Solar Energy Development on Department of Defense Installations in the Mojave and Colorado Deserts

Robert Kwartin, Sarah Alexander, Martin Anderson, Donald Clark, John Collins, Chris Lamson, Garrett Martin, Ryan Mayfield, Lindsay McAlpine, Daniel Moreno, Jeffrey Patterson, Craig Schultz, and Emily Stiever

ICF International
January 2012

Solar Energy Development on Department of Defense Installations in the Mojave and Colorado Deserts

ICF International Study Team

Study Director	Robert Kwartin
Deputy Director	Garrett Martin
Geographic Setting of the Deserts	Sarah Alexander
Mission Compatibility	John Collins, Chris Lamson, Jeffrey Patterson
Solar Technology Characterization	Emily Stiever, Garrett Martin
Solar Potential Assessment	Craig Schultz, Donald Clark, Daniel Moreno, Ryan Mayfield
Energy Security Implications	Martin Anderson
Policy and Program Review	Garrett Martin, Lindsay McAlpine, Emily Stiever

ESTCP Project Manager
James Galvin

HGL Incorporated Project Manager
Sam Figuli

Acknowledgements

The authors would like to thank Jeff Marqusee and Jim Galvin of the Environmental Security Technology Certification Program and Sam Figuli of HydroGeoLogic, Inc. for their invaluable support, review, and encouragement throughout the development of this report. The authors would also like to thank Optony, Inc. and Power Ten, Inc. for their contributions to the research and review of this report. In addition, the team wishes to thank all of the individuals from each of the Services and from the Office of the Secretary of Defense for volunteering their time and expertise to support this analysis.

Table of Contents

List of Figures

List of Tables

Executive Summary

ES.1 Key Findings

- This analysis determined that over 7,000 megawatts (MW_{AC}) of solar energy development is technically feasible and financially viable at several Department of Defense (DoD) installations in the Mojave and Colorado Deserts of California.
- Approximately 25,000 acres are ―suitable” for solar development and another 100,000 acres are ―likely” or ―questionably” suitable for solar.
- This level of solar potential exists even though 96 percent of the surface area of the installations is unsuitable for solar energy development due to conflicts between solar energy development and military mission activities occurring at the installations or due to steep slope, flash flood hazards, biological resource conflicts, cultural resource conflicts, and other factors.
- Private developers can tap the solar potential with no capital investment requirement from the DoD.
- The Federal Government could potentially receive approximately $100 million/year in the form of rental payments, reduced cost power, in-kind considerations, or some combination among them.
- There are a range of technical, policy and programmatic barriers that can slow or, in some cases, stop solar development. Transmission capacity and the management of withdrawn lands are the two most important issues.

ES.2 Report Purpose

This study addresses current solar development activities and includes an evaluation of the potential for solar energy development inside the boundaries of nine large military installations located in the Mojave and Colorado Deserts of southern California and Nevada (see Figure ES.1 and Table ES.1). In addition to assessing the solar energy potential of the military installations, this report also discusses the potential mission compatibility and energy security impacts of on-installation solar energy development and the broader context for solar energy development in the Mojave and Colorado Deserts. The Department initiated the study in response to a congressional request.

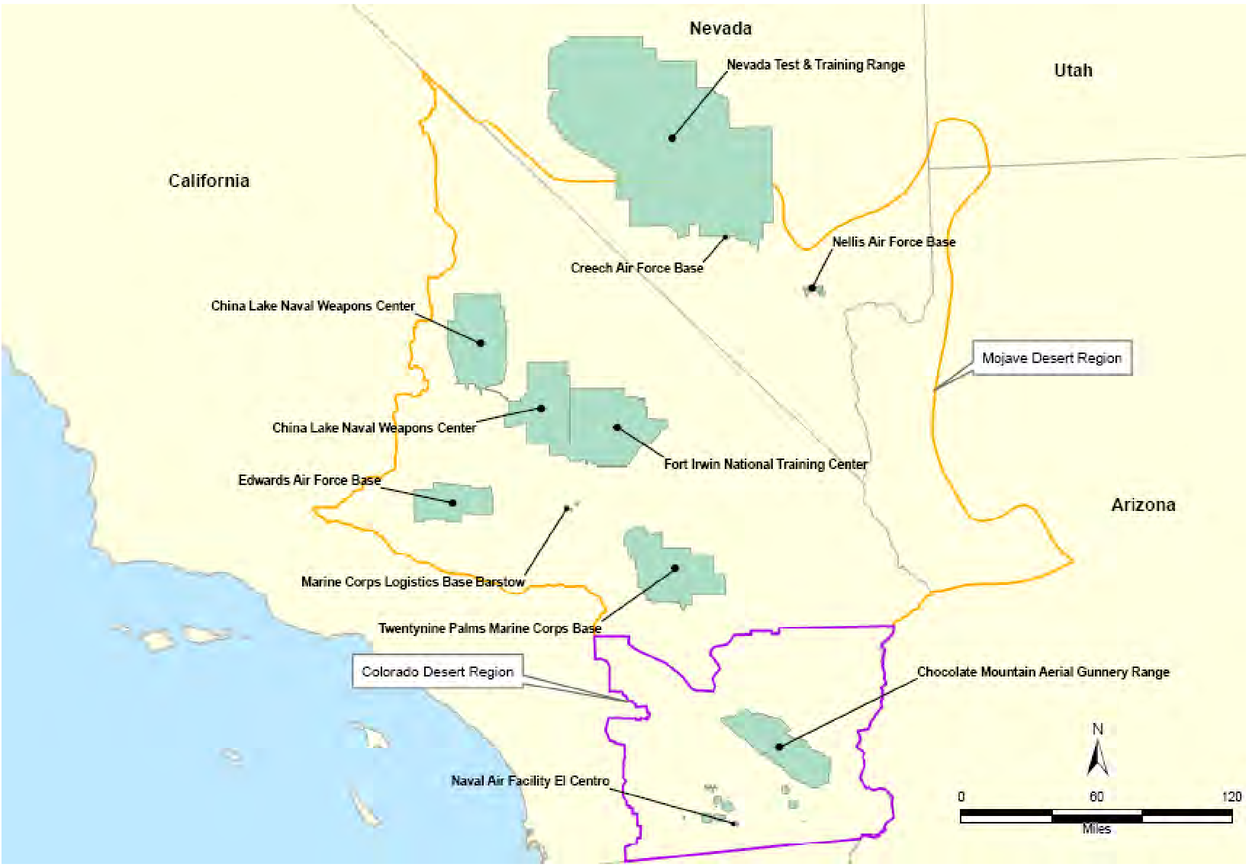


Figure ES.1 – DoD Installations Addressed by this Study

The nine installations are diverse, and each needs to be considered in the context of its unique mission role, land endowment, utility service arrangements, and solar development flexibility. The installations include representation from the Army, Air Force, Navy and Marine Corps. Their mission roles span a wide range of activities, including air, ground and combined arms training; weapons system research and development; human- and technical-factor weapons system testing and evaluation; and logistics support and management. Most of these installations already have 1-2 megawatts (MW) of solar energy systems in operation, and Nellis AFB is host to the largest photovoltaic (PV) system sited on a military facility in the U.S., a 14.2 MW solar PV facility completed in 2007.

Table ES.1 – U.S. Department of Defense Installations Reviewed in Study

Installation	Service	State	Geographic Region
Marine Corps Air to Ground Combat Center (MCAGCC) Twentynine Palms	Marine Corps	CA	Mojave Desert
Marine Corps Logistics Base (MCLB) Barstow	Marine Corps	CA	Mojave Desert
Chocolate Mountain Aerial Gunnery Range (CMAGR)	Marine Corps	CA	Colorado Desert
Naval Air Weapons Station (NAWS) China Lake	Navy	CA	Mojave Desert
Naval Air Facility (NAF) El Centro	Navy	CA	Colorado Desert
Edwards Air Force Base (AFB)	Air Force	CA	Mojave Desert

Fort Irwin	Army	CA	Mojave Desert
Creech Air Force Base (AFB)	Air Force	NV	Mojave Desert
Nellis Air Force Base (AFB) and the Nevada Test and Training Range (NTTR)	Air Force	NV	Mojave and Great Basin Deserts

ES.3 Mission Compatibility

The military services use the nine military installations as key assets for training, test and evaluation, and research and development. Their size and relatively remote locations offer the military the ability to train personnel and conduct research and development on technology in ways that would not be possible at other locations. The military's need for large, unrestricted landholdings has increased in recent years because modern systems and platforms – aircraft, missiles, sensors, etc. – have effective ranges and impacts vastly larger than their predecessors from the 1940s, when most of the installations in this study were established. Large areas are needed to test, evaluate and train with these systems, both to exploit their full capabilities, and to ensure that any unanticipated incidents occur over controlled ranges, rather than populated areas.

Although the effective battlespace requirement is growing, the military's landholdings are not. Because it is unlikely that any new major installations will be created in the region, the existing installations should be considered irreplaceable, and any degradation of their ability to perform their missions has an impact on both the near and long term capabilities of the military to protect and defend the U.S. Any plan for large-scale solar development on these installations needs to acknowledge and start with that premise.

There are two broad categories of conflict between solar technology and mission activities. The first category comprises –spectrum" issues, where the conflict between solar technology and military activities occurs through interactions in the radio frequency, infrared or visual spectra (see Table ES.2).

Table ES.2 – Function and Band of Military EM Spectrum Use

Spectrum	Sensors	Weapons	Communications
UV	Threat Warning	Missile Guidance	Data Link
Visible	Optical, Telescopic sights, NVD, Electro-Optical imaging, precision tracking	Aiming and Guidance, Fuzing	Light signals, Navigation lights
IR	Threat warning, NVD, IR Imaging, Laser warning, Laser ranging, Precision tracking	Active and passive Laser guidance, IR passive guidance, Laser Proximity fuzing, High Power Laser	IR beacons, Modulated Laser Data link, voice
Radio	Threat Warning, Electronic Support, Radar, IFF, GPS, Navigation, Telemetry, Precision measurement	HPM, Electronic Attack (Jammers), Anti-Radiation Missiles, Radar and Radio guided Missiles, Proximity Fuzing	AM, FM, HF Voice, Data Link, SATCOM, Telemetry, UAS Control

See Appendix C for full names of the acronyms in the table.

The second category comprises –physical” issues, where the conflict arises from hazardous or destructive interaction between military vehicles, ordnance, and other hardware on the one hand, and solar technology on the other (see Table ES.3).

Table ES.3 – Summary of Training and Testing Activities on Bases and Ranges

	Fort Irwin	NAWS China Lake	El Centro NAF	MCAGCC Twentynine Palms	MCLB Barstow	Chocolate Mtn. AGR	Edwards AFB	Nellis AFB & NTTR	Creech AFB
Live Training	X	X	X	X	X	X	X	X	X
Dismounted Maneuver Training	X	X		X		X			
Mounted Maneuver Training	X	X		X					
Air Operations Training	X	X	X	X		X	X	X	X
Individual & Unit Live Fire Weapons Training	X	X	X	X	X	X	X	X	
Joint/Combined Arms Maneuver Training	X	X	X	X		X			
Joint/Combined Arms Live Fire and Maneuver Training	X	X		X		X	X	X	
Test and Evaluation		X		X			X	X	X
Support Facilities	X	X	X	X	X		X	X	X

Because the installations support the complex scope of the Nation's military activities, the range of interactions between their activities and solar development is also complex and wide-ranging. Certain issues are more prevalent on some installations, while others are present at all of the installations. Some conflicts can be mitigated, while others cannot. It is also important to note that each installation is home to a diversity of activities, so that while mission conflicts may exclude solar development from active range areas, other areas of the installation may be free of mission conflicts. Each proposed facility needs to be evaluated in the context of its specific location and the current, and potential future, mission activities occurring there.

Although the study provides a screening level review of potential mission conflicts, there are gaps in data and analysis on mission compatibility. Very few detailed studies of conflicts between mission activities and solar development are available in the public domain.

ES.4 Solar Potential Assessment

<u>Results</u>

Because the two installations in Nevada lack significant solar development potential in addition to projects already developed or planned, the solar potential assessment portion of this study focuses on the seven military installations located in southern California. For the seven California installations, 96 percent of the land surface, largely active range land, is unsuitable for solar development. About 25,000 acres are “suitable” for solar development and another 100,000 acres are “likely” or “questionably” suitable for solar.

Assuming that 100 percent of the “suitable” acreage plus 25 percent of the “likely” and “questionable” acreage is available for solar development, the study determined that over 7,000 MW_{AC} of technically and economically feasible solar capacity could be sited on these lands. In this study “economically feasible” means that the solar projects would be financially attractive from the perspective of the project investor. However, the study found that only private investors would find it attractive to invest in these projects because private investors have access to Federal and State tax-based incentives, which permit them to earn an attractive rate of return on their investments. The study found that government investment (e.g., direct DoD funding of construction) would be financially unattractive in all cases. The most important federal solar tax incentive is mandated to be available through the end of 2016, but it is possible that legislative action in the interim could phase-out or eliminate this incentive, which would make private project investment less viable.

Assuming private development and ownership of economically-viable solar capacity on the seven California installations, the Federal Government could expect to receive over $100 million of annual value, in the form of rental payments, discounted power, in-kind considerations, or some combination thereof. Full development would also result in the avoided emissions of millions of tons of greenhouse gases and criteria air pollutants.

These available acreage and solar capacity figures represent the maximum potential for solar electricity development, if one placed solar on all sites that could feasibly host it from the technical and economic perspectives. The actual level of solar energy development on these military installations is likely to remain well below the maximum potential number for a wide variety of reasons, including a shortage of available transmission in the region, environmental constraints that could not be incorporated into this study, administrative and legal complexity, and competition from other generation sources.

The potential annual electricity generation from this solar energy capacity would be equivalent to two-thirds of the current annual electricity consumption of the entire DoD, nationwide. While complete development of all of the identified solar energy potential is unlikely, allowing full solar development on approximately 6% of the identified, economically-viable lands would generate enough electricity to meet all of the DoD’s EPAct 2005 renewable energy goals while solar development on less than half of the identified lands would be sufficient to meet all of the DoD’s NDAA 2010 renewable energy goals (25% of facility energy supplied by renewable energy sources in 2025).

It is important to note that the geographical and technical aspects of this analysis were not designed to be a detailed engineering analysis of specific solar projects, nor was the economic analysis intended to be of sufficient detail for investment decision-making for any particular site. Rather, this process provides a reasonable estimate of the technical and economic potential for solar development across millions of acres of complex landscape within a constrained study schedule and budget. However, while bearing this disclaimer in mind, it is reasonable to treat the results of this study as a robust screening of potential solar development areas. Each installation and each Service's center of expertise for solar development (e.g., NAVFAC, AFCESA, Corps of Engineers, MCI, etc.) can use the outputs of this analysis as inputs to their own process of solar site selection and development.

Methodology

The study organized the many issues affecting solar viability into three categories – geographic, technological, and economic.

Geographic Analysis

The study analyzed these issues in a step-by-step manner, with **geographic** screening analyses occurring first. The geographic analysis identified potential sites for roof, parking, and ground-mounted solar projects from among the military installations' total inventory of buildings, parking facilities, and lands. Five distinct ―site types" were used: building rooftops; shading structures over paved parking lots; shading structures over unpaved parking lots; cantonment[1] ground sites; and, range ground sites. Hundreds of layers of Geographic Information System (GIS) data were obtained from public, Service and installation databases in support of this study (see Figure ES.2).

[1] Each installation except for Chocolate Mountain AGR, was segmented into a cantonment area representing the developed zone of the installation, and a range area representing the undeveloped zone. The study applied different criteria and decision rules for solar projects in the two zones, except Edwards AFB where transmission calculations for the installation's cantonment and range zones were combined because they are especially co-mingled.

