Scale Power (EDFR-DSP). EDFR-DSP has engaged Environmental Resources Management, Inc. (ERM) to conduct a glare analysis for the proposed Project in response to the County’s request for additional technical studies to inform the Conditional Use Permit (CUP) application and the California Environmental Quality Act (CEQA) review.

In support of this process, ERM has prepared this memorandum summarizing the methodologies utilized and results of the glare analysis. Glare analysis documentation from the industry-standard ForgeSolar online glare analysis tool is provided in Appendix A.

### 2. PROJECT AND SITE DESCRIPTION

The proposed Project is located on a 30-acre parcel with a fenced area of 18.9 acres containing PV arrays and other Project infrastructure (Site). The Site is located at 2151 Erwin Ranch Road (north side of road), approximately 0.4 mile east of the Lakewood Drive intersection in the unincorporated community of Big Bear, California (Figures 1, 2, and 3). The Project will have a generation capacity of 5.7 megawatts (MW). The Project will eventually be owned and operated by BVES.

The Project’s PV panels will be mounted on single-axis trackers oriented south at 180 degrees with a tracking angle range of motion of +/-60 degrees. The average height of center of the PV panels above ground will be approximately 5 feet. The ground

coverage ratio (GCR) of the PV panels will be 0.40 (40 percent), and the PV panels will contain smooth glass with an anti-reflective coating. The PV panel tracking modules will implement a shade- and slope-aware backtracking strategy with the shallowest possible angle of east/west rotation during backtracking of 0 degrees.

The fenced area of the Site to be developed is open, flat land covered with low shrubs. Elevation of the fenced area ranges from approximately 6,770 to 6,790 feet above mean sea level. A forested hillside immediately north of the fenced area rises approximately 500 feet above the Site. The Project vicinity features flat, open shrubland with scattered homes and ranches to the west, south, and east. The Site is bordered to the west by Lakewood Drive and to the south by Erwin Ranch Road.

### 3. VIEWPOINT SUMMARY AND DISCUSSION

A representative sample of potential viewpoints was identified within a half-mile radius of the proposed Project. Viewpoints are locations from which the Project may be visible to human receptors, such as residents, motorists, pilots, recreationists, and tourists. Such viewers may be sensitive to potential glare caused by the PV panels. These viewpoints, referred to as “receptors” in the glare analysis results (Appendix A), were identified through review of aerial imagery, topographic maps, and other publicly available online mapping resources.

Based on ERM’s review of the Federal Aviation Administration (FAA) database,<sup>1</sup> aerial photos, and a Google search, the nearest aircraft facility is Big Bear Airport (L35), located 2.6 miles west-northwest of the Project. ERM evaluated a total of three 2-mile-long flight paths (FP 1, FP 2, and FP 3) to Runway 08/26 at this airport as part of the glare analysis (Figure 3). As documented by the FAA and Big Bear Airport,<sup>2</sup> Runway 08 approach (FP 1) has a bearing of 74 degrees and threshold crossing height of 29 feet. Runway 26 has two approaches, bearing 270 degrees (FP 2) and bearing 256 degrees (FP 3), both with a threshold crossing height of 46 feet. All three flight paths have a glide slope of 4.3 degrees. Big Bear Airport does not have an air traffic control tower (ATCT). ERM identified no other airports within 10 miles of the Site.

ERM identified 16 stationary locations to serve as representative viewpoints for the glare analysis. These viewpoints are identified using the abbreviation “OP” and are numbered sequentially—OP 1 through OP 16 (Figures 1 and 2). OP 1 is located on a pickleball court at Big Bear Ranch Park, a San Bernadino County Parks and Recreation facility at 2080 Erwin Ranch Road. OP 7 is on the grounds of the Big Bear Equestrian Center & Bear Valley Farms at 1601 East Big Bear Boulevard. The remaining 14 viewpoints represent individual residences in the vicinity of the Project. ERM also

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<sup>1</sup> Federal Aviation Administration. Circle Search for Airports. Available online <https://oeaaa.faa.gov/oeaaa/external/searchAction.jsp?action=showCircleSearchAirportsForm>. Accessed 5 November 2024.

<sup>2</sup> Big Bear Airport. Approach and Departure Procedures. Available online <https://www.bigbearcityairport.com/pilots/>. Accessed 5 November 2024.

identified six road segments including Erwin Ranch Road, Lakewood Drive, Central Lane, Willow Lane, Cypress Lane, and Jensen Drive – Ringwood Trail to evaluate whether glare could potentially be observed by motorists traveling these roads.

To mitigate potential visual impacts (including glare) observed from these viewpoints, the Project design includes a visual screen consisting of a vegetative buffer along the southern and western boundaries of the Site (Figures 1 and 2). A fixed-knot agricultural-style fence is also proposed along the southwestern side of the Site where it abuts residential properties; however, this type of fence would not provide significant visual screening.

At full growth, the vegetative buffer along the frontages of Erwin Ranch Road and Lakewood Drive is conservatively expected to provide a fully opaque screen up to a minimum estimated height of 8 feet. At full growth, the vegetative buffer between the Site and residential properties is conservatively expected to provide a fully opaque screen up to a minimum estimated height of 6 feet. Because the ForgeSolar tool assumes that visual obstructions provide complete screening, these conservative height estimates were used in this analysis. At full growth, however, the vegetative buffers may provide at least partial screening up to an estimated height of 12 feet. For comparison, the glare analysis results without the visual buffers are provided in Appendix B.

## 4. GLARE ANALYSIS

This glare analysis is based on design parameters provided by EDFR-DSP for single-axis trackers as described above in Section 2. It is important to note that glare would not be experienced if the solar panels are screened by topography, structures, or vegetation. Therefore, locations where glare may occur would be limited to areas with direct views of the proposed solar panels. Potential visibility could change over time due to planting or removal of vegetation or construction or removal of structures. The ForgeSolar tool does not, by default, consider the screening effects of vegetation, structures, or topographic features between a PV array and the identified viewpoints. However, the proposed visual buffers described in Section 3 above were incorporated into this glare analysis.

### 4.1 BACKGROUND

PV panels are designed to absorb rather than reflect sunlight to maximize energy capture. Many PV panels utilize textured glass and/or have anti-reflective coatings to further minimize reflectivity. Based on information provided by EDFR-DSP, the Project's PV panels will contain smooth glass with an anti-reflective coating. ERM included this parameter in the glare analysis.

PV solar projects do not typically cause harmful or nuisance levels of glare, defined as a continuous source of bright light that may be visible to nearby residents, motorists,

or pilots. The absorbing, rather than reflecting, nature of PV technology, in conjunction with proper site planning and design, has allowed PV panels to be commonly and safely installed on airport properties nationwide.<sup>3</sup> Additionally, PV panels have a lower index of refraction/reflectivity than common sources of glare in residential environments. The glare and reflectance levels from a given PV system are lower than those of steel, snow, standard glass, plexiglass, and smooth water. The glare and reflectance levels of modules are further reduced with the application of anti-reflective coatings. PV suppliers typically use stippled glass for panels as the "texturing" of the glass allows more light energy to be channeled/transmitted through the glass while weakening the reflected light. With the application of anti-reflective coatings and the use of modern glass technology, Project PV panels would display overall low reflectivity. In addition, because tracker systems follow the sun, the underside of the PV panels and most of the structure supporting them are shadowed throughout the day.

Light reflected from the PV panels would travel above the line of sight of most, if not all, viewers. PV tracking systems position the array so that the sun's rays are always perpendicular to the face of the panel. Reflected light is directed back toward the sun. During midday conditions, when the sun is high in the sky, the rays of the sun are reflected directly upwards. When the sun is low on the horizon (near dawn or dusk), the sun's angle in the sky is low; however, reflected rays would still be directed away from ground-level receptors because the maximum downward angle of the arrays would not be below 30 degrees. Due to their low reflectivity, the panels are not expected to cause visual impairment for motorists on local roadways near the Project site.

The amount of light reflected from solar panels depends on several factors, including the amount of sunlight hitting the panel surface, the surface's reflectivity (based on variables such as the presence of textured glass and/or anti-reflective coatings), the geographic location, time of year, weather conditions, and solar panel orientation. These factors affect the angle of incidence of the sun relative to sensitive viewers, and the amount of glare experienced.<sup>3</sup> With respect to glare, angle of incidence is the angle at which light deviates from perpendicular to a surface. The angle of incidence changes as the sun moves across the sky and is generally lowest at solar noon (when the sun is at its highest point above the horizon and light is reflected toward the sky) and highest at dawn and dusk (when the sun is low in the sky and light is reflected from a high angle of incidence in the opposite direction).

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<sup>3</sup> Federal Aviation Administration. 2018. *Technical Guidance for Evaluating Selected Solar Technologies on Airports*. Version 1.1, April 2018. Available online <https://www.faa.gov/sites/faa.gov/files/airports/environmental/FAA-Airport-Solar-Guide-2018.pdf>.

## 4.2 METHODOLOGY

ERM used the industry standard ForgeSolar GlareGauge<sup>4</sup> tool to assess potential glare and ocular impact at the 16 viewpoints and along the 6 road segments as shown on Figures 1 and 2. Glare was also assessed along flight approach paths FP 1, FP 2, and FP 3 at Big Bear Airport located 2.6 miles west-northwest of the Site (Figure 3). The tool calculates ocular impact from anticipated levels of retinal irradiance (amount of light received by the retina) and the subtended angle (size and distance) of the glare source. The ForgeSolar tool uses three categories to report potential ocular hazards ranging from retinal burns to temporary after-image, defined as a visual phenomenon in which glare persists in the viewer's vision, even after looking away from the source. These categories include:

- "Green" ratings indicate a low potential to cause after-image (flash blindness);
- "Yellow" ratings indicate the potential to cause temporary after-image; and
- "Red" ratings indicate potential to cause retinal burn and permanent eye damage.<sup>5</sup>

When simulating glare, the ForgeSolar tool modifies the vertex elevations of a PV array footprint so that all points of the PV array reside on a single planar surface. The ForgeSolar tool also may convert PV array footprints with large concavities into a convex shape by filling in these concavities. Therefore, to enhance the accuracy of the glare analysis (by preventing the flattening of hills and reducing the presence of large concavities), ERM divided the PV array area into three smaller sections (labeled PV 01 through PV 03) as shown on Figures 1 and 2.

The ForgeSolar tool considers the direction the PV panels face throughout the day and the slope of the PV array, based on the underlying topography, elevation, and height above ground of the PV panels. Analysis of potential glare observed from stationary viewpoints (OP 1 through OP 16) is based on a 360-degree field of view. By comparison, analysis of glare along the six road segments is calculated using a 100-degree field of view (50 degrees to the left and right) centered on the direction of travel (in both directions) along the routes. Glare assessment along the flight paths also use a 100-degree field of view with a maximum downward viewing angle of 30 degrees. This default value is based on FAA research, which determined that the impact of glare beyond a 100-degree field of view is mitigated.<sup>6</sup>

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<sup>4</sup> ForgeSolar Glare Analysis tool. Available online <https://www.forgesolar.com/>. Accessed 5 November 2024.

<sup>5</sup> ForgeSolar. Fundamentals: About Glint and Glare. Available online <https://www.forgesolar.com/help/#glare>. Accessed 5 November 2024.

<sup>6</sup> Rogers, J. A., et al. 2015. "Evaluation of Glare as a Hazard for General Aviation Pilots on Final Approach." Federal Aviation Administration, Office of Aerospace Medicine. Report No. DOT/FAA/AM-15/12. Available online [https://www.faa.gov/sites/faa.gov/files/data\\_research/research/med\\_humanfacs/oamtechreports/201512.pdf](https://www.faa.gov/sites/faa.gov/files/data_research/research/med_humanfacs/oamtechreports/201512.pdf).

### 4.3 RESULTS

As summarized in Table 1 and documented in Appendix A, the glare analysis results predict the Project will generate green and yellow glare along Jensen Drive – Ringwood Trail from a point southwest of OP 6 to the intersection with Lakewood Drive near the northwest corner of the Site. Along Erwin Ranch Road, green glare is predicted west of the intersection with Lakewood Drive. A negligible amount of yellow glare (1 minute per year) is predicted on Erwin Ranch Road. The analysis predicts green glare at the northern end of Lakewood Drive near Jensen Drive. No yellow glare is predicted on Lakewood Drive, and no glare of any type is predicted along Central Lane, Cypress Lane, or Willow Lane.

The analysis predicts green glare along flight path FP 1, the approach to Runway 08 at Big Bear Airport. No yellow glare is predicted along FP 1, and no glare of any type is predicted along FP 2 or FP 3, the two approaches to Runway 26.

No yellow glare is predicted at any of the viewpoints OP 1 through OP 16. Green glare is predicted at viewpoints OP 3 through OP 7. No glare of any type is predicted at viewpoints OP 1, OP 2, and OP 8 through OP 16.

**Table 1: Bear Valley Solar Energy Project – Summary of Predicted Glare (with visual buffers)**

Viewpoint Location	Annual Green Glare (minutes/year)	Annual Yellow Glare (minutes/year)	Glare Source	Distance and Direction to Source	Approximate Time of Year and Day	Maximum Daily Duration (Green and Yellow combined) (minutes/day)	Comments
Erwin Ranch Road	68	none	PV 01	0.3 mi NE	Jun to Jul - morning	3	Glare predicted along western segment of road, northwest of Big Bear Ranch Park
	518	1	PV 02	0.2 mi NE	May to Aug - morning	7	Glare predicted along segment of road west of Lakewood Drive
Jensen Drive – Ringwood Trail	1,956	137	PV 01	630 ft SE	Nov to Jan - morning	31	
	1,269	none	PV 02	0.2 mi SE	Nov to Jan - morning	19	
Lakewood Drive	413	none	PV 02	0.2 mi SE	Dec to Jan - morning	11	Glare predicted at northern end of road near Jensen Drive
FP 1	459	none	PV 01	3.5 mi E	Feb to Mar and Sep to Oct - morning	12	
	146	none	PV 02	3.6 mi E	Feb to Mar and Sep to Oct - morning	5	
OP 3	101	none	PV 02	450 ft ENE	Apr to Sep - morning	2	

**Table 1: Bear Valley Solar Energy Project – Summary of Predicted Glare (with visual buffers)**

Viewpoint Location	Annual Green Glare (minutes/year)	Annual Yellow Glare (minutes/year)	Glare Source	Distance and Direction to Source	Approximate Time of Year and Day	Maximum Daily Duration (Green and Yellow combined) (minutes/day)	Comments
OP 4	73	none	PV 01	570 ft NE	May to Jul - morning	4	
	429	none	PV 02	640 ft ENE	Feb to May and Jul to Sep - morning	8	
OP 5	341	none	PV 01	350 ft NE	Apr to Aug - morning	8	
	304	none	PV 02	870 ft E	Mar, May, and Aug - morning	10	
OP 6	86	none	PV 02	0.3 mi SE	Dec - morning	6	
OP 7	73	none	PV 01	0.4 mi ESE	Feb to Mar and Oct - morning	8	

All viewpoints where glare is predicted in Table 1 are located on the western side of the PV array(s) generating the glare. Consequently, predicted glare would occur in the morning at these locations when the sun is low in the eastern sky and a person may observe glare when looking eastward toward the PV array. Graphs in Appendix A provide additional detail showing both the hour of day and daily duration of predicted glare each day throughout the year for every PV array and viewpoint combination.

It should be noted that glare observed at a viewpoint from multiple PV arrays may partially occur at the same time, particularly when glare is reflected from PV arrays that appear closely aligned relative to the observer. As a result, the total annual duration of glare predicted for each viewpoint in the Appendix A Summary of Results Table may include overlapping periods of glare for viewpoints that receive glare from more than one PV array.

In addition, the glare analysis does not consider potential cloud cover. The amounts of glare predicted in Table 1 and Appendix A represent total potential amounts of glare assuming clear, sunny skies every day throughout the year.

#### 4.4 CONCLUSIONS

As currently designed, the Project would potentially reflect glare onto segments of Erwin Ranch Road, Jensen Drive – Ringwood Trail, and Lakewood Drive, as well as other viewpoints identified in Table 1 during certain periods of the year. However, the proposed visual buffers significantly reduced predicted glare along Erwin Ranch Road, Lakewood Drive, and at OP 3, OP 4, OP 5, and OP 7. The visual buffers eliminated

predicted glare at OP 1, OP 2, OP 8, and OP 15. (The glare analysis results without the visual buffers are provided in Appendix B for reference.)

Because viewpoints OP 6 and Jensen Drive – Ringwood Trail are located up to 110 feet above and northwest of the Site, the lines of sight from these viewpoints would not be affected by the proposed buffers. Consequently, predicted glare at these locations remained nearly unchanged. At OP 6, however, only 86 minutes of annual green glare (a maximum of 6 minutes per day) is predicted.

In 2021, the FAA issued an updated policy regarding reviews of solar projects on federally obligated airport property in which the FAA concluded that in most cases “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.”<sup>7</sup> FAA policy focuses on potential impacts on crews in ATCTs, which would not apply to airports without ATCTs such as Big Bear Airport.

Along flight path FP 1, located 3.5 miles west of the Site, the results predict a maximum of around 12 minutes of green glare in the morning per day for about one month in the spring and fall. These levels and duration of glare from the Project potentially observed by pilots would likely be similar to or less than levels occasionally reflected from the much larger Big Bear Lake located directly under FP 1. In addition, Baldwin Lake, located 2.1 miles east-northeast and roughly in line with FP 1, could also be a potential source of glare for pilots at certain times. Based on these factors, glare impacts on pilots caused by the Project are expected to be minimal.

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<sup>7</sup> FAA. 2021. Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports. 86 FR 25801.

## FIGURES

## APPENDIX A - FORGESOLAR GLARE ANALYSIS RESULTS (WITH VISUAL BUFFERS)

## APPENDIX B - FORGESOLAR GLARE ANALYSIS RESULTS (WITHOUT VISUAL BUFFERS)

**Table 2: Bear Valley Solar Energy Project –  
 Summary of Predicted Glare (without visual buffers)**

Viewpoint Location	Annual Green Glare (minutes/year)	Annual Yellow Glare (minutes/year)	Glare Source	Distance and Direction to Source	Approximate Time of Year and Day	Maximum Daily Duration (Green and Yellow combined) (minutes/day)	Comments
Erwin Ranch Road	279	none	PV 01	0.3 mi NE	May to Jul - morning	5	Glare predicted along western segment of road, northwest of Big Bear Ranch Park
	743	874	PV 02	60 ft N to NE	Mar to Sep - morning	10	Glare predicted along segment of road south and southwest of PV 02
	245	606	PV 03	60 ft N to NE	May to Aug - morning	12	Glare predicted along segment of road south and southwest of PV 03
Jensen Drive – Ringwood Trail	1,965	130	PV 01	630 ft SE	Nov to Jan - morning	31	
	1,269	none	PV 02	0.2 mi SE	Nov to Jan - morning	19	
Lakewood Drive	963	234	PV 02	730 ft E	Mar to May, Jul to Sep, and Dec to Jan - morning	10	Glare predicted from Erwin Ranch Road intersection northward
FP 1	818	none	PV 01	3.5 mi E	Feb to Mar and Sep to Oct - morning	15	
	807	none	PV 02	3.6 mi E	Feb to Mar and Sep to Oct - morning	12	
OP 1	599	none	PV 02	780 ft ENE	Apr to Sep - morning	10	
OP 2	290	none	PV 02	330 ft NE	May to Jul - morning	8	
	20	none	PV 03	460 ft ENE	May and Jul - morning	2	
OP 3	673	386	PV 02	290 ft E	Apr to Sep - morning	13	
OP 4	310	none	PV 01	500 ft NE	May to Jul - morning	9	
	1,686	none	PV 02	580 ft E	Intervals throughout the year - morning	12	
OP 5	498	182	PV 01	250 ft NE	Apr to Aug - morning	11	
	1,133	none	PV 02	870 ft E	Aug to May - morning	11	
OP 6	93	none	PV 02	0.3 mi SE	Dec to Jan - morning	7	
OP 7	460	none	PV 01	0.3 mi ESE	Oct to Mar - morning	12	
	476	none	PV 02	0.5 mi SE	Oct to Feb - morning	11	
OP 8	437	none	PV 01	0.3 mi E	Feb to Mar and Sep to Oct - morning	11	

**Table 2: Bear Valley Solar Energy Project –  
 Summary of Predicted Glare (without visual buffers)**

Viewpoint Location	Annual Green Glare (minutes/year)	Annual Yellow Glare (minutes/year)	Glare Source	Distance and Direction to Source	Approximate Time of Year and Day	Maximum Daily Duration (Green and Yellow combined) (minutes/day)	Comments
	423	none	PV 02	0.5 mi ESE	Feb to Mar and Oct to Nov - morning	10	
OP 15	104	none	PV 02	810 ft SW	Jan to Feb - evening	5	