APPENDIX H-3
AIRPORT SAFETY AND COMPATIBILITY TECHNICAL MEMORANDUM

This page is intentionally blank.

TETRA TECH

Administrative Draft

Technical Memorandum

Date: September 6, 2018; updated January 25, 2019

To: Aarty Joshi, Senior Manager, Environmental Permitting
Clearway Energy Group

From: Patti Murphy, Senior Project Manager, Tetra Tech, Inc.

Subject: Barstow-Daggett Airport Safety and Compatibility – Daggett Solar Power Facility Project

1.0 Introduction

This technical memorandum addresses safety and compatibility issues related to the project and the Barstow-Daggett Airport (Airport), a public airport located in Daggett, California. The Airport is a publicly owned, public use airport classified in the National Plan of Integrated Airport Systems as a general aviation, general utility facility that accommodates general aviation aircraft with maximum gross takeoff weights of 12,500 pounds. The Airport is located on 1,087 acres in an unincorporated area of San Bernardino County, 15 miles east of the City of Barstow. There are no topographical restrictions to expansion possibilities. However, airport growth to the south is restricted by the Atchinson-Topeka and Santa Fe Railroad and U.S. Route 66.

The U.S. Army (Fort Irwin) uses the Barstow-Daggett Airport to store and operate approximately 25 aircraft. Fort Irwin's Airport operations consist primarily of helicopter training and logistical transportation of key personnel. Fort Irwin's main facility is located approximately 37 miles northeast of Barstow.

2.0 Airport Land Use Compatibility

An evaluation of the project's land use compatibility with the policies in the Airport Comprehensive Land Use Plan (ACLUP) is included in Attachment 1. The ACLUP, prepared by the Planning Department of San Bernardino County, designates zones around the airport intended to promote safe operations on the ground and in the air. The ACLUP designates the uses that are compatible with Airport operations. Safe and efficient airport operations require that certain areas on and near the airport be clear of objects or restricted to objects with a certain function, composition or height and are intended to protect both airborne and ground activities. Land uses that are restricted are controlled in the Runway Protection Zone, Runway Object Free Area, and Obstacle Free Zone and are generally designated in the areas over or immediately adjacent to taxiways and runways. Safety in the air is achieved through designation of Approach, Transitional and Horizontal Areas (imaginary surfaces); in these areas height restrictions for development are established to allow aircraft room to maneuver and to ensure that runways are not adversely affected by obstructions in the airspace. Many land uses are conditionally acceptable with more land uses being conditionally acceptable in the Transitional and Horizontal Areas than the Approach Area. The culmination of these designations are three Safety Review Area categories; each Safety Review Area reflects a particular level and type of aviation related hazard or risk. Safety Review Area 1 covers the areas at the end of the runways and designated Runway Protection Zone. Safety Review Area 2 covers the runways where noise is expected to be loudest. Safety Review Area 3 are the remaining areas in the ACLUP boundary area not covered by Safety Review Areas 1 and 2. The Safety Review Areas are used by the Airport Land Use Commission in

Tetra Tech, Inc.
17885 Von Karman Avenue, Suite 500, Irvine, CA 92614
Tel 949.809.5000 Fax 949.809.5010 tetratech.com

considering a project's consistency in ensuring safe airport operations and protection of people. Refer to Figure A1 for an overview of Safety Areas at the Airport. Figure A2 shows the Daggett Solar Power Facility CUP Area 4 with the updated RPZs (Safety Area 1) and how the RPZs correspond to the project layout (FAA 2012). The FAA updated the runway designations in FAA Advisory Circular 150/5300-13A, Table A7-7 through A7-12, September 28, 2012 and these updated designations are shown on Figure A2.

ACLUP Safety Review Areas cover some of the project area adjacent to the Airport. A small portion of the project area is designated RPZ or Safety Area 1 at the ends of the Runways 8/26 and 04/22 (Figure B). The areas designated Safety Area 1 are discussed further in Section 4 of this report based on an analysis prepared by Capital Airspace of the Runway Protection Zones. The project is also partially designated Safety Review Area 3 by the ACLUP. The project site does not contain Safety Area 2 designation. As required, the project's components located within the area under the jurisdiction of the Airport Land Use Commission will be reviewed and a recommendation will be made to the Planning Commission regarding compliance with the ACLUP. In addition, project facilities including solar panels, fences and transmission line poles within the RPZ or Safety Area 1 will be reviewed by the Federal Aviation Administration FAA and the FAA will issue a Determination of No Hazard if these facilities are acceptable and do not pose a hazard to Airport activities. The applicant has stated that the final project design will comply with the requirements of the Airport Land Use Commission's recommendation regarding safety and the FAA's guidance in order to obtain Determinations of No Hazard for project facilities. See Attachment 1 for a more detailed discussion of the project's compatibility with the ACLUP and Section 4 of this report for a more detailed discussion of the Runway Protection Zones.

3.0 Consultation with Airport and Fort Irwin

Consultation with the Airport and Fort Irwin has been ongoing since January 2017, beginning with a pre-application meeting with San Bernardino County on January 11, 2017, attended by San Bernardino County Department of Airports (DOA) Director James Jenkins. The applicant subsequently began reaching out to the DOA (i.e. DOA Director James Jenkins, and Assistant Director Terry Stover) via telephone and e-mail.

The applicant met with representatives from the Fort Irwin National Training Center on June 22, 2018. The purpose of this meeting was for the applicant to provide an overview of the Daggett Solar Power Facility to the Fort Irwin military base representatives as a follow-up to the letter submitted by Fort Irwin on the Notice of Preparation published pursuant to California Environmental Quality Act (CEQA), and to solicit feedback on preliminary design and potential for compatibility with Fort Irwin operations.

Documentation related to these contacts is included in Attachment 2.

4.0 Federal Aviation Administration Obstruction Evaluation and Incorporation of Recommended Measures

An Obstruction Evaluation and Airspace Analysis was prepared by Capital Airspace Group for the project in accordance with the guidance provided in the Notice of Criteria Tool (Attachment 3). The FAA requires that all structures exceeding 14 CFR Part 77.9 notification criteria be submitted to the FAA so that an aeronautical study can be conducted. The FAA's objective in conducting aeronautical studies is to ensure that proposed structures do not have an effect on the safety of air navigation and the efficient utilization of navigable airspace by aircraft. The end result of an aeronautical study is the issuance of a determination of 'hazard' or 'no hazard' for relevant project facilities that can be used by the proponent to obtain necessary construction permits.

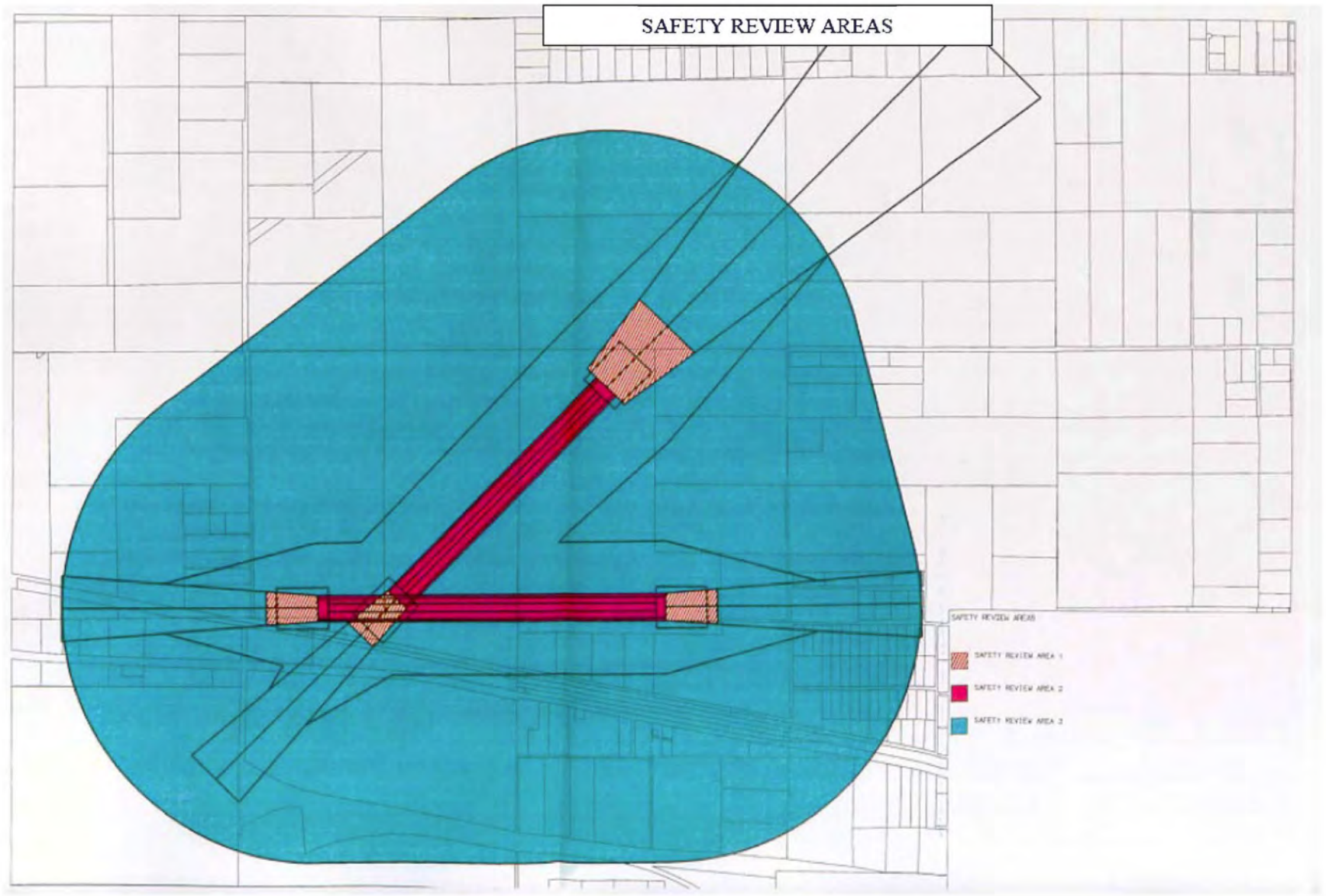
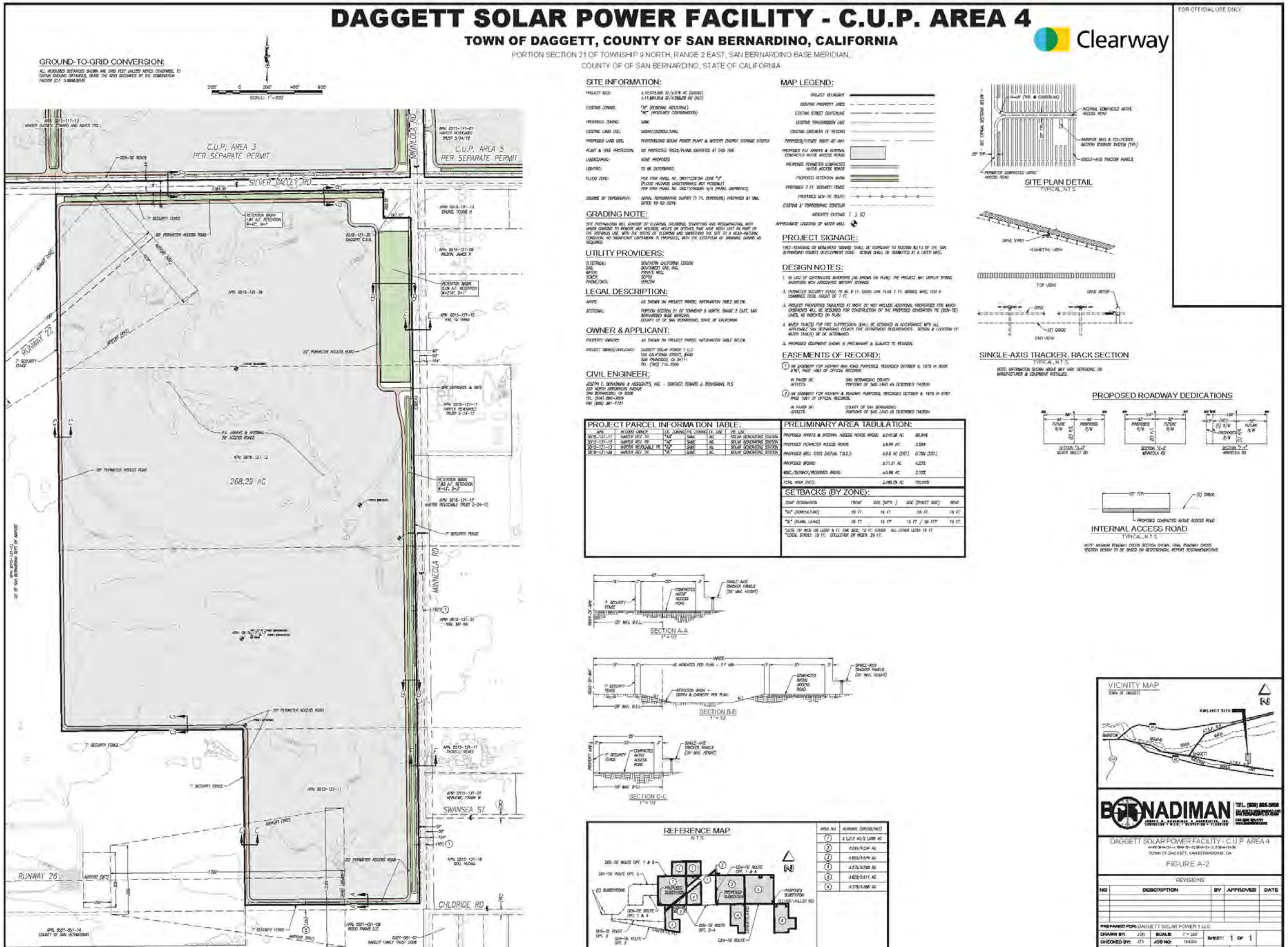
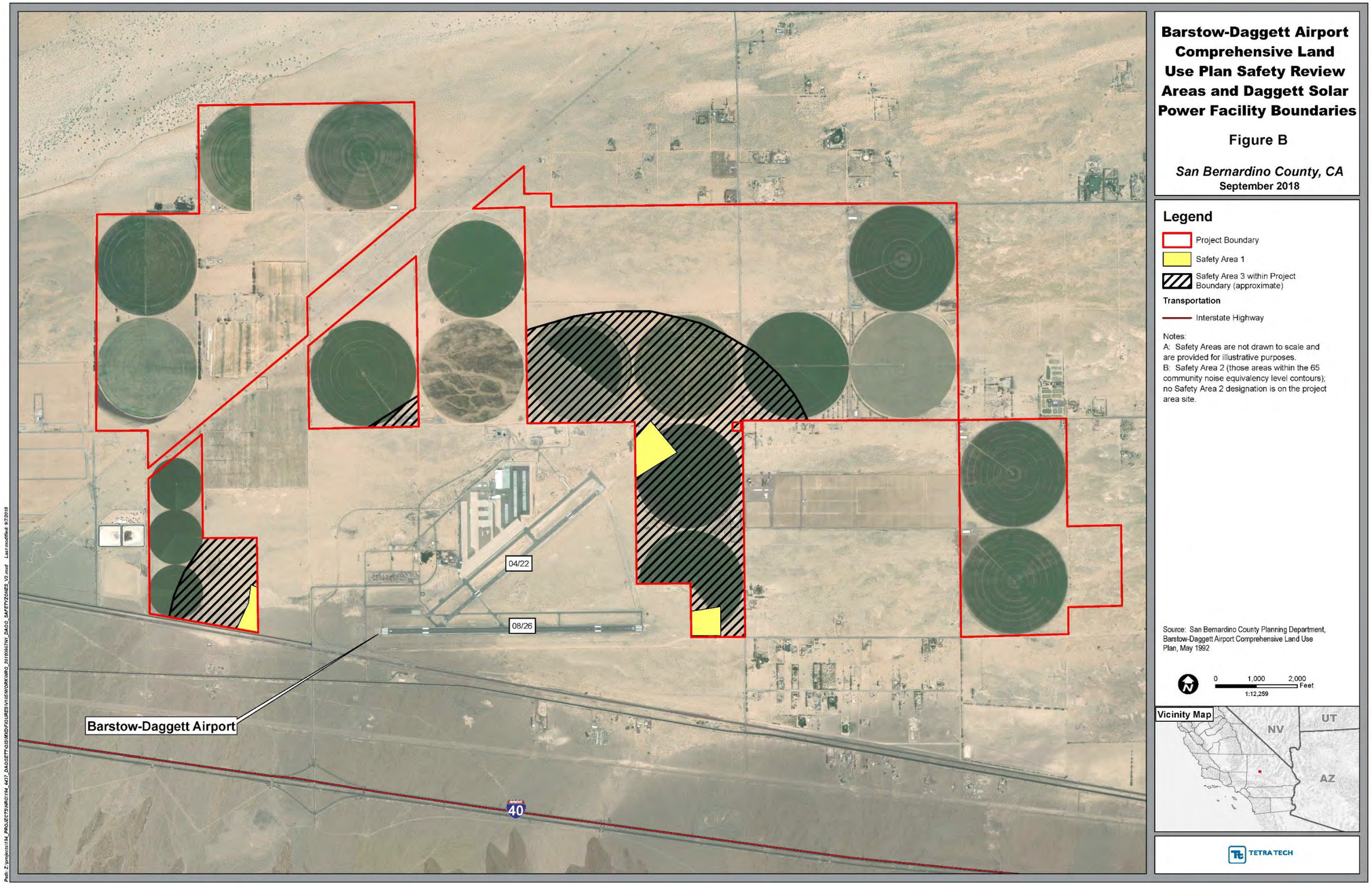


Figure A-1: Barstow-Daggett Airport Safety Review Areas


DAGGETT SOLAR POWER FACILITY - C.U.P. AREA 4
TOWN OF DAGGETT, COUNTY OF SAN BERNARDINO, CALIFORNIA
Clearway
GROUND-TO-GRID CONVERSION:
SITE INFORMATION:
MAP LEGEND:
GRADING NOTE:
UTILITY PROVIDERS:
LEGAL DESCRIPTION:
OWNER & APPLICANT:
CIVIL ENGINEER:
PROJECT SIGNAGE:
DESIGN NOTES:
EASEMENTS OF RECORD:
PROJECT PARCEL INFORMATION TABLE:
PRELIMINARY AREA TABULATION:
SETBACKS (BY ZONE):
SITE PLAN DETAIL
SINGLE-AXIS TRACKER, RACK SECTION
PROPOSED ROADWAY DEDICATIONS
INTERNAL ACCESS ROAD
C.U.P. AREA 3 PER SEPARATE PERMIT
C.U.P. AREA 5 PER SEPARATE PERMIT
SILVER VALLEY RD
MINNEOLA RD
SWANSEA ST
CHLORIDE RD
RUNWAY 22
RUNWAY 26
268.29 AC
SECTION A-A
SECTION B-B
SECTION C-C
REFERENCE MAP
VICINITY MAP
BONADIMAN
DAGGETT SOLAR POWER FACILITY - C.U.P. AREA 4
FIGURE A-2
FOR OFFICIAL USE ONLY



Barstow-Daggett Airport Comprehensive Land Use Plan Safety Review Areas and Daggett Solar Power Facility Boundaries

Figure B

San Bernardino County, CA
September 2018

Legend

- Project Boundary
- Safety Area 1
- Safety Area 3 within Project Boundary (approximate)

Transportation

- Interstate Highway

Notes:
A: Safety Areas are not drawn to scale and are provided for illustrative purposes.
B: Safety Area 2 (those areas within the 65 community noise equivalency level contours); no Safety Area 2 designation is on the project area site.

Source: San Bernardino County Planning Department, Barstow-Daggett Airport Comprehensive Land Use Plan, May 1992

0 1,000 2,000 Feet
1:12,259

Vicinity Map

TETRA TECH

Path: Z:\projects\NA_PROJECTS\NRG\NA_447_DAGGETT\GIS\MXD\FIGURES\VISWORK\MRO_20180927\NI_DAGG_SAFETYZONES_V2.mxd Last modified: 9/7/2018

Once environmental review is complete, final project design will incorporate the findings from the CEQA process, the Obstruction Evaluation and Airspace Analysis, consultations with San Bernardino DOA and Fort Irwin staff, the Airport Land Use Commission and the FAA.

The Obstruction Evaluation noted that the project's transmission line structures in central, southern, and southwestern sections of the study area, including along a small central section of the proposed transmission line route could exceed acceptable heights. In response, the applicant is evaluating the use of shorter transmission poles as well as an alternative to locate a segment of the transmission line underground. If the transmission line is not located underground, marker balls or other FAA-required safety features may be installed, as required by the FAA. See Attachment 3 which contains an Obstruction Evaluation and Airspace Analysis prepared by Capital Airspace Group.

5.0 Analysis of Glare Hazard

FAA Interim Policy 78 FR 63276 establishes procedures for analysis of glare hazard at solar facilities near airports. The method for assessing glare hazard for solar farm projects is a tool referred to as the Solar Glare Hazard Analysis Tool (SGHAT). A glint and glare study was completed by Capitol Airspace using the SGHAT tool to address the potential for glare impacts at the Barstow-Daggett Airport. The results are described below and the report is included in Attachment 4.

Capitol Airspace performed a Glint and Glare Analysis to identify whether the project significantly impacts Airport operations. Specifically, this analysis considered the impact on aircraft approaching land on Runways 08/26 and 04/22. The study was conducted in accordance with the FAA interim policy for Solar Energy System projects on Federally Obligated Airports. The results of the study show that there is a "low potential for after image" associated with glare emanating from Array 6 only. This glare may be seen by aircraft making approaches to Runway 22. This level of glare is deemed acceptable by FAA standards per the interim policy for Solar Energy System projects on Federally Obligated Airports. No glare was identified that would have an effect on Runway 08/26 from any of the arrays.

With respect to nighttime glare impacts, unlike concentrating solar projects, the project consists of photovoltaic panels that would not be a source of nighttime reflection and thus would not significantly contribute to glare in the area. There would be lights on site, primarily at the substations. The lights would have standard shades and be directed at the ground for safety purposes. Although the project would result in a change in the environment where Fort Irwin training exercises occur, the additional lights would not prevent or significantly impact the exercises.

6.0 Impacts on Operating Procedures

As noted in Section 4.0 above, an Obstruction Evaluation and Airspace Analysis was prepared by Capital Airspace Group for the project in accordance with the guidance provided in the Notice of Criteria Tool (Attachment 3). The purpose of the evaluation was to provide the aviation safety data necessary to be incorporated into the final project design. The applicant is currently incorporating the data into the project design so that minor modifications can be made and an FAA Determination of No Hazard can be obtained. In the Obstruction Evaluation, Figures 12 and 13 summarize height constraints and clearances. These figures depict the constraints listed below. In consultation with the FAA, the applicant will revise the project's current project design to avoid the areas of height constraints and locate structures in the area identified on Figure 13 as clearance areas, as required to obtain an FAA Determination of No Hazard.

- Solar Panels – The Obstruction Evaluation shows that some of the 20-foot AGL solar panels in close proximity to Barstow-Daggett Airport Runway 22 would exceed its 77.19(d) *approach* surface and would be identified as obstructions; additionally, solar panels in this area would exceed the Runway 04 initial climb area (ICA) 40:1 obstacle clearance surface. However, due to their low height, 20-foot AGL solar panels meet "low, close-in" criteria and would only require notation on the Runway 04 takeoff minimums and obstacle departure procedure. Since notation on the departure procedure does not impact the minimum climb gradient these solar panels should still be able to receive favorable determinations of no hazard. Solar panels throughout the remainder of the study area (orange, yellow, and green areas, Figure 13) would not exceed any Part 77 imaginary surfaces or obstacle clearance surfaces and should be able to receive favorable *Does Not Exceed* determinations. However, it should be noted that current FAA guidance does not allow solar panels to be placed within runway protection zones (RPZs). If required by the FAA, the project will be redesigned and the panels in the RPZ will be removed.
- Substations/Battery System Enclosures – At their proposed locations the 40-foot AGL substation/battery system enclosures do not exceed any Part 77 imaginary surfaces or obstacle clearance surfaces. As a result, these structures should be able to receive favorable *Does Not Exceed* determinations.
- Transmission Line Structures –
  - 125-foot[1] transmission line structures along an approximately 3,900-foot length of proposed routing in the southwestern section of the study area will exceed the Barstow-Daggett Airport Part 77.19(b) horizontal surface by as much as 26 feet. However, United States Geological Survey (USGS) elevation data indicates that transmission line structures along this section would not exceed obstacle clearance surfaces and therefore should be able to receive favorable determinations of no hazard.
  - 125-foot transmission line structures along an approximately 3,100-foot length of proposed routing in the central section of the study area will exceed the Barstow-Daggett Airport Runway 22 Part 77.19(d) approach surface by as much as 70 feet. USGS elevation data also indicates that transmission line structures along this section would exceed Barstow-Daggett Airport Runway 04/22 VFR traffic pattern airspace, the Runway 22 PAPI obstacle clearance surface (Figure 6), and the Runway 04 ICA 40:1 obstacle clearance surface. If required by the FAA, transmission line structures along this segment would be shortened in order for a Determination of No Hazard to be issued; the applicant assumes that transmission structures could be shortened to as low as 84 feet AGL (based on USGS elevation data) or may be placed undergrounded in order to remain below these obstacle clearance surfaces.

In addition, the applicant will include FAA requirements for temporary construction equipment in the project contractor's specifications to avoid impacts on Barstow-Daggett Airport operations from cranes and other temporary construction equipment that could exceed FAA obstacle clearance surfaces. Because the applicant will revise project design, as applicable, to facilitate issuance of Determinations of No Hazard by the FAA, no mitigation measures are proposed.

[1] The Obstruction Evaluation prepared by Capital Airspace evaluated transmission structures up to 125 feet AGL, based on USGS elevation data, as a maximum impact analysis. However, the applicant's application requests approval for transmission poles up to 120 feet.

7.0 Heat Island Effect

In their scoping letter, Fort Irwin staff raised their concerns that the project could contribute to the general warming of air temperatures at the project site and in the area, a phenomenon referred to as a heat island effect. A technical memorandum related to the issue of heat islands is included in Attachment 5. The conclusion of the memo is that the project would not contribute to increased temperatures at the project site or in the surrounding area. The memo describes the science behind heat islands and shows how solar photovoltaic panels convert the sun's energy to electrical energy without increasing the air temperature.

8.0 Conclusion

The project is being designed in conformance with the ACLUP policies as well as taking into account the concerns raised by the Airport and Fort Irwin Training Center staff. The project will be required to seek a Determination of No Hazard from the FAA for each gen-tie structure and the applicant has stated that design modifications and safety features will be incorporated into the design in accordance with the Obstruction Evaluation (Figure 13) to the location of structures in the clearance areas, if required by the FAA. In addition, final design of the transmission line and solar panel layout will avoid restrictions noted in Figure 12 of the Obstruction Evaluation, if required, to obtain the FAA Determination of No Hazard. In addition to the FAA Determination of No Hazard, the project's final design will be reviewed by the Airport Land Use Commission for compatibility and authorized by the County Planning Commission and Board of Supervisors.

Attachments:

Attachment 1: Land Use Review Criteria and Consistency Statements

Attachment 2: Consultation

Attachment 3: Obstruction Evaluation and Airspace Analysis

Attachment 4: Glint and Glare Study

Attachment 5: Heat Island Memorandum

Attachment 1

Land Use Review Criteria and Consistency Statements

The project was assessed with respect to the policies in the San Bernardino County's Airport Comprehensive Land Use Plan, Barstow -Daggett Airport, May 1992. Section VIII of the ACLUP contains the land use development review criteria and standards listed and discussed in the following table.

Land Use Review Criteria and Standards (page 40 of ACLUP; http://www.sbcounty.gov/Uploads/lus/Airports/BarstowDagget.pdf)	
Land Use Criteria/Development Standard	**Consistency Statement/Discussion**
All discretionary projects, as defined by CEQA, to include any size expansion or modification of an existing facility or use, in Safety Review Area 3 if the project is not consistent with this ACLUP. (Consistency is determined by compatibility with airport operations and the textual provisions of this plan.)	The project includes areas designated Safety Review Area 3 with a limited portion in Safety Review Area 1 at the end of Runways 08, 22 and 26 (Figure A and see Attachment 3, Obstruction Evaluation for Runway Protection Zones). During a preapplication meeting, the Applicant met with the Airport staff to solicit their comments and/or concerns. A Glare study and Obstruction Evaluation was completed and concluded that the proposed solar project would not interfere with approaching or departing aircraft with minor design modifications. If required by the FAA, poles for the above-ground generation tie line would be shorter than the 120-foot height currently planned or a segment of the line would be placed underground so the line would not pose a hazard for aircraft as regulated by the FAA and other project facilities would be modified as well depending on the FAAs Determination of No Hazards. Prior to issuance of grading and building permits, the applicant will obtain FAA Determination of No Hazard to Navigation for the gen-tie poles and other relevant project facilities in the airport vicinity and comply with safety measures, as required.
All discretionary projects, as defined by CEQA, that are determined to be conditionally acceptable.	The project is currently being assessed by the County in compliance with CEQA. An environmental impact report is being prepared.
All expansions, revisions or establishment of airport facilities.	Not applicable. The proposed project does not entail any expansion, revisions or establishment of an airport facility.
All discretionary projects, as defined by CEQA, to include any size expansion of existing facility or use, requiring a major variance.	Not applicable. The proposed project does not entail any expansion of an existing facility or use.
All proposed amendments to the text or maps of the San Bernardino County General Plan, Development Code or any Specific Plan, or changes in the existing permitted land use or building standards in Safety Review Areas 1, 2, or 3.	The project has designations of Safety Review Area 3 with a small portion in Safety Review Area 1 at the end of Runways 8/26 and 04/22 (See Attachment 3, Obstruction Evaluation). However, the project is not proposing prohibited uses in these Safety Areas; and therefore, no changes to the San Bernardino County General Plan are required.

Land Use Review Criteria and Standards (page 40 of ACLUP; http://www.sbcounty.gov/Uploads/lus/Airports/BarstowDagget.pdf)	
Land Use Criteria/Development Standard	**Consistency Statement/Discussion**
All projects, to include any size expansion of existing facility or use, in Safety Review Areas 1 and 2.	A small portion of the project area is designated Safety Area 1 at the end of the Runways 8/26 and 04/22. The areas designated Safety Area 1 are discussed further in Section 4 of this report based on an analysis prepared by Capital Airspace of the Runway Protection Zones. The project is also partially designated Safety Review Area 3 by the ACLUP. As required, the project's components located within the area under the jurisdiction of the Airport Land Use Commission will be reviewed and a recommendation will be made to the Planning Commission regarding compliance with the ACLUP and FAA.
All changes in use or type of occupancy for any existing structure in Safety Review Areas 1 and 2.	A small portion of the project area is designated Safety Area 1 at the end of the Runways 8/26 and 04/22. The areas designated Safety Area 1 are discussed further in Section 4 of this report based on an analysis prepared by Capital Airspace of the Runway Protection Zones. The project is also partially designated Safety Review Area 3 by the ACLUP. As required, the project's components located within the area under the jurisdiction of the Airport Land Use Commission will be reviewed and a recommendation will be made to the Planning Commission regarding compliance with the ACLUP.
All projects, to include any size expansion of existing facility or use, with a construction foundation elevation of 2043' MSL or greater.	Obstacle clearance surfaces overlying the Daggett solar project range from 1,933 to 2,280 feet AMSL. The project is seeking an FAA Determination of No Hazard to Navigation and will modify the project's layout and structures to conform to FAA requirements.
All projects, to include any size expansion of existing facility or use, that involves a structure or portion thereof that exceeds thirty-five (35) feet in height.	The proposed gen-tie poles are expected to be up to 120 feet in height. An Obstruction Evaluation was completed and structures that exceed 14 CFR Part 77.19 imaginary surfaces will be identified in the final design; however, heights in excess of these surfaces are feasible provided proposed structures are located outside of RPZs and do not exceed FAA obstacle clearance surfaces. The final design will avoid placing structures that exceed Part 77 surfaces in the RPZs and a Determination of No Hazard will be obtained from FAA.

Land Use Review Criteria and Standards (page 40 of ACLUP; http://www.sbcounty.gov/Uploads/lus/Airports/BarstowDagget.pdf)	
Land Use Criteria/Development Standard	**Consistency Statement/Discussion**
The proposed structures and the normal mature height of any vegetation shall not exceed the height limitations provided by Federal Aviation Regulations, PART 77, Objects Affecting Navigable Airspace.	The proposed gen-tie poles are expected to be up to 120 feet in height. The project will be designed as stated above and the project will obtain Determinations of no Hazard for the gen-tie poles and project components in the RPZ or Safety Area 1 from the FAA to confirm that there are no obstructions to airport navigation.
Development of residential or other noise sensitive land uses shall require interior noise exposure levels of 45 CNEL or less with windows and doors closed. Noise sensitive land uses include residential uses, schools, hospitals, nursing homes, churches and libraries. Interior noise exposure levels for retail commercial, banks and restaurants and industrial uses shall be 50 and 55 CNEL respectively.	Not applicable. The project does not entail development of noise sensitive land uses.
The proposed use or structure shall not reflect glare, emit electronic interference or produce smoke that would endanger aircraft operations.	A Glint and Glare analysis was completed by Capitol Airspace to determine potential impacts from project operation on the Barstow-Daggett Airport. The analysis was conducted in accordance with FAA established policy for solar energy projects, and concluded that the there was a “low potential for after impacts” associated with glare emanating from Array 6, which may be seen by aircraft making approaches to Runway 22; this level of glare is deemed acceptable by FAA standards. Therefore, there would be a less than significant impact. An Electromagnetic Interference analysis was completed by Spohnheimer Consulting Airspace Systems, LLC to determine if the proposed project would generate electrical noise that could potentially have an effect on aircraft avionics. The analysis determined that the arrays would be located more than 700 feet from the runways, and therefore magnetic effects would be expected to be minimal. Electrical noise radiation from the power conversion equipment capable of affecting aircraft avionics was predicted to be minimal. Therefore, the project was determined to present minimal risk to operation of aircraft avionics and there would be a less than significant impact. No smoke would be produced by the project that would endanger aircraft operations.

Land Use Review Criteria and Standards (page 40 of ACLUP; http://www.sbcounty.gov/Uploads/lus/Airports/BarstowDagget.pdf)	
Land Use Criteria/Development Standard	**Consistency Statement/Discussion**
The proposed use does not involve the storage or dispensing of volatile or otherwise hazardous substances that would endanger aircraft operations.	Not applicable. The project does not involve storage or dispensing of hazardous materials that would endanger aircraft operations. No fuel tanks would be located in the RPZs nor would fueling operations be conducted in the restricted areas.
The proposed use or structure complies with the San Bernardino County Development Code Standards specified by each official land use district.	The project is consistent with the San Bernardino County Development Code standards for solar development.
The short or long-term concentration of people for a proposed use or structure shall not exceed the maximum gross density or maximum assembly limits specified by the density criteria of the land use compatibility in the airport Safety Review Area chart.	Renewable Energy and/or solar development is not specifically listed in the ACLUP's Table 4 "Land Use Compatibility – Airport Safety Review Areas". However, "Utilities", "Manufacturing" and "Warehouse", which are similar in nature to the project, are considered to be "Normally Acceptable" in Safety Review Area 3. These uses are designated unacceptable in Safety Review Area 1, the project applicant will conform to the requirements of the Airport Land Commission and FAA, see Section 4 of this report for further discussion.
The proposed use or structure shall not attract large concentrations of birds.	The proposed project would not serve as an attractant to large concentrations of birds. Although it has not been verified by the scientific community, some have suggested that water birds could perceive solar facilities as an illusion of a lake; this is known as the "lake effect" hypothesis. Biological surveys have been conducted to document general avian use at the site, which showed that no water birds were documented at the project site.

Attachment 2 – Consultation

Meeting Summary: Daggett Solar Power Facility – Meeting with Ft. Irwin

Attendees:	Chief Richard Glosson – NTC AVN Safety Dave Acker – NTC G3 Force Integration Karen Grey – Strategic Planner, Marine Corps Logistics Base Eric Negrete – NTC G3 Force Integration Aarty Joshi (NRG) James Kelly (NRG) Jared Foster (NRG) Rick Coles (Capital Airspace)
Date:	June 22, 2018
Location:	Coolwater Generating Station, Daggett, CA; 1-3 pm
Projects Discussed:	Daggett Solar Power Facility

The purpose of this meeting was for NRG provide an overview of the Daggett Solar Power Facility to the Ft. Irwin military base as a follow-up to the letter prepared by Ft. Irwin on the Notice of Preparation published pursuant to CEQA, and to solicit feedback on preliminary design and potential for conflicts with Ft. Irwin operations. The following bullets summarize the meeting discussion:

Department of the Army Headquarters, National Training Center (NTC) & Fort Irwin Military Activities:

- Ft. Irwin considered building a 500 MW 14,000 acre solar thermal and photovoltaic facility at Ft. Irwin in partnership with Acciona but it was cancelled. The USMC currently has an operating wind turbine at the Marine Corps Logistics Base nearby in Barstow .
- Barstow-Daggett Airport – Joint use (military and civilian) airport. Has 2 runways referred to as 22 and 26. Ft. Irwin occupies northern end of runway 22 of airport. Runway 26 is used for traffic patterns (i.e. training). Most landings and departures are from Runway 22. Ft. Irwin operations are mainly with helicopters but sometimes they have senior personnel (VIPs) also arrive via small aircraft.
    - Landing/departure based on wind condition. Aircraft land and take-off with nose into the wind so that less fuel is used. That's why Runway 22 is the standard approach/departure and Runway 26 is used for traffic pattern work (i.e. training)
- New pilot training and annual evaluations occur at airport. Barstow-Daggett airport is also Ft. Irwin's only emergency runway – the airports in Apple Valley and Victorville are the nearest airports but military staff are not as familiar with those.
- Ft. Irwin does other aviation activities that civilian aircraft do not do – like obstacle training, which also needs to be considered in NRG analysis. Ft. Irwin conducts helicopter training at night.

- Ft. Irwin does instrument training (VOR and GPS) as helicopters approach runways. VOR is VHF (Very High Frequency) Omni-directional Radio-range and is a navigational aid that is used to guide aircraft. Ft. Irwin noted that they are concerned if they will experience interference with that signal. They are flying blind and if they get interference, they can get into trouble.
- They conduct more aggressive landings and takeoffs than civilian aircraft typically do
- Force Integration: They look at projects (either military or civilian) 6-10 years out that have the potential for impacts to their mission and existing capability. They are responsible for long-range planning for the commanding general.
- Ft. Irwin stated that they worked with County on a draft Military Readiness Element as part of the overall General Plan update. The draft Element includes a description of their activities. They are sure if that document is publicly available yet.

Obstruction Concerns:

- Last year they had an Apache helicopter flying at night and it hit the LADWP line, because there were no marker balls on the LADWP line. They are in the process of working with LADWP to get markers on the line. They have been flying here the last 40 years, and they've had 9 incidents with one fatality.
- Ft. Irwin noted that they will formally request that NRG install lighted marker balls (that flash at night) at the very least. NRG noted that they are considering undergrounding a segment of the line, if possible, in that area and Ft. Irwin stated that that would be ideal, if it is possible. Ft. Irwin stated that they can see a flashing light about 2 miles away using night vision goggles. Lights can be okay if shielded and/or pointed downward.
- Ft. Irwin also noted that once a structure is above certain height, the structure needs to be marked. Permanent obstacles (like poles/lines) will be added to nautical charts.
- Ft. Irwin asked if the locations of the substations were confirmed and what the height of the components would be. NRG stated that the substations are not in a fixed location, but were located based on the preferred transmission line route.
- Capital Airspace will be performing an Obstruction Evaluation/Aeronautical Study which will identify all of the issues with respect to approaches/departures. Expected to be completed in mid to late July.
- As currently designed, the project would impact landing and departure at airfield because structures will be added at ground-level. Once constructed, FAA may have to re-TERP (terminal instrument route procedures) the airport, which involves mapping the elevations that incoming/outcoming aircraft will need to adhere to. FAA does this after project is built. NRG does not need to do anything at this time, however prior to construction, NRG should plan to submit the necessary forms to FAA for approval and then post-construction they will re-evaluate the altitudes based on as-builts. NRG stated that they experienced this same process on other projects located on airport property.
    - Ft. Irwin will send NRG a copy of the approaches and departures (DOD Flip) so that Capital Airspace can confirm they are using correct assumptions in Overhead Obstruction (OE) analysis.

Radio Frequency Interference:

- The Ft. Irwin Environmental and Spectrum staff could not attend the meeting. They would like more information on the type of communications equipment that would be used, and asked if NRG could provide technical specs. NRG stated that there would be wireless and wired communications, and that they would provide the specification sheets. Ft. Irwin will review those with their Spectrum Center because they have a lot of equipment that run on different frequencies. They have charts identifying the acceptable spectrums and they will review this to confirm that there are no conflicts. They have some equipment that is magnetized and interference can occur. Ft. Irwin requested specs for any equipment that will emit radio frequency and the power level.
- Ft. Irwin asked if the OE evaluation will consider VOR, and Capital Airspace confirmed that it would to 8 miles out per FAA standards.
- Capital Airspace stated that they have not had any project on an airport that caused or was predicted to cause interference.

Glint and Glare:

- NRG explained that unlike previous technology, solar PV panels absorb sunlight and do not reflect light. The panels would track the sun; NRG has designed and built several projects on airport property. Ft. Irwin confirmed that glint and glare during the daytime is not a big concern for them. However, they asked that NRG also consider glint and glare from the moonlight. Because military personnel do night flying and use night vision goggles, glint and glare is not only a daytime issue but also a night issue; it is just as bright at night with moon light and goggles on. The moon is often the only light source in a night environment.
- Capital Airspace has done over 50 glint and glare studies and have found that with tracking systems there is minimal glare because panels are always tracking the sun. Ft. Irwin asked if the analysis include night flights. Capital Airspace stated that it does not – they use the FAA tool created by Sandia Laboratories, which is the leading tool for these types of analyses. They will research to find out if the tool could be used for night activities.
- Ft. Irwin stated that when they were looking at building the solar project at NTC, they did a study that determined that the night analysis had the same results as daytime conditions (i.e. naked eye in day versus use of goggles at night). NRG asked for a copy of report, which Ft. Irwin stated that they would provide.
- In terms of glint/glare, Ft. Irwin stated that if we are using modern technology with matte/black surface that absorbs light and does not reflect, they do not expect issues.

Other:

- Ft. Irwin stated that many of their training activities require a dark sky and that light encroachment affects night training. NRG stated that there are not a lot of lights at a solar facility. There may be some security lighting at the substation but it will be downward shielded.

- Ft. Irwin stated that in looking at the project layout, that they expect their operations would be most impacted by Phase 2 and/or 3 since those phases are closer to the runways. Those phases would not start until about 2021 and reach operation by 2023. They do not expect any issue with Phase 1.
- Heat island: Ft. Irwin identified this as a potential issue in their NOP letter and they were concerned with the general warming of air temperatures since it is already hot in this area. They often have to use filters because of the temperature. Ft. Irwin has since read up on this issue and understands that heat dissipates and it is not much different from flying over a black top. They do not anticipate this to be a big deal since this is a typical obstacle for them that they already experience.
- NRG left two publicly available papers with Ft. Irwin
    - "Renewable Energy, Photovoltaic Systems Near Airfields: Electromagnetic Interference" April 2015, NREL and Naval Facilities Engineering Command
    - "Analysis of the Potential for a Heat Island Effect in Large Solar Farms" Fthenakis and Yu, Columbia University

From:	Kelly, James
To:	Jenkins, James E.
Cc:	Rahhal, Terri; Snelgrove, Maureen; Woodruff, Cyle; Joshi, Aarty
Subject:	RE: Barstow-Daggett Airport - Solar
Date:	Wednesday, May 30, 2018 10:58:44 AM
Attachments:	image001.png image002.jpg image003.jpg image005.png image006.png image007.png

Hello Mr. Jenkins,

With regards to your questions below:

1) Yes, we have submitted several Form 7460-1 filings to the FAA for preliminary transmission structure locations along Silver Valley road, which would be the tallest component of the proposed project. The FAA issued a Determination of No Hazard (DNH) for the majority of these filings. As we refine the projects design and proposed structure locations, we will continue to work through the FAA process as required and the County Airport Land Use Commission to mitigate any potentially significant impacts.

2) This will be addressed in our technical reports and as part of the Environmental Impact Report (EIR) for the project.

If any further questions on the project, please do not hesitate to contact me.

Regards,

James Kelly
760-450-6031

From: Jenkins, James E. [mailto:jjenkins@airports.sbcounty.gov]
Sent: Monday, May 14, 2018 4:54 PM
To: Kelly, James
Cc: Rahhal, Terri; Snelgrove, Maureen; Woodruff, Cyle
Subject: RE: Barstow-Daggett Airport - Solar

Mr. Kelly, my office is the point of coordination. Advise when you would like to share your information. At this point the DofA does not have questions. We are interested to know:

1. Have you submitted the Form 7460-1 to the FAA for consideration and review.
2. Is there a bird study component related to the panel installation? Recent industry developments indicate birds may be attracted to solar farms; they (solar panels in aggregate) apparently appear as bodies of water.

When your project is formally considered by the County Planning Commission, the planning body will be augmented by two members of the Airport Commission to form the County Airport Land Use Commission. The Department of Airports does not have a role in this described planning body.

James E. Jenkins
Director
Department of Airports
Phone: 909-387-8812
Cell: 909-844-3334
Fax: 909-387-8815
777 East Rialto Avenue
San Bernardino, CA 92415-0831

Our job is to create a county in which those who reside and invest can prosper and achieve well-being.
www.SBCountyWings.com / www.SBCounty.gov

From: Kelly, James <James.Kelly@nrg.com>
Sent: Monday, May 14, 2018 4:15 PM
To: Jenkins, James E. <jjenkins@airports.sbcounty.gov>
Subject: FW: Barstow-Daggett Airport - Solar

Hi James,

Just following up on the email below. I was wondering if there is a good contact to reach out to at the airport to discuss the glare study we've conducted for the solar project. We also have a meeting scheduled in June with folks from Ft. Irwin and wondering if there is a representative from the airport that could join or that I could meet with around the same time to discuss the project further.

Thanks,

James Kelly
760-450-6031

From: Kelly, James
Sent: Wednesday, May 02, 2018 1:45 PM
To: Jenkins, James E.
Subject: FW: Barstow-Daggett Airport - Solar

Hello James,

Just wanted to reach out and let you know we held a scoping meeting with San Bernardino County on our proposed solar project in Daggett back on 4/11/18. Ft. Irwin was in attendance and we are currently engaged with them in addressing comments.

If there are any questions from your department or if you would like an update, please let me know. My understanding is that members of the Airport Land Use Commission will be involved in the review of our projects evaluation by the County.

Thanks,

James Kelly
760-450-6031

From: Kelly, James
Sent: Friday, March 23, 2018 2:38 PM
To: 'Stover, Terry'; Jenkins, James E.
Subject: RE: Barstow-Daggett Airport - Solar

Hello Terry and James,

I hope you are doing well. I just wanted to check in and let you know I've been reaching out to Sandy Key at Ft. Irwin (housing manager) to connect on the solar project we have under development adjacent to the Barstow Daggett airport. We submitted a permit application to the County in November and I'm reaching out to gather input as a next step in the process.

I'd appreciate the chance to give you an update as well. I tried Terry at the 2371 number below but did not connect. Please let me know if there is a time that works best to catch up.

Thanks,
James

NRG Simply Smart

James Kelly
Sr. Director, Development
NRG Energy, Inc.
5790 Fleet Street, Suite 200, Carlsbad, CA 92008
Direct: 760.710.2205
Mobile: 760.450.6031

From: Stover, Terry [mailto:tstover@airports.sbcounty.gov]
Sent: Wednesday, May 17, 2017 7:56 AM
To: Jenkins, James E.; Kelly, James
Subject: RE: Barstow-Daggett Airport - Solar

I contacted the Garrison Commanders office at FT Irwin and spoke with Pamela (760-380-6872) who is the XO for the Garrison. I provided her with Mr. Kelly's contact info and she will forward it to the appropriate contact.

Terry L. Stover, C.A.E.
Assistant Director
Department of Airports
Phone: 760.247.2371
Fax: 760.247.2182
21600 Corwin Road, Ste 13
Apple Valley, CA 92307

Our job is to create a county in which those who reside and invest can prosper and achieve well-being.
www.SBCountyWings.com / www.SBCounty.gov

From: Jenkins, James E.
Sent: Tuesday, May 16, 2017 10:05 AM
To: Kelly, James <James.Kelly@nrg.com>; Stover, Terry <tstover@airports.sbcounty.gov>
Subject: RE: Barstow-Daggett Airport - Solar

Terry, please coordinate with Mr. Kelly and put him in touch with a liaison at Fort Irwin. This is in connection

with a 3500-4000 Acre solar farm.

James E. Jenkins
Director
Department of Airports
Phone: 909-387-8812
Cell: 909-844-3334
Fax: 909-387-8815
777 East Rialto Avenue
San Bernardino, CA 92415-0831

Our job is to create a county in which those who reside and invest can prosper and achieve well-being.
www.SBCountyWings.com / www.SBCounty.gov

From: Kelly, James [mailto:James.Kelly@nrg.com]
Sent: Tuesday, May 16, 2017 9:53 AM
To: Jenkins, James E. <jjenkins@airports.sbcounty.gov>
Subject: RE: Barstow-Daggett Airport - Solar

Hi James,

Just wanted to check in and see if perhaps tomorrow or Thursday might be a good time to connect.

Thanks,
James
760-450-6031

From: Jenkins, James E. [mailto:jjenkins@airports.sbcounty.gov]
Sent: Friday, May 05, 2017 10:21 AM
To: Kelly, James
Cc: Woodruff, Cyle; Stover, Terry; Hernandez, Elvia
Subject: RE: Barstow-Daggett Airport - Solar

I sincerely apologize for delay. I have been engaged in litigation. I will reach out to you Tuesday, 5/9/2017 to discuss matters related to your planning effort.

James E. Jenkins
Director
Department of Airports
Phone: 909-387-8812
Cell: 909-844-3334
Fax: 909-387-8815
777 East Rialto Avenue
San Bernardino, CA 92415-0831

Our job is to create a county in which those who reside and invest can prosper and achieve well-being.
www.SBCountyWings.com / www.SBCounty.gov

From: Kelly, James [mailto:James.Kelly@nrg.com]
Sent: Friday, April 21, 2017 9:59 AM
To: Jenkins, James E. <jjenkins@airports.sbcounty.gov>
Subject: FW: Barstow-Daggett Airport - Solar

James,

Just wanted to follow up on this email from last week. I called your office number this morning and left a message with your admin. Look forward to connecting when you have a chance.

Thanks,
James Kelly
760-450-6031

From: Kelly, James
Sent: Friday, April 14, 2017 8:59 AM
To: 'jjenkins@airports.sbcounty.gov'
Cc: Rick Coles (rick.coles@capitolairspace.com); von Allmen, Daniel
Subject: Barstow-Daggett Airport - Solar

Hello James,

I'm following up on our discussion from February regarding the proposed solar project that NRG is developing adjacent to the Barstow-Daggett airport in San Bernardino County.

NRG is scoping out aviation-related studies for the project and I was hoping to confirm whether the airport uses a Navigational Aid system that we should be aware of. Is there a contact we should work with for specific questions related to operations at this facility as we scope out our studies?

I was also hoping you would please provide the appropriate contact at the Dept. of Defense so we can understand their use and interaction with the airport. I believe you had mentioned this would be someone at Ft. Irwin. I'd appreciate your response when you have a chance and happy to discuss on the phone if any questions.

Thanks,
James

NRG Simply Smart

James Kelly
Sr. Director, Development
NRG Energy, Inc.
5790 Fleet Street, Suite 200, Carlsbad, CA 92008
Direct: 760.710.2205
Mobile: 760.450.6031

Attachment 3 – Obstruction Evaluation and Airspace Analysis

Daggett Solar Power Facility

NRG Renew

San Bernardino County, California

Obstruction Evaluation & Airspace Analysis

July 20, 2018

Capitol Airspace Group

capitolairspace.com

(703) 256 - 2485

Summary

Capitol Airspace conducted an obstruction evaluation and airspace analysis for the Daggett Solar Power Facility in San Bernardino County, California. The purpose for this analysis was to identify obstacle clearance surfaces established by the Federal Aviation Administration (FAA) that could limit 20 foot above ground level (AGL) solar panels, 40 foot AGL battery system enclosures (blue, ***Figure 1***), and 125 foot AGL transmission line structures (purple, ***Figure 1***) proposed within the study area (red outline, ***Figure 1***).

The FAA requires that all structures exceeding 14 CFR Part 77.9 notification criteria be submitted to the FAA so that an aeronautical study can be conducted. The FAA's objective in conducting aeronautical studies is to ensure that proposed structures do not have an effect on the safety of air navigation and the efficient utilization of navigable airspace by aircraft. The end result of an aeronautical study is the issuance of a determination of 'hazard' or 'no hazard' that can be used by the proponent to obtain necessary local construction permits. It should be noted that the FAA has no control over land use in the United States and cannot enforce the findings of its studies.

Height constraints overlying the Daggett Solar Power Facility range from 1,933 to 2,280 feet above mean sea level (AMSL) and are associated with Barstow-Daggett Airport (DAG) visual flight rules (VFR) traffic pattern airspace, visual glide slope indicators, instrument departure procedures, and instrument approach procedures. Proposed structures that exceed these surfaces would have an impact on VFR operations, require an increase to instrument departure procedure minimum climb gradients, and require an increase instrument approach procedure minimum altitudes. If the FAA determines that one or the sum of these impacts would constitute a substantial adverse effect, it could be used as the basis for determinations of hazard.

United States Geological Survey (USGS) elevation data indicates that these surfaces could limit 40 foot AGL battery system enclosures in the central section of the study area. However, none of the proposed battery system enclosures are located in this area. Additionally, these surfaces could limit 125 foot AGL transmission line structures in central, southern, and southwestern sections of the study area, including along a small central section of the proposed transmission line route. Additionally, Barstow-Daggett Airport Runway Protection Zones (RPZs) could further prohibit development in the central and southern sections of the Daggett Solar Power Facility.

This study did not consider electromagnetic interference on communications, navigation, or radar surveillance systems.

Capitol Airspace applies FAA defined rules and regulations applicable to obstacle evaluation, instrument procedures assessment and visual flight rules (VFR) operations to the best of its ability and with the intent to provide the most accurate representation of limiting airspace surfaces as possible. Capitol Airspace maintains datasets obtained from the FAA which are updated on a 56 day cycle. The results of this analysis/map are based on the most recent data available as of the date of this report. Limiting airspace surfaces depicted in this report are subject to change due to FAA rule changes and regular procedure amendments. Therefore, it is of the utmost importance to obtain FAA determinations of no hazard prior to making substantial financial investments in this project.

Methodology

Capitol Airspace studied the proposed project based upon location and height information provided by NRG Renew. United States Geological Service (USGS) elevation data indicates that the project site elevation ranges from 1,881 to 2,002 feet AMSL. Using this information, Capitol Airspace generated graphical overlays to determine proximity to runways (***Figure 1***), published instrument procedures, enroute airways, and FAA minimum vectoring altitude and minimum instrument flight rules (IFR) altitude charts.

Capitol Airspace evaluated all 14 CFR Part 77 imaginary surfaces, published instrument approach and departure procedures, visual flight rules operations, FAA minimum vectoring/IFR altitudes, and enroute operations. All formulas, headings, altitudes, bearings and coordinates used during this study were derived from the following documents and data sources:

- 14 CFR Part 77 Safe, Efficient Use, and Preservation of the Navigable Airspace
- FAA Order 7400.2L Procedures for Handling Airspace Matters
- FAA Order 8260.3D United States Standard for Terminal Instrument Procedures
- FAA Order 8260.58A United States Standard for Performance Based Navigational (PBN) Instrument Procedure Design
- FAA Advisory Circular 150/5300-13A Airport Design
- United States Government Flight Information Publication, US Terminal Procedures
- National Airspace System Resource Aeronautical Data
- Obstruction Evaluation/Airport Airspace Analysis Technical Operations Evaluation Desk Guide Version 1.3.0

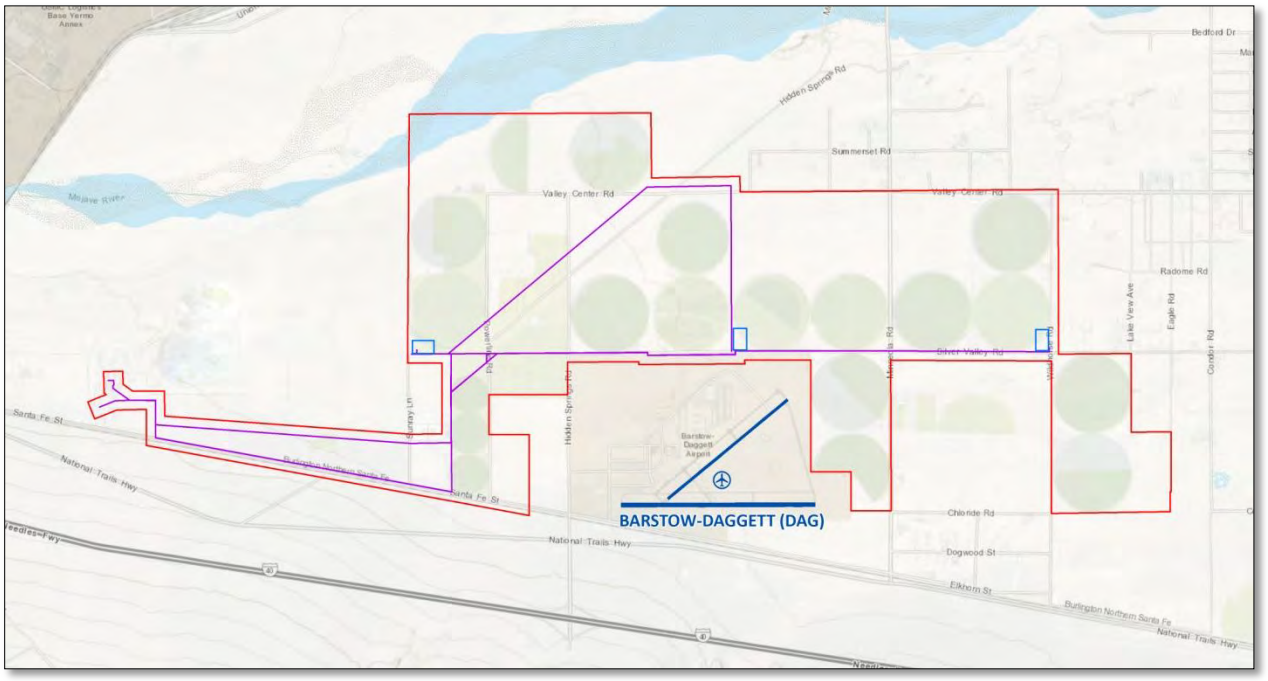


Figure 1: Daggett Solar Power Facility (red) and Barstow-Daggett Airport (DAG)

Study Findings

14 CFR Part 77 Imaginary Surfaces

The FAA uses level and sloping imaginary surfaces to determine if a proposed structure is an obstruction to air navigation. Structures that are identified as obstructions are then subject to a full aeronautical study and increased scrutiny. However, exceeding a Part 77 imaginary surface does not automatically result in the issuance of a determination of hazard. Proposed Structures must have airspace impacts that constitute a substantial adverse effect in order to warrant the issuance of determinations of hazard.

14 CFR Part 77 imaginary surfaces (***Figure 2***) overlying the Daggett Solar Power Facility:

Barstow-Daggett (DAG)
77.17(a)(2): 2,130 to 2,221 feet AMSL
77.19: 1,923 to 2,280 feet AMSL

At 20 feet AGL (orange area, ***Figure 2***), 40 feet AGL (orange and yellow areas, ***Figure 2***), and 125 feet AGL (orange, yellow and brown areas, ***Figure 2***), proposed structures in central, southern, and southwestern sections of the study area will exceed the Barstow-Daggett 14 CFR Part 77.19(a) *horizontal surface*, 77.19(b) *conical surface*, 77.19(d) *approach surface*, and 77.19(e) *transitional surface*. Proposed structures that exceed these surfaces will be identified as obstructions and may require marking and lighting in accordance with FAA Advisory Circular 70/7460-1L. However, heights in excess of these surfaces are feasible provided proposed structures do not exceed FAA obstacle clearance surfaces.

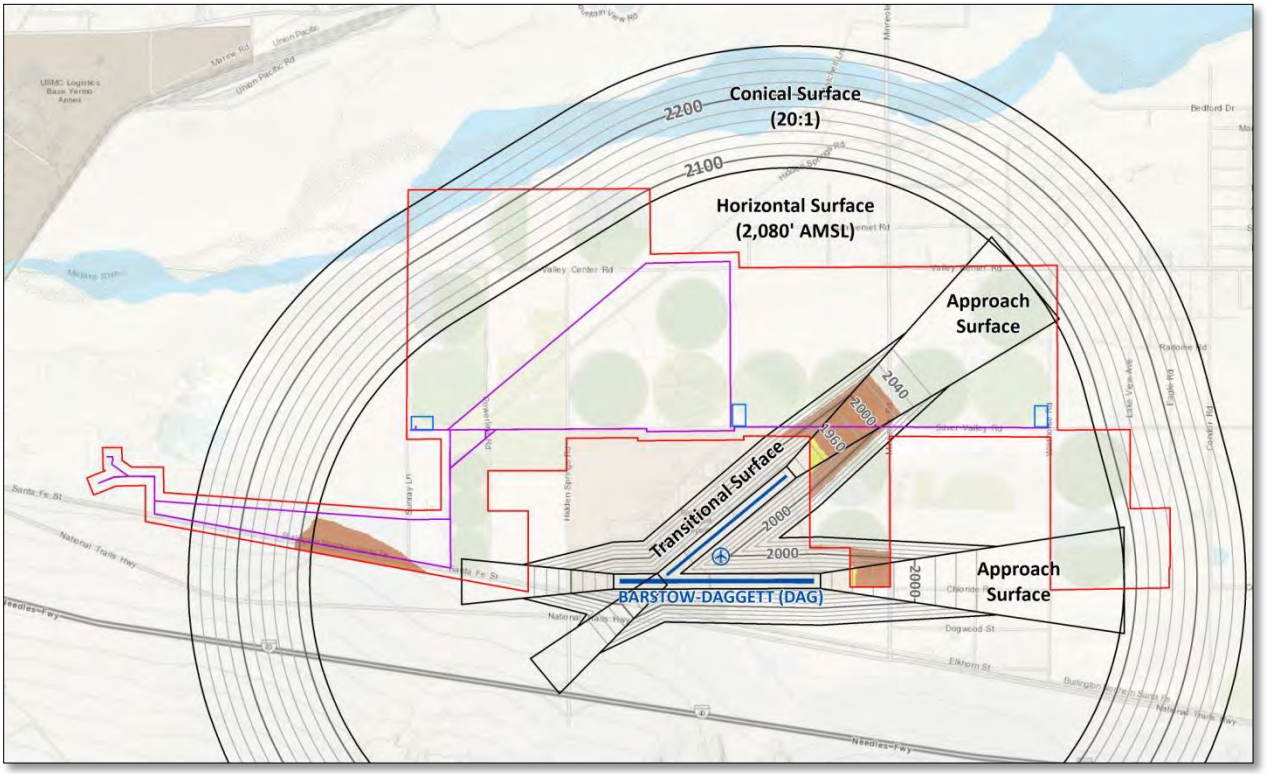


Figure 2: Barstow-Daggett (DAG) 14 CFR Part 77.19 imaginary surfaces (black)

Runway Protection Zones

The FAA has established Runway Protection Zones (RPZ) to designate areas located along the extended runway centerline where the protection of people and property on the ground is enhanced. In order to ensure enhanced safety, the FAA recommends airport control of this area to guarantee the RPZ remain clear of incompatible objects and activities. The size of the RPZ is directly related to the airplane design group and approach categories that the runway is expected to serve as well as the visibility minimums associated with instrument approach procedures.

Barstow-Daggett Airport (DAG)

Runway 22 & Runway 36 Approach RPZs

The Approach RPZs overlie small central and southern sections of the study area (black and orange, ***Figure 3***). In order to comply with guidance set forth in FAA Advisory Circular 150/5300-13A Airport Design, the FAA will likely object to non-compliant land-uses within the RPZ. In general, the FAA does not recommend that airports locate solar projects in the RPZ. However, the FAA will review specific airport proposals on a case-by-case basis.[1] Furthermore, an assessment of land use compatibility will be completed by the Airport Land Use Commission, as part of its review of the Daggett Solar Power Facility.

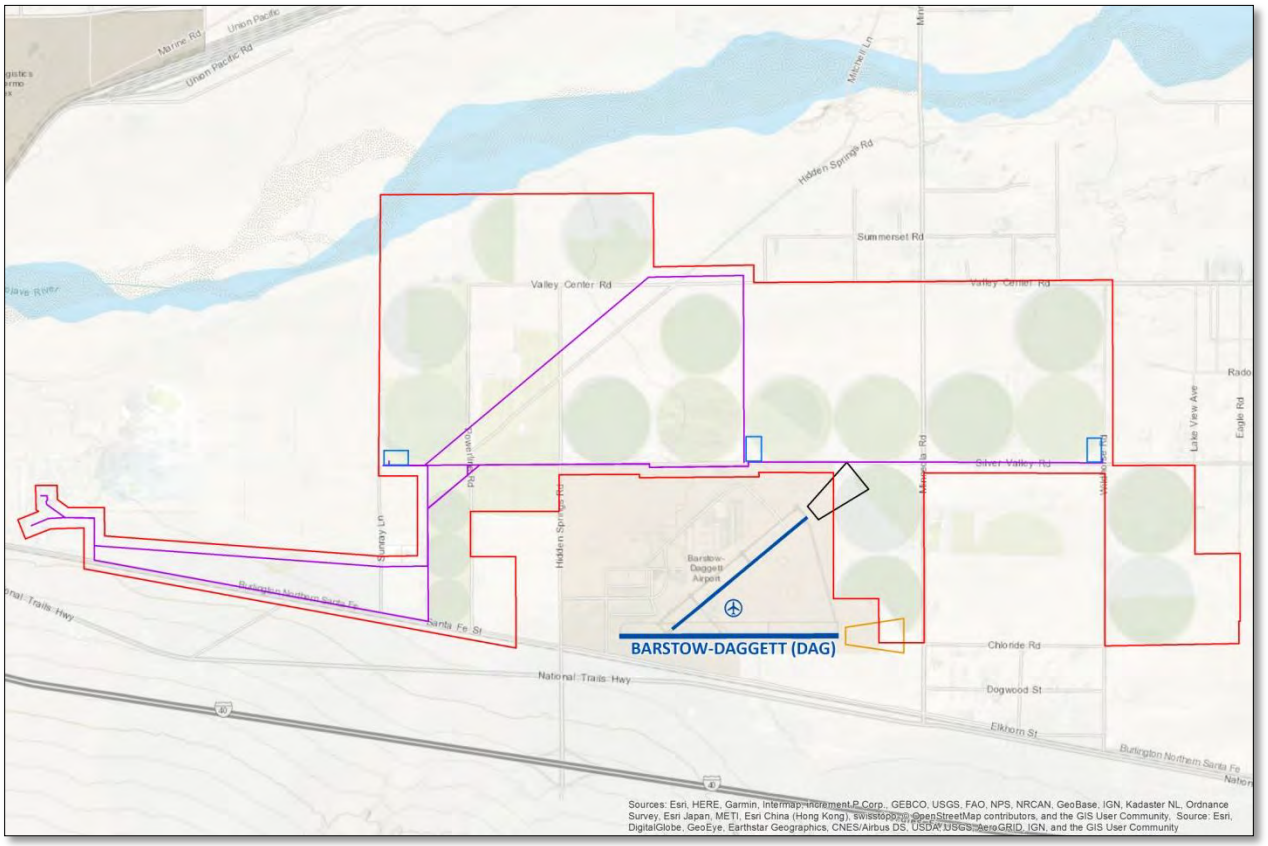


Figure 3: Barstow-Daggett Airport (DAG) Runway 22 (black) and Runway 26 (orange) approach RPZs

[1] Technical Guidance for Evaluating Selected Solar Technologies on Airports, FAA Office of Airports, November 2010

Visual Flight Rules (VFR) Traffic Pattern Airspace

VFR traffic pattern airspace is used by pilots operating during visual meteorological conditions. The airspace dimensions are based upon the category of aircraft which, in turn, is based upon the approach speed of the aircraft. 14 CFR Part 77.17(a)(2) and 77.19 (applied to a *visual* runway) imaginary surfaces establish the height constraints within VFR traffic pattern airspace.

Proposed structures that exceed these surfaces would have an impact on VFR traffic pattern operations. If the FAA determines that this impact would affect a significant volume of operations, it could be used as the basis for determinations of hazard.

Barstow-Daggett Airport (DAG)

Runway 04/22 (***Figure 4***)

Obstacle clearance surfaces range from 1,935 to 2,429 feet AMSL and are the lowest height constraints overlying the majority of the study area. USGS elevation data indicates that these surfaces could limit 40 foot AGL battery system enclosures in a small central section of the study area (orange area, ***Figure 4***). However, none of the proposed battery system enclosures are located in this area. Additionally, these surfaces could also limit 125 foot AGL transmission line structures in the central section of the study area (orange and yellow areas, ***Figure 4***), including along a small central section of the proposed transmission line route.

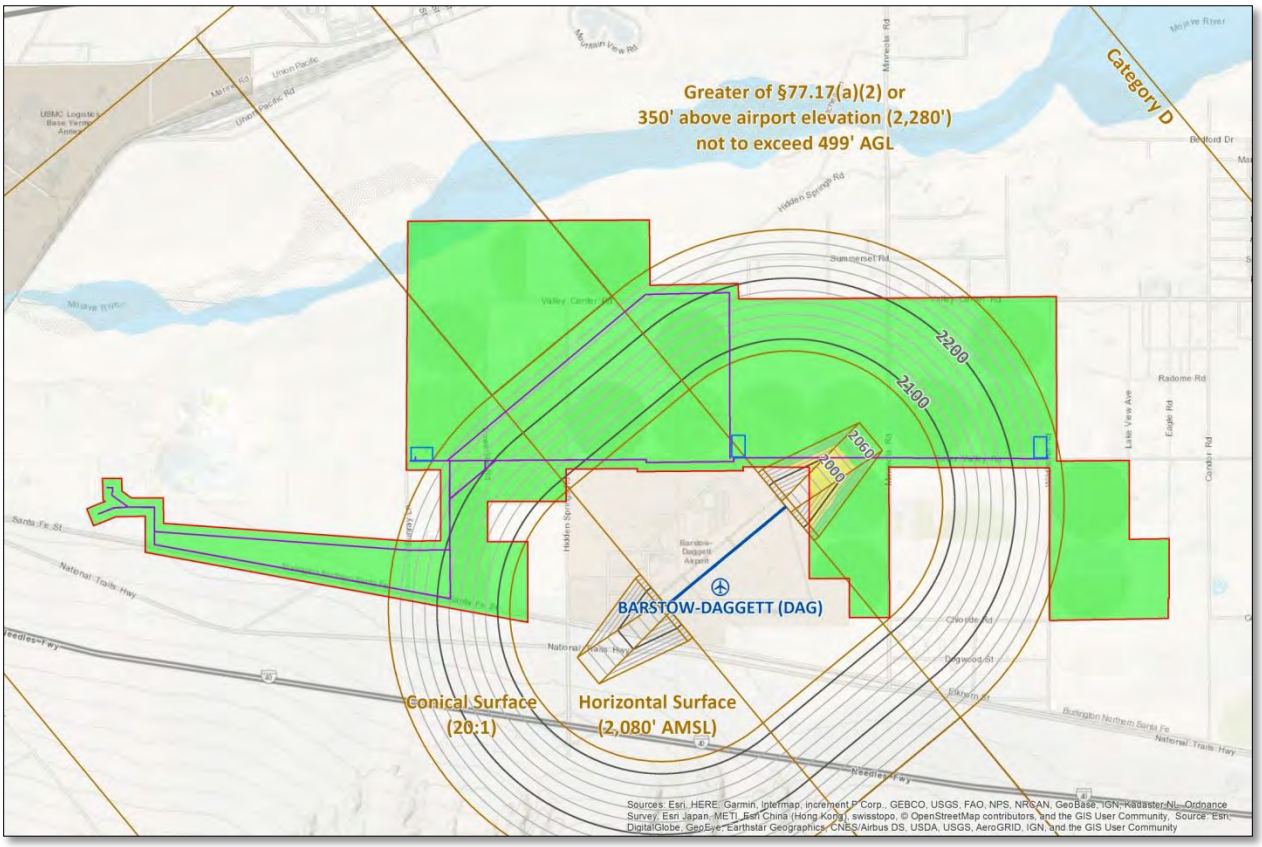


Figure 4: Barstow-Daggett Airport (DAG) Runway 04/22 VFR traffic pattern airspace

Runway 08/26 (***Figure 5***)

Obstacle clearance surfaces range from 1,957 to 2,429 feet AMSL and are the lowest height constraints overlying the majority of the study area. USGS elevation data indicates that these surfaces could limit 125 foot AGL transmission line structures in the central section of the study area (yellow area, ***Figure 4***). However, the proposed transmission line is not routed through this area.

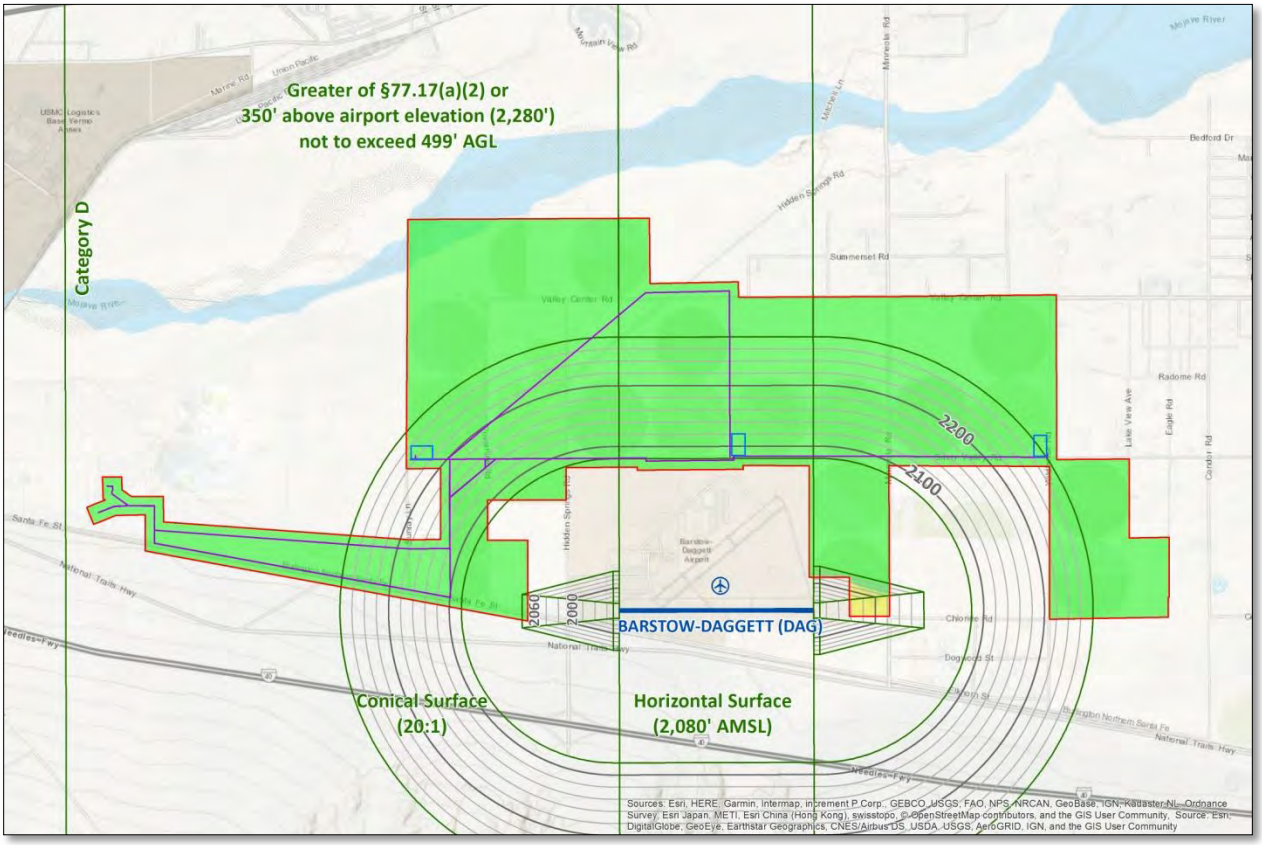


Figure 5: Barstow-Daggett Airport (DAG) Runway 08/26 VFR traffic pattern airspace

Visual Glide Slope Indicators

Visual Glide Slope Indicators (VGSI) provide a visual aid to aircraft approaching to land. Different light combinations indicate an approaching aircraft's position relative to the published visual glide path angle. Proposed obstacles that exceed VGSI obstacle clearance surfaces would require an increase to the published visual glidepath angle and/or threshold crossing height. If the FAA determines this impact to constitute a substantial adverse effect, it could be used as the basis for objecting to proposed development.

Barstow-Daggett Airport (DAG)

Runway 08, 22 & 36 Precision Approach Path Indicators (PAPIs) (***Figure 6***)

The obstacle clearance surfaces range from 1,954 to 2,520 feet AMSL and are some of the lowest height constraints throughout the study area. USGS elevation data indicates that these surfaces could limit 125 foot AGL transmission line structures in western, central, and southern sections of the defined study area (yellow areas, ***Figure 6***), including a small central section of the proposed transmission line route.

Proposed structures that exceed the 10° obstacle clearance surface (blue, ***Figure 6***) would require an increase to the visual glidepath angle and/or threshold crossing height. However, in most cases the only resolution is to remove the VGSI from service, which would likely result in the issuance of determinations of hazard. Proposed structures outside of the 10° splay that only exceed the 15° splay (orange, ***Figure 6***) may still be approved. However, a Flight Inspection is required to identify the lateral limits of the PAPI visible light beam to determine if "baffling" is necessary. The costs associated with the Flight Inspection and potential subsequent baffling would be the responsibility of the solar project.

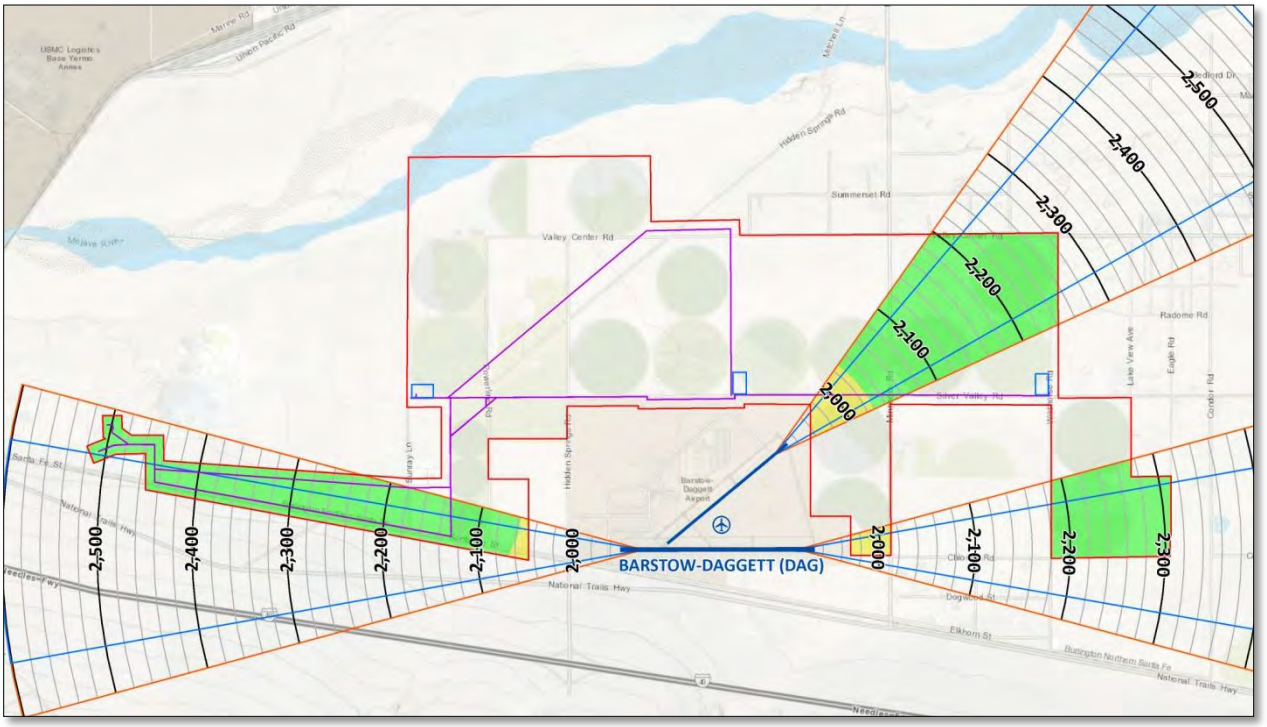


Figure 6: Barstow-Daggett Airport (DAG) Runway 08, 22, and 26 PAPIs

Instrument Departures

In order to ensure that aircraft departing during marginal weather conditions do not fly into terrain or obstacles, the FAA publishes instrument departure procedures that provide obstacle clearance to pilots as they transition between the terminal and enroute environments. These procedures contain specific routing and minimum climb gradients to ensure clearance from terrain and obstacles.

Proposed structures that exceed instrument departure procedure obstacle clearance surfaces would require an increase to instrument departure procedure minimum climb gradients. If the FAA determines that this impact would constitute a substantial adverse effect, it could be used as the basis for determinations of hazard.

Barstow-Daggett Airport (DAG)

Obstacle *Departure Procedure*

The Runway 04 and Runway 08 initial climb areas (ICA) overlie the Daggett Solar Power Facility (***Figure 7***). At 20 feet AGL, 40 feet AGL, and 125 feet AGL, proposed structures in the central and southern sections of the study area would exceed these surfaces. However, these structures would be located within the ICA and would require a minimum climb gradient termination altitude of 200 feet or less above the departure end of the runway. As a result, these structures would meet "low, close-in" criteria. Low, close-in obstacles do not impact published minimum climb gradients and only require notation on published departure procedures. Since there is no impact on the published minimum climb gradient, the FAA has not historically considered the notation of low, close-in obstacles to constitute a substantial adverse effect. As a result of this practice, Capitol Airspace only considered height constraints associated with obstacles that could not meet "low, close-in" criteria within the ICA and the nominal 40:1 (run:rise) obstacle clearance surface outside of the ICA.

The resulting obstacle clearance surfaces range from 2,060 to 2,804 feet AMSL overlying the study area and are some of the lowest height constraints in the central and eastern sections of the study area. However, USGS elevation data indicates that these surfaces should not limit the proposed Daggett Solar Power Facility structures (green area, ***Figure 7***).

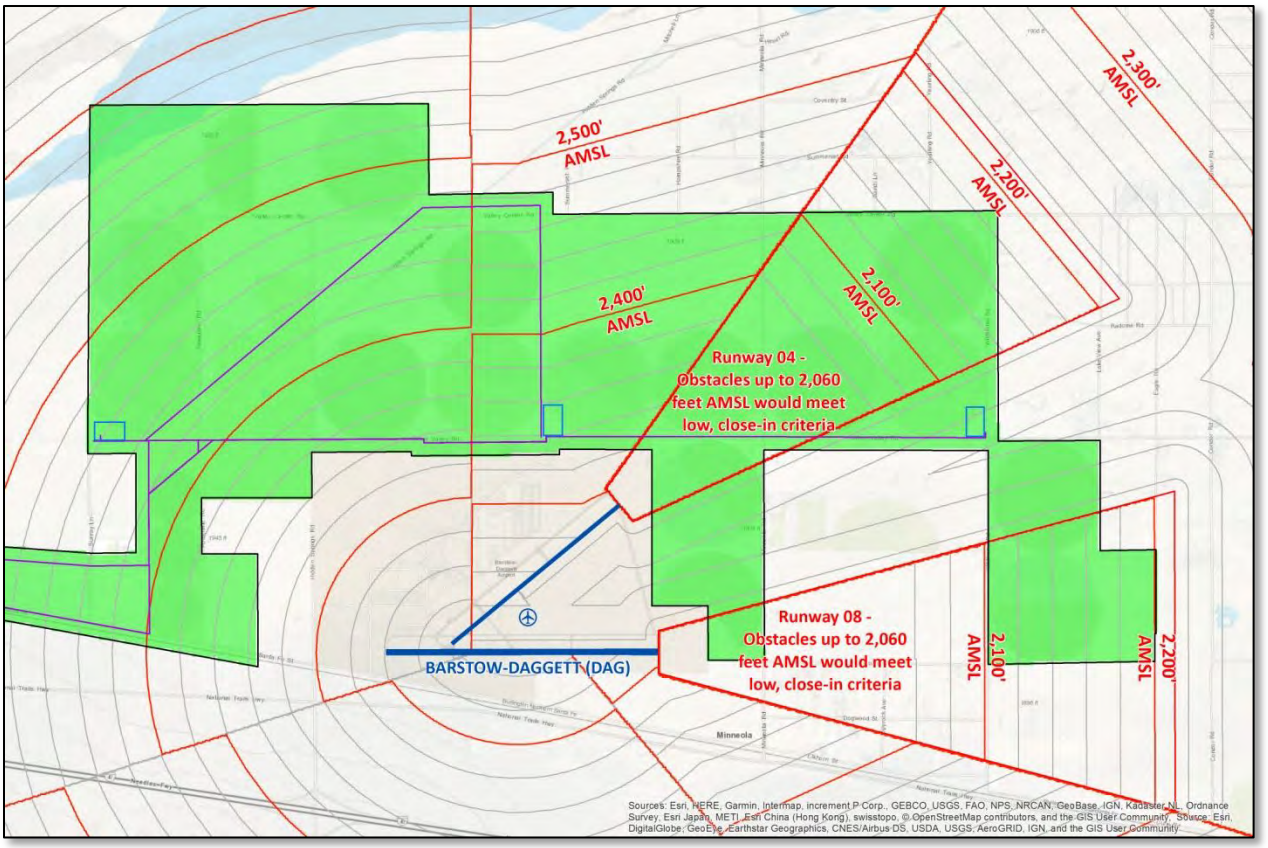


Figure 7: Barstow-Daggett Airport (DAG) Runway 04 and Runway 08 obstacle departure procedure assessment

Instrument Approaches

Pilots operating during periods of reduced visibility and low cloud ceilings rely on terrestrial and satellite based navigational aids (NAVAIDS) in order to navigate from one point to another and to locate runways. The FAA publishes instrument approach procedures that provide course guidance to on-board avionics that aid the pilot in locating the runway. Capitol Airspace assessed a total of three published instrument approach procedures at Barstow-Daggett Airport:

Barstow-Daggett (DAG)
RNAV (GPS) Approach to Runway 22
RNAV (GPS) Approach to Runway 26
VOR or TACAN Approach to Runway 22

Proposed structures that exceed instrument approach procedure obstacle clearance surfaces would require an increase to their minimum altitudes. Increases to these altitudes, especially critical *decision altitudes (DA)* and *minimum descent altitudes (MDA)*, can directly impact the efficiency of instrument approach procedures. If the FAA determines this impact to constitute a substantial adverse effect it could be used as the basis for determinations of hazard.

Barstow-Daggett Airport (DAG)

RNAV (GPS) Approach to Runway 22/VOR or TACAN Approach to Runway 22

The 20:1 (rise:run) visual area obstacle identification surfaces range from 1,933 to 2,706 feet AMSL and are some of the lowest height constraints in the central section of the study area. USGS elevation data indicates that these surfaces could limit 40 foot AGL battery enclosures in this area. However, none of the proposed battery system enclosures are located in this area. These surfaces could also limit 125 foot AGL structures in the central section of the study area, including a small central section of the proposed transmission line route.

RNAV (GPS) Approach to Runway 26

The final (including vertical guidance surface and 20:1 visual area obstacle identification surface) and missed approach segment obstacle clearance surfaces (***Figure 8***) range from 1,949 to 2,280 feet AMSL where they are the lowest height constraints in the central, eastern, and southern sections of the study area. USGS elevation data indicates that these surfaces could limit 125 foot AGL transmission line structures in the southern section of the study area. However, the proposed transmission line is not routed through this area.

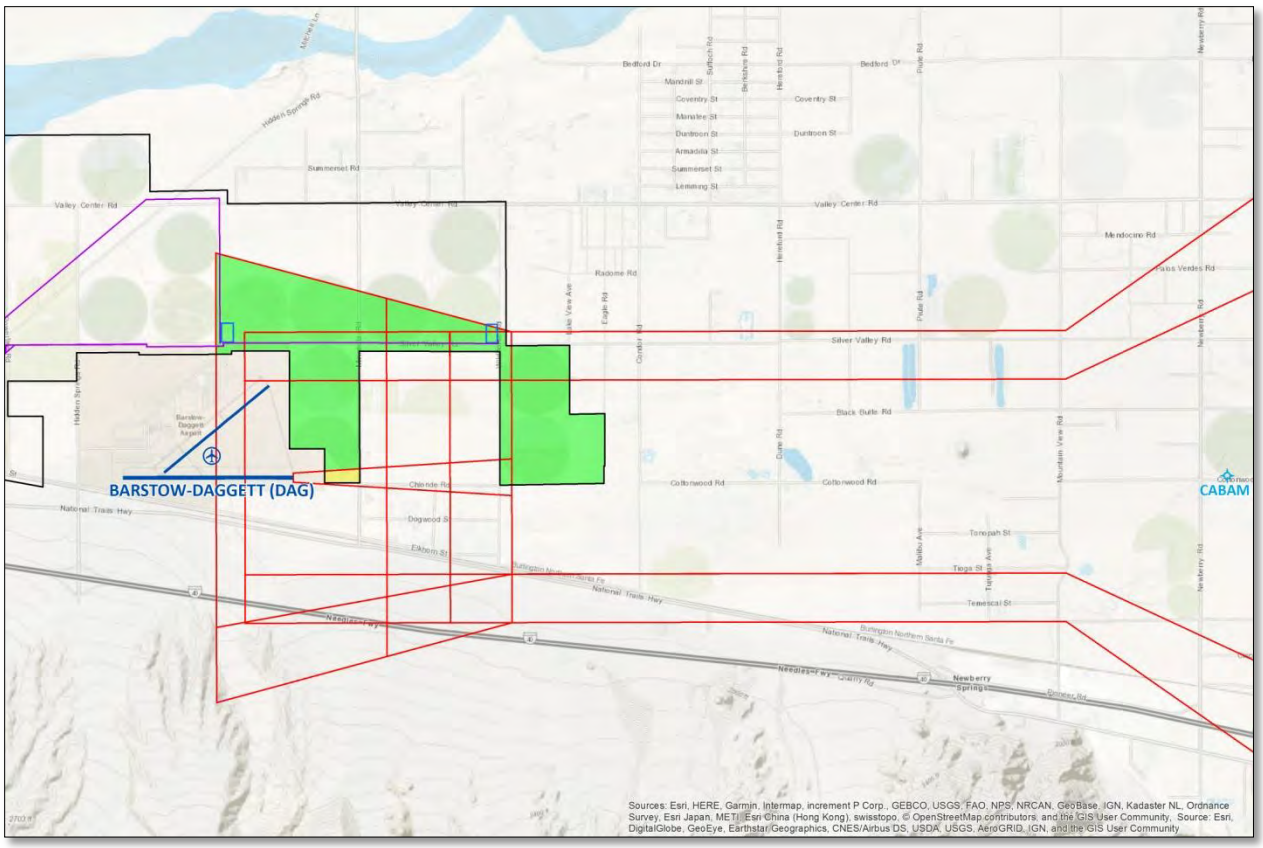


Figure 8: Barstow-Daggett Airport (DAG) RNAV (GPS) Approach to Runway 26 VNAV final and missed approach segments

Enroute Airways

Enroute airways provide pilots a means of navigation when flying from airport to airport and are defined by radials between VHF omni-directional ranges (VORs). The FAA publishes minimum enroute altitudes for airways to ensure clearance from obstacles and terrain. The FAA requires that each airway have a minimum of 1,000 feet of obstacle clearance in non-mountainous areas and normally 2,000 feet in mountainous areas.

Low altitude enroute airway (***Figure 9***) obstacle clearance surfaces are in excess of other lower surfaces and should not limit the proposed Daggett Solar Power Facility structures.

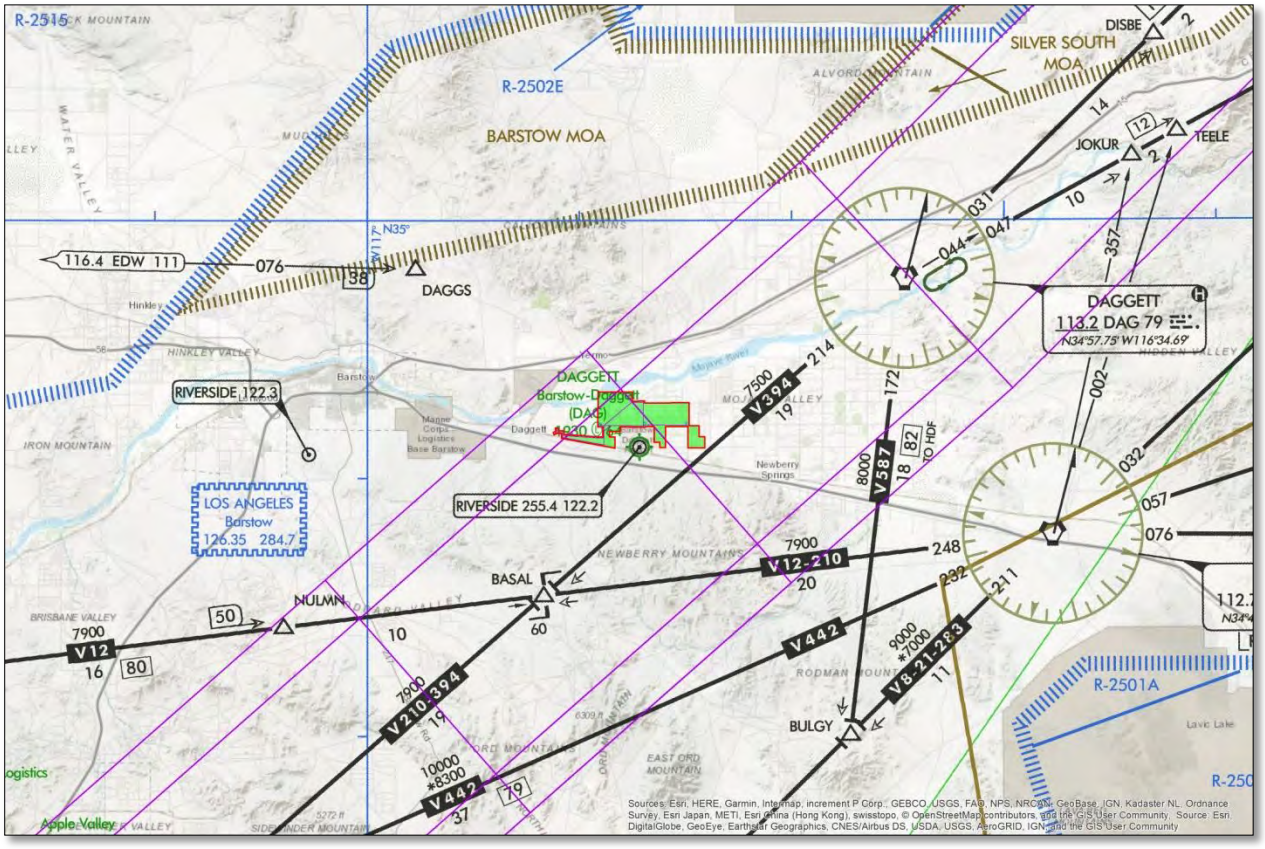


Figure 9: Low altitude enroute chart L-07 with V394 obstacle clearance surfaces (purple)

Minimum Vectoring/IFR Altitudes

The FAA has created minimum vectoring altitude (MVA) and minimum instrument flight rules (IFR) altitude charts that define sectors with the lowest altitudes at which air traffic controllers can issue radar vectors to aircraft based on obstacle clearance. The FAA requires that sectors have a minimum of 1,000 feet of obstacle clearance in non-mountainous areas and normally 2,000 feet in mountainous areas.

Minimum vectoring/IFR altitude sector (e.g., ***Figure 10***) obstacle clearance surfaces are in excess of other lower surfaces and should not limit the proposed Daggett Solar Power Facility structures.

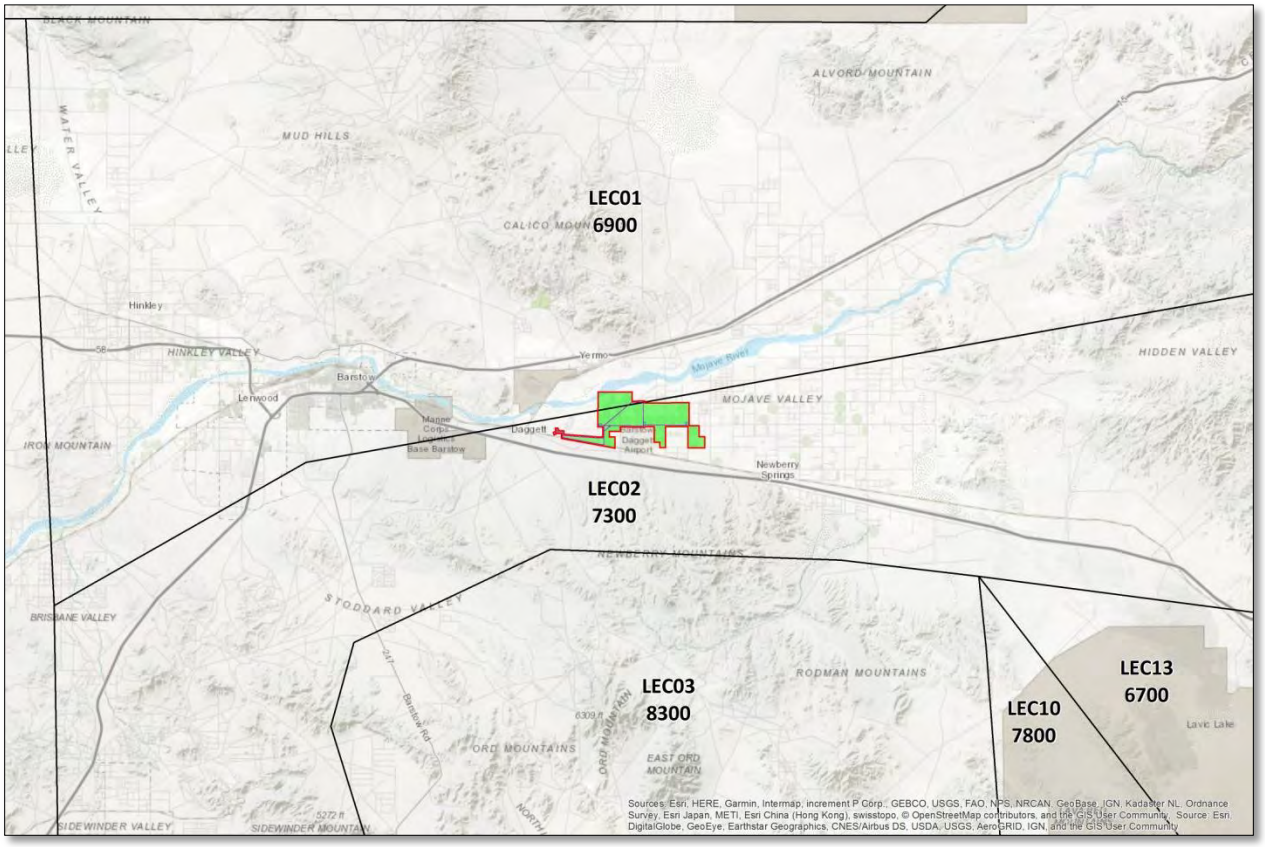


Figure 10: Los Angeles (ZLA) Air Route Traffic Control Center (ARTCC) minimum IFR altitude sectors (black)

Very High Frequency (VHF) Omni-Directional Range (VOR)

The FAA has established screening surfaces in order to identify proposed structures that may have a negative impact on VORs. For larger structures including transmission lines, this surface extends upward and outward from the VOR at a vertical angle of 1.00° (Conventional VOR) and 1.20° (Doppler VOR) for a distance of 2 nautical miles. Proposed structures that exceed this surface may interfere with the services provided by the VOR. If the FAA determines this impact to be significant it can be used as the basis for determinations of hazard.

VOR screening surfaces do not overlie the Daggett Solar Power Facility (e.g., ***Figure 11***). As a result, proposed structures would not require in depth review by the FAA Technical Operations for impact on VORs. In accordance with FAA Technical Operations OEAAA Desk Guide Version 1.2.1, §6.2.1(b)(1), FAA Technical Operations should issue a 'No Objection.'

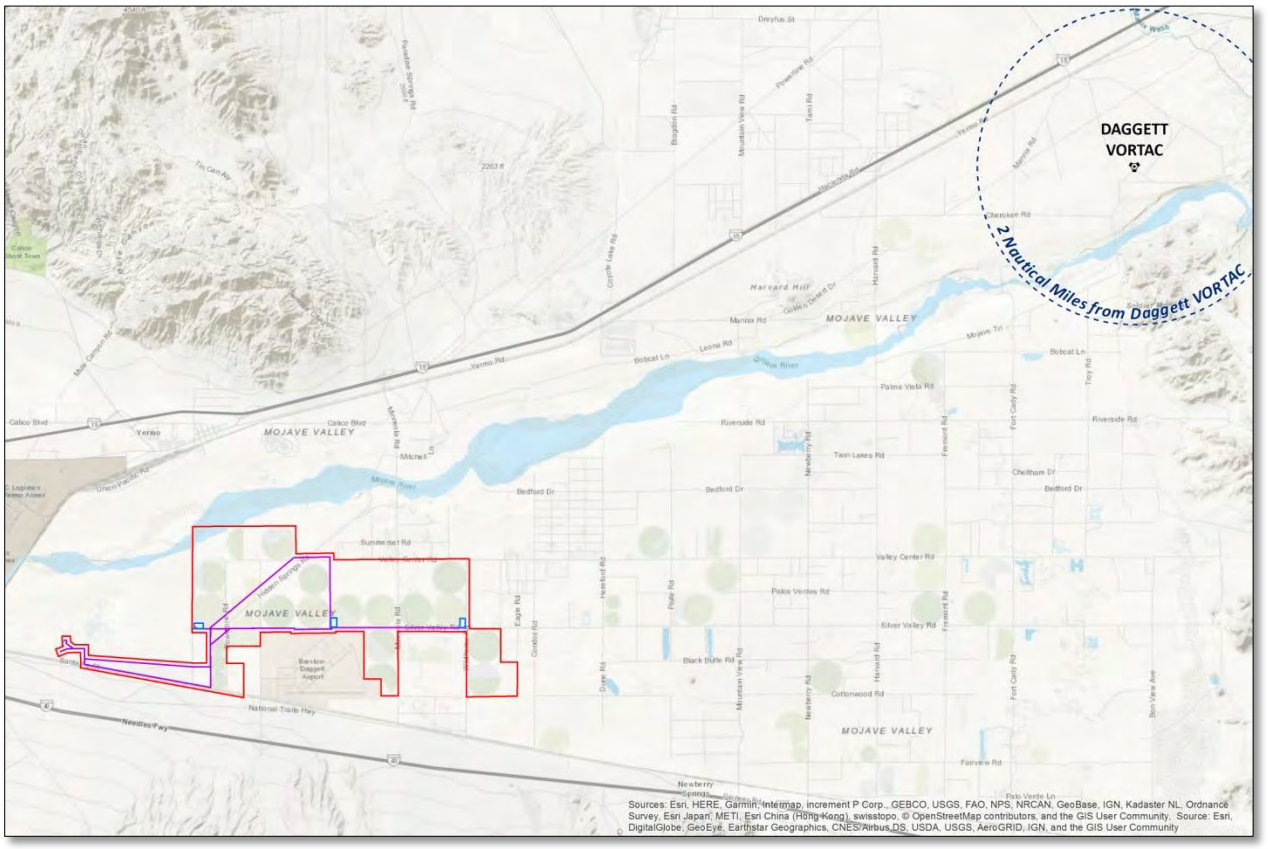


Figure 11: Daggett (DAG) VOR/DME 1.00° screening surface

Conclusion

Proposed structures that do not exceed Part 77 imaginary surfaces (***Figure 2***) or obstacle clearance surfaces (***Figure 12***) should be able to receive favorable *Does Not Exceed* determinations. However, proposed structures that exceed Part 77 imaginary surfaces can still receive favorable determinations of no hazard provided they do not exceed FAA obstacle clearance surfaces.[2] Obstacle clearance surfaces overlying the Daggett Solar Power Facility range from 1,933 to 2,280 feet AMSL (***Figure 12***) and are associated with Barstow-Daggett Airport VFR traffic pattern airspace (***Figure 4*** & ***Figure 5***), visual glide slope indicators (***Figure 6***), instrument departure procedures (***Figure 7***), and instrument approach procedures (***Figure 8***).

USGS elevation data indicates that proposed structures within the study area could exceed these surfaces depending on placement and structure height (red, orange, and yellow areas, ***Figure 13***).

Solar Panels

20 foot AGL solar panels in close proximity to Barstow-Daggett Runway 22 would exceed its 77.19(d) *approach* surface and would be identified as obstructions (orange area, ***Figure 2***). Additionally, solar panels in this area would exceed the Runway 04 initial climb area (ICA) 40:1 obstacle clearance surface (***Figure 7***). However, due to their low height, 20 foot AGL solar panels meet "low, close-in" criteria and would only require notation on the Runway 04 takeoff minimums and obstacle departure procedure. Since notation on the departure procedure does not impact the minimum climb gradient these solar panels should still be able to receive favorable determinations of no hazard.[2]

20 foot AGL solar panels throughout the remainder of the study area (orange, yellow, and green areas, ***Figure 13***) would not exceed any Part 77 imaginary surfaces or obstacle clearance surfaces and should be able to receive favorable *Does Not Exceed* determinations. However, it should be noted that current FAA guidance does not allow solar panels to be placed within RPZs (hatched red, ***Figure 12*** & ***Figure 13***).

Substations/Battery System Enclosures

At their proposed locations (blue, ***Figure 12*** & ***Figure 13***), the 40 foot AGL substation/battery system enclosures do not exceed any Part 77 imaginary surfaces or obstacle clearance surfaces. As a result, these structures should be able to receive favorable *Does Not Exceed* determinations.

Transmission Line Structures

125 foot AGL transmission line (dashed purple, ***Figure 12*** & ***Figure 13***) structures along an approximately 3,900 foot length of proposed routing in the southwestern section of the study area (brown area, ***Figure 2***) will exceed the Barstow-Daggett Airport Part 77.19(b) *horizontal* surface by as much as 26 feet. However, USGS elevation data indicates that transmission line

[2] Proposed structures that receive determinations of no hazard but exceed Part 77 imaginary surfaces typically require marking and lighting in accordance with FAA Advisory Circular 70/7460-1L *Obstruction Marking and Lighting*.

structures along this section would not exceed obstacle clearance surfaces and therefore should be able to receive favorable determinations of no hazard.[2]

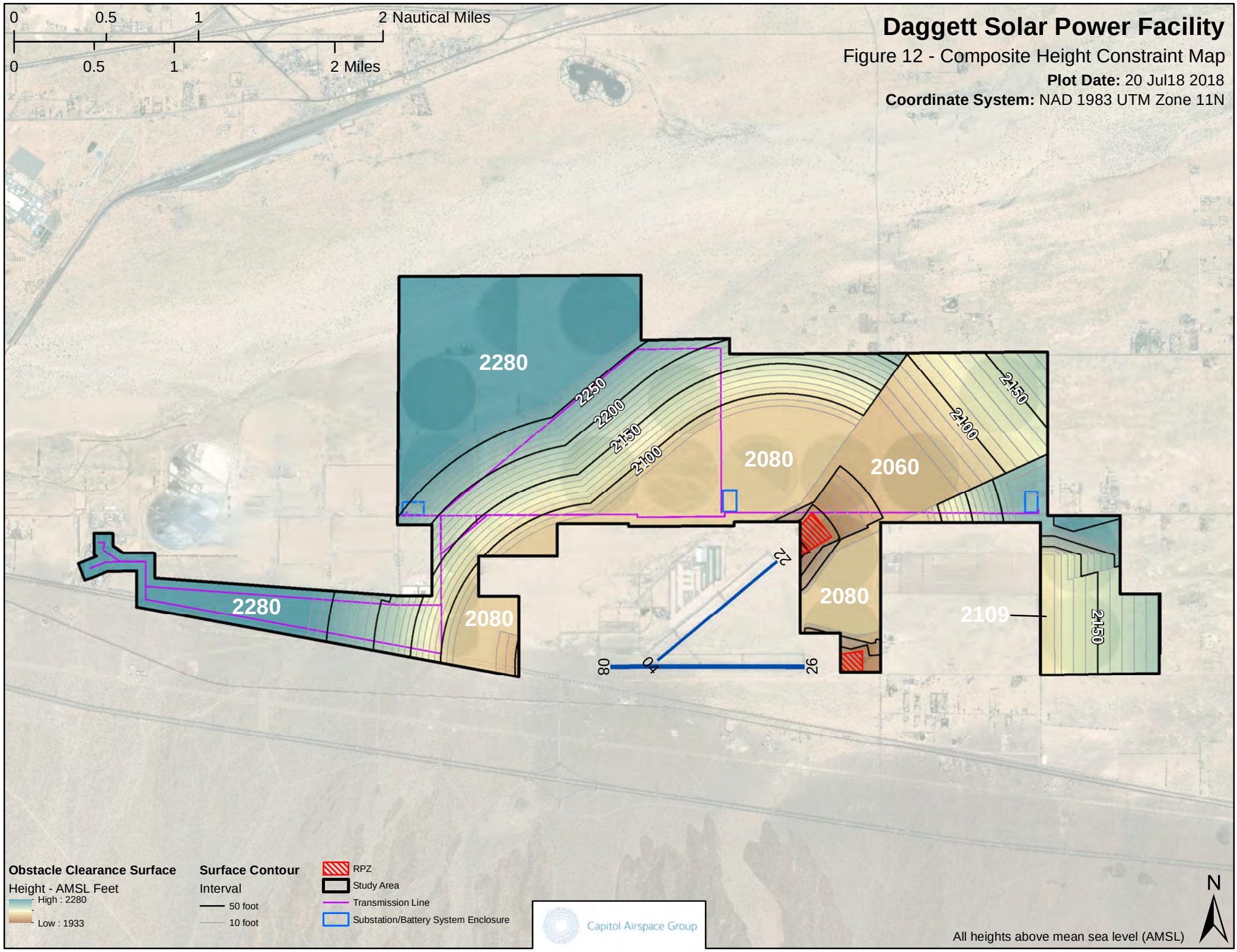
125 foot AGL transmission line structures (dashed purple, ***Figure 12*** & ***Figure 13***) along an approximately 3,100 foot length of proposed routing in the central section of the study area (brown area, ***Figure 2***) will exceed the Barstow-Daggett Airport Runway 22 Part 77.19(d) *approach* surface by as much as 70 feet. USGS elevation data also indicates that transmission line structures along this section would exceed Barstow-Daggett Airport Runway 04/22 VFR traffic pattern airspace (***Figure 4***), the Runway 22 PAPI obstacle clearance surface (***Figure 6***), and the Runway 04 ICA 40:1 obstacle clearance surface (***Figure 7***).

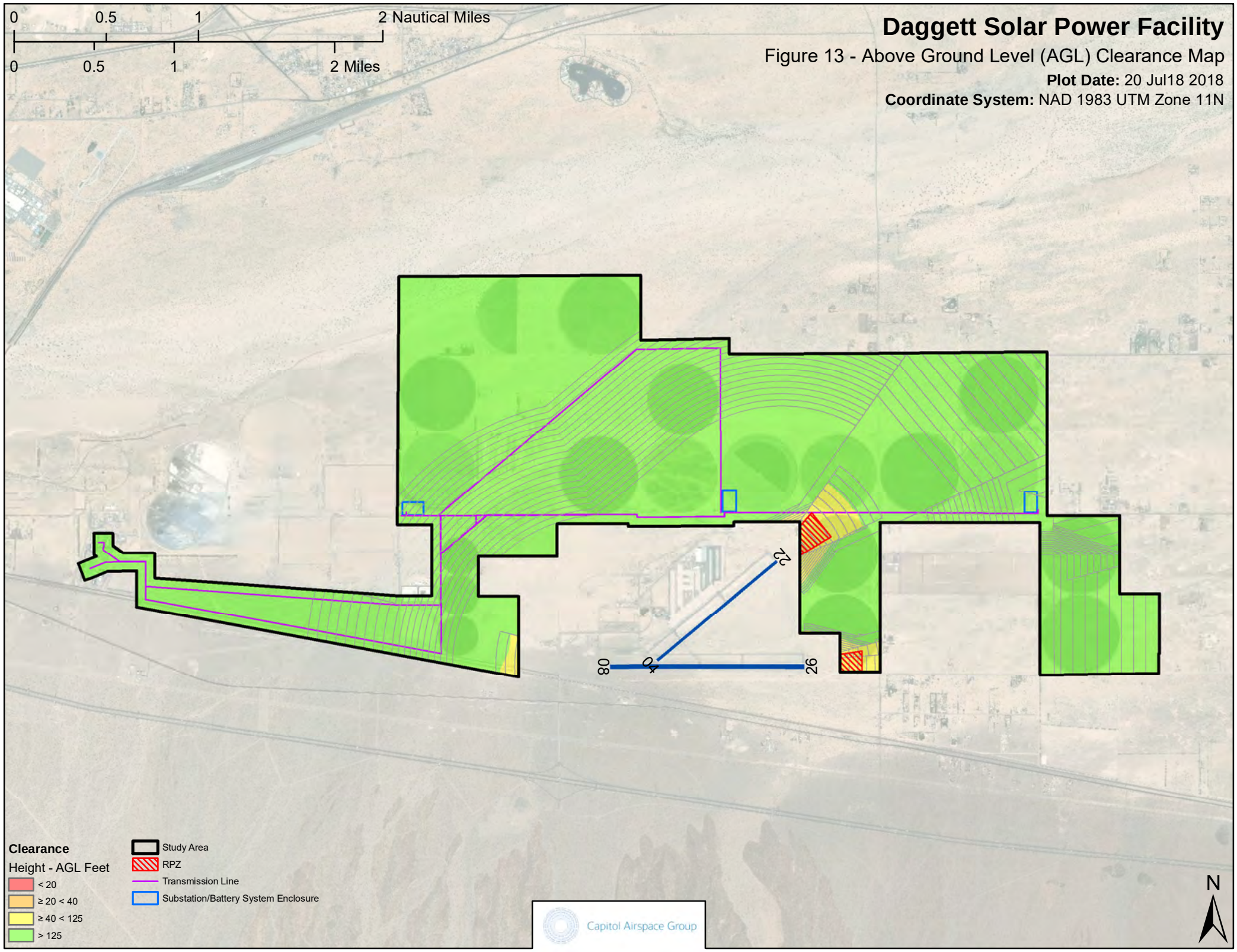
Since this section of the transmission line would meet "low, close-in" criteria, exceeding the Runway 04 ICA 40:1 obstacle clearance surface should not result in determinations of hazard. However, it is likely that the FAA would use the impact on Runway 04/22 VFR traffic pattern airspace and the Runway 22 PAPI as the basis for determinations of hazard. As a result, transmission line structures along this segment should be reduced to as low as 84 feet AGL (based on USGS elevation data) in order to remain below these surfaces.

Construction equipment, including cranes, must also be filed with the FAA and receive favorable determinations. If temporary equipment required to construct the Daggett Solar Power Facility exceeds FAA obstacle clearance surfaces, it may not receive favorable temporary determinations due to its impact on Barstow-Daggett Airport operations.

The AGL Clearance Map (***Figure 13***) is based on USGS National Elevation Dataset (NED) 1/3 Arc Second data which has a vertical accuracy of generally +/- 7 meters. Therefore, the AGL Clearance Map should only be used for general planning purposes and not exact structure siting. In order to avoid determinations of hazard, proposed structure heights should adhere to the height constraints depicted in the Composite Map (***Figure 12***).

If you have any questions regarding the findings of this study, please contact ***Rick Coles*** or ***Orlando Olivas*** at (703) 256-2485.


0
0.5
1
2 Nautical Miles
0
0.5
1
2 Miles
Daggett Solar Power Facility
Figure 12 - Composite Height Constraint Map
Plot Date: 20 Jul18 2018
Coordinate System: NAD 1983 UTM Zone 11N
2280
2250
2200
2150
2100
2080
2060
2150
2100
2280
2080
2080
2109
2150
22
04
26
80
Obstacle Clearance Surface
Height - AMSL Feet
High : 2280
Low : 1933
Surface Contour
Interval
50 foot
10 foot
RPZ
Study Area
Transmission Line
Substation/Battery System Enclosure
Capitol Airspace Group
N
All heights above mean sea level (AMSL)


0
0.5
1
2 Nautical Miles
0
0.5
1
2 Miles
Daggett Solar Power Facility
Figure 13 - Above Ground Level (AGL) Clearance Map
Plot Date: 20 Jul18 2018
Coordinate System: NAD 1983 UTM Zone 11N
22
04
08
26
Clearance
Height - AGL Feet
< 20
≥ 20 < 40
≥ 40 < 125
> 125
Study Area
RPZ
Transmission Line
Substation/Battery System Enclosure
Capitol Airspace Group
N

Attachment 4 – Glint and Glare Study

Administrative Draft

NRG Coolwater Solar

NRG Renew

San Bernardino County, CA

Glint & Glare Analysis

August 31, 2017

Capitol Airspace Group

capitolairspace.com

(703) 256 - 2485

5400 Shawnee Road, Suite 304
Alexandria, VA 22312
703-256-2485
capitolairspace.com

Table of Contents

Summary

NRG Renew is proposing to construct a new utility-scale photovoltaic solar energy project near Barstow-Daggett Airport in San Bernardino County, California. On behalf of NRG Renew, Capitol Airspace performed a Glint and Glare Analysis to identify any potential impact on Barstow-Daggett Airport operations. Specifically, this analysis considered impact on aircraft approaching to land on Runways 08/26 and 04/22. Since Barstow-Daggett Airport is an uncontrolled field, this analysis did not consider impact on air traffic control tower personnel. The study is conducted in accordance with the FAA established interim policy for Solar Energy System Projects on Federally Obligated Airports.

The results of the study show that there is a "low potential for after image" associated with glare emanating from Array 6 only. This glare may be seen by aircraft making approaches to Runway 22. This level of glare is deemed acceptable by FAA standards per the interim policy for Solar Energy System Projects on Federally Obligated Airports.

Methodology

The FAA established an interim policy for Solar Energy System Projects on Federally Obligated Airports on October 23, 2013. The FAA adopted this interim policy in order to enhance safety by providing standards for measuring ocular impact of proposed solar energy systems on pilots and/or air traffic controllers. In cooperation with the Department of Energy (DOE), the FAA developed and validated the Sandia National Laboratories' "*Solar Glare Hazard Analysis Tool*" (SGHAT), now licensed through ForgeSolar. The FAA requires the use of the SGHAT to demonstrate compliance with the standards for measuring ocular impact.

In order for the FAA to approve a revised airport layout plan depicting a solar installation and/or issue a determination of no hazard, the airport sponsor is required to show that the solar installation meets the standards set forth in the interim policy. The interim policy states that a project:

1. *Must not have a potential for glint or glare in the existing or planned Airport Traffic Control Tower (ATCT) cab, (Green, Yellow or Red) and*
2. *Must not have a potential for glare (Yellow or Red) 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 (ALP). An airport may have a "low potential for after image" (Green) within these areas. The final approach path is defined as two (2) miles from fifty (50) feet above the landing threshold using a standard three (3) degree glidepath.*

   Ocular impact must be analyzed over the entire calendar year in one (1) minute intervals from when the sun rises above the horizon until the sun sets below the horizon.

   ***Note:** The most recent version of SGHAT also provides a result describing the potential for glare beyond 50 degrees from pilot line-of-site. The interim policy order makes no mention of potential glare in this category.*

Capitol Airspace utilized the SGHAT based guidance provided in User's Manual v.3. Solar array specifications were provided by NRG Renew. The arrays are currently based on geographical boundaries in order to refine the analysis. Each array is a single axis tracking solar array (***Figure 1***).

The flight path data is developed by reviewing airport specific operations before entering it into the SGHAT tool. Each flight path has configurable parameters and observation points. One of the configurable inputs allows for limiting the downward and azimuthal angles of view from the flight path to simulate a pilots view out the window of the cockpit. NRG Renew specified that the analysis be conducted from the FAA's approved default settings in the SGHAT tool which utilizes the view from the pilot's perspective.

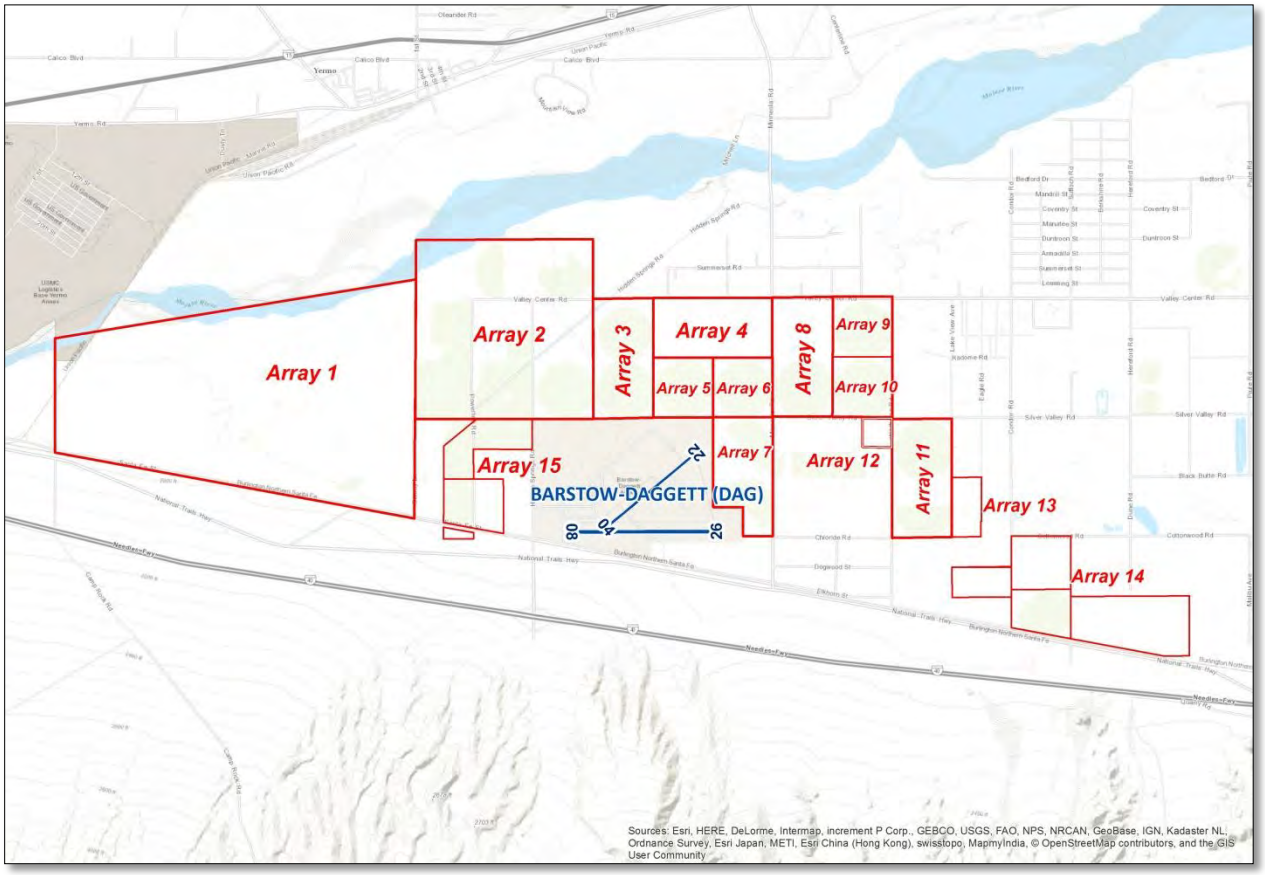


Figure 1: Location of solar arrays in reference to runways

Data

NRG Renew provided the following data for the solar projects expected total footprint, which was divided into 15 arrays, based on the input parameters defined in the SGHAT User's Manual v.3.

The data for PV Array 1 is as follows:

Analysis Name	PV Array 1
PV array axis tracking	Single-axis tracking
Tracking axis orientation	180 deg
Tracking axis tilt	0 deg
Tracking axis panel offset	0.0 deg
Limit tracking rotation?	Yes
Maximum tracking angle	60.0 deg
Vary reflectivity	Yes
PV surface material	Smooth glass with ARC
Time zone offset	-8.0
Vary reflectivity with sun position?	Yes
Correlate slope error with surface type?	Yes
Slope error:	8.43 mrad

Table 1: PV Array 1 Inputs

ID	Latitude	Longitude	Ground Elevation (feet)	Height Above Ground (feet)	Total Elevation
1	34.875042	-116.873901	1955.68	8.00	1963.68
2	34.882119	-116.820740	1914.91	8.00	1922.91
3	34.853121	-116.821060	1958.63	8.00	1966.63
4	34.861183	-116.873936	1989.43	8.00	1997.43

Table 2: PV Array 1 Vertices

The data for PV Array 2 is as follows:

Analysis Name	PV Array 2
PV array axis tracking	Single-axis tracking
Tracking axis orientation	180 deg
Tracking axis tilt	0 deg
Tracking axis panel offset	0.0 deg
Limit tracking rotation?	Yes
Maximum tracking angle	60.0 deg
Vary reflectivity	Yes
PV surface material	Smooth glass with ARC
Time zone offset	-8.0
Vary reflectivity with sun position?	Yes
Correlate slope error with surface type?	Yes
Slope error:	8.43 mrad

Table 3: PV Array 2 Inputs

ID	Latitude	Longitude	Ground Elevation (feet)	Height Above Ground (feet)	Total Elevation
1	34.879773	-116.785794	1907.23	8.00	1915.23
2	34.879812	-116.768307	1895.77	8.00	1903.77
3	34.872560	-116.768272	1896.72	8.00	1904.72
4	34.872523	-116.785776	1910.02	8.00	1918.02

Table 4: PV Array 2 Vertices

The data for PV Array 3 is as follows:

Analysis Name	PV Array 3
PV array axis tracking	Single-axis tracking
Tracking axis orientation	180 deg
Tracking axis tilt	0 deg
Tracking axis panel offset	0.0 deg
Limit tracking rotation?	Yes
Maximum tracking angle	60.0 deg
Vary reflectivity	Yes
PV surface material	Smooth glass with ARC
Time zone offset	-8.0
Vary reflectivity with sun position?	Yes
Correlate slope error with surface type?	Yes
Slope error:	8.43 mrad

Table 5: PV Array 3 Inputs

ID	Latitude	Longitude	Ground Elevation (feet)	Height Above Ground (feet)	Total Elevation
1	34.879680	-116.794688	1914.69	8.00	1922.69
2	34.879773	-116.785794	1910.45	8.00	1918.45
3	34.865295	-116.785777	1914.23	8.00	1922.23
4	34.865164	-116.794621	1920.25	8.00	1928.25

Table 6: PV Array 3 Vertices

The data for PV Array 4 is as follows:

Analysis Name	PV Array 4
PV array axis tracking	Single-axis tracking
Tracking axis orientation	180 deg
Tracking axis tilt	0 deg
Tracking axis panel offset	0.0 deg
Limit tracking rotation?	Yes
Maximum tracking angle	60.0 deg
Vary reflectivity	Yes
PV surface material	Smooth glass with ARC
Time zone offset	-8.0
Vary reflectivity with sun position?	Yes
Correlate slope error with surface type?	Yes
Slope error:	8.43 mrad

Table 7: PV Array 4 Inputs

ID	Latitude	Longitude	Ground Elevation (feet)	Height Above Ground (feet)	Total Elevation
1	34.879680	-116.794688	1914.69	8.00	1922.69
2	34.879773	-116.785794	1910.45	8.00	1918.45
3	34.865295	-116.785777	1914.23	8.00	1922.23
4	34.865164	-116.794621	1920.25	8.00	1928.25

Table 8: PV Array 4 Vertices

The data for PV Array 5 is as follows:

Analysis Name	PV Array 5
PV array axis tracking	Single-axis tracking
Tracking axis orientation	180 deg
Tracking axis tilt	0 deg
Tracking axis panel offset	0.0 deg
Limit tracking rotation?	Yes
Maximum tracking angle	60.0 deg
Vary reflectivity	Yes
PV surface material	Smooth glass with ARC
Time zone offset	-8.0
Vary reflectivity with sun position?	Yes
Correlate slope error with surface type?	Yes
Slope error:	8.43 mrad

Table 9: PV Array 5 Inputs

ID	Latitude	Longitude	Ground Elevation (feet)	Height Above Ground (feet)	Total Elevation
1	34.872523	-116.785776	1910.01	8.00	1918.01
2	34.872542	-116.777024	1902.90	8.00	1910.90
3	34.865305	-116.777001	1904.65	8.00	1912.65
4	34.865295	-116.785777	1911.29	8.00	1919.29

Table 10: PV Array 5 Vertices

The data for PV Array 6 is as follows:

Analysis Name	PV Array 6
PV array axis tracking	Single-axis tracking
Tracking axis orientation	180 deg
Tracking axis tilt	0 deg
Tracking axis panel offset	0.0 deg
Limit tracking rotation?	Yes
Maximum tracking angle	60.0 deg
Vary reflectivity	Yes
PV surface material	Smooth glass with ARC
Time zone offset	-8.0
Vary reflectivity with sun position?	Yes
Correlate slope error with surface type?	Yes
Slope error:	8.43 mrad

Table 11: PV Array 6 Inputs

ID	Latitude	Longitude	Ground Elevation (feet)	Height Above Ground (feet)	Total Elevation
1	34.872542	-116.777024	1903.00	8.00	1911.00
2	34.872560	-116.768272	1895.49	8.00	1903.49
3	34.865311	-116.768229	1899.69	8.00	1907.69
4	34.865305	-116.777001	1904.65	8.00	1912.65

Table 12: PV Array 6 Vertices

The data for PV Array 7 is as follows:

Analysis Name	PV Array 7
PV array axis tracking	Single-axis tracking
Tracking axis orientation	180 deg
Tracking axis tilt	0 deg
Tracking axis panel offset	0.0 deg
Limit tracking rotation?	Yes
Maximum tracking angle	60.0 deg
Vary reflectivity	Yes
PV surface material	Smooth glass with ARC
Time zone offset	-8.0
Vary reflectivity with sun position?	Yes
Correlate slope error with surface type?	Yes
Slope error:	8.43 mrad

Table 13: PV Array 7 Inputs

ID	Latitude	Longitude	Ground Elevation (feet)	Height Above Ground (feet)	Total Elevation
1	34.865305	-116.777001	1904.80	8.00	1912.80
2	34.865311	-116.768229	1899.66	8.00	1907.66
3	34.850913	-116.768221	1900.20	8.00	1908.20
4	34.850926	-116.772624	1902.44	8.00	1910.44
5	34.854439	-116.772623	1905.39	8.00	1913.39
6	34.854448	-116.777021	1908.65	8.00	1916.65

Table 14: PV Array 7 Vertices

The data for PV Array 8 is as follows:

Analysis Name	PV Array 8
PV array axis tracking	Single-axis tracking
Tracking axis orientation	180 deg
Tracking axis tilt	0 deg
Tracking axis panel offset	0.0 deg
Limit tracking rotation?	Yes
Maximum tracking angle	60.0 deg
Vary reflectivity	Yes
PV surface material	Smooth glass with ARC
Time zone offset	-8.0
Vary reflectivity with sun position?	Yes
Correlate slope error with surface type?	Yes
Slope error:	8.43 mrad

Table 15: PV Array 8 Inputs

ID	Latitude	Longitude	Ground Elevation (feet)	Height Above Ground (feet)	Total Elevation
1	34.879812	-116.768307	1895.77	8.00	1903.78
2	34.879876	-116.759294	1888.29	8.00	1896.29
3	34.865344	-116.759417	1890.96	8.00	1898.97
4	34.865421	-116.768230	1900.22	8.00	1908.22

Table 16: PV Array 8 Vertices

The data for PV Array 9 is as follows:

Analysis Name	PV Array 9
PV array axis tracking	Single-axis tracking
Tracking axis orientation	180 deg
Tracking axis tilt	0 deg
Tracking axis panel offset	0.0 deg
Limit tracking rotation?	Yes
Maximum tracking angle	60.0 deg
Vary reflectivity	Yes
PV surface material	Smooth glass with ARC
Time zone offset	-8.0
Vary reflectivity with sun position?	Yes
Correlate slope error with surface type?	Yes
Slope error:	8.43 mrad

Table 17: PV Array 9 Inputs

ID	Latitude	Longitude	Ground Elevation (feet)	Height Above Ground (feet)	Total Elevation
1	34.879876	-116.759294	1888.64	8.00	1896.64
2	34.879922	-116.750568	1885.50	8.00	1893.50
3	34.872605	-116.750542	1885.66	8.00	1893.66
4	34.872621	-116.759309	1890.99	8.00	1898.99

Table 18: PV Array 9 Vertices

The data for PV Array 10 is as follows:

Analysis Name	PV Array 10
PV array axis tracking	Single-axis tracking
Tracking axis orientation	180 deg
Tracking axis tilt	0 deg
Tracking axis panel offset	0.0 deg
Limit tracking rotation?	Yes
Maximum tracking angle	60.0 deg
Vary reflectivity	Yes
PV surface material	Smooth glass with ARC
Time zone offset	-8.0
Vary reflectivity with sun position?	Yes
Correlate slope error with surface type?	Yes
Slope error:	8.43 mrad

Table 19: PV Array 10 Inputs

ID	Latitude	Longitude	Ground Elevation (feet)	Height Above Ground (feet)	Total Elevation
1	34.872621	-116.759309	1891.64	8.00	1899.64
2	34.872605	-116.750542	1885.66	8.00	1893.66
3	34.865279	-116.750563	1883.19	8.00	1891.20
4	34.865355	-116.759370	1890.37	8.00	1898.37

Table 20: PV Array 10 Vertices

The data for PV Array 11 is as follows:

Analysis Name	PV Array 11
PV array axis tracking	Single-axis tracking
Tracking axis orientation	180 deg
Tracking axis tilt	0 deg
Tracking axis panel offset	0.0 deg
Limit tracking rotation?	Yes
Maximum tracking angle	60.0 deg
Vary reflectivity	Yes
PV surface material	Smooth glass with ARC
Time zone offset	-8.0
Vary reflectivity with sun position?	Yes
Correlate slope error with surface type?	Yes
Slope error:	8.43 mrad

Table 21: PV Array 11 Inputs

ID	Latitude	Longitude	Ground Elevation (feet)	Height Above Ground (feet)	Total Elevation
1	34.865047	-116.750622	1883.24	8.00	1891.24
2	34.865070	-116.741851	1878.30	8.00	1886.30
3	34.850725	-116.741891	1881.44	8.00	1889.44
4	34.850622	-116.750659	1887.48	8.00	1895.48

Table 22: PV Array 11 Vertices

The data for PV Array 12 is as follows:

Analysis Name	PV Array 12
PV array axis tracking	Single-axis tracking
Tracking axis orientation	180 deg
Tracking axis tilt	0 deg
Tracking axis panel offset	0.0 deg
Limit tracking rotation?	Yes
Maximum tracking angle	60.0 deg
Vary reflectivity	Yes
PV surface material	Smooth glass with ARC
Time zone offset	-8.0
Vary reflectivity with sun position?	Yes
Correlate slope error with surface type?	Yes
Slope error:	8.43 mrad

Table 23: PV Array 12 Inputs

ID	Latitude	Longitude	Ground Elevation (feet)	Height Above Ground (feet)	Total Elevation
1	34.865139	-116.754959	1887.79	8.00	1895.79
2	34.865149	-116.750621	1883.26	8.00	1891.26
3	34.861620	-116.750648	1888.06	8.00	1896.06
4	34.861676	-116.754942	1890.89	8.00	1898.89

Table 24: PV Array 12 Vertices

The data for PV Array 13 is as follows:

Analysis Name	PV Array 13
PV array axis tracking	Single-axis tracking
Tracking axis orientation	180 deg
Tracking axis tilt	0 deg
Tracking axis panel offset	0.0 deg
Limit tracking rotation?	Yes
Maximum tracking angle	60.0 deg
Vary reflectivity	Yes
PV surface material	Smooth glass with ARC
Time zone offset	-8.0
Vary reflectivity with sun position?	Yes
Correlate slope error with surface type?	Yes
Slope error:	8.43 mrad

Table 25: PV Array 13 Inputs

ID	Latitude	Longitude	Ground Elevation (feet)	Height Above Ground (feet)	Total Elevation
1	34.857965	-116.741824	1880.27	8.00	1888.27
2	34.858001	-116.737445	1880.24	8.00	1888.24
3	34.850786	-116.737567	1875.14	8.00	1883.14
4	34.850766	-116.741844	1881.50	8.00	1889.50

Table 26: PV Array 13 Vertices

The data for PV Array 14 is as follows:

Analysis Name	PV Array 14
PV array axis tracking	Single-axis tracking
Tracking axis orientation	180 deg
Tracking axis tilt	0 deg
Tracking axis panel offset	0.0 deg
Limit tracking rotation?	Yes
Maximum tracking angle	60.0 deg
Vary reflectivity	Yes
PV surface material	Smooth glass with ARC
Time zone offset	-8.0
Vary reflectivity with sun position?	Yes
Correlate slope error with surface type?	Yes
Slope error:	8.43 mrad

Table 27: PV Array 14 Inputs

ID	Latitude	Longitude	Ground Elevation (feet)	Height Above Ground (feet)	Total Elevation
1	34.847084	-116.741846	1877.11	8.00	1885.11
2	34.843426	-116.741835	1877.53	8.00	1885.53
3	34.843445	-116.733112	1877.73	8.00	1885.73
4	34.839740	-116.733125	1883.53	8.00	1891.53
5	34.838383	-116.724368	1875.53	8.00	1883.53
6	34.836252	-116.710625	1865.75	8.00	1873.75
7	34.836264	-116.706917	1864.65	8.00	1872.65
8	34.843529	-116.706887	1862.15	8.00	1870.15
9	34.843478	-116.724347	1872.72	8.00	1880.72
10	34.850822	-116.724319	1869.62	8.00	1877.62
11	34.850838	-116.733089	1873.65	8.00	1881.65
12	34.847146	-116.733113	1874.86	8.00	1882.86

Table 28: PV Array 14 Vertices

The data for PV Array 15 is as follows:

Analysis Name	PV Array 15
PV array axis tracking	Single-axis tracking
Tracking axis orientation	180 deg
Tracking axis tilt	0 deg
Tracking axis panel offset	0.0 deg
Limit tracking rotation?	Yes
Maximum tracking angle	60.0 deg
Vary reflectivity	Yes
PV surface material	Smooth glass with ARC
Time zone offset	-8.0
Vary reflectivity with sun position?	Yes
Correlate slope error with surface type?	Yes
Slope error:	8.43 mrad

Table 29: PV Array 15 Inputs

ID	Latitude	Longitude	Ground Elevation (feet)	Height Above Ground (feet)	Total Elevation
1	34.847084	-116.741846	1877.11	8.00	1885.11
2	34.843426	-116.741835	1877.53	8.00	1885.53
3	34.843445	-116.733112	1877.73	8.00	1885.73
4	34.839740	-116.733125	1883.53	8.00	1891.53
5	34.838383	-116.724368	1875.53	8.00	1883.53
6	34.836252	-116.710625	1865.75	8.00	1873.75
7	34.836264	-116.706917	1864.65	8.00	1872.65
8	34.843529	-116.706887	1862.15	8.00	1870.15
9	34.843478	-116.724347	1872.72	8.00	1880.72
10	34.850822	-116.724319	1869.62	8.00	1877.62
11	34.850838	-116.733089	1873.65	8.00	1881.65
12	34.847146	-116.733113	1874.86	8.00	1882.86

Table 30: PV Array 15 Vertices

Results

Capitol Airspace utilized the previous inputs to analyze potential glint and glare at various points along the flight paths. Capitol Airspace obtained flight path inputs including runway end coordinates, visual glide path angles and threshold crossing heights from the FAA's National Airspace System Resources (NASR) data set. SGHAT uses this information to analyze each flight path between a two mile final and the runway threshold.

If glare is detected, "Glare Occurrence Plots" are generated by SGHAT. The plots show when glare can occur (as viewed from the prescribed observation point) throughout the year. The color indicates the potential ocular hazard. The colors are defined as:

- Green: Low potential for temporary after-image
- Yellow: Potential for temporary after-image
- Red: Potential for permanent eye damage

Summary of Results:

Component	Green Glare (minutes / year)	Yellow Glare (minutes / year)	Red Glare (minutes / year)
PV Array 1	0	0	0
PV Array 2	0	0	0
PV Array 3	0	0	0
PV Array 4	0	0	0
PV Array 5	0	0	0
PV Array 6	73	0	0
PV Array 7	0	0	0
PV Array 8	0	0	0
PV Array 9	0	0	0
PV Array 10	0	0	0
PV Array 11	0	0	0
PV Array 12	0	0	0
PV Array 13	0	0	0
PV Array 14	0	0	0
PV Array 15	0	0	0

Table 31: Glint and Glare summary

Runway 4/22

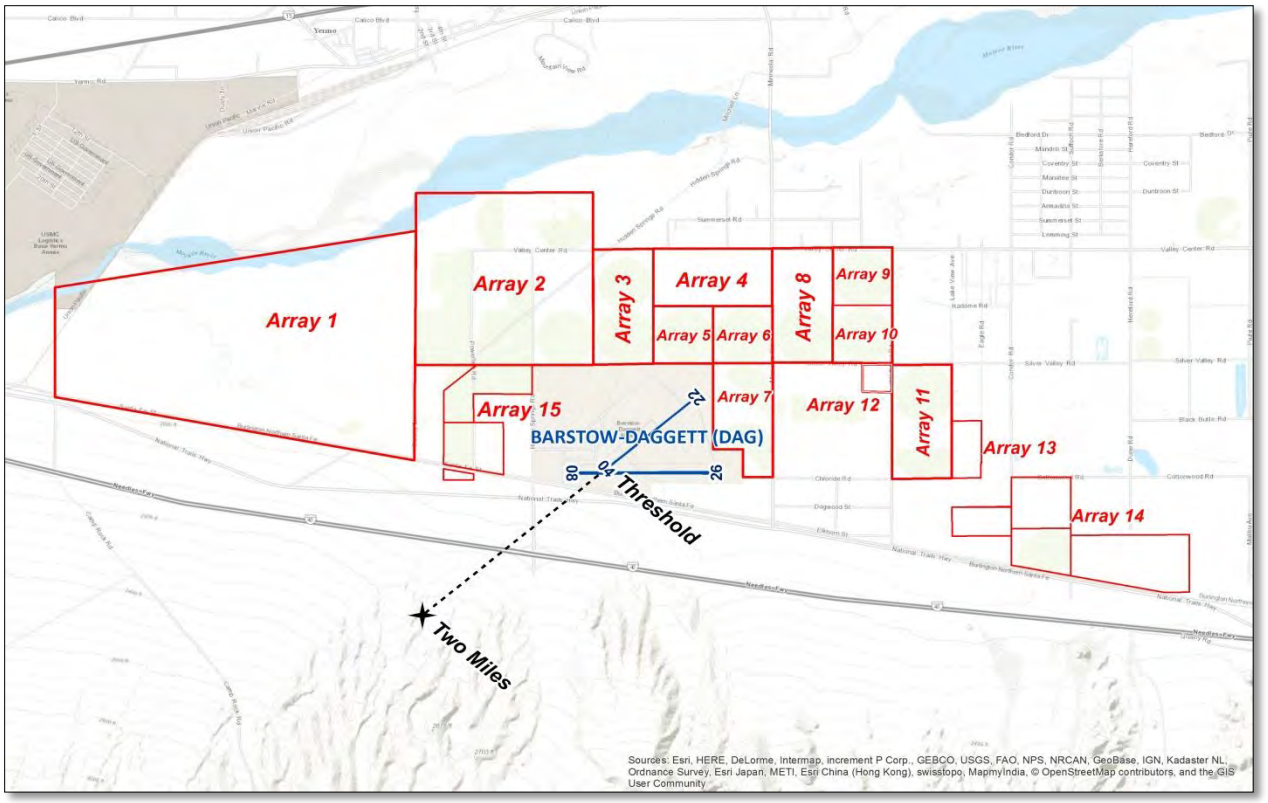


Figure 2: Runway 04 SGHAT flight path (dashed blue)

Analysis Name	RWY 04
Threshold height (ft)	50
Direction (deg)	50
Glide slope (deg)	3.0
Consider pilot visibility from cockpit	Yes
Vertical view restriction (deg)	30
Azimuthal view restriction (deg)	120

Table 32: Runway 04 flight path and viewing parameters

Observation Point	Latitude	Longitude	Ground Elevation (feet)	Height above ground (feet)	Total Elevation (feet)
Threshold	34.852038	-116.792708	1920.16	50.00	1970.16
2-mile point	34.833453	-116.819729	2256.54	267.07	2523.62

Table 33: Runway 04 flight path observation points

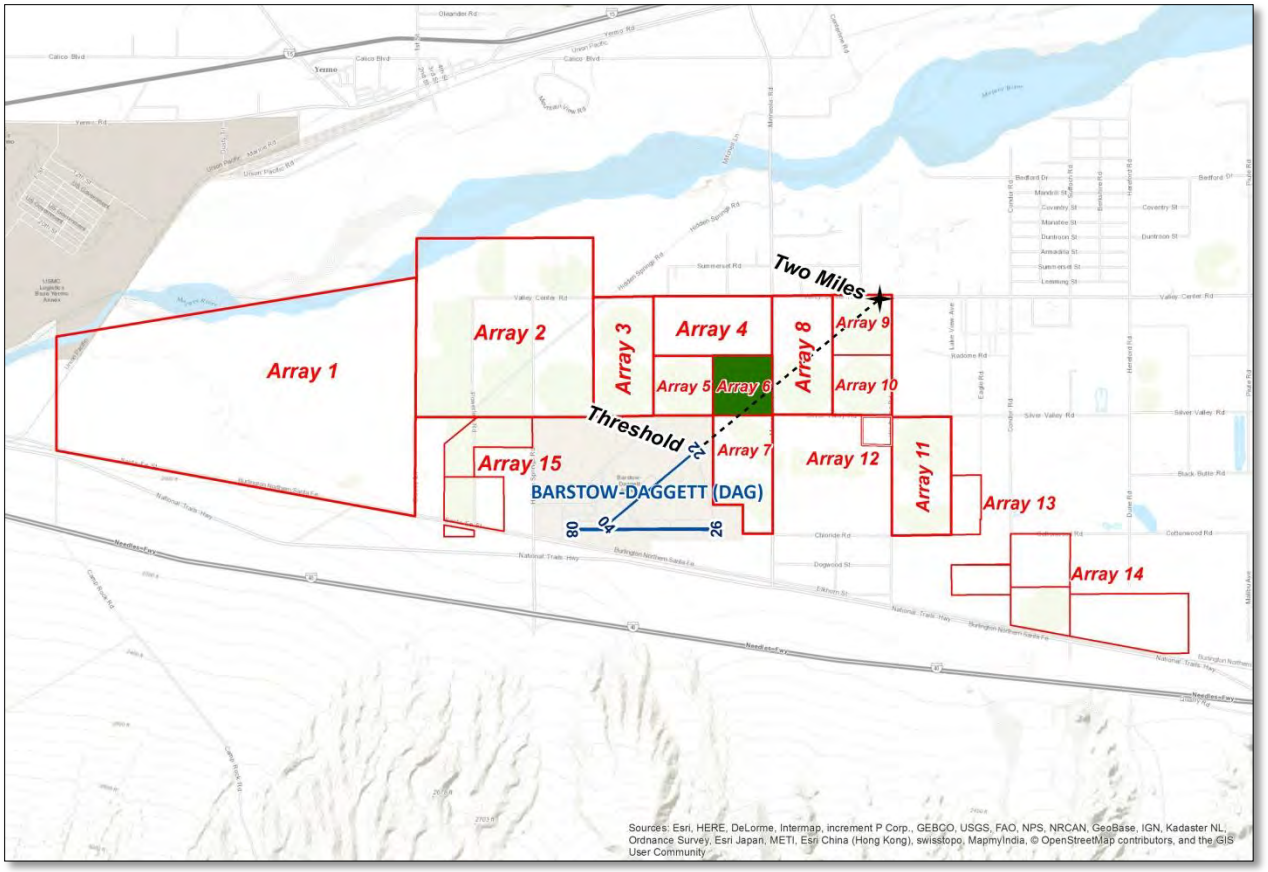


Figure 3: Runway 22 SGHAT flight path

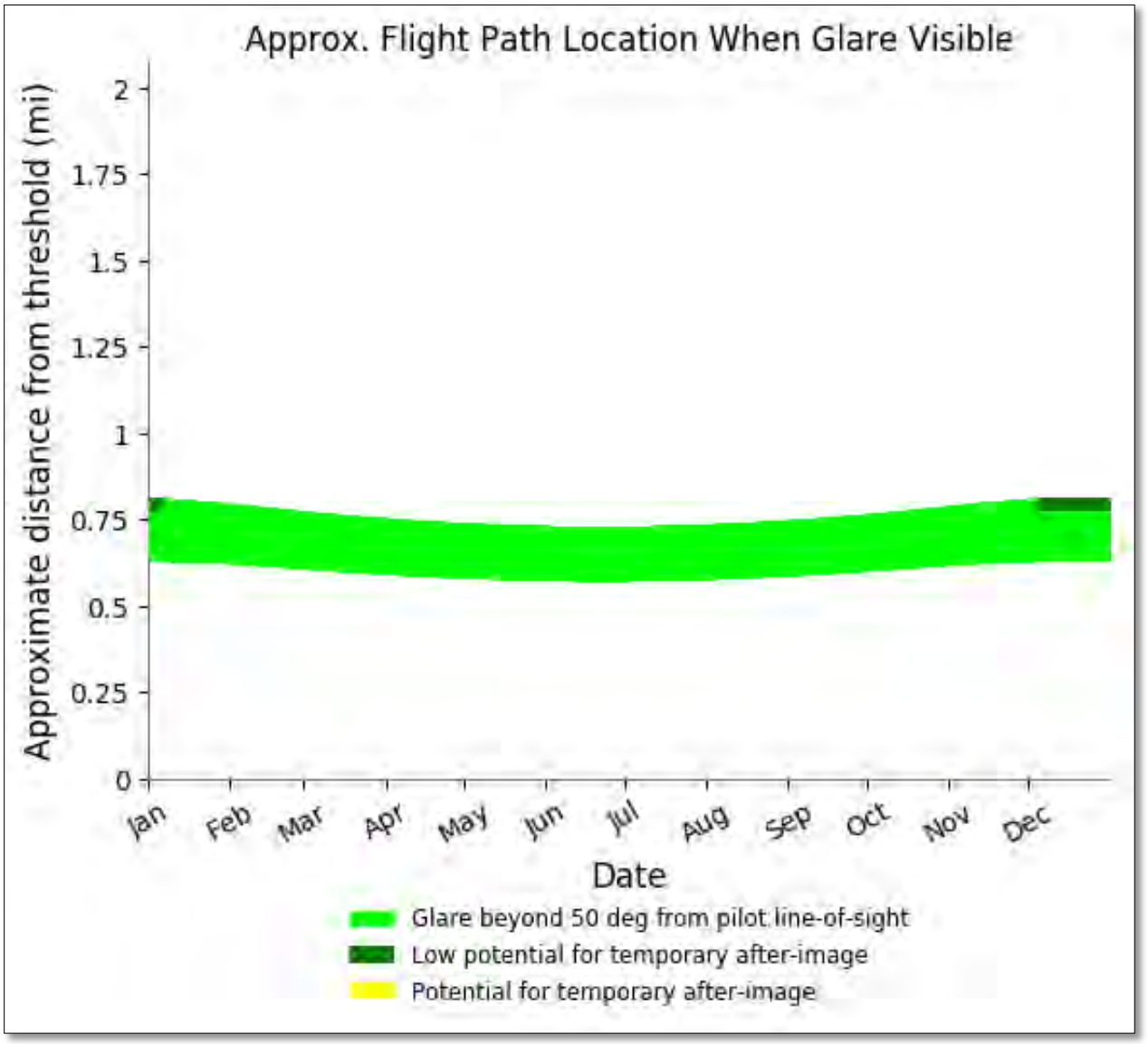
Analysis Name	RWY 22
Threshold height (ft)	50
Direction (deg)	230
Glide slope (deg)	3.0
Consider pilot visibility from cockpit	Yes
Vertical view restriction (deg)	30
Azimuthal view restriction (deg)	120

Table 34: Runway 22 flight path and viewing parameters

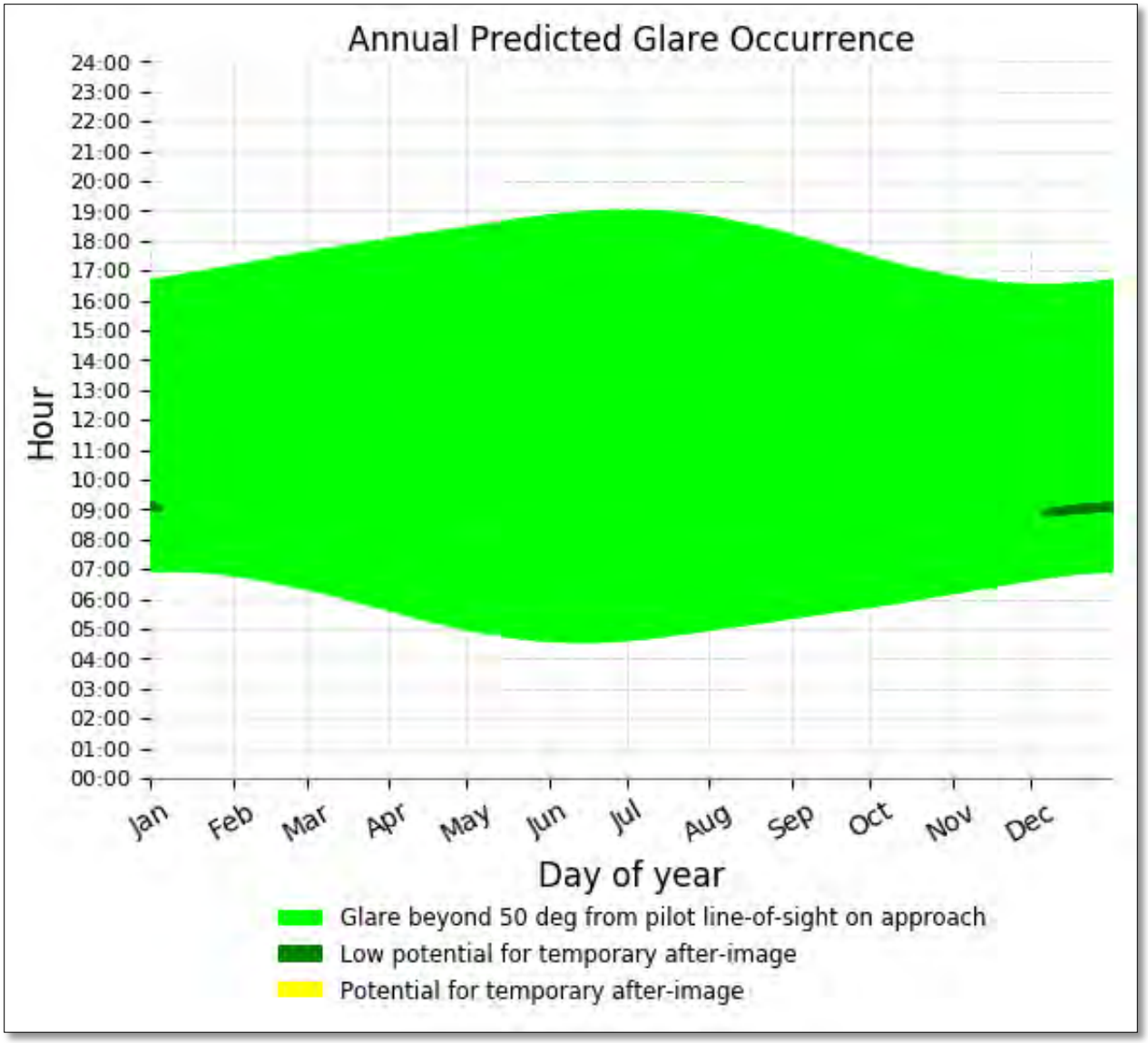
Observation Point	Latitude	Longitude	Ground Elevation (feet)	Height above ground (feet)	Total Elevation (feet)
Threshold	34.860971	-116.779541	1905.89	50.00	1955.89
2-mile point	34.879555	-116.752517	1883.92	625.43	2509.35

Table 35: Runway 22 flight path observation points

Glare Runway 22 - Threshold through 2 miles



Array 6 Glare: Runway 22 SGHAT Glare flight path location



Array 6 Glare: Runway 22 SGHAT Glare 1 minute time interval

SGHAT did not identify glare for the approach to Runway 04. However, glare was identified for the approach to Runway 22 on Array 6 at a distance approximately .8 miles from the threshold.

Runway 08/26

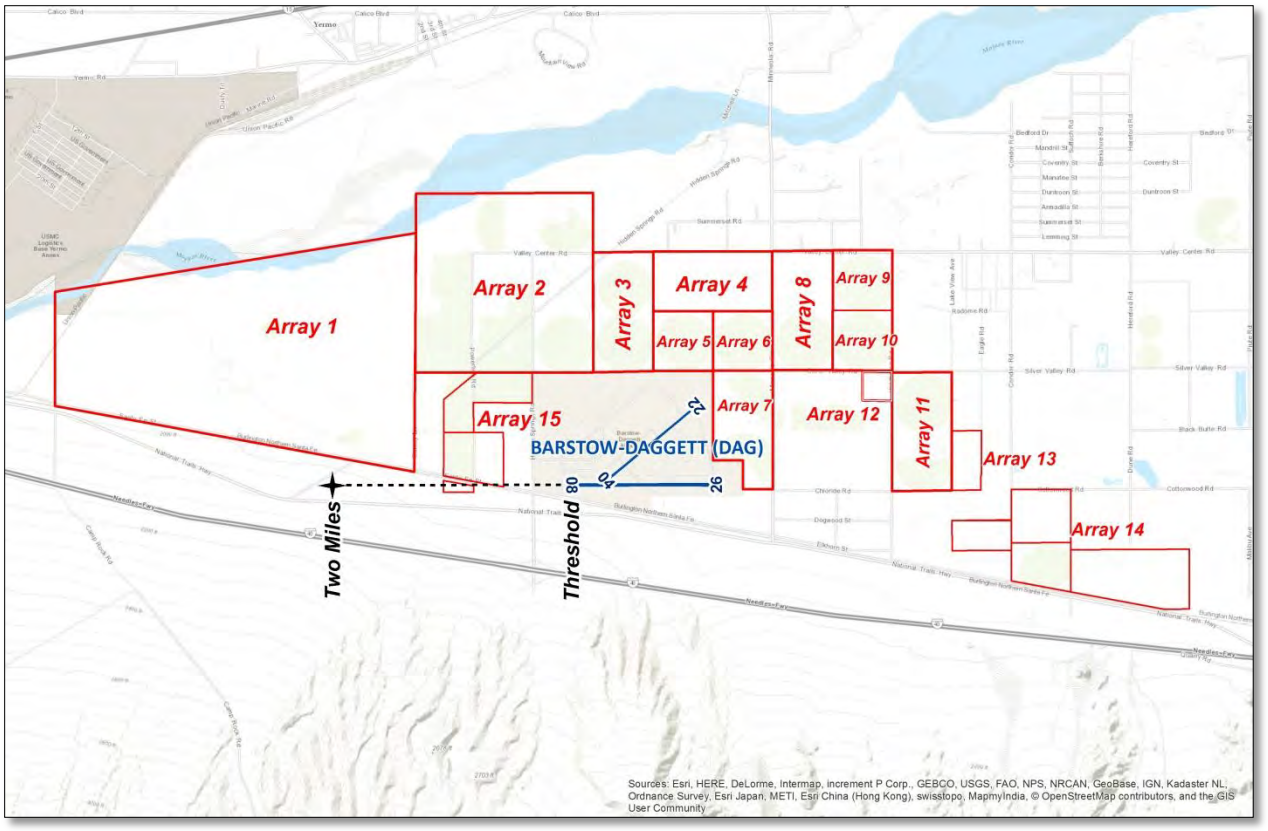


Figure 4: Runway 08 SGHAT flight path

Analysis Name	RWY 08
Threshold height (ft)	50
Direction (deg)	89
Glide slope (deg)	3.0
Consider pilot visibility from cockpit	Yes
Vertical view restriction (deg)	30
Azimuthal view restriction (deg)	120

Table 36: Runway 08 flight path and viewing parameters

Observation Point	Latitude	Longitude	Ground Elevation (feet)	Height above ground (feet)	Total Elevation (feet)
Threshold	34.851483	-116.797808	1929.64	50.00	1979.65
2-mile point	34.850979	-116.833076	2034.63	498.47	2533.10

Table 37: Runway 08 flight path observation points

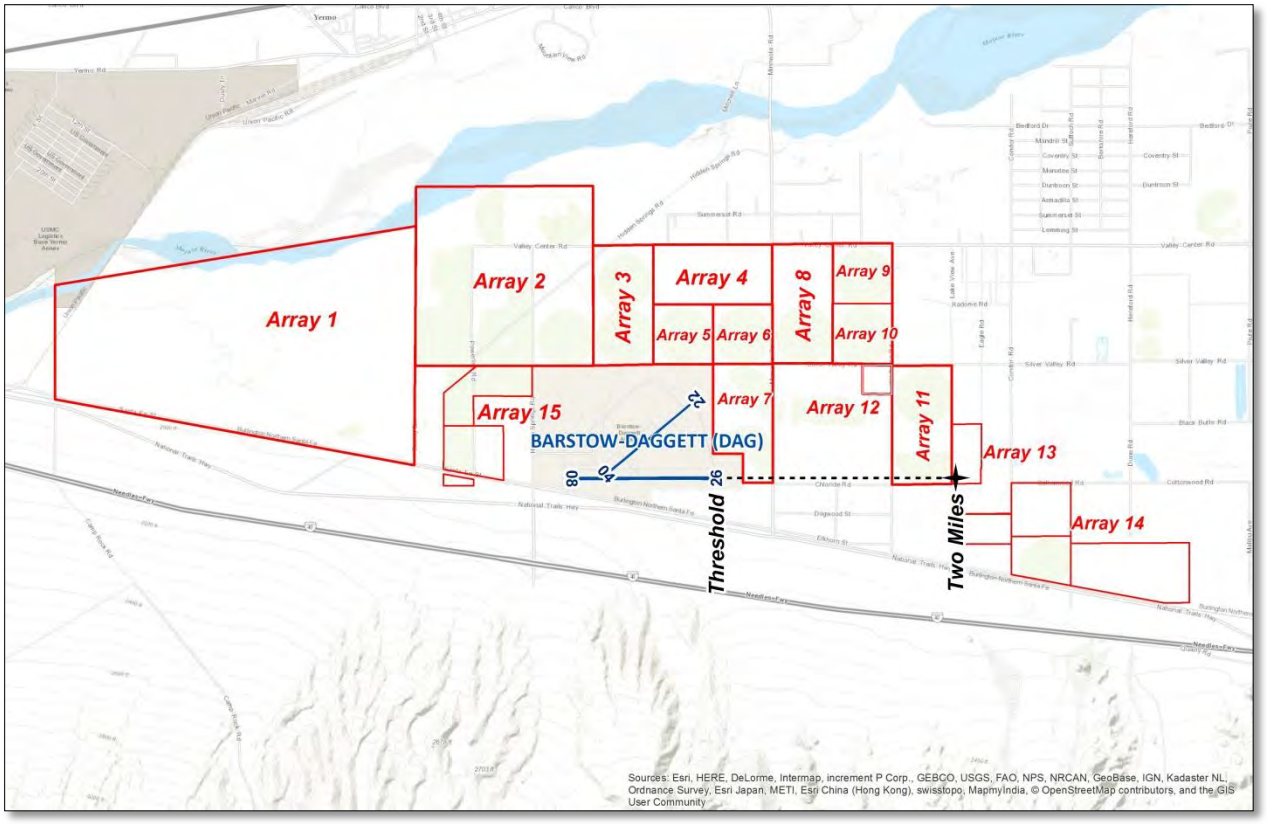


Figure 5: Runway 34R SGHAT flight path and North Array

Analysis Name	RWY 26
Threshold height (ft)	50
Direction (deg)	270
Glide slope (deg)	3.0
Consider pilot visibility from cockpit	Yes
Vertical view restriction (deg)	30
Azimuthal view restriction (deg)	120

Table 38: Runway 26 flight path and viewing parameters

Observation Point	Latitude	Longitude	Ground Elevation (feet)	Height above ground (feet)	Total Elevation (feet)
Threshold	34.851478	-116.776546	1905.79	50.00	1955.80
2-mile point	34.851478	-116.741273	1881.82	627.43	2509.25

Table 39: Runway 26 flight path observation points

Capitol Airspace's analysis of Runway 08/26 did not identify glare resulting from any of the solar arrays.

Conclusion

The SGHAT analyzed the expected total footprint of the proposed solar project as 15 separate arrays and identified glare occurrences resulting only from proposed Array 6 for approaches to Runway 22 for Barstow-Daggett Airport. The glare occurrences identified are in the acceptable threshold and are not considered an impact to ocular safety as defined by the FAA when utilizing the SGHAT tool. No glare was identified for any of the other 14 arrays. No glare was identified for Runways 04, 08 and 26 from any of the 15 arrays. Since Barstow-Daggett Airport is an uncontrolled airport there was no requirement to assess glint and glare on Air Traffic Control personnel in an Air Traffic Control Tower. The findings show that the project is compliant with the FAA interim policy for Solar Energy System Projects on Federally Obligated Airports.

SGHAT Analysis results:

Runway 04/22

No Glare was identified for Runway 04; however 73 minutes per year of acceptable glare for "low potential for after-image" in an airplane cockpit was identified for approaches to Runway 22 from Array 6 only.

Runway 08/26

No Glare identified for either runway.

If you have any questions regarding the findings in this analysis, please contact ***Ben Doyle*** or ***Rick Coles*** at (703) 256-2485.

Attachment 5 – Heat Island Memorandum

TETRA TECH

Administrative Draft

Technical Memorandum

Date: July 30, 2108

To: Aarty Joshi, Senior Manager, Environmental Permitting
Clearway Energy Group

From: Robert G. Kennedy III, PE, Senior Systems Engineer VI
Tetra Tech, Inc.

Subject: Analysis of Potential for Heat Island Effects Related to the Daggett Solar Power Facility Project, San Bernardino County, California

1.0 INTRODUCTION

The purpose of this memorandum is to present an analysis of the potential for the proposed Daggett Solar Power Facility Project ("Project") to contribute to a heat island effect that could adversely affect the environment. The Project is a proposal to construct and operate a utility-scale, solar photovoltaic (PV), electricity generation and energy storage facility that would produce up to 650 megawatts of power with up to 450 megawatts of battery storage capacity on approximately 3,500 acres of land. The Project would use new and existing electrical transmission infrastructure adjacent to the existing Coolwater Generating Station, a recently retired natural gas-fired power plant, to deliver renewable energy to the electric grid.

Large developments or urban areas are sometimes associated with having warmer temperatures than their surrounding rural areas, especially at night times and when winds are weak. This effect is sometimes referred to as an urban heat island or simply a heat island. This memorandum discusses the science behind heat effects of developments, and also explains why the Project will not contribute a significant increase in temperature.

2.0 ANALYSIS

2.1 About Heat Islands and Albedo

The correct term, "urban heat island" (UHI), is indeed a real phenomenon. A UHI is defined as an urban area or metropolitan area that is warmer than its surrounding rural areas due to human activities.[1] The key to understanding UHI is the concept of ***albedo***, which is how much light bounces off a surface versus how much is absorbed.[2] A pitch black surface has albedo = 0; a perfect mirror's albedo is 1. Every material used by people is somewhere between these two extremes, as shown in Figure 1.

While solar radiation enters the atmosphere very readily, because air is transparent to sunlight, the same is not true for infrared radiation, i.e. heat. Minor gases in our atmosphere like water vapor, carbon dioxide, or methane tend to block infrared radiation from escaping, just like a greenhouse which holds heat in. That is why they are called "greenhouse gases" (GHG).[3] In an UHI, dark surfaces absorb sunlight and immediately convert it to heat during the day. Light surfaces immediately reflect some of that light away, before it can become heat. Dark-colored materials tend to retain heat, releasing it well after sunset, making the environment hotter for longer into the night than it otherwise would be.

Tetra Tech, Inc.
17885 Von Karman Avenue, Suite 500, Irvine, CA 92614
Tel 949.809.5000 Fax 949.809.5010 tetratech.com

FIGURE 1

Examples:

- Buildings constructed of dark material such as brick walls and black tar roofs
- Road paving with dark materials such as asphalt
- Some forms of agriculture – wet soil, plants, and forests are darker than bare dry ground

The UHI effect is worsened with the addition of anthropogenic heat, i.e., heat released by or due to human activities.

Examples:

- Local electricity generation using ***thermal*** power cycles, such as burning coal or gas; due to thermodynamics, more than half of the chemical energy in the fuel is rejected as waste heat into the immediate environment
- Transportation with combustion engines such as planes, trains, and automobiles, which emit exhaust and waste heat into the immediate environment
- Air conditioning, which removes heat from occupied spaces by consuming electricity and rejecting the heat-plus-work to the immediate environment outside

2.2 Three Common Misconceptions About UHIs

Although in general UHIs are real given the right conditions, there are three common misconceptions associated with them:

- *Misconception 1: Solar panels can somehow increase the total amount of energy coming into an area*. This is false since solar panels do not cause sun rays or light rays to be attracted to the panels – the sun rays will enter an area with the same intensity whether panels are present or not. Sunlight is not "attracted" to solar panels.
- *Misconception 2: An increase in heat in one locality causes global warming*. Though the situation is complicated, this is generally false and can be explained by demonstrating the scale of the project in the "big picture." The global biosphere is vast compared to a local area/project. Earth's total surface is 500 million square kilometers; land covers 150 million square kilometers. In contrast, the Daggett Solar Power Facility would occupy 15 square kilometers (***10 million*** times smaller). At the Equator, about 1 ***billion*** watts of sunlight falls on ***each*** square kilometer.[4] Another illustration of scale is that the amount of sunlight hitting Earth is about 10,000 times greater than all the power that people command. In other words, the energy ***in one hour*** of sunlight (which comes in whether we harness it or not) is roughly equal to the energy budget of the entire human race ***in one year***.

- *Misconception 3: An area with solar panels somehow gets hotter than an area without panels*. Though the exact answer is complicated and depends on the specific situation, Misconception #3 is generally false. In fact, the opposite is true in the case of solar panels as compared to a bare soil ground-surface, or most any other natural surface. For three inter-related reasons solar power generation will tend to cool things down, both locally and far away including: 1) the average albedo of the area is reduced, 2) energy from the local environment is exported, and 3) thermal power generation is displaced. These three environmental benefits of solar power are explained below.

2.3 Benefit 1: Reducing Local Temperature by Reducing Average Albedo

Solar panels are comprised largely of glass. When incoming light hits glass (or any other shiny surface) at a shallow angle, it tends to reflect off the top surface of the glass immediately and go back into space, preventing any heating effects. See the left-hand side of Figure 2 below. At low angles, such as early in the morning or late in the afternoon, when the sun is low on the horizon, a horizontal pane of glass behaves like a nearly perfect mirror, i.e. glass's albedo is nearly 1 (far right element in Figure 1 above). As the incoming angle increases, while the sun follows its arc overhead during the day, more and more of the light penetrates the top surface of the glass, thus reaching the silicon cells underneath. A small percentage of light continues to be unavoidably reflected, but significantly less. See the right-hand side of Figure 2 below. At solar noon, the albedo of a horizontal pane of glass is nearly 0 (far left element in Figure 1 above). Nearly all the light is absorbed and gets converted to electric or heat energy.[5] This is why solar panels are tilted to face the Sun directly as much as possible.

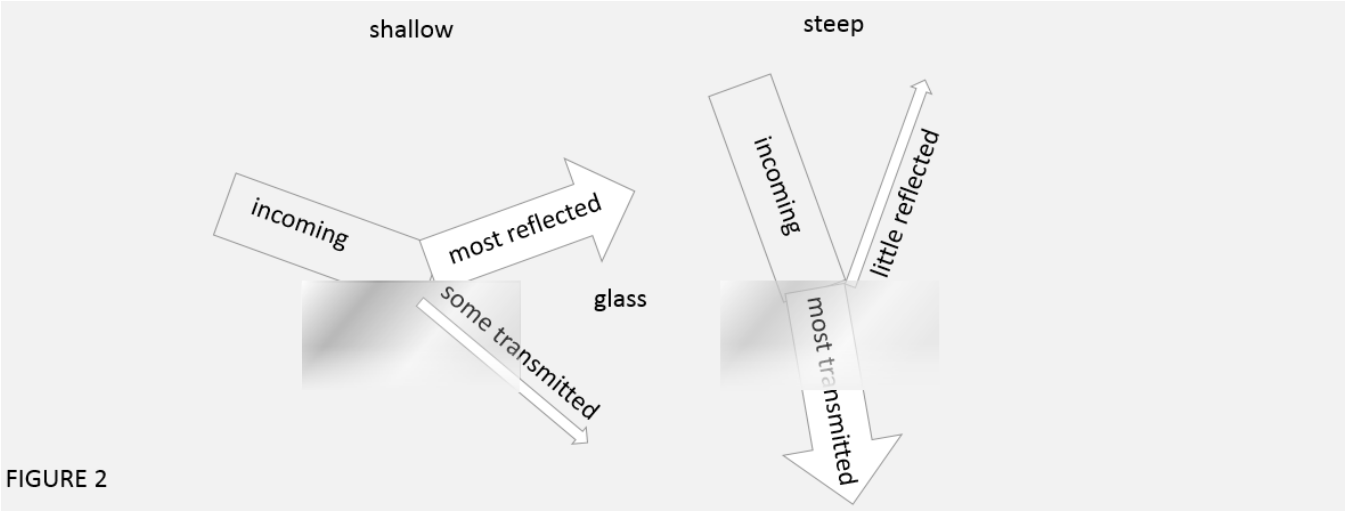
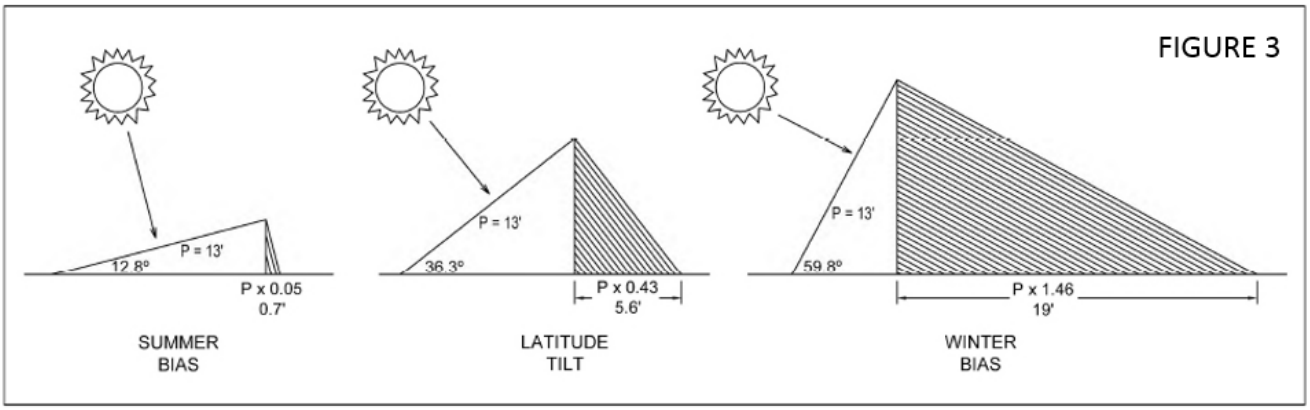


FIGURE 2

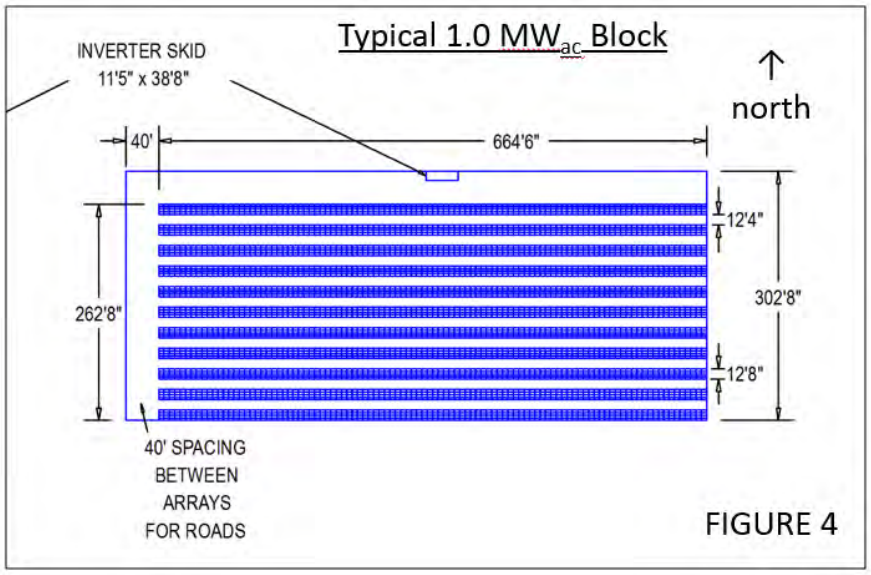
Referring to Figure 1, comparing the middle element (dirt) with the far-right element (mirror), bare dirt absorbs more sunlight converting it into heat than a shiny surface does. At the Project site, this dirt or soil surface consists primarily of younger Quaternary alluvium (a sandy soil). Furthermore, unlike glass, the amount of absorption is not dependent on the angle of incidence for soil and absorbs the same regardless of solar angle. Therefore, on balance, bare ground around a solar panel absorbs more heat over the course of a day than a panel does. By shading the dirt underneath, and reflecting some light off itself early and late in the day, a solar panel absorbs less heat over the course of a day than the soil does. Other metallic parts in a PV solar power facility also tend to be shiny and/or bright. Utility sheds or enclosures are typically painted in light colors, and the inspection/access roads are typically paved with light gravel rather than blacktop/asphalt as in nearby cities and suburbs. Therefore, the more area

that is covered by bright surfaces and fabricated materials, the cooler that area will be. This reduction in heat flux, although minor, is measurable and can be explained as follows:

Obviously, a solar collector of any kind, solar-thermal or PV, will not work if it is shaded, i.e., if the light it is supposed to be collecting is blocked by other collectors. It is particularly important that PV panels do not shade each other, as this causes deleterious electrical effects that reduce operating efficiency. Therefore, solar panels and other collectors must be spaced apart well enough to avoid shading each other. The degree of spacing depends on the latitude: higher latitude means more land is required for the same amount of power. Figure 3 illustrates this principle for flat panels at three different tilt angles (the viewer is looking to the west, and south is to the left).

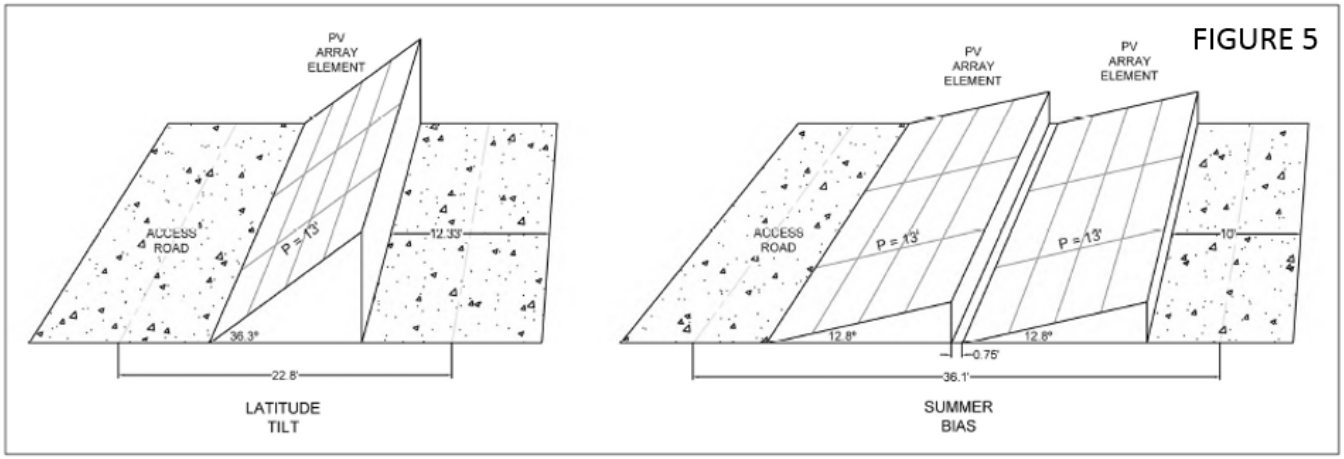


This constraint is true whether a system is fixed-tilt (such as typical rooftop solar panels) or tracking (such as proposed for the Project). Fixed-tilt flat-plate systems necessarily run in an east-west orientation. Figure 4 depicts the east-west orientation of a typical *non-tracking*, fixed-tilt, flat panel 1-megawatt building block of a utility-scale PV power plant.

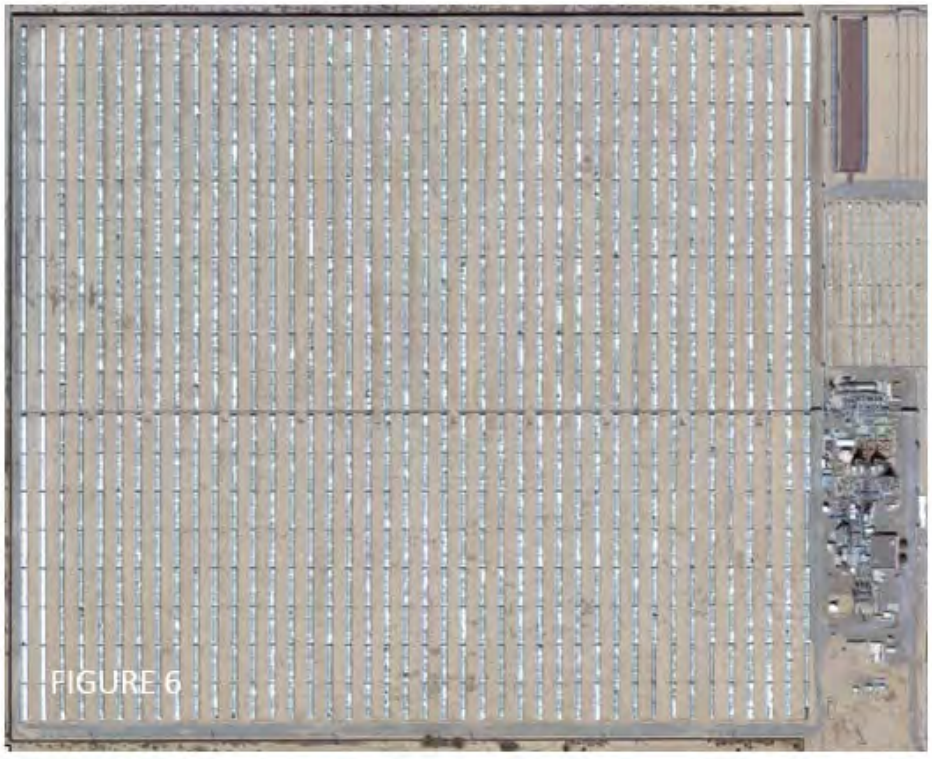


In a system optimized for the summertime generation (far left element of Figure 3), or at a low latitude near the Equator, panels lay much flatter and can be packed closer together, which increases the effective utilization of land per unit of power produced. In a fixed-tilt system in the far north, or one

optimized to produce in the winter, the land requirement per megawatt is much greater. See in Figure 5 how much less open space is wasted when panels lay almost flat.



Now, consider a tracking system in which the long rows of panels turn to follow the sun over its entire arc during the day (sun rising in the east and setting in the west) in order to maximize total production. Therefore, tracking systems should have their long axis oriented north-south, because it is much easier to roll a long skinny object side to side than it is to make a long object tip up and down. See Figure 6, a satellite photograph of a portion one of the SEGS plants, also in Daggett, California. These solar-thermal plants are based on old-style parabolic collectors, oriented north-south, which track and concentrate the sunlight for maximum thermal performance. Note, the wide spacing between troughs: over two-thirds of the area is, in fact, open space.



In the early morning or late afternoon, the panels in a tracking system must face the sun, which means they would resemble the element pictured on the far-right side of Figure 3. For a panel which is tilted steeply in order to face the sun directly at the beginning and end of every day, the spacing between the long rows of panels has to be quite significant, which Figure 6 illustrates.

The packing principle is true and unavoidable for both fixed-tilt and tracking systems: *in order to avoid self-shading, solar power plants are mostly occupied by bare ground*. The takeaway lesson from a thermal-environmental standpoint is, then that *solar power plants behave primarily like bare ground, and therefore do not heat up the environment or create a "heat island" any more than bare soil would*. On the contrary, the overall thermal situation should be expected to improve slightly, because a solar power plant would reflect a small portion of the incoming sunlight destined for that ground back into space, resulting in somewhat less local heating than otherwise would be expected.

2.4 Benefit 2: Reducing Local Temperature by Exporting Energy from The Local Environment

Above, we illustrated that at least two-thirds of the area of a solar power plant is simply bare ground. In some cases, the proportion of open ground approaches 90 percent, when factoring in service roads, security setbacks, etc. Therefore, only the remaining 10 to 30 percent is occupied by solar collectors. The efficiency of PV technology of every type is continually improving; today the efficiency of converting sunlight into electricity is approximately 20 percent. Thus, a few percent (2 to 6 percent at most) of the light that would have fallen on a solar power plant will be converted to electricity instead of heat. About 10,000 MW of sunlight falls on the grounds of the project which is planned to be capable of up to 650-MW, or 6 percent under optimal conditions. The generated electricity will be either instantaneously exported offsite via the pre-existing transmission wires or stored onsite in utility-scale batteries for export at a later time. Since a few percent of the incoming energy is removed from the thermal flux that would otherwise enter into the immediate environment, the opposite of a "heat island" results.

2.5 Benefit 3: Reducing Local Temperature by Displacing Conventional Thermal Power Generation

Unlike the conventional fossil-fired (natural gas) thermal power plant on the Project site (the recently-retired Coolwater Generating Station of nearly identical capacity), solar power generation using PV modules is a ***non-combustion*** process. Thermal power is subject to the laws of thermodynamics, which dictate that a single power cycle can only be 30-40 percent efficient at best. This means that most of the chemical energy in the fuel is wasted as rejected heat in order for the process to work. For example, in a large hypothetical fossil fuel-fired power plant, with a nameplate capacity of 1000-megawatts-electric, 2000-megawatts or more of waste heat must also be generated by importing and burning fossil fuel, which is a limited commodity. Regardless of whether this fuel ends up as useful electricity, or useless waste heat, all of it must be paid for with money by ratepayers, and all of it generates GHG emissions. Furthermore, this fuel has to be mined, processed and transported into the local area, all activities which have a GHG signature of their own. This "embodied energy" to bring the fuel from its source to its point of final use amounts to an additional cost of at least 11 percent for coal, and up to 25 percent for petroleum-derived fuels. After combustion, the waste heat is usually rejected in the immediate vicinity of the power plant, heating the local atmosphere for air-cooled plants, or heating a nearby lake, river, or ocean for water-cooled plants. Historically, in the western U.S., large fossil fuel-fired power plants were often constructed in conjunction with large water projects. Canals were built to transport water, not only to supply the community but also provide cooling water to the plants, while the plants provided electricity. If the power plant happened to be near a city, then that would indeed create a true UHI.

By contrast, solar power plants enjoy free unlimited fuel. Although PV technology is 20 percent efficient (at present), with the rest turned into waste heat, no more heat is emitted into the local environment than would have arrived there anyway in the form of sunlight landing on bare ground. From a thermal-environment standpoint, this makes solar power much less of an impact environmentally.

Finally, because solar power plants offset some amount of conventional thermal power, this acts to reduce overall heat flux into the environment, either at the immediate vicinity, or in someone else's community far removed from the location where the power was generated. Thus, solar power plants provide the opposite of a global warming effect.

3.0 REFERENCES

1 William D. Solecki, Cynthia Rosenzweig, Lily Parshall, Greg Pope, Maria Clark, Jennifer Cox, "Mitigation of the heat island effect in urban New Jersey" *Global Environmental Change Part B: Environmental Hazards*, Volume **6**, 2005 - Issue 1, pp. 39-49 https://doi.org/10.1016/j.hazards.2004.12.002.

2 Eugene Hecht and Alfred Zajac, *Optics*, Addison-Wesley, 1979.

3 R. Revelle and H.E. Suess, "Carbon Dioxide Exchange between Atmosphere and Ocean and the Question of an Increase of Atmospheric CO2 during the Past Decades", *Tellus*, **9**, p.18, 1957.

4 G. Kopp and J.L. Lean, "A new, lower value of total solar irradiance: Evidence and climate significance", *Geophys. Res. Lett.*, **38**, L01706, 2011. doi:10.1029/2010GL045777.

5 Frank Incropera and David Dewitt, *Fundamentals of Heat and Mass Transfer*, Wiley, 1981.