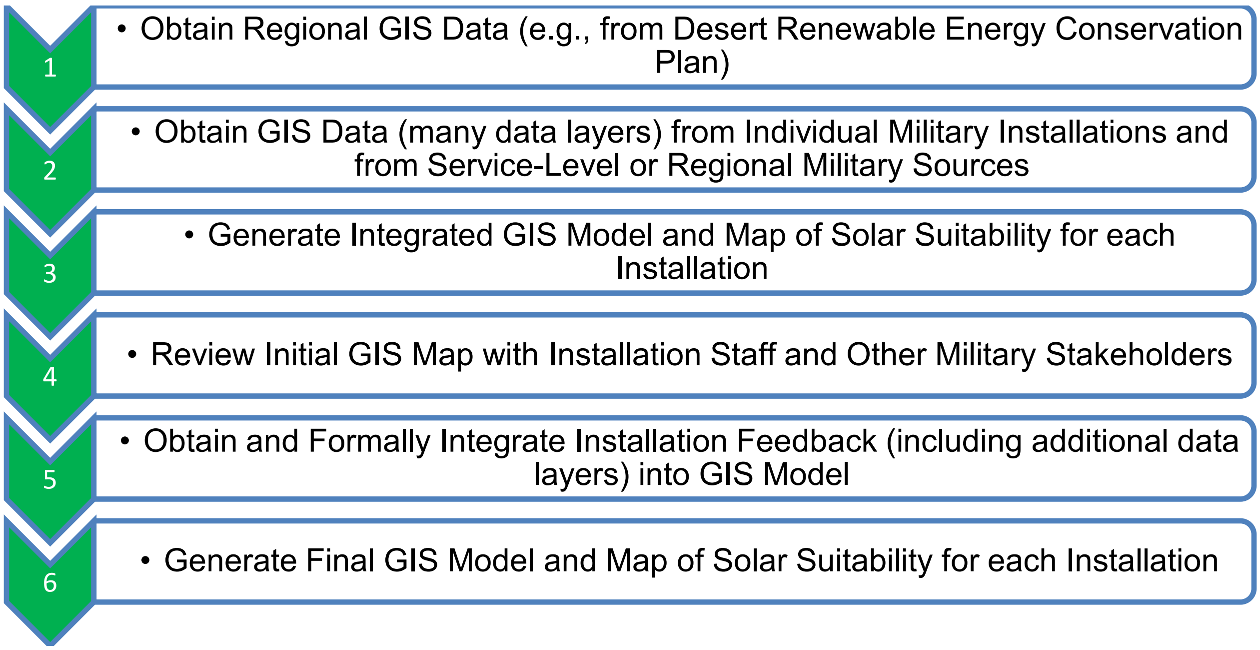


Figure ES.2 – GIS Data Collection Methodology

For the ground sites that comprise the vast majority of this study, GIS techniques were used to overlay 20 to 40 independent variables per installation to identify areas where solar development can and cannot occur. The GIS variables were typically in the categories of built infrastructure, construction plans, biological resources, cultural resources, environmental resources and hazards, military mission and operational activities including explosive arcs, topography, shading, and buffers around various areas. Figure ES.3 summarizes the GIS analysis process.

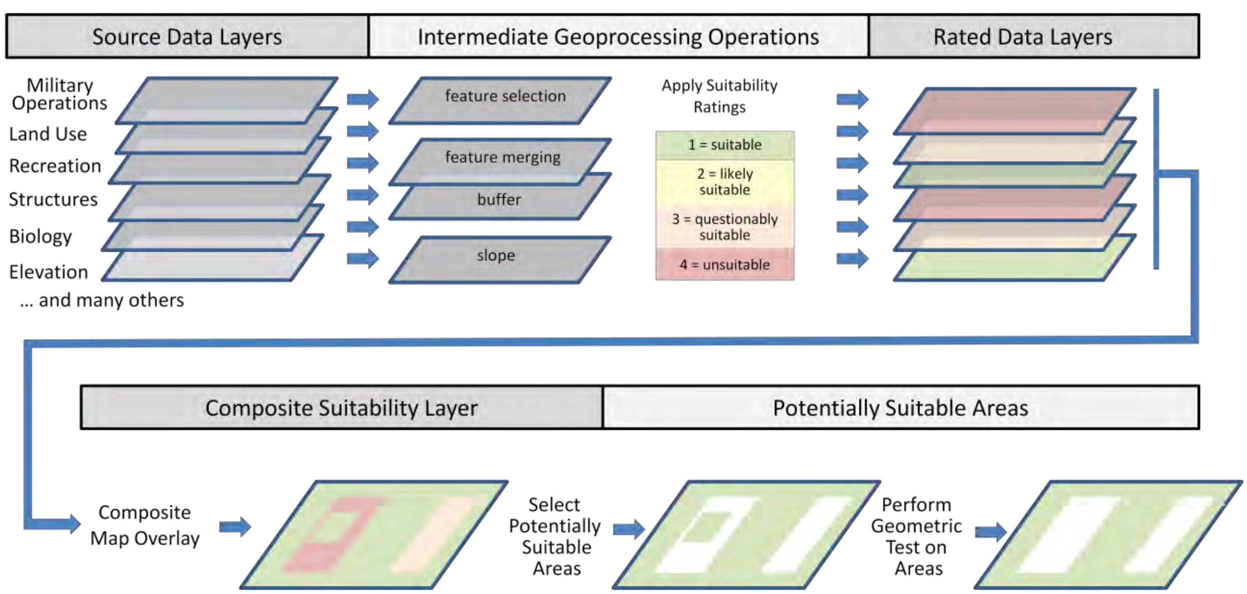


Figure ES.3 – Geographic Information Systems Analysis Flow

As shown in Figure ES.4 below (an example drawn from NAWS China Lake), at most of the installations studied, the vast majority of the land surface was screened out during the geographic analysis phase due to mission compatibility conflicts.

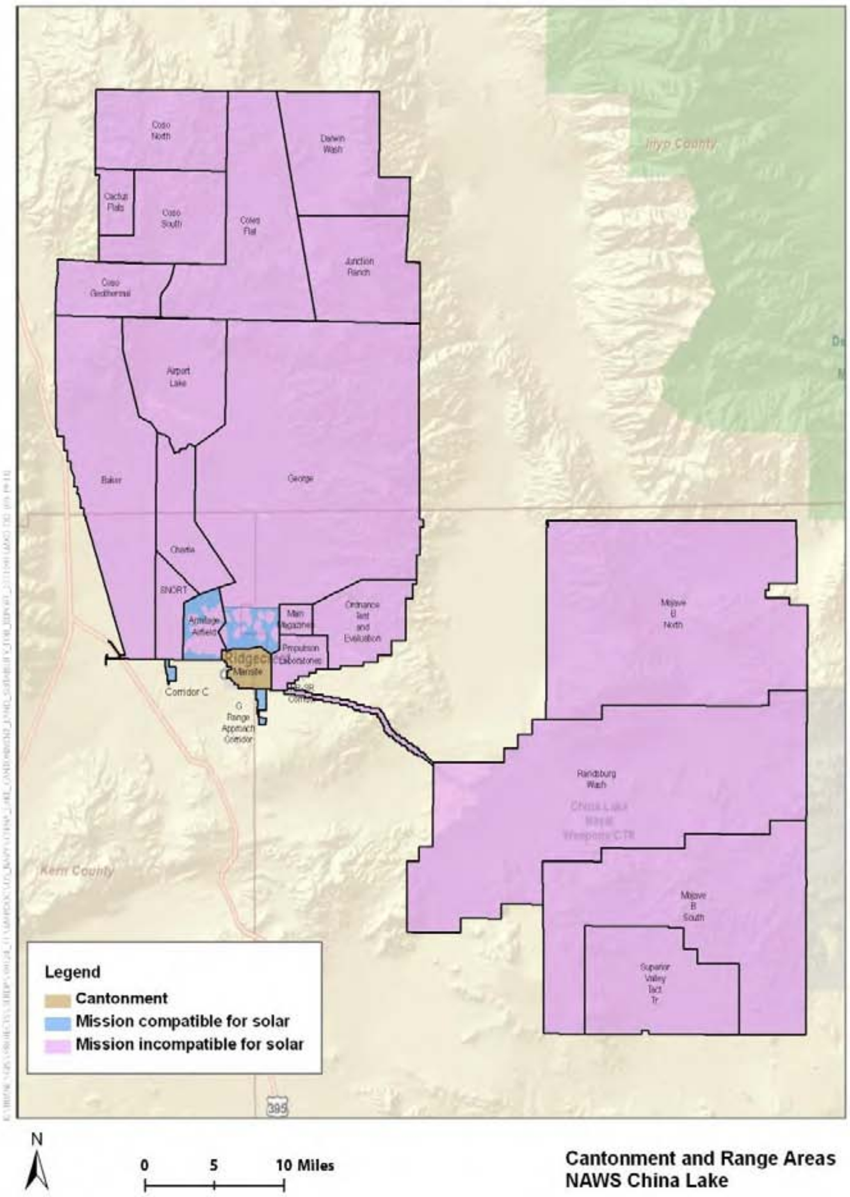


Figure ES.4 – Mission Compatibility at NAWS China Lake

However, as show in Figure ES.5, even the relatively small area surviving this screening process still has significant solar potential.

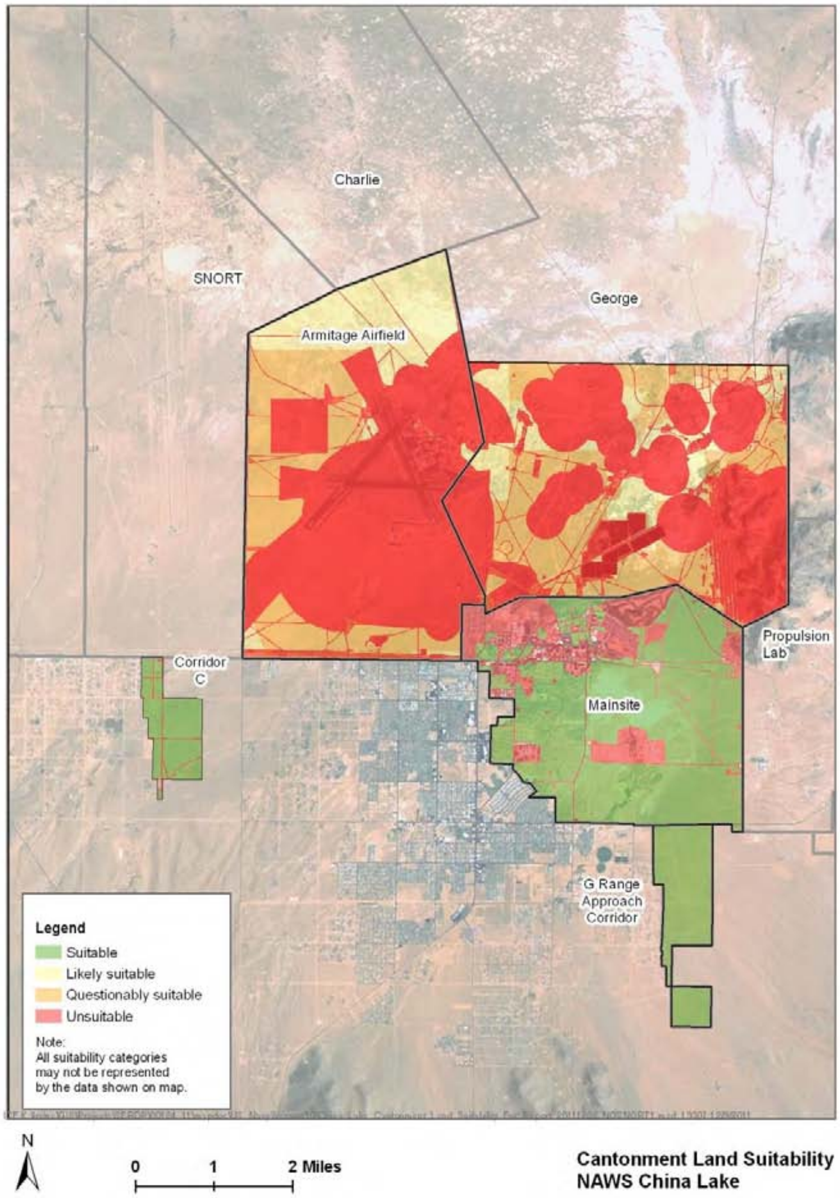


Figure ES.5 – Solar Suitability at NAWS China Lake

The geographic analysis calculated the acres of roof, parking, and ground sites that are suitable for solar development on each installation. Table ES.4 presents the total number of acres for each military installation that passed all the screening variables resulting in a ―suitable” rating (suitability score = 1) for solar development for each type of solar site.

Table ES.4 – Acres Suitable for Solar Development (Suitability Score = 1 after minimum parcel size test)								
Military Installation	**(A) Rooftop (acres)**	**(B) Paved Parking (acres)**	**(C) Unpaved Parking (acres)**	**(D)= (B)+(C) Subtotal – All (Paved & Unpaved) Parking (acres)**	**(E) Canton-ment Ground Sites (acres)**	**(F) Range Ground Sites (acres)**	**(G)= (E)+(F) Subtotal – All Ground Sites (acres)**	**(A) + (D) + (G) All Site Types (acres)**
MCAGCC Twentynine Palms	8	110	N/A	110	461	0	461	579
MCLB Barstow	13	17	2	19	660	0	660	692
NAWS China Lake	3	43	N/A	43	3,930	1,339	5,269	5,315
Chocolate Mountain AGR	N/A	N/A	N/A	N/A	N/A	3,768	3,768	3,768
NAF El Centro	0	14	N/A	14	377	0	377	391
Edwards AFB	17	104	38	142	6	1,760	1,766	1,925
Fort Irwin	4	121	230	351	5,757	12,091	17,848	18,203
Total Acres of All Installations by Solar Site Type	**45**	**409**	**270**	**679**	**6,140**	**18,958**	**30,149**	**30,873**

N/A = Not applicable (i.e., the site type is not present at the installation)

The 30,873 acres found to be ―suitable" for solar development represented about 1% of the surface area of the seven California installations. Additional areas – rated as ―likely suitable" (23,389 acres all seven California installations) and ―questionably suitable" (77,485 acres) were also identified at each installation; these represented a further 3% of the surface area of the installations.[2] The other 96% of the surface area was found to be unsuitable due to mission incompatibility, biological resource conflicts, excessive slope, cultural resource conflicts, and many other reasons.

Key implications of the solar geographic analysis

- The ranges of most installations were deemed ―unsuitable" because of conflicts with military mission activities, as detailed in the chapter on Mission Compatibility.
- The GIS modeling results indicated that solar development potential exists within or adjacent to nearly all installation cantonment areas.
- Even though extensive range areas were found to be unsuitable, there were still substantial areas suitable for ground-mounted solar development in other range areas and in installation cantonments.
- Rooftop installations are familiar, economically-viable, and seen by many people, but ground sites offer the vast majority of the acreage available for solar development.

[2] Only 25% of the ―likely suitable" and ―questionably suitable" areas were carried forward into subsequent analytical steps, to account for the probability that much of this area would be found to be unsuitable during on-the-ground investigations.

Technological Analysis

The second step – **technological** analysis – defined the characteristics for each of six solar technology packages on areas that survived the geographic screening process. These packages included crystalline PV, thin film PV, solar trough and Dish/Stirling engine technology. The technological analysis calculated the maximum ―technical potential” for solar electricity on each site – i.e., the potential, in capacity and annual electricity output, for solar development unconstrained by project economics.

Economic Analysis

The capacity and output results from the technological analysis was then passed on to last step in the analytic process – **economic analysis.** The heart of the economic analysis was a financial model that calculated the 20-year investment returns for each potential solar project under private or military ownership. The analysis assumed that all construction would occur in 2015 (to allow the DoD sufficient time to complete program planning, site studies and procurement actions), and that PV prices would fall approximately 20% from their Spring 2011 levels. Concentrating solar technology prices in 2015 were assumed to remain level with 2011 prices.

The model included a wide range of other cost inputs:

- Capital costs (e.g., panels, racking, trackers, balance of system, installation labor)
- Running costs (e.g., O&M labor, insurance, inverter replacement accrual, decommissioning accrual)
- Water cost (for concentrating solar power plants only)
- Land lease rates for 3rd party owned projects
- Transmission extension costs

The following revenue and tax-related incentives were included in the model:

- Electricity prices (20-year wholesale and self-generation projection)
- Renewable Energy Certificate (REC) prices (20-year projection)
- Solar incentives taken by private developers (which are not available if funded by MILCON)
    - Business Investment Tax Credit (30% of installed cost)
    - Modified Accelerated Cost Recovery System (MACRS) Depreciation

The 20-year discounted cash-flow model calculated the Net Present Value (NPV) and Internal Rate of Return (IRR) for each technology on each parcel of land for which it was technically suitable. Those ―projects” whose IRRs exceeded the investor's discount rate were deemed financially feasible.

Table ES.5 shows the results of the economic analysis by military installation for the five site types using a private project ownership model. (The economic analysis found that no solar energy projects would be economically-viable under military ownership, which demonstrates the importance of the many tax-based incentives for solar energy development that private developers can utilize and the dependence that the DoD will have on those incentives if it wishes to achieve favorable rates of return from solar projects on its installations.)

Table ES.5 – Capacity of Solar Technology with Highest IRR for Economically-Viable Solar Development Sites, under Private Project Ownership (MW_{AC} in Installed Solar Capacity)

Military Installation	Cantonment Ground Sites[3]	Range Ground Sites	Building Roofs[4]	Paved Parking Canopies	Unpaved Parking Canopies	Total (All Site Types)
MCAGCC Twentynine Palms	77	0	3	0	N/A	**80**
MCLB Barstow	0	0	5	0	0	**5**
NAWS China Lake	557	403	1	0	N/A	**961**
Chocolate Mountain AGR	N/A	0	N/A	N/A	N/A	**0**
NAF El Centro	0	0	N/A	0	N/A	**0**
Edwards AFB	134	3,347	7	0	0	**3,488**
Fort Irwin	808	1,821	1	0	0	**2,630**
Total	**942**	**5,571**	**17**	**0**	**0**	**7,164**

Table ES.6 shows the significant difference in the economic viability between solar energy technologies assessed in the study. While fixed-mount crystalline silicon PV resulted in the most MW of economically-viable installed capacity, single-axis tracking crystalline silicon PV had the highest overall internal rate of return (IRR) among the six solar technologies evaluated on ground sites. In comparison, the economic viability of concentrating solar power (CSP) technologies was limited, because of higher installation costs, fewer parcels of land within the military installations that met the size, shape, and continuity requirements for these technologies, and special mission conflicts for Dish/Stirling technology at one installation.

[3] Crystalline-silicon PV on single-axis tracking had the highest overall internal rate of return (IRR) among the six solar technologies evaluated on large ground sites. Crystalline-silicon tracking capacity results are reported uniformly in this table for economically-viable sites. However, there was one site at which a different technology had the highest IRR – at the NASA Goldstone range at Fort Irwin, thin-film tracking had a slightly higher IRR than crystalline-tracking and the highest IRR among the three technologies that were economically-viable on the Goldstone range.

[4] Crystalline-silicon PV fixed-axis had the higher internal rate of return among the two solar technologies evaluated on building roofs.

Table ES.6 – Capacity for Economically-Viable Solar Development Across Installations, by Solar Technology under Private Project Ownership (MW_{AC})						
	PV Technologies				CSP Technologies	
Military Installation	Crystalline-Silicon Fixed-Mount	Thin-Film Fixed-Mount	Crystalline-Silicon Tracking	Thin-Film Tracking	Dish/Stirling	Trough
MCAGCC Twentynine Palms	116	72	77	49	88	0
MCLB Barstow	5	3	0	0	0	0
NAWS China Lake	1,452	901	960	602	0	0
Chocolate Mountain AGR	0	0	0	0	0	0
NAF El Centro	0	0	0	0	0	0
Edwards AFB	5,308	3,295	3,481	2,184	0	0
Fort Irwin	3,930	1	2,629	1,144	0	0
Total	**10,811**	**4,272**	**7,147**	**3,979**	**88**	**0**

The key implications of the economic analysis include:

- Large ground sites on the installations in California are economically viable for PV technologies. Depending on installation specifics, solar development potential may exist in an installation's cantonment and/or range areas.
- Solar development on building roof sites is economically viable, but cannot make a large-scale contribution to the installations' utility scale solar development compared with ground sites.
- Solar development opportunities on paved and unpaved parking facilities at installations are significant, but their economics are currently poor due to the added cost of metal parking canopies.
- Crystalline-silicon PV with single-axis tracking is the solar technology with the highest projected investment returns in the study, due to its combination of low cost of installation and high electricity output. The other PV technology packages analyzed also generate attractive financial returns on many large ground sites.
- The CSP technologies studied were not economically viable in most cases due to their higher installed costs, though great uncertainty exists about present and future CSP costs due to the scarcity of recent CSP projects in the U.S.
- Only privately developed projects were economically viable. Projects funded by the government (e.g., using military construction funds) were not viable, given the current costs of the technology and the tax-based nature of federal solar incentives.

ES.5 Energy Security

Energy security for the DoD means having assured access to reliable supplies of energy and the ability to protect and deliver sufficient energy to meet operational needs. Solar energy can potentially address one key facet of the energy security question: an installation's vulnerability to disruptions of the public electricity grid that powers the installation.

Currently, the DoD relies on individual diesel generators tied to individual critical loads to insure power in case of a grid outage. As the DoD moves toward using secure micro-grids to meet energy security needs, solar power on the installations can play an increasingly important role. Due to the intermittent nature of solar it is unlikely to provide 100% of the required energy and will require energy storage to fully integrate into a micro-grid. The cost and value of solar energy to meet DoD's installation energy security needs is sensitive to individual installation requirements, the future costs of energy storage, and the design and value of the required micro-grid.

ES.6 Solar Development Context

Solar development on the nine DoD installations addressed by this study is governed by a complex web of laws, regulations, and market rules, administered by public and quasi-public entities at the Federal, State, and local levels. Few if any of these rules were designed with solar in mind; several were promulgated long before solar energy began its real penetration in the marketplace in the past 10 years. DoD staff and the private developers they increasingly work with need to fully understand these rules to avoid or mitigate policy barriers and to maximize the benefit of any available incentives.

The Federal Government has challenging goals for renewable energy development on DoD installations. In addition, Federal and state governments created a number of incentives for the development of solar energy. These incentives can reduce the installed cost of a solar energy facility by half or more depending upon the size and location of the facility. In addition, the DoD has more flexibility than other Federal agencies to enter into long-term contracts with third-parties; under these contracts, the third-party developer builds, owns, and operates the solar facility, and the DoD purchases the electricity generated by the solar facility and/or leases the DoD land used for solar development. However, a number of challenges to large-scale solar development on Federal lands exist, most notably the lack of transmission capacity in the Mojave and Colorado Deserts.

A second challenge is the uncertainty related to developing solar projects on withdrawn lands within the boundaries of the nine installations (see Table ES.7). These lands are part of the public domain supervised by the Bureau of Land Management (BLM), but have been withdrawn from the operation of public land laws to serve military mission needs. There is disagreement among the DoD, the Services, and the BLM regarding which organization has the lead for authorizing and managing renewable energy development on withdrawn lands; this creates uncertainty in the development process and leaves private-sector developers unclear as to who their counterparty is.

In addition, the large footprint of utility-scale solar energy facilities means that ground-mounted systems must be individually reviewed to determine their impact on biological, cultural, and visual resources and a wide variety of construction, interconnection, and other permits must be acquired before a potential solar development can move forward. Finally, there is inconsistency within the DoD, and between the DoD and other Federal agencies, in how certain laws, mandates, and processes should be applied; these inconsistencies slow the solar development process and create uncertainty for private sector solar developers.

Table ES.7 – Withdrawn Lands[5]			
Base	**Acres Withdrawn**	**Total Acres**	**Withdrawn %**
Edwards AFB	83,110	308,123	27%
Fort Irwin	725,062	754,134	96%
China Lake	1,108,956	1,108,956	100%
Chocolate Mtn.	226,711	463,623	49%
El Centro	47,870	56,289	85%
29 Palms	472,649	595,578	79%
MCLB Barstow	3,683	6,176	60%
Nellis AFB	10,290	14,000	74%
Nevada T&TR	2,919,890	2,919,890	100%
Creech AFB	2,940	2,940	100%
Total	5,601,161	6,229,709	90%

Source: (Pease, 2011)

ES.7 Conclusions and Recommendations

The study quantifies the technically feasible and economically viable solar potential on several DoD installations. This potential can be harnessed without impact on mission performance and can result in substantial value delivery to the DoD. However, to realize this opportunity, the DoD would need to develop a thoughtful program, with the necessary funding, leadership support, and capacity building to see it to fruition. The following actions may improve the opportunities to develop solar energy in a manner consistent with the military mission:

1. **Clarify withdrawn lands policy with the Department of the Interior (DOI)**
   Withdrawn lands make up the majority of the lands within the boundaries of the nine installations considered in this study, and resolving their status and potential use in third-party financed projects with the DOI is critical if the DoD intends to develop utility-scale solar energy projects.

2. **Work with stakeholders to accelerate transmission development**
   The lack of transmission capacity is the single largest barrier to large-scale solar development on the seven California installations. The DoD and the many other stakeholders affected by this constraint could increase their efforts to encourage transmission owners and planners to expand capacity on existing transmission lines and expedite the necessary transmission build-out.

3. **Clarify DoD policy on REC ownership and accounting**
   In the third-party finance model that will likely dominate renewable energy development on military installations, it is the developer, not the installation that is the initial owner of any RECs arising from a project. While an added expense, the DoD will likely have to

[5] The withdrawn land acreage figures reported in this table are currently under review by the DoD/DOI Interagency Land Use Coordinating Committee and should be considered preliminary data only. For example, other sources indicate that 8% of China Lake is DoD fee land and 92% is withdrawn land.

join the larger renewable energy market in retaining or purchasing RECs in order to make progress towards complying with its renewable energy mandates and goals.

4 Clarify and develop programs to achieve energy security goals
The DoD should continue to demonstrate secure micro-grid technologies on military installations. The DoD could also develop guidance about what types of energy security challenges military installations need to be prepared to overcome, the types of actions that can be taken to improve energy security, and the ―price" or value that could be assigned to energy security benefits in the investment process so that the DoD can launch targeted programs to address its energy security needs.

5 Increase coordination and integration of renewable energy projects and initiatives between military installations and Services
The DoD should consider making a greater effort to keep energy managers and other key personnel involved in renewable energy project planning at each military installation informed about the efforts, initiatives, and lessons learned by other military installations and Services. This could be one element of a broader effort to build renewable energy analysis and development capacity at the installation and support organization levels. As part of this activity, the DoD could also identify and work to address the inconsistent interpretation of goals, rules, and procedures that currently exists across installations and Services.

6 Develop a consistent and incentive-focused formula to allocate project benefits and costs between the host installation and parent organizations
Providing clear incentives for military installations to invest the considerable time and effort required to host renewable energy projects will likely generate increased interest and support from military installation staff.

7 Work with BLM to ensure that the Federal Government is maximizing its compensation from land rentals consistent with fair market value while allowing solar developers to make an attractive rate of return
BLM's solar land lease rates could increase substantially and still provide an attractive rate of return for private developers under the study's assumptions. The DoD should consider working with BLM to evaluate whether Federal compensation could be re-calibrated under the BLM's solar rental formula to continue to capture fair market value for the Federal Government against the backdrop of rapidly-changing and regionally-variable solar economics. The DoD and BLM should maintain a cooperative approach so that private solar developers won't have an incentive to work with one agency over the other because of more attractive land rental rates.

8 **Develop and apply a consistent methodology for mission compatibility analysis within DoD installations, and analyze DoD lands in advance of programmatic scale-up**
―Conflicts with mission performance" was the single most important factor limiting the potential for solar development across the nine installations evaluated. This study relied on discussions with range operators and training managers for most of the mission

compatibility analysis. Because the results relied, to a great degree, on the best professional judgment of range management staff, they were non-reproducible and difficult to generalize to other installations or to communicate to the solar development community. In the future, the DoD should consider developing a mission compatibility assessment methodology that can be applied within its own installations to address the full range of renewable energy technologies and the full range of mission activities. Developing this methodology will require coordination of representative installation-level staff; managers in the Service-level range management offices; OSD's Training, Readiness, Test and Evaluation offices; OSD's Facilities Energy office; as well as the existing DoD Siting Clearinghouse.

The steps listed above may greatly improve the implementation environment for solar energy on DoD lands. The results of the study's Solar Potential Assessment provide a useful starting point from which each installation can identify high priority areas for further investigation. Private developers could respond to competitive solicitations to conduct the necessary due diligence and to offer the DoD some combination of rental payments, discounted power, in-kind consideration, and/or energy security capability in return for access to these lands.

It is clear that solar developers are highly motivated to develop projects under present conditions, and those conditions are only expected to improve through 2016 as solar prices continue their expected decline. However, at the end of 2016 the most important solar tax incentive will decrease by two thirds. The DoD is in the position to take advantage of the value offered during this 5-year window. It will take time to address the preparatory steps suggested above and to create and launch a focused solar development program. By pursuing these challenging opportunities, the DoD may be able to take advantage of solar resources on military installations in a manner consistent with the military mission.

1 Introduction

This study was written in response to the FY 2010 Congressional direction to conduct an ―Alternative Energy Study” to review current solar development activities and to evaluate the potential for solar energy development inside the boundaries of nine large military installations located in the Mojave and Colorado Deserts of southern California and Nevada. In addition to assessing the solar energy potential of the military installations, this report also discusses the potential mission compatibility and energy security impacts of on-installation solar energy development and the broader context for solar energy development in the Mojave and Colorado Deserts.

The study addresses the following issues:

- evaluate the technical and economic feasibility of locating solar energy generation within the identified military installations and identify potential areas for solar energy development;
- evaluate limitations on the use of solar energy because of military mission, environmental, and jurisdictional constraints; and,
- analyze the feasibility and potential for on-installation solar energy generation to provide additional security benefits for the military installations.

Chapter 2, Geographic Setting Characterization provides a geographic overview of the Mojave and Colorado Desert regions followed by a discussion of the area's legal regime and primary land uses. Chapter 3, Mission Compatibility, reviews the various ways that solar projects and military mission activities can conflict. Chapter 4, Technology Characterization, provides a technical description of major existing concentrating solar power and PV technologies, including a discussion of important system components and efficiencies. Chapter 5, Solar Potential Assessment, describes the analytic process employed to determine how much solar generation could be developed on military installations in the Southern California Deserts, given real world technical and economic constraints. Chapter 6, Energy Security, reviews the range of issues to be considered in evaluating installation-level energy security risks and solutions, and describes technologies that can provide on-installation energy security. The chapter concludes with a description of options for the use of diesel generators and large-scale solar located on a microgrid-equipped installation. Chapter 7, Solar Development Context, addresses federally-mandated renewable energy goals that are a major driver for solar development on DoD installations, followed by a review of the principal challenges confronting large-scale solar development. Finally, Chapter 8 provides a summary of conclusions and recommendations, including key findings, and recommended policy and programmatic actions.

Solar energy development can be a complex undertaking in any setting, affected as it is by an evolving policy framework, a geographically-varied economic environment, a dynamic technology market, and a range of motivations for installing the technology. Solar development is even more complex within a military installation, where preservation of mission capability is the paramount consideration, and where solar projects must be implemented within an intricate framework of Federal, DoD, and Service rules and requirements.

This report demonstrates that there is significant potential to develop solar energy on the nine installations with no capital investment by the DoD and without impinging upon mission performance. Doing so would create considerable value for the installations, Services, DoD, and the country as a whole.

2 Geographic Setting Characterization

2.1 General Characteristics

The Mojave and Colorado Desert habitats are home to a wide variety of resources and biological communities, which are under increasing pressure by the growing number of stakeholders in the area. This chapter provides a geographic overview of the Mojave and Colorado Desert regions followed by discussions of the area's legal regime and primary land uses.

2.1.1 Mojave Desert

The Mojave Desert covers over 32 million acres, extending from southern California and Nevada into Utah and Arizona. Approximately 20 million acres of the Mojave lie in California, comprising approximately one-fifth of the state (CDFG, 2011), and approximately 6.5 million acres of the Mojave lie in Nevada. Military installations located in the Mojave include Creech AFB, NAWS China Lake, Fort Irwin, Edwards AFB, MCAGCC Twentynine Palms, Nellis AFB, and MCLB Barstow. The Mojave is a rain shadow desert, meaning that it was formed because California's major mountain axis, which bounds the desert in the west, prevents moisture-rich clouds from the Pacific Ocean from reaching the protected eastern side of the range. As air rises over the range, water is precipitated, and the air loses its moisture content, resulting in a desert on the leeward side of the mountains (USGS, 1997). The desert extends north from the northern boundary of the Colorado Desert in California along the eastern face of California's major mountain axis (e.g. the Sierra Nevada, San Bernardino, and San Gabriel Mountains) to the Owens Valley, where it meets the Great Basin Desert to the north. The Mojave's northern boundary winds its way through a succession of desert basins and mountain ranges to the east, where it meets an abrupt boundary with the Colorado Plateau and Apache Highland eco-regions of Utah, Nevada, and Arizona (see Figure 2.1) (CalPIF, 2009).

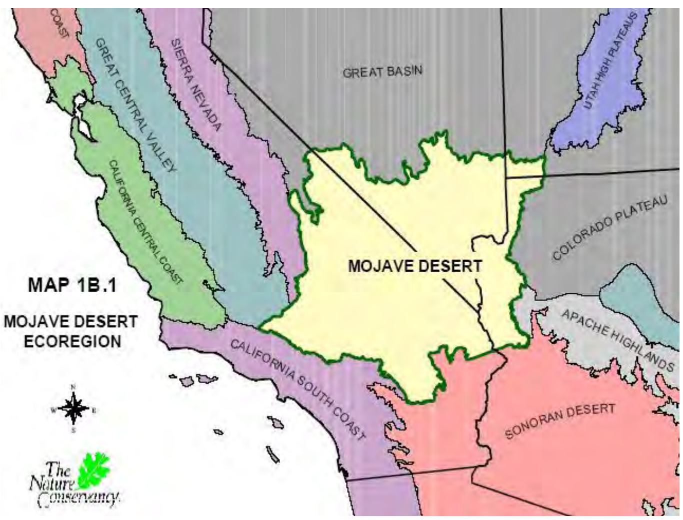


Figure 2.1 – Mojave Desert Eco-region (CalPIF, 2009)

The Mojave exhibits a wide variety of topography, with elevations ranging from 280 feet below sea level in Death Valley to approximately 11,000 feet above sea level in the Panamint Mountains (CDFG, 2011). The Mojave experiences a wide range of temperatures: the temperature in Death Valley can exceed 130° F (54° C) in late July and early August while temperatures may drop as low as 0° F (-18° C) at higher elevations (Randall et al. 2010). Precipitation in the desert is typically between 65 and 190 mm (2.5 – 7.5 inches) annually, most of which falls during the winter season. Snow is not uncommon in the Mojave during the winter. Precipitation levels vary depending on topography and elevation (USGS, 2006).

2.1.2 Colorado Desert

The Colorado Desert, one of the six sub-sections of the Sonoran Desert, spans approximately seven million acres in southeastern California (see Figure 2.2). The Colorado Desert is also a rain shadow desert, extending from the Peninsular mountain range in the west to the Colorado River in the east (CDFG 2011a). It extends south of the US-Mexican border and extends north to the Mojave Desert. Military installations in the Colorado Desert include Chocolate Mtn. AGR and NAF El Centro.

The majority of the Desert lies at a relatively low elevation (below 1,000 feet) with the lowest point of the desert floor at approximately 275 feet below sea level in the Salton Trough. Most of the region's mountains do not exceed 3,000 feet, although the highest peaks of the Peninsular Range (along the western border of the desert) can reach approximately 10,000 feet. (CalPIF, 2009). Summer daily high temperatures in the Colorado Desert are regularly above 104° F (40° C). The winter season is cooler, with daily high temperatures averaging around 72° F (22° C) and nighttime lows reaching approximately 41° F (5° C). Sub-freezing temperatures are uncommon and snow is very rare (Michaelsen, 2009). The Colorado Desert has two rainy seasons per year (winter and late summer) as opposed to the Mojave, which for the most part only experiences winter rains. The majority of the Colorado Desert's annual precipitation comes from sporadic winter storms that are strong enough to overcome the mountain ranges to the west, but it also receives occasional bouts of monsoonal moisture in the summer from the southeast (CalPIF, 2009). Annual rainfall amounts range from 2-6 inches (USDA, 2011).

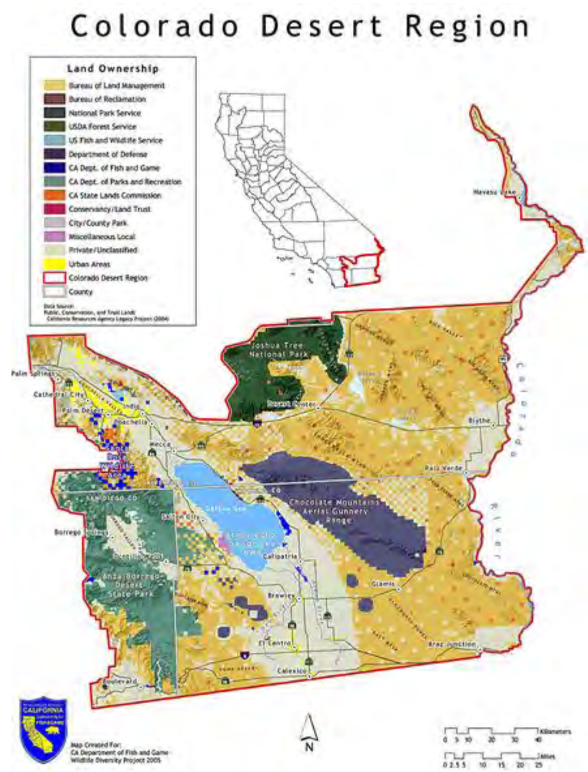


Figure 2.2 – Colorado Desert boundaries and land ownership distribution (CADFG, 2011a)

2.1.3 Desert Habitats

Mojave and Colorado Desert habitats are home to a wide variety of plant life and habitat types. The Mojave Desert eco-region contains approximately 230 special status plant species[6], the majority of which are endemic to the region (Randal et al., 2010). Creosote Bush Scrub is the most extensive cover type, covering approximately 57% of the land surface (Thomas et al., 2004). There are relatively few tree-dominated communities in the region with the exception of

[6] Special status plant species are those plants found on public lands administered by BLM and determined to be either (a) federal endangered, threatened, or proposed plants, or (b) BLM sensitive plants, which have been listed by the BLM State Director for special management consideration (BLM, 2010d).

the Joshua tree. The Joshua tree occurs in approximately 15% of the Desert and is rated as ―very threatened" by the California Department of Fish and Game's (CDFG) Natural Heritage Division (Randall et al., 2010). Small patches of pinyon-juniper woodland habitats also occur in the Mojave Desert, covering approximately 2% of the region (Thomas et al., 2004).

The Colorado Desert's terrestrial habitats include creosote bush scrub; mixed scrub (including yucca and cholla cactus); desert saltbush; sandy soil grasslands; and desert dunes. Higher elevations are dominated by pinyon pines and California juniper, and in the southern portion of the desert, additional moisture from summer rainfall supports smoketree, ironwood, and palo verde trees. In this Desert's arid environment, aquatic and wetland habitats (such as alluvial fans, desert washes, freshwater marshes, streams, and desert riparian vegetation communities) are limited in extent but critically important to wildlife.

Below are descriptions of common and notable habitats found in the Mojave and Colorado Deserts:

Desert Riparian

Desert Riparian habitats are located adjacent to permanent surface water (e.g. rivers, streams, seeps, and springs) in the Mojave and Colorado Deserts. These habitats are generally found at elevations below 3,000 feet and are characterized by dense groves of low, shrub-like trees or tall shrubs. They are composed of overstory species such as tamarisk and willows and a sub-canopy with species such as desert lavender and seep willow. There is often an abrupt transition between these habitats and the more open desert habitats (e.g., desert wash and desert cactus scrub). Given the desert's generally arid conditions, desert riparian habitat is of utmost importance to wildlife populations, and serves as important lay-over spots for migratory birds. With the exception of some palm oasis habitats, these habitats support more bird species at greater densities than other desert habitats (NDOW, 2006).

Creosote Bush Scrub

Creosote bush scrub, an ecological system also referred to as warm desert scrub, is characterized by low-lying expanses and widely spaced shrubs with bare ground in between. Growth in this habitat occurs during the spring if rainfall is sufficient. Growth is prevented by cold weather in the winter and by drought in other seasons (Holland, 1986). Creosote bush scrub is home to the threatened desert tortoise, which digs burrows in the sandy, well-drained soils (NDOW, 2006).

Desert Dunes

Prevailing winds carry sands from dry lakes and other areas in desert sinks and washes to form desert dune habitats. Sand dunes can rise up to 800 feet in height. Sand dunes may appear to be barren, but they support a variety of plant and wildlife species, including evening primrose, kangaroo rats, kit foxes, and the Mojave fringe-toed lizard (Feller, 2011).

Joshua Tree Woodland

Joshua tree woodland is associated only with the Mojave Desert and is especially prominent in the Joshua Tree National Monument area. The Joshua tree, a species of yucca that may grow up to 50 feet tall, is commonly found in flat and gradually sloping areas. Joshua trees support a range of wildlife species, such as the Scott's oriole, the American kestrel, and the desert night lizard, which lives in decaying plant matter, such as downed Joshua trees (Feller, 2011).

Desert Fan Palm Oasis
Desert fan palm oases are rare ecological communities located predominantly in the Colorado Desert region. Palm oasis habitats generally occupy sites with permanent water sources (e.g., seeps, springs, and streams) and may be found next to desert riparian and desert wash habitats. The largest desert fan palm oases are along permanent streams or at large springs. Palm oases are also located on hillsides or in canyons. Many sites are adjacent to earthquake faults, especially along the San Andreas Fault, where underground water frequently emerges. This habitat provides unique islands of shade, moisture, vegetation in an otherwise arid and sparse landscape. Therefore, many wildlife species (e.g. bighorn sheep) inhabit palm oases (CDFG, 2011).

Desert Wash
Desert wash habitats form when water flows intermittently after heavy rains, especially late summer thunderstorms. Desert wash soils tend to be sandy to gravelly. Plant life is typically lush and deep-rooted, ranging from catclaw acacia and four-wing saltbush to taller desert willow and cottonwood trees. Washes attract many birds (e.g. migratory finches and tanagers), mammals (e.g. blacktail jackrabbit) and other wildlife (e.g. red-spotted toad, desert tortoise) (Baxter, 1988; Laudenslayer, 2011).

2.1.4 Prominent Ecological Features

Ecological features found throughout the Mojave and Colorado Deserts, both on and off-installation, include desert pavement, underground water stores, and dry lakes. These prominent features are described below.

Desert Pavement
Desert pavement is a surface armor that forms on the ground in hot desert environments, such as those covering the Colorado and Mojave Deserts. Desert pavements generally consist of a thin layer of densely packed, angular to sub-rounded coarse rock fragments overlying a soft, silty layer, commonly referred to as a vesicular horizon (Webb et al., 2009). They typically occur on surfaces with very little relief and lie above a layer of well developed soil; their exposed surface is often characterized by a dark and shiny coating or varnish of minerals (e.g., iron oxide) and organic carbon (McFadden et al., 1987). Desert pavements are less susceptible to disturbance than biological soil crusts, but both plant growth (especially perennial shrubs) and burrowing by rodents can cause disruption of pavement development (Quade, 2001). Human activities, such as military maneuvers and operation of tanks and other vehicles, can also disrupt desert pavement. Once disturbed, pavements lose their armoring function, and soil loss due to surface runoff or wind erosion becomes much more likely (Thomas et al., 2004).

Aquifers
Beneath the Mojave Desert is an extensive system of aquifers comprised of underground layers of unconsolidated, porous, or fractured rock capable of containing water. The water tables of these basin aquifers are often tapped for municipal, agricultural, and industrial use. Perched aquifers, which occur on hillsides above the regional water table, are primarily recharged by local rain and snow melt. These aquifers feed the natural springs and seeps in the mountains of

the deserts. Because the aquifers depend on local precipitation, the location of resulting springs and seeps may vary throughout the year, and from year to year. Summer monsoons are unpredictable, so late summer through mid-fall is usually the time of year with the least available surface water at desert springs and seeps. In years with winter droughts preceded by summers without monsoon rains, it is common for these ephemeral springs to dry up (NPS, 2011).

Dry Lakes

Numerous playa lakes, also referred to as dry lakes, are interspersed throughout the desert mountain ranges. Dry lakes form when water drains into basins with no outlet and then quickly evaporates under arid conditions. In wet years, some playas may hold standing water. In the more common drier periods, water that lies very near the surface of the playa is drawn upward by capillary action and then evaporates, leaving a white crust of evaporite minerals, such as sodium carbonate and sodium bicarbonate (USGS, 2004). There are a number of dry lakes located on Mojave and Colorado Desert installations, including:

- Rogers and Rosamond Lakes (Edwards AFB);
- Emerson, Mesquite, Dead Man's, Galway, Melville, Means, and Lavic Lakes (MCAGCC Twentynine Palms with proposed expansion);
- Goldstone, Red Pass, Nelson, Bicycle, Leach, and Drinkwater Lakes (Fort Irwin);
- China and Airport Lakes (NAWS China Lake); and
- Groom, Dog Bone, Mud, and Antelope Lakes (NTTR).

2.1.5 Cross-Cutting Ecological Issues

The Mojave and Colorado Deserts are characterized by several cross-cutting ecological issues, including wind erosion, invasive species, and habitat fragmentation. These issues have been exacerbated by the increased demand for land and resources in the area for urban development, military maneuvers, grazing, mining, recreation, and energy infrastructure development. Several of the primary regional issues are outlined below.

Human Soil Disturbance and Wind Erosion

As mentioned above, when desert pavement and other soil-stabilizing factors (e.g., rock cover and physical crusts) are disturbed by vehicles and the trampling effects of livestock and humans, the desert soils are highly vulnerable to wind erosion. Wind forces that exceed the ability of stabilizing factors to hold soil in place generate airborne dust. Once airborne, the soil becomes a non-point source of air pollution with potentially significant health effects. Deposition of this soil may also be problematic because it reduces the fertility of plants and contributes to sedimentation in surface water bodies (Belnap et al., 2007).

Habitat Fragmentation and Migration Corridor Disruption

Conservation efforts have helped to maintain habitat connectivity in the region, especially in the Mojave Desert, where private conservation organizations (e.g., the Conservation Fund, the Nature Conservancy, and Preserving Wild California) have worked to protect thousands of acres of essential habitat (CDFG, 2011c). Nonetheless, urban growth and resulting infrastructure development (e.g., power lines and road construction), off-highway vehicle (OHV) activity (which adds dirt roads and trails), and renewable energy development have all resulted in habitat fragmentation and migration corridor disruption in the region (CDFG, 2011c). The construction and expansion of military installation facilities as well as field training (including tank maneuvers and air-to-ground bombing) have also contributed to habitat fragmentation and corridor disruption (CDFG, 2011c). Bighorn sheep depend on established migration corridors between habitats with adequate water and protection. Disruption of these corridors can block access to these habitats and separate populations, which limits the potential for natural colonization and gene exchange and threatens the health of bighorn sheep populations (Wehausen, 2006). Habitat fragmentation has also been documented as posing a substantial threat to desert tortoise and Mohave ground squirrel populations (CDFG, 2011c).

Invasive species

At present, there are approximately 232 non-native taxa in the California deserts (Baldwin et al., 2002). The early proliferation of non-native species was associated with agriculture and grazing, which introduced non-native species such as tumbleweed and annual beard grass (Pavlik, 2008). Current human activities and land uses in the desert regions that can promote the invasion of non-native species include utility and transmission line access roads; mining; illegal dumping; grazing; and OHV activities that disturb soils. Additionally, non-native invasive plants have been associated with altered fire regimes on military installations in the region (SERDP, 2011).

Invasive plant species are common in desert wetland and riparian communities (approximately 20% of the plant species in territory along the Mojave River are non-native) (Dudley, 2009). The most damaging and widespread invasive in desert riparian habitats is tamarisk (also referred to as salt cedar), which is common along the Mojave and Amargosa rivers in the Mojave Desert (Dudley, 2009; Pavlik, 2008) and along the lower Colorado River (Pavlik, 2008). Tamarisk is extremely drought tolerant and is capable of explosive reproduction, which provides it a competitive advantage over many native riparian species such as cottonwoods and willows. Dense stands of tamarisk can exacerbate overbank flooding and erosion. Additionally, tamarisk sends it roots down into the water table, resulting in the extreme loss of water resources for native riparian species, and a reduction of the diversity and abundance of native wildlife (Dudley, 2009).

2.1.6 Species

While they appear to be barren, the Colorado and Mojave Deserts are home to a wide variety of wildlife, most of which exhibit morphological, physiological, or behavioral adaptations that allow them to survive hot, arid conditions. Over 439 vertebrate species inhabit the Mojave at some point in their life cycle (including 252 species of birds, 101 mammals, 57 reptiles, 10 amphibians, and 19 fish species), and over 481 vertebrate species inhabit the Colorado Desert at some point in their life (including 282 bird, 82 mammal, 66 reptile, 16 amphibian, and 35 fish species) (Randall et al., 2010; CDFG, 2011b). A major challenge for military installations has been to develop land management plans that protect the species inhabiting the installations while allowing for necessary missions and training activities. Of primary concern have been the sensitive and special status species that inhabit the installations (see Table 2.1 for installations where these endangered species may be found). This section describes several of these species as well as the impacts the military has had on the species.

Desert Tortoise (*Gopherus agassizii*)

The Desert Tortoise, which ranges in size from 2 to 15 inches in length, may be found in the Mojave and Sonoran Deserts in southwestern Utah, southern Nevada, southeastern California, and western Arizona at elevations ranging from sea level to approximately 3,500 feet (NFWO, 2011). The desert tortoise spends up to 95% of its life in underground burrows, which range from 18 inches to over 8 feet in length. Spring and summer burrows are much more shallow compared to winter burrows, which are usually located 2-3 feet below the surface (NFWO, 2011). The desert tortoise inhabits a variety of habitats but commonly lives on flats and alluvial fans, where soils are suitable for den construction (Baxter, 1988; BLM, 2007). Because the desert tortoise derives most of its water from the plants it eats, access to water resources is not essential. They depend on shrubs for shade and protection from predators such as ravens and coyotes, and their diet generally consists of wildflowers, grasses, and cacti. In the most densely populated areas, there may be 1 tortoise per 2.5 acres. However, densities are typically closer to 1 tortoise per 100 acres (NFWO, 2011).

Desert Tortoise
Image courtesy of the Los Angeles Times

The desert tortoise was listed as ―threatened" under the California Endangered Species Act (CESA) in 1989 and the Federal Endangered Species Act (FESA) in 1990 (BLM, 2007). The Bureau of Land Management (BLM) has since taken the lead role in tortoise habitat management, administering approximately 75% of the remaining high-quality desert tortoise habitat (Feller, 2011). The DoD and the military services have also actively participated in tortoise population management efforts. Primary threats to desert tortoises include lost, degraded, and fragmented habitat due to human activities (e.g., off-highway vehicles, military installation training, sheep and cattle grazing, and mining), and predation of young tortoises by ravens and coyotes. Additional threats include disease, fire, collection, poachers, mining, drought, and invasion of non-native grasses and weeds. Scientists suspect that there is not one threat that impacts tortoises more than another – it is an accumulation of threats that takes a toll on the population (NFWO, 2011).

Military Impact on the Desert Tortoise

Desert tortoises have been identified on numerous military installations, including Edwards AFB, Nellis AFB, Chocolate Mtn. AGR, Fort Irwin, NAWS China Lake, MCAGCC Twentynine Palms, and MCLB Barstow (Duncan, 2011). The decline of desert tortoise populations has been a continual challenge on military installations, where air-to-ground bombing, tank maneuvers, and explosives testing all cause significant habitat disturbance. Resulting changes in plant communities can adversely affect the desert tortoises. Noise from vehicles, military aircraft, and explosions may also damage their hearing (USFWS, 2010a). Military installations are required to employ ecosystem management principles and DoD installations in the western Mojave Desert initiated and continued many conservation programs for the desert tortoise, including creating on-installation protected lands for desert tortoise habitation. Additionally, the DoD has conducted numerous research projects on disease, predation, head starting (shown on the following page), and population monitoring and demographics, some of which have broad applications beyond military installation boundaries (Henen et al., 2011).

Juvenile Hatchery at Edwards Tortoise Study Site (JHETSS)
Image courtesy of Don Clark

Mohave Ground Squirrel (*Spermophilus mohavensis*)

The Mohave ground squirrel is found primarily in the western Mojave Desert. The species occupies desert scrub habitats in the eastern foothills of the Sierra Nevada up to 5,600 feet in elevation. Food resources and the existence of soils with good composition for burrow construction are the most important characteristics for ground squirrel habitats. Mohave ground squirrels often maintain several home burrows for use at night, as well as additional burrows used for temperature control and predator avoidance. Their burrows are typically constructed beneath large shrubs. In general, ground squirrel diet varies based on season and resource availability. However, it is primarily comprised of leaves and seeds from forbs and shrubs as well as the leaves, flowers, and seeds of annual wildflowers (Laabs, 2001).

The Mohave ground squirrel was listed as –threatened” under the CESA in 1998 but has been determined to not warrant a federal listing by the USFWS at this time. The primary threat to the Mohave ground squirrel is loss, degradation, and fragmentation of habitat. Causes of this degradation and fragmentation include urban/suburban development, off-highway vehicle use, agriculture, and livestock grazing. Military operations have also contributed to habitat degradation and fragmentation, especially in the area surrounding Fort Irwin. Additionally, energy development, including geothermal and solar energy development, has contributed to habitat loss for Mohave ground squirrel (Laabs, 2001).

Mohave ground squirrel
Image courtesy of Smithsonian

Military Impact on the Mohave Ground Squirrel

Mohave ground squirrels have been detected on several military installations in the Mojave region, including Fort Irwin, Edwards AFB, and NAWS China Lake (Duncan, 2011). Fort Irwin training areas encompass over 350,000 acres of ground squirrel habitat (Stewart 2005). Military maneuvers have been associated with ground squirrel deaths both directly and indirectly.

Additionally, fragmentation of ground squirrel habitat by military installations (e.g., Fort Irwin and NAWS) has been a subject of increasing concern for conservationists and government entities (i.e., the CDFG) (DMG, 2011). In an effort to mitigate the deleterious effects of installation vehicles and maneuvers, Edwards AFB has implemented an extensive ground squirrel monitoring program to document population distribution within the installation and has developed conservation plans for long-term protection of ground squirrel habitat (Leitner, 2008; DMG, 2011). Fort Irwin has also shown interest in conservation partnerships that will both protect ground squirrels and prevent future development encroachment that might restrict its training mission (Defenders of Wildlife, 2011).

Desert Cymopterus (*Cymopterus deserticola*)

Desert cymopterus is found in the western Mojave Desert within the BLM's Western Mojave Plan Area. An early-spring flowering, herbaceous perennial in the carrot family, desert cymopterus sprouts purple flowers in a clustered globe at the end of each leafless stalk (Bagley, 2011). The plant typically grows in the cool, moist weather conditions of winter and spring and flowers from March to early May. It then quickly dries out and goes dormant with the end of the rainy season and the onset of hotter summer weather around May. There is therefore a long period of dormancy when the plants are not visible above ground (Bagley, 2011).

Desert cymopterus is known to occur in deep, loose, well-drained soils of alluvial fans and basins, often in stabilized low sand dunes or sandy slopes. It also occurs in Mojave creosote bush scrub, desert saltbush scrub, and Joshua tree woodland with scrub understory (Bagley, 2011). The plant generally inhabits elevations of 2,000 to 3,000 feet. Threats to desert cymopterus are not well known but are thought to include sheep grazing and human land use disturbance activities (e.g. on and off-highway vehicles, urbanization, military operations, etc.) (Bagley, 2011). Desert cymopterus is currently designated as a Federal Species of Concern but the USFWS has determined that it does not warrant a FESA listing at this time.

Desert cymopterus plant
Image courtesy of Don Clark

Military Impact on the Desert Cymopterus

Desert Cymopterus has been identified at Edwards AFB, Fort Irwin, and NAWS China Lake (Duncan, 2011). Edwards AFB has taken the lead thus far in surveying desert cymopterus populations. Efforts to inventory the species on Edwards AFB have far exceeded off-base efforts. This is one explanation proposed for the skewed species population distribution – approximately 97% of reported desert cymopterus plants are known to occur on Edwards AFB, with 2% on private land and 1% on BLM land (Bagley, 2011).

Barstow Woolly Sunflower *(Eriophyllum mohavense)*

The Barstow woolly sunflower is endemic to the west-central portion of California's Mojave Desert, preferring sandy or rocky areas within chenopod scrub, Mojave desert scrub, and creosote bush scrub. It also occurs on desert playas (NatureServe, 2010). Barstow woolly sunflower is very small (0.4-1.0 inch) and tends to be clumped together. Once the flower goes to fruit around the month of May, it can be very difficult to detect, which may impact population records and estimates (NatureServe, 2010). This was evidenced in 1993, when the U.S. Fish and Wildlife Service (USFWS) determined that the proposal to list Barstow woolly sunflower as endangered or threatened may have been appropriate, but sufficient data on biological vulnerability and threats were not available to support a proposed rule (DRECP, 2011a).

Barstow Woolly Sunflower
Image courtesy of Bureau of Land Management

Threats to Barstow woolly sunflower include energy development, grazing, off-road vehicle use, highway and road improvements and other human activities, such as urban development (NatureServe, 2010; CNPS, 2011).

Military Impact on the Barstow Woolly Sunflower
Barstow woolly sunflower has been identified on Edwards AFB. The Edward's AFB Integrated Natural Resources Management plan establishes conservation areas for the sunflower (Edwards AFB, 2008).

Southwestern Willow Flycatcher *(Empidonax traillii extimus)*
Southwestern willow flycatcher is generally found in southern California, southern Nevada, southern Utah, Arizona, New Mexico, and southwestern Colorado. The southwestern willow flycatcher is rare in the Mojave and Colorado Desert regions and is generally restricted to lower elevation riparian habitats occurring along streams or wetlands. However, it does show some adaptability to occupy riparian habitats composed of either native broadleaf species, a mix of native and exotic species, or solely exotic species (DRECP, 2011c). Their diets therefore generally consist of bees, wasps, flies, leaf hoppers, and beetles, but may vary according to territory and prey availability.

The CDFG and USFWS listed the southwestern willow flycatcher as endangered in 1992 and 1995, respectively (OCWD, 2008). The USFWS also designated approximately 120,824 acres of critical habitat in 2005, including some areas of the Mojave Desert (USFWS, 2005). The primary threat to the southwestern willow flycatcher is loss, modification, and fragmentation of riparian habitat, which the species requires. Habitat disturbance has facilitated brood parasitism by the brown-headed cowbird, which can contribute to nest failure. Anthropogenic disturbances have also facilitated the invasion of tamarisk into riparian habitats. Because tamarisk is highly flammable, it poses a threat to the species' habitat (USFWS, 2002).

Southwestern Willow Flycatcher
Image courtesy of Arizona Game and Fish Department

Military Impact on the Southwestern Willow Flycatcher

The southwestern willow flycatcher has not been identified on any of the military installations in the Mojave and Colorado Desert regions (Duncan, 2011).

Nelson's Bighorn Sheep (*Ovis canadensis nelsoni*)

Nelson's Bighorn Sheep
Image courtesy of California Department of Fish and Game

Nelson's bighorn sheep (bighorn sheep) occurs in the desert mountain ranges of the Colorado and Mojave Deserts. Critical habitat has been designated for the Peninsular bighorn sheep, a distinct population segment in the Peninsular Ranges of southern California, and Nelson's bighorn sheep is fully protected within the western Mojave Planning Area (DRECP, 2011b). Bighorn sheep are generalist foragers and feed on a wide variety of plant species, and diet composition may vary with season and location (Wehausen, 2006). Although bighorn sheep have a large range, individual sub-populations may be widely scattered and discrete from one another. Bighorn sheep require specific habitat characteristics in terms of topography, visibility, forage resources, and water availability. They generally inhabit palm oases, desert riparian, desert scrub, pinyon-juniper woodland, and perennial grassland habitats (Zeiner et al. 1990; Wehausen 2006). They do not migrate regionally, but bighorn sheep depend on local migration corridors between areas with adequate water, which they inhabit during the summer months, and alternative habitats, to which they venture in the cooler, wetter season (DRECP, 2011b).

A broad survey by the CDFG indicates a stable bighorn sheep population overall, but local populations have shown more variability with some in decline (DRECP, 2011b). Nelson's bighorn sheep are threatened by loss and fragmentation of important habitats as well as disruption of migration corridors, disease, drought, and other negative human interactions. Historically, disease contracted from domestic sheep has been a significant factor in population declines (Wehausen, 2006). Negative human interactions are also an increasing threat to Nelson's bighorn sheep populations. Urban development and fencing along highways cause habitat loss, fragmentation, and the disruption of local migration. These physical obstacles limit the potential for natural colonization of vacant areas and contribute to reduced genetic diversity (CDFG, 2010a). Additionally, on and off-road vehicle and aircraft activities (both military and non-military) can affect bighorn behavior by disrupting foraging and use of important areas (e.g. water sources, lambing areas, and traditional migration corridors).

Military Impact on Nelson's Bighorn Sheep

The majority of bighorn sheep herds are located on military installations, especially NAWS China Lake and MCAGCC Twentynine Palms. Therefore, as urban and rural development, road construction, disease, and mining all pressure bighorn sheep populations, conservation and management plans on these installations are increasingly important to species survival (BLM, 2005).

Flat-tailed Horned Lizard *(Phrynosoma mcallii)*
The flat-tailed horned lizard is generally found south of the Coachella Valley into Baja California. Flat-tailed horned lizard ranges from Anza-Borrego Desert State Park in the west through the lower Colorado Desert in Arizona. The flat-tailed horned lizard has one of the most restricted ranges of all North American horned lizards. It inhabits the hottest, most barren areas of the Sonoran Desert, such as stabilized sand dunes and creosote bush scrub, and is found at elevations ranging from below sea level to approximately 820 feet above sea level. During the winter months (mid-October to mid-February), the flat-tailed horned lizard hibernates in burrows approximately 2-5 inches below the surface (DRECP, 2011d). It feeds almost exclusively on harvester ants but will eat small beetles, caterpillars, or termites if necessary (FTHL ICC 2003).

Flat-Tailed Horned Lizard
Image courtesy of Endangered Species Law & Policy

There are three discrete populations of the flat-tailed horned lizard in California, which are located in the Coachella Valley, the west side of the Salton Sea, and the east side of the Imperial Valley (NatureServe, 2010). Major threats to the species include: agricultural development, urbanization, off-highway vehicle use, road construction, military activities, renewable energy development, cattle grazing, and other human activities that disturb the ground (FTHL ICC, 2003). The flat-tailed horned lizard has been proposed for listing by the USFWS on four separate occasions (1993, 2001, 2005, 2010) (USFWS, 2010). The USFWS withdrew the most recent proposal with the explanation that available data did not indicate that threats, as analyzed under FESA, will endanger the species in the foreseeable future in a significant portion of its habitat range (U.S. Federal Register, 2011). However, the USFWS has signed the Flat-Tailed Horned Lizard Rangewide Management Strategy (RMS) with the following State and Federal agencies:

- BLM (California and Arizona State Offices),
- Bureau of Reclamation (Lower Colorado Region),
- Arizona Game and Fish Department,
- California Department of Fish and Game, and
- California Department of Parks and Recreation.

The goal of the RMS is to provide guidance for the conservation and management of the habitat for flat-tailed horned lizards (FTHL ICC, 2003).

Military Impact on the Flat-Tailed Horned Lizard
Flat-Tailed Horned Lizards are found on NAF El Centro-administered ranges but are not known to inhabit any of the other Mojave or Colorado Desert military installations (FTHL ICC, 2003; Duncan, 2011). Flat-tailed horned lizards experience negative impacts primarily as a result of installation activities related to ground disturbance from off-road vehicles and other mission-related activities. However, explosions and aircraft noise can cause deafness in lizards. Additionally, fires resulting from military activities (e.g., use of flares and bombing) can destroy lizard habitat (FTHL ICC, 2003).

Table 2.1 – Military Installations On Which Select Special Status Species May Be Found						
	Desert Tortoise	Mohave Ground Squirrel	Desert Cymopterus	Barstow Woolly Sunflower	Southwestern Willow Flycatcher	Flat-Tailed Horned Lizard
Edwards AFB	X	X	X	X	None	None
MCAGCC Twentynine Palms	X	None	None	None	None	None
Chocolate Mtn. AGR	X	Unknown	None	None	None	None
Fort Irwin	X	X	X	None	None	None
NAWS China Lake	X	X	X	None	None	None
Nellis AFB	X	Unknown	Unknown	Unknown	Unknown	Unknown
MCLB Barstow	X	None	None	None	None	None
NAF El Centro	None	None	None	None	None	X
Creech AFB	None	None	None	None	None	None

Source: Duncan, 2011.

2.2 Legal Regime governing Mojave and Colorado Deserts

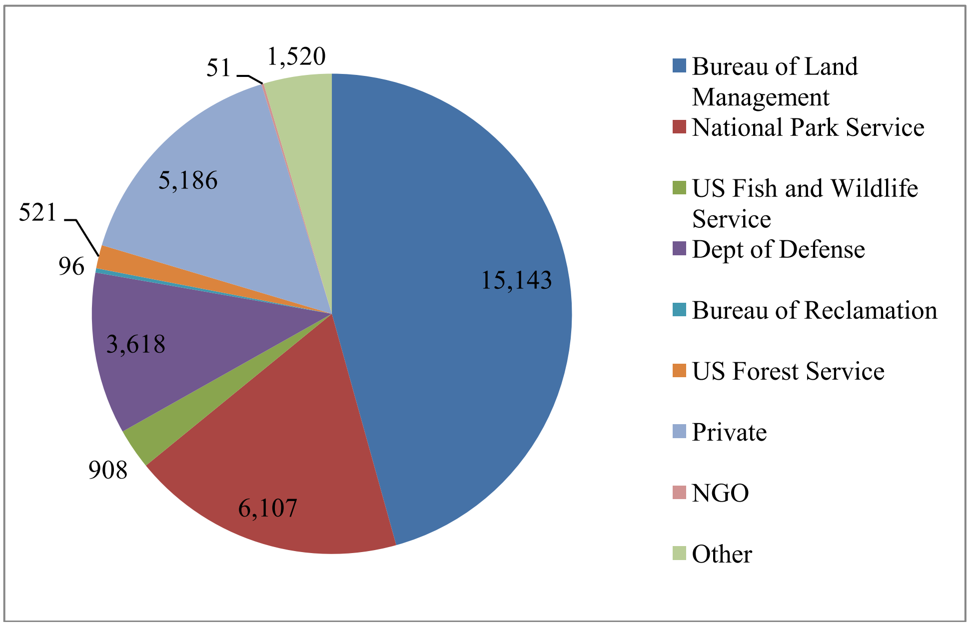
Given the demand for the use of Mojave and Colorado Desert resources, ownership patterns in the Mojave and Colorado deserts provide a blend of opportunities and challenges for stakeholders in the area. The Mojave Desert has the highest proportion of public ownership of any eco-region in North America, with approximately 85% of the land managed by Federal and State agencies (Randall et al., 2010). See Table 2.2 and Figure 2.3 for a breakdown of land ownership types. The BLM is the region's largest land manager, administering 46% of the Mojave Desert. The National Park Service (NPS) administers approximately 20% of the Mojave, including Death Valley National Park, Mojave National Preserve, Joshua Tree National Park, and Lake Mead National Recreation Area (Randall et al., 2010). The Department of Defense (DoD) manages approximately 12% of the Mojave, including Fort Irwin, NAWS China Lake, MCAGCC Twentynine Palms, MCLB Barstow, Edwards AFB, and Nellis AFB. Additional government entities managing Mojave lands include:

- U.S. Department of Agriculture (USDA) Forest Service,
- USFWS,
- U.S. Department of the Interior (DOI),
- California Department of Parks and Recreation (State Parks), and
- California Department of Fish and Game (CDFG).

In the United States, nearly 70% of the greater Sonoran Desert is owned by Federal or State agencies (Marshall et al., 2000). Similar management patterns can be found in the Colorado Desert, with BLM managing approximately 43.1% of the region and DoD lands accounting for 7% of the region. The USFWS, NPS, CDFG and State Parks also manage Colorado Desert lands.

Table 2.2 – Land Ownership in the Mojave and Colorado Deserts (thousand acres)			
	Mojave Desert		Colorado Desert
	CA	NV	
BLM	8,821	3,410	2,911
National Park Service	5,205	539	363
USFWS	6	850	52
DoD	2,624	465	529
Bureau of Reclamation	0	34	61
US Forest Service	190	318	13
Private	2,873	625	1,688
NGO	27	0	23
Other	310	262	948

Note: Totals based on data from Protected Areas Database 2010, Conservation Biology Institute edition.



Note: Totals based on data from Protected Areas Database 2010, Conservation Biology Institute edition.

Figure 2.3 – Land Ownership in the Mojave and Colorado Desert (thousands of acres)

The primary Federal agencies managing desert lands include the BLM, USFWS, and NPS.

BLM: The BLM manages over 245 million acres of surface land in the United States, most of which is located in the 12 Western states. The BLM manages under a ―multiple-use mission," which was set forth in the Federal Land Policy and Management Act of 1976 and mandates that the BLM manage public land resources for a variety of uses, including energy development, recreation, livestock grazing, and timber harvesting, while protecting the natural, cultural, and historical resources provided by the land. In order to develop management strategies for these lands, BLM coordinates with local, state and tribal governments as well as the public, and stakeholder groups (e.g., Non-Governmental Organizations (NGOs)) (BLM, 2011b).

USFWS: The USFWS acts as the principal federal partner responsible for administering FESA. Therefore, it takes a leading role in coordinating with public and private landowners to recover and conserve species identified as threatened or endangered (USFWS, 2011). In the effort to conserve endangered species, USFWS is responsible for designating critical habitat. Once land is designated as such, activities involving a Federal permit, license, or funding, and are likely to adversely modify an area of critical habitat must be modified as seen fit and approved by the USFWS (USFWS, 2011a).

NPS: The National Park service (NPS) has taken responsibility for the National Park System since 1916 and currently manages approximately 84,000,000 acres of land in the United States. The NPS mission, as signed by President Wilson in the Organic Act, is to ―conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (NPS, 2010).

DoD: The DoD has also taken an active role in Mojave and Colorado Desert management. For example, Edwards AFB manages over 300,000 acres of desert lands, most of which have only been partially grazed or farmed and supports a relatively healthy, undisturbed, and sizeable area of diverse plant and animal communities. But the impacts vary from installation to installation and also within each installation. At some installations, the land surface is heavily used for maneuver training, gunnery practice, and other activities that can have deleterious impacts on habitat over extensive areas. In other cases, the military uses their ranges for activities such as the testing of new aircraft, rocket engines, and weapon systems, which tend to have a much smaller impact on habitat or have an impact on a much smaller area of land (DOW, 2007).

In many cases, the various managing governmental agencies coordinate through intergovernmental partnerships and conservation plans in order to achieve cohesive and appropriate land management strategies. Other groups, such as NGOs, have also taken an active role in the management of the region. For example, over 100 NGOs participated in the development of the West Mojave Plan (BLM, 2005). Active NGOs in the region include the Mojave Desert Land Trust, The Nature Conservancy, and California Partners in Flight.

This section addresses notable conservation plans and legislation as well as major intergovernmental partnerships in the region.

2.2.1 California Desert Conservation Area (CDCA)

The CDCA is a 25 million acre expanse of land in southern California, which was designated by Congress in 1976 through the Federal Land Policy and Management Act. BLM manages approximately 10 million acres in the area, as shown by the yellow colored areas in Figure 2.4. Because of the land's value and proximity to population centers, Congress required BLM to develop and implement a comprehensive plan for the management, use, development, and protection of the land that emphasized the concepts of multiple use, sustained yield, and maintenance of environmental quality (BLM, 2010c).

BLM’s management plan for the CDCA designates distinct multiple use classes for the area and establishes a framework to manage the resources within the different classes. Approximately 4 million acres are ―Class C” (controlled). These lands include 69 wilderness areas and are generally limited to non-motorized means of transportation. Approximately 4 million acres are ―Class L” (limited use), and are managed to protect sensitive and scenic ecological and cultural resources. Low-intensity, controlled multiple uses may be allowed. Approximately 1.5 million acres are ―Class M” (moderate use), and are managed to balance higher-intensity use (e.g. mining, livestock grazing, recreation, energy and utility development) and protection. Approximately 500,000 acres are ―Class I” (intensive use) and are managed to meet human needs (BLM, 2010c).

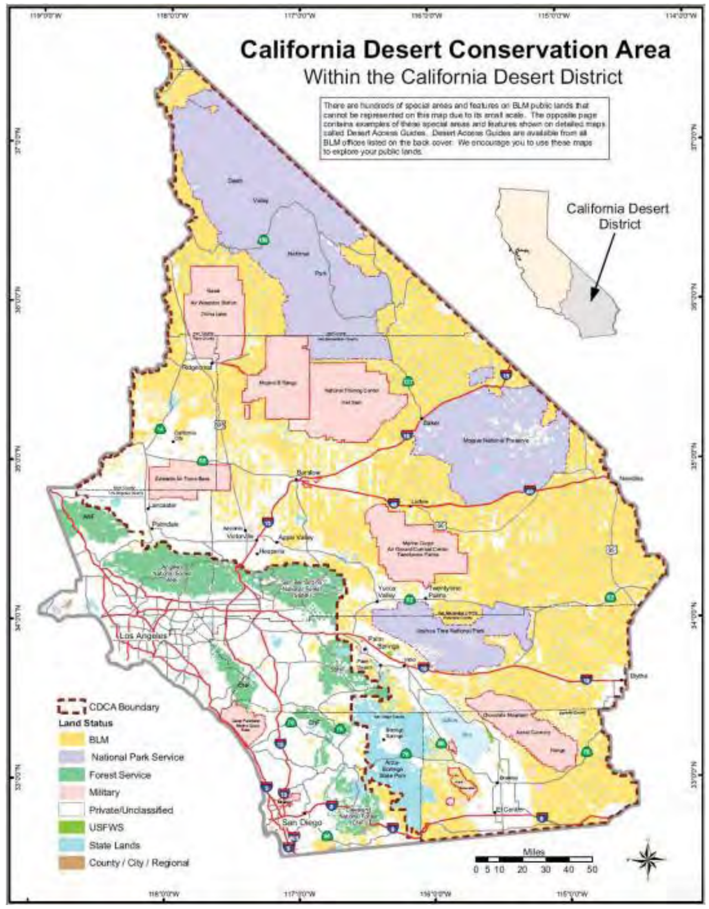


Figure 2.4 – Land Ownership in the California Desert Conservation Area (BLM, 2006)

The DoD has also taken an active management role in the CDCA, as a number of installations are located in the area, including NAWS China Lake, Fort Irwin NTC, MCAGCC Twentynine Palms, Edwards AFB, and the Chocolate Mountains AGR. Other agencies managing land in the CDCA include the USDA Forest Service, NPS, USFWS, and California State Lands (BLM, 2006).

2.2.2 California Desert Protection Act (CDPA) of 1994

The CDPA of 1994 (Act) protects approximately 6.37 million acres of desert lands in southern California managed by the BLM, including the Mojave and Colorado Deserts. Passed with the goal of preserving the scenic, geologic, and wildlife values of the California desert, the Act designated nearly 3.5 million acres of BLM land as wilderness (Feinstein, 2011). The main establishments resulting from the Act include:

- **Death Valley National Park**
  The Act abolished Death Valley National Monument (established in 1933) and incorporated its lands into a new, larger 3,372,800 acre Death Valley National Park, which is administered as part of the National Park System. A Death Valley National Park Advisory Commission was established to assist in the development and implementation of a management plan for the park’s lands (USGPO, 1994)

- **Joshua Tree National Park**
  The Act abolished Joshua Tree National Monument, established in 1936, and incorporated its lands into the 789,745 acre Joshua Tree National Park. A Joshua Tree National Park Advisory Commission was established to assist in the development and implementation of a management plan for the park (USGPO, 1994).
- **Mojave National Preserve**
  The Act abolished the East Mojave National Scenic Area, designated in 1981, and incorporated its lands into the 1,534,819 acre Mojave National Preserve. Park lands were to be managed in accordance with National Park System laws, meaning that grazing was permitted at current levels and hunting, fishing, and trapping were permitted (USGPO, 1994).

Additionally, the Act required that Tribal groups have access to the lands designated under the Act for traditional cultural and religious purposes in recognition of their prior use of the lands for such purposes (USGPO, 1994).

In 2009, Senator Feinstein of California presented the California Desert Protection Act of 2010 to provide for the conservation, enhanced recreation opportunities, and development of renewable energy in the California Desert Conservation Area (PPF, 2011). The proposed Act was not passed in 2010 but was reintroduced in January of 2011 as the California Desert Protection Act of 2011 (CWC, 2011). The proposed legislation has been referred to the Senate Committee on Energy and Natural Resources (Library of Congress, 2011).

The CDPA of 2011 would extend protection to 1.6 million acres of desert landscape in addition to the area already protected by CDPA of 1994, including:

- Establishment of 2 new national monuments
  - **Mojave Trails National Monument**
    This Monument would consist of approximately 940,000 acres between Joshua Tree National Park and the Mojave Preserve managed by the BLM. Existing recreation as well as construction of transmission lines and development of renewable energy would be permitted. An advisory committee with local, state and Federal Government, conservation and recreation groups, and local Native American Tribes would develop a management plan for the Monument (USGPO, 2011).
  - **Sand to Snow National Monument**
    This Monument would consist of over 130,000 acres of Federal land between Joshua Tree National Park and San Bernardino National Forest that would be jointly managed by the BLM and USDA Forest Service (USGPO, 2011). Figure 2.5 depicts the proposed Sand to Snow National Monument boundaries and the surrounding area.
- Designation of Wilderness (approximately 394,807 acres) (CWC, 2011)
- Death Valley National Park expansion (approximately 41,000 acres) (USGPO, 2011)
- Joshua Tree National Park expansion (approximately 2,900 acres) (USGPO, 2011)
- Mojave National Preserve expansion (approximately 30,000 acres) (USGPO, 2011)

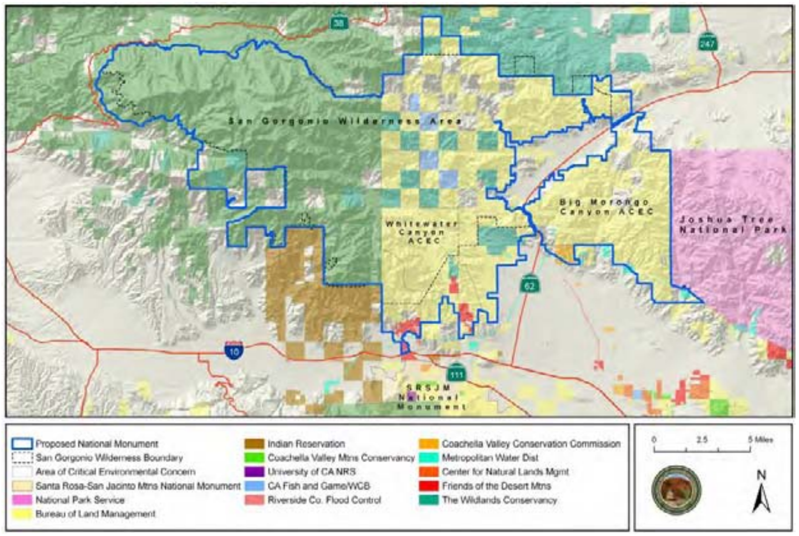


Figure 2.5 – Proposed Sand to Snow National Monument, CDPA of 2011 (CCD, 2011)

The proximity of the proposed CDPA protected lands to a number of military installations in the Mojave Desert, including Fort Irwin, MCAGCC Twentynine Palms, and NAWS China Lake, can be seen in Figure 2.6.

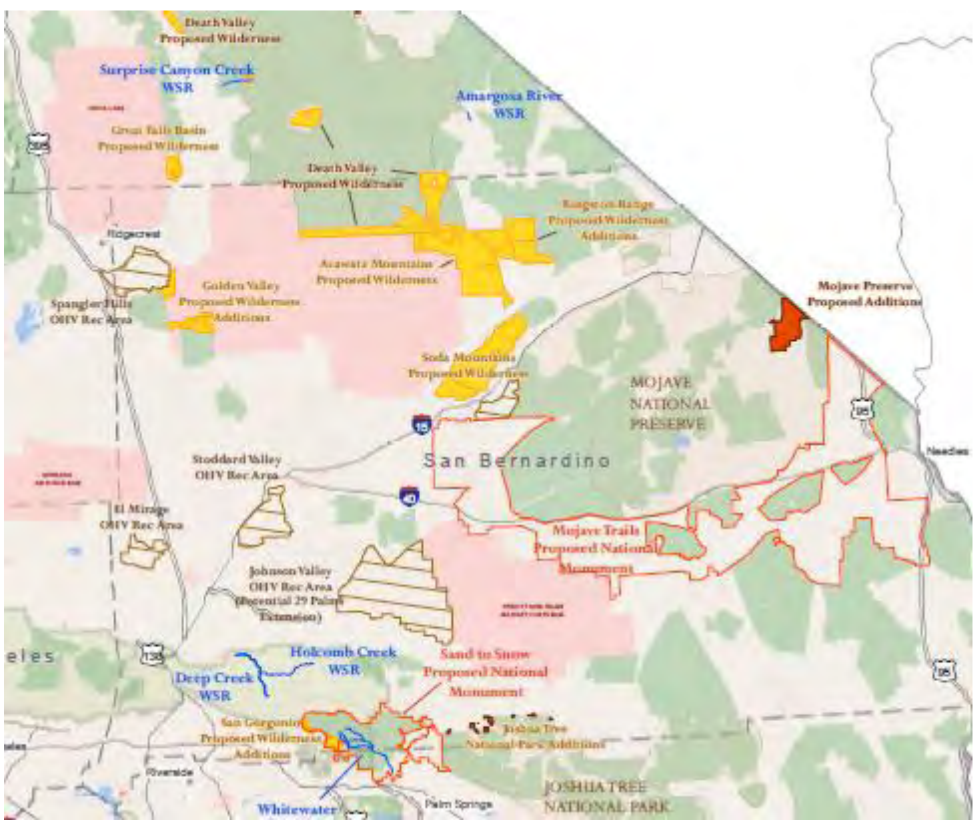


Figure 2.6 – Overview of Proposed Additions in CDPA of 2011 (CCD, 2011)

Additionally, the CDPA of 2011 would require Federal agencies managing the lands (e.g. BLM, DoD, and USFWS) to study the viability and potential environmental impacts of renewable energy development in the region (USGPO, 2011).

2.2.2.1 DoD Involvement with the CDPA of 2011

The DoD has been heavily involved in the congressional discussions surrounding this legislation. The bill incorporates many provisions that would protect military operations and renewable energy development interests. The CDPA of 2011 also proposes that 248,000 acres of land be designated as national park wilderness areas, much of which is located directly adjacent to military installations such as Fort Irwin and NAWS China Lake. The DoD has noted the importance of the legislation, given its commitment to developing renewable and alternative energy resources. However, while the DoD supports environmental protection and a strategic approach to energy and climate change, it has reminded Congress that ―some conflicts may be unavoidable, and sustaining our ability to conduct our current and projected mission requirements must be our overriding consideration" (Robyn, 2010).

2.2.3 West Mojave Plan

The West Mojave Plan (Plan) is a multiple species habitat conservation plan (MSHCP) and CDCA Plan amendment. The goals of the Plan are to conserve sensitive plant and animal species (e.g. the desert tortoise and Mohave ground squirrel) and the communities on which they depend and to streamline the FESA permitting process (Haigh & Scott, 2004). Developed through a collaborative effort of BLM and 27 other Federal and State agencies, cities, and counties, the Plan applies to approximately 9.3 million acres of the western portion of the Mojave Desert in southern California (BLM, 2005; BLM, 2011). Key Plan participants in addition to BLM include: San Bernardino, Kern, and Inyo Counties, USFWS, CDFG, California Department of Transportation, and the DoD (Haigh & Scott, 2004).

2.2.3.1 DoD Involvement with the West Mojave Plan

The West Mojave Plan was designed to be consistent with the integrated natural resource management plans that have been adopted by the five installations in the planned area. Given the large military presence in the Plan area, the west Mojave Plan emphasizes the importance of coordinating with the installations, particularly with regard to species management (BLM, 2011).

2.2.4 California Desert Renewable Energy Conservation Plan (DRECP)

The goal of the DRECP is to provide binding, long-term endangered species permit assurances and facilitate renewable energy project review and approval processes. As shown in Figure 2.7, the DRECP covers an area of over 35,000 square miles (23 million acres) in southeastern California, spanning the region's deserts and adjacent areas. The DRECP Area is bounded by Baja California, Mexico to the south, Arizona and Nevada to the east, the Sierra Nevada and Tehachapi Mountain Ranges to the northwest, and the Peninsular and Transverse Mountain Ranges to the southwest. The DRECP has been designed to support the public lands and managed conservation areas already in place in the Plan Area.

The Renewable Energy Action Team (REAT) oversees the implementation of the DRECP. REAT consists of the California Natural Resources Agency, California Energy Commission (CEC), CDFG, BLM, and USFWS. The Team has developed a best practices manual, Best Management Practices and Guidance Manual: Desert Renewable Energy Projects, and is now in the process of developing three additional products (REAT, 2009):

- Draft Conservation Strategy (which identifies and maps areas for renewable energy project development and areas intended for long-term natural resource conservation as a foundation),
- Desert Renewable Energy Conservation Plan (a joint State and Federal Natural Communities Conservation Plan (NCCP) that will be part of other Habitat Conservation Plans), and
- A joint State and Federal DRECP Environmental Impact Report/Environmental Impact Statement.

Figure 2.7 – Boundaries of DRECP Area (DRECP 2011)

2.2.5 Desert Manager's Group

The Desert Manager's Group (DMG) has served the role of coordinating desert conservation, visitor services, public outreach, and public safety in the region since 1994. Initially, the DMG represented State and Federal land management, recreation, and wildlife agencies. In 2005, the Group also expanded to include participants from the desert counties (CDFG, 2011). Today the DMG consists of:

- DoD (NAWS China Lake, Edwards AFB, NTC Fort Irwin, MCAGCC Twentynine Palms, MCLB Barstow, and Marine Corps Air Station Yuma),
- DOI (Bureau of Indian Affairs, BLM, USFWS, National Park Service, and U.S. Geological Survey),
- State of California (Department of Fish and Game, Department of Transportation, State Parks – Colorado Desert Sector and Mojave Desert Sector), and
- California State Counties (Kern County, Imperial County, and San Bernardino County)
- USDA Forest Service (DMG, 2011)

The DMG is an important region-wide forum for facilitation of conservation and cooperation in solving the conflicting demands for use of California desert lands. The Group has been involved in identifying research needs, conservation planning, restoration projects, and conservation programs. The DMG also helps secure funding for efforts once specific needs have been identified (CDFG, 2011).

2.2.6 Nevada Wildlife Action Plan

Nevada's Comprehensive Wildlife Conservation Strategy, now known as the Wildlife Action Plan, is a roadmap designed by the Wildlife Action Plan Team at the Nevada Department of Wildlife. The goal of the Plan is to conserve the state's wildlife by sustaining healthy populations and preventing species from becoming threatened or endangered. The plan covers the entire state but effectively targets certain regions (such as the Mojave), because it focuses on the state's species of greatest conservation need as well as their key habitats (WAPT, 2006). Targeted wildlife includes 72 bird, 52 mammal, 34 fish, 2 mollusk, 7 amphibian, and 18 reptile species. The Plan also targets 27 habitats that have been determined as ―key habitats" for the species addressed. Because the Mojave Desert characterizes much of southern Nevada, its habitats and species are addressed in the Plan. Specifically, Mojave/Sonoran warm desert scrub, Mojave mid-elevation mixed desert scrub, and Mojave's rivers and streams are included in the Plan's 27 key habitats (WAPT, 2006).

2.2.7 Clark County Multi-Species Habitat Conservation Plan (MSHCP)

Clark County, which contains the metropolitan area of Las Vegas, is the southern-most county in Nevada (see Figure 2.8). With a population of nearly 2 million living in close proximity to the delicate ecosystems of the Mojave Desert, Clark County faces various land management challenges (U.S. Census Bureau, 2011a). The Clark County Desert Conservation Program, which manages FESA compliance for non-Federal activities in Clark County, developed the Clark County MSHCP in response to these challenges. Its goal is to address the conservation needs of all biological resources in the County. The plan covers 79 species and their associated habitats, with an additional 103 species listed as ―Evaluation Species" and 51 species listed as ―Watch List Species" (CCDCP, 2000).

Figure 2.8 – Map of Clark County, Nevada (shaded purple) (BLM, 2011b)

Additional conservation plans in the region include but are not limited to: The Desert Bird Conservation Plan; The Northern and Eastern Mojave Desert Management Plan; The Northern and Eastern Colorado Desert Coordinated Management Plan; The Lower Colorado River Multi-Species Conservation Program; and the Coachella Valley Multiple Species Habitat Conservation Plan.

2.3 Land Use in the Mojave and Colorado Deserts

The question of renewable energy development on military installations is bound in the context of the larger desert ecosystem and the numerous stakeholders competing for use of the ecosystem's resources. Among these many interests are:

- natural resource conservation,
- recreation,
- agriculture, and
- urban development.

This section will describe the land uses in the Mojave and Colorado Desert region as well as how these various uses interplay. In describing desert land use, the chapter will also portray how the installations have the power to both protect and degrade desert resources throughout the deserts. Because of their central role in desert resource management, the decisions made on each installation can affect the quality of natural resources throughout the deserts.

2.3.1 Historic Land Use

Evidence of human existence in the Mojave and Colorado Desert region extends back to the close of the Pleistocene, nearly 10,000 years ago. Evidence of human inhabitation has been found along the shorelines of pluvial lakes in the area. However, the size of these early human populations is thought to be minimal. It is likely that human predation and Holocene climate change caused the disappearance of large mammals (e.g., California lion, saber-toothed cat, dire wolf) from the area (USGS, 2009).

Small numbers of Native Americans inhabited the Mojave and Colorado Desert region at the time of European arrival in the 1600s and 1700s. Tribes in the area included the Mojave, Halchidmoma, and Paiute tribes as well as the Cahuilla, Shoshone, and Serrano tribes (USGS, 2009; NPS, 2011). When the Spanish arrived in the region in the 17th century, the Mojave tribe represented the largest concentration of people in the Southwest (NPS, 2011). The Mojave and other tribes were typically organized into small, mobile clans that traveled between established summer and winter locations where water and food resources were available (Randall et al., 2010). Natives of the Mojave and Colorado Deserts often practiced a dry farming method, relying on the regular overflow of the Colorado River to irrigate crops planted along the banks. These crops were supplemented with wild seeds and roots as well as game and fish from river systems in these deserts (NPS, 2011).

The earliest European migration into the Mojave and Colorado Desert region began with Spanish explorers in the late 17th century. Two early travel routes – the Old Spanish Trail and the Mojave Road – crossed portions of the current Mojave National Preserve and are suspected to have used older Indian trails connecting water sources (USGS, 2009). Although the Spanish arrived in the Mojave and Colorado Deserts in the 17th century, most Europeans and Americans avoided settling in the inhospitable region until the mid-19th century, viewing the land as an obstacle to cross in order to gaining access to more livable areas in western California. Jedediah Smith, who arrived in the region in 1826 while investigating a route from the Colorado River to San Bernardino, is thought to have been the first American to actively explore the Mojave (Pike, 2005). However, settlers were still not drawn to the region until the discovery of gold in the mid-19th century.

Following James Wilson Marshall's discovery of gold in the Sierras in 1848, prospectors flocked to the Mojave Desert, and communities began to develop (CADC, 2005). The General Mining Law of 1872 further encouraged settlement in the region by allowing individuals to stake a claim on an area of land where a mineral deposit was discovered (NPS, 2011). Miners flocked to the area to extract gold as well as silver, lead, copper, and iron, among other materials. During this period, a small number of ranchers, prompted by the Homestead Act of 1826, also settled in the region to graze cattle and sheep on public livestock allotments (Randall et al., 2010). Although most of the arable land in the western half of the US was occupied by the early 1900s, the momentum of the Homestead movement continued to draw settlers west. As a result, the dry Mojave and Colorado Desert lands were homesteaded in the early 1900s. Water demand proved to be a source of controversy between homesteaders and ranchers, both of whom depended on water resources for crops and livestock. The lack of water resources and other challenges, such as extreme temperatures, caused many farms and small homesteads to be abandoned. The abandoned small homestead cabins are still scattered throughout the desert, some of which are located on existing DoD lands (Feller, 2011).

The military entered the region in 1850 and has had a strong presence in the region since (NPS, 2011). The U.S. Armed Services operate a number of installations in the region and have taken an active role in land management strategies in both deserts.

2.3.2 Timeline of Land Use Developments in Mojave and Colorado Eco-region

- 1604 – Juan de Onate is the first European to meet the Mojave Indians while in search of the ―Southern Sea” (the Gulf of California).
- 1774-1775 – Juan Bautista de Anza expedition from Mexico to today's San Francisco passes through present-day Yuma, AZ and the Imperial valley
- 1826 – Jedediah Smith explores the Mojave territory
- 1848 – Discovery of gold in California
- 1850 – California territory acquired by the United States
- 1862 – Gold Rush substantially increased steamboat trade; Homestead Act opens public lands to ranchers and farmers
- 1877 – First diversion of water for agricultural uses in the Palo Verde Valley in Blythe
- 1901 – Completion of Alamo Canal to divert water for agricultural uses in the Imperial Valley, with additional expansions of diversions to agricultural areas in California and Arizona in 1909, 1913, 1927, 1948, 1957
- 1905 – Breaching of temporary diversion structure, flooding of Salton Sink and subsequent creation of the present-day Salton Sea
- 1909-1966 – Series of dams completed
- 1933 – Muroc Lake Bombing and Gunnery Range (predecessor to Edwards AFB) established near Lancaster, CA
- 1935 – Boulder (Hoover) Dam completed
- 1936 – Desert National Wildlife Refuge established
- 1940 – Fort Irwin established near Barstow, CA and Nellis AFB established northeast of Las Vegas, NV
- 1942 – MCLB Barstow established near Barstow, CA (comprised of 3 sites), and Chocolate Mtn. AGR established
- 1943 – NAWS China Lake established near Ridgecrest, CA and Creech AFB established northwest of Las Vegas, NV
- 1946 – NAF El Centro commissioned in El Centro, CA as a Naval Air Station

- 1946 – BLM established by combining the U.S Grazing Service and the General Land Office.
- 1952 – MCAGCC Twentynine Palms established in response to need for live-fire training site.
- 1994 – Joshua Tree National Park, Mojave National Preserve established by the California Desert Protection Act.

2.3.3 Current Land Uses and Impacts

The military is one of an increasing number of the stakeholders vying for Mojave and Colorado Desert land and resources. This section addresses land use patterns in the Mojave and Colorado Deserts, including urban development, conservation, grazing, tribal reservations, mining, transportation, infrastructure development, and renewable energy development.

Urban Development

Approximately 6% of the region is used for urban development, including low-to-high intensity urban development, rural development, and open space associated with developed areas (e.g. golf courses, urban parks) (see red-highlighted regions in Figure 2.9) (DRECP, 2011). This development began with the establishment of mining settlements in the mid-19th century.

In 2000, an estimated 2.36 million people resided in the Mojave Desert eco-region, of which approximately one million resided in California. In 2009, the population estimate for the main population centers in the Western Mojave Desert was more than 500,000 people (U.S. Census Bureau, 2011). The single largest urban area within the Mojave Desert is Las Vegas, NV which lies in the northeastern section of the desert and has seen rapid population growth and geographic expansion in recent decades. With the addition of almost 600,000 residents to the Las Vegas metropolitan area between 2000 and 2010, the current population within the Mojave Desert eco-region is likely near 3 million people (U.S. Census Bureau, 2011b).

The main population areas in the Colorado Desert region tend to either border the Los Angeles metro area or are associated with the large-scale agricultural activities in the Imperial Valley (the pink-colored regions surrounding the Salton Sea in Figure 2.9). Although the Colorado Desert is significantly less urbanized than the Mojave and other surrounding deserts, the urban development and other human activities (e.g. agriculture) that have occurred in the Colorado Desert have substantially impacted the region's habitats and wildlife. Many of the Desert's ecological communities, particularly aquatic and dune systems, are limited in distribution and separated by vast expanses of inhospitable desert terrain. Therefore, even limited human disturbances can have significant impacts on the endemic species supported by these habitats (CDFG, 2011).

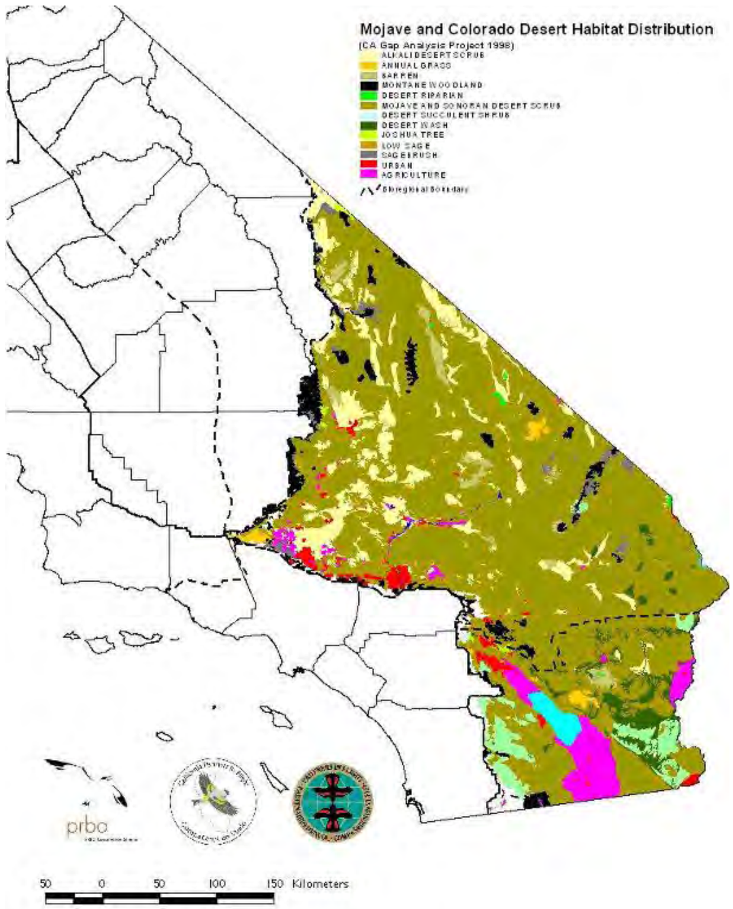


Figure 2.9 – Habitat Distribution and Urban/Agricultural land use in the Californian Mojave and Colorado Deserts (CalPIF, 2009)

Impacts of urban development include direct habitat loss, degradation, and fragmentation. Water use can also be a significant issue. Some of the most significant human-caused effects on the Colorado Desert region have resulted from water diversions and flood control measures along the Colorado River. These measures have altered the region's hydrology by redistributing the water supply to metropolitan coastal areas and large expanses of irrigated agriculture areas (CDFG, 2011).

Table 2.3 – Historical Population for 5 Major Counties of Mojave and Colorado Deserts						
Year	**Kern (CA)**	**San Bernardino (CA)**	**Riverside (CA)**	**Imperial (CA)**	**Clark County (NV)**	**Total**
1990	543,477	1,418,380	1,170,413	109,303	741,459	**3,983,032**
2000	661,645	1,709,434	1,545,387	142,361	1,375,765	**5,434,592**
2010	839,631	2,035,210	2,189,641	174,528	1,951,269	**7,190,279**

Source: U.S. Census Bureau, 1990, 2000, 2010.

Conservation

Despite agricultural and urban development in the region, many areas remain undeveloped as shown by the green, yellow, and black colored regions in Figure 2.9. As discussed earlier in this section, given the delicate ecosystems of the Colorado and Mojave Deserts, there have been extensive conservation efforts in the region both on and off-installation to preserve these undeveloped ecosystems and the wildlife inhabiting them. Primary conservation areas include: Death Valley National Park, Joshua Tree National Park, Mojave National Preserve, and the Desert National Wildlife Refuge (NWR).

Water Resources

Due to low levels of precipitation, Colorado and Mojave Desert inhabitants rely on intact watersheds and groundwater resources for adequate water supplies. Therefore, maintaining the integrity of watersheds is critical to the health of both the aquatic and terrestrial habitats in the region (Randall et al., 2010). Given the importance of these aquatic habitats, water resources such as the Salton Sea, Colorado River, and Mojave River are of special concern, particularly given the additional human demand for these resources (Thomas et al., 2004). While outside sources of water from northern California, northern Nevada, and the Colorado River are commonly used to sustain urban development, agriculture, and mining activities in the area, these resources are utilized only after regional resources have been depleted or are near depletion. Such depletion can have negative impacts on riparian habitat areas and the wildlife populations reliant on such water sources (Randall et al., 2010). Water diversions and groundwater pumping can also facilitate alterations that encourage the invasion of non-native plants that can withstand periods of drought (DRECP, 2011).

Grazing

Grazing was introduced to the Colorado and Mojave Deserts following the gold rush years in the mid-1800s and the Homestead Act of 1862. By the turn of the century, tens of thousands of cattle and sheep and smaller numbers of horses were grazing in the region (Pavlik, 2008). While livestock numbers have been declining since World War II, grazing still occurs on privately owned land and on several large grazing allotments located on BLM and U.S. Forest Service lands. Grazing animals in the desert include cattle, sheep, horses, and feral burros (Randall et al., 2010).

If unmanaged, grazing can alter the composition and productivity of native plant cover. Alterations include the introduction or facilitation of non-native species. When these vegetation communities are modified, there may be negative impacts on the region’s terrestrial and aquatic wildlife species, many of which depend on relatively undisturbed conditions. The impact of livestock hooves can also damage the soil itself (in the form of soil compaction) and disturb desert pavement, which facilitates wind erosion (Randall et al., 2010).

Farming/Agriculture

Agriculture occurs on approximately 3% of the Mojave and Colorado Desert lands (DRECP, 2011). Farming is primarily concentrated in three regions: the Imperial Valley (south of the Salton Sea), the Palo Verde Valley, and Antelope Valley (in the western Mojave) (see pink-highlighted regions, Figure 2.9). Agriculture in all three areas provides important wintering and migration habitat for many bird species. However, agriculture has also introduced non-native species into the region and is responsible for habitat fragmentation and significant water diversion (DRECP, 2011).

Military
Military presence in the Mojave and Colorado Deserts dates back to 1850, when military companies travelled west to newly annexed territory to survey and map a railroad route from Fort Smith, Arkansas to the Pacific Ocean (NPS, 2011). The DoD currently administers approximately 13% of the Mojave and Colorado Deserts (DRECP, 2011). Military installations in the area include:

- Fort Irwin NTC (754,134 acres)
- NAWS China Lake (1,108,956 acres)
- NAF El Centro (56,289 acres)
- MCAGCC Twentynine Palms (595,578 acres)
- MCLB Barstow (6,176 acres)
- Chocolate Mtn. AGR (463,623 acres)
- Edwards AFB (308,123 acres)
- Nellis AFB (14,000 acres)
- Creech AFB (2,940 acres)
- NTTR (2,919,890 acres)[7]

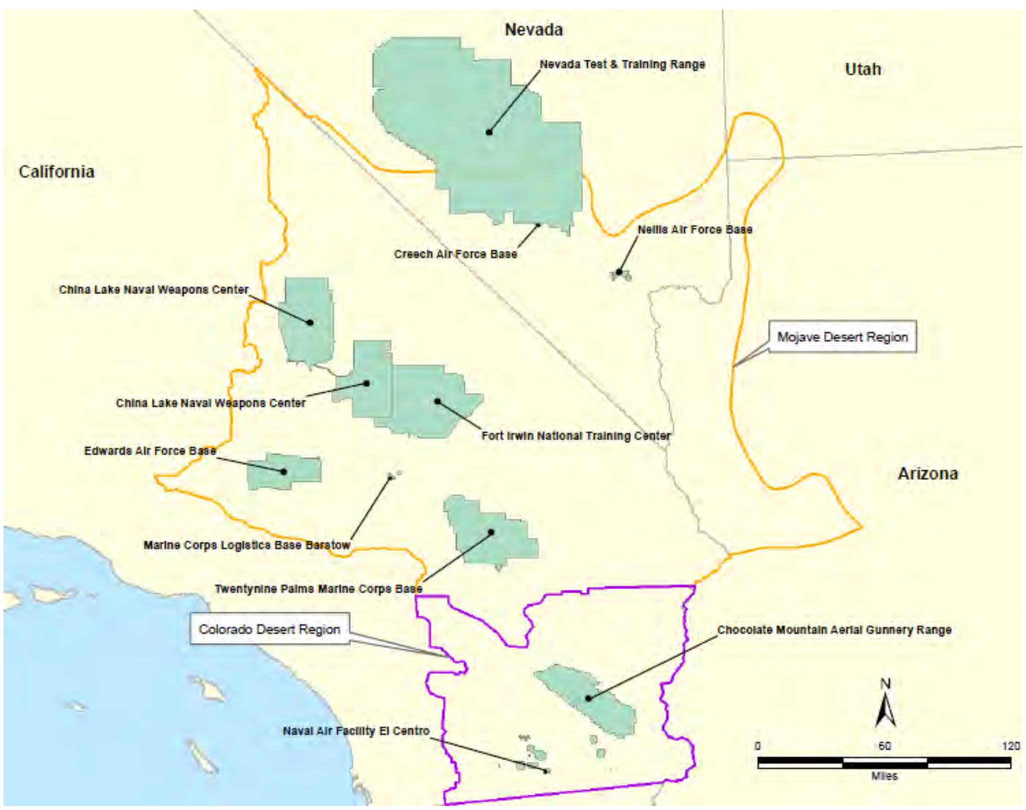


Figure 2.10 – Military Installations of the Mojave and Colorado Deserts

[7] Note: This acreage is split across the Mojave and Great Basin Deserts

Military training activities at southwestern installations include ground troop activities, tracked vehicles, bombing strikes and other explosives and Combined Armed Exercises (CAX). The resultant military training, maneuvers, and bombing practice can have impacts on desert ecosystem processes and inhabitants. For example, the effects of the original maneuvers conducted by General Patton almost 70 years ago are still visible as soil erosion, surface scarring and vegetation removal (Pavlik, 2008). There have been, and continue to be, efforts at Fort Irwin to translocate desert tortoises, which can also be affected by maneuvers. The Army is currently working with the USFWS to address challenges with the initiative such as the high level of desert tortoise mortality that has resulted from high predation by coyotes at the release sites (Pavlik, 2008; Randall et al., 2010).

Alternately, military land use can also benefit desert ecosystems by restricting public access and buffering against encroaching developments (Randall et al., 2010). For example, more remote areas of Fort Irwin, Edwards AFB, and NAWS China Lake are some of the best representative habitats of the Mojave Desert region as a direct result of their limited land use over the last fifty years and inaccessibility to the general public (CDFG, 2011c).

Tribal

Tribal lands comprise approximately 0.6% of the Mojave and Colorado Deserts and are primarily concentrated along the Arizona border near the Colorado River (DRECP, 2011). Reservations are listed below:

- Chemehuevi Reservation (29,209 acres)
- Colorado River Reservation (40,300 acres)
- Fort Independence Reservation (347 acres)
- Fort Mojave Reservation (6,045 acres)
- Fort Yuma (Quechan) Reservation (49,399 acres)
- Lone Pine Reservation (230 acres)
- Torres-Martinez Reservation (6,704 acres)
- Twentynine Palms Reservation (402 acres).

Mining

Following the discovery of gold in the region in 1848, miners were some of the first non-Indian settlers in the region. Since then, mining has continued to impact the eco-region both directly and indirectly. Resources mined from the Mojave Desert include: borates, copper, lead, zinc, coal, calcite, tungsten, uranium, precious metals (e.g. gold and silver), gem quality non-metals, and building materials (e.g., sand, cinders, decorative rock, and gravel) (Randall et al., 2010). Many active mining operations and abandoned mines remain throughout the deserts.

Mining impacts water resources because many operations require large amounts of water for processing. Additionally, mining's surface disturbances may result in damage to desert soils, which in turn may result in wind erosion. Open-pit and abandoned mines also provide ideal disturbance conditions for invasion of non-native plants, and mining access roads may damage and fragment habitat.

Recreation

Recreation represents a major land use in the Mojave and Colorado Deserts. For example, over 1.25 million people visit Joshua Tree National Park and nearly 1 million people visit Death Valley National Park each year. Recreational activities in the area include backpacking, camping, hiking, horseback riding, rock hounding, and hunting. The environmental impacts of different recreational activities vary in severity. However, recreation has the potential to significantly affect desert ecosystems, as described in the discussion of off-highway vehicle (OHV) use, below.

Off-Highway Vehicle Use

OHV recreation has become an increasingly popular form of recreational land use in recent decades. OHV recreational areas in the Mojave include Dove Springs, Dumont Dunes, El Mirage, Jawbone Canyon, Johnson Valley, Rasor, Spangler Hills, and Stoddard Valley. Table 2.4 shows the OHV recreation areas (including area acreage) in the Californian Mojave and Colorado Deserts. As mentioned above, Johnson Valley OHV recreational area has received significant attention, as the military is looking to acquire over 146,000 acres of the area for live-fire exercises.

Table 2.4 – OHV Areas in the Californian Mojave and Colorado Deserts

OHV Area	Manager	Location	County	Acreage
Heber Dunes	Cal State Parks	W of Calexico, CA	Imperial	343
Ocotillo Wells	Cal State Parks	E of Ocotillo Wells, CA	Imperial, San Diego	80,000
Dove Springs	BLM	N of Mojave, CA	Kern	5,000
Jawbone Canyon	BLM	N of Mojave, CA	Kern	7,000
Dumont Dunes	BLM	N of Baker, CA	San Bernardino	8,150
El Mirage	BLM	NW of Adelanto, CA	San Bernardino	24,000
Johnson Valley	BLM	W of MCAGCC Twentynine Palms, CA	San Bernardino	188,000
Imperial Sand Dunes	BLM	E of Brawley, CA	Imperial	118,000
Plaster City	BLM	Plaster City, CA	Imperial	41,000
Superstition Mountain	BLM	W of Imperial, CA	Imperial	13,000
Spangler Hills	BLM	SE of Ridgecrest, CA	Kern	57,000
Rasor	BLM	SW of Baker, CA	San Bernardino	22,500
Stoddard Valley	BLM	S of Barstow	San Bernardino	53,000

Source: CSP, 2011; BLM, 2011c.

OHV use can significantly impact desert ecosystem processes, especially where trails are dense and occupy a large portion of the landscape (Webb et al., 2009). Although many individual OHV trails may have low travel frequency, even minimal vehicular passes can cause significant surface disruption, including soil compaction, and alteration of soil composition. OHV travel off trails can result in the destruction of biological crusts, and desert pavement. All of these may lead to greater wind and water erosion and facilitate the invasion of non-native plant species (Webb et al., 2009; Randall et al., 2010). OHVs may also contribute to habitat loss and fragmentation, disruption of migration corridors, destruction of burrows, and mortality from collisions (Randall et al. 2010). Prior to 1980, almost all of the 12.1 million acres of BLM land in the desert was open to various intensities of OHV use (Pavlik, 2008). Since the signing of the 1980 California Desert Conservation Area (CDCA) Plan, BLM lands have been classified as “open,” “limited,” or “closed,” depending on the type and intensity of motorized vehicle use authorized for the area.

Utilities, Infrastructure, and Transportation

Transportation

Paved and maintained dirt roads are among the most pervasive forms of anthropogenic disturbance in the Mojave and Colorado deserts, resulting in habitat loss and fragmentation as well as animal mortality and injury from vehicular collisions. Major transportation corridors in the Mojave Desert include Interstate 15 (Cajon Pass to Las Vegas), Interstate 40 (Barstow to Needles), and Highway 395 (Adelanto to the Owens Valley), Highway 58 (Mojave to Barstow), and Highway 14 (Palmdale to Highway 395). Fewer major transportation corridors exist in the Colorado Desert. Corridors include: Interstate 10 (Coachella Valley to Blythe), Interstate 8 (San Diego County to Yuma, AZ), Highways 86 and 111 (paralleling the Salton Sea to the El Centro area), and Highway 78 (Brawley to Blythe) (DRECP, 2011).

Infrastructure and Utilities

Industrial-scale electrical power plants generate electricity that is transmitted through transmissions lines, which extend across Mojave and Colorado deserts to urban centers. Increased development of utility-scale electrical generation plants in the desert requires additional transmission lines to distribute the electricity generated. These lines require construction of access roads, which may cause soil disruption, plant uprooting, habitat fragmentation, and other negative impacts [see transportation impacts, above] (Webb et al., 2009).

High Voltage Power Lines Crossing the Mojave Desert
Image courtesy of Associated Press

Construction, operation, and maintenance of the transmission lines themselves may also cause habitat loss, degradation, and fragmentation (Randall et al., 2010). Additionally, transmission towers may serve as perching and nesting sites for ravens, providing ideal vantage points for hunting. The towers facilitate the ravens’ capacity to prey on newly-hatched desert tortoises and other small animals (e.g. the flat-tailed horned lizards, fringe-toed lizards). Structures such as transmission lines, wind turbines, and power towers, also pose a direct threat to flying birds and bats from strikes and collisions. Routine maintenance and repair operations along transmission corridors can also result in collisions between wildlife and patrol and maintenance vehicles. Because many of these facilities are remote, utilities and infrastructure development are accompanied by associated infrastructure and access roads that facilitate public access to otherwise remote and relatively pristine areas (DRECP, 2011).

Solar Energy Development

Renewable power sources are increasingly gaining importance in the United States and particularly in California, where one third of the state’s power will be required to come from renewable sources by 2020 (NPR, 2010). Because of the vast expanses of open land and valuable solar resources in the Mojave and Colorado Deserts, the development of renewable energy in the region has become a popular topic of debate. Projects, such as Terra-Gen’s Alta Wind Energy

Center (AWEC), have already begun construction in the region. The AWEC Alta-Oak Creek Mojave Project will consist of over 300 wind turbines, ancillary facilities, and support infrastructure, generating up to 800 megawatts (MW) once completed (Terra-Gen, 2009). Solel Solar Systems, a solar company now owned by Siemens, is also developing the Mojave Solar Park on 6,000 acres of Mojave Desert lands. The Park will provide over 550 MW of solar power annually to Pacific Gas & Electric (PG&E), a major California utility, when complete (MSNBC, 2007).

Renewable energy development has also begun on military installations in the region. A 14-MW photovoltaic (PV) solar energy system at Nellis AFB saves approximately $1 million annually, and NAWS China Lake has been operating a 270-MW geothermal plant since 1987 (Carden, 2010). The DoD is also researching the feasibility of installing additional renewable energy facilities at several sites in the Mojave and Colorado Deserts.

While renewable energy projects in the region have the potential to generate significant amounts of energy, many stakeholders are concerned about the significant impacts these projects might have on the surrounding land and wildlife species. Vegetation removal and soil disturbance from grading, rainfall obstruction, accidental chemical discharges or leaks, and resulting increases in vehicle traffic are potential impacts that may occur due to solar development (Swartley, 2010). Further discussion of solar energy developments and their impact on the Mojave and Colorado Deserts can be found in the Solar Development Context Chapter.

3 **Mission Compatibility**

3.1 Introduction

Solar energy is diffuse and existing solar technologies require a substantial surface area to generate significant volumes of electricity. Solar developers need hundreds of square feet for kilowatt-scale solar development and many acres to site projects of the megawatt scale. The need for surface resources can bring solar development into conflict with other, higher priority uses for that same surface area.

For both civilian and military site owners, an ideal solar project creates no interference with the primary use of the building or ground site that will host the project. The best site for a solar project is real estate where there is no other ―mission" use, such as building rooftops; greenfield ground sites with no planned uses or competing needs; brownfields (such as capped landfills and remediated hazardous waste sites) that are otherwise in low demand; etc. If a proposed solar project begins to impinge upon the primary function of the building or ground site that it is proposed for, the solar project can, in some instances, be modified to eliminate the impingement. In other cases, mission activities can be modified, although site hosts justifiably expect that the solar project's real estate demands will be subordinate to their own. If the conflict cannot be resolved, the military mission will take priority over the solar project being built.

The nine military installations covered by this report are key assets of the military services, used extensively for training, test and evaluation, and research and development. Their size and relatively remote locations offer the military the ability to train personnel and conduct research and development on technology in ways that would not be possible at other locations. The demands placed on the installations have increased in recent years because modern systems and platforms – aircraft, missiles, sensors, etc. -- have effective ranges and impacts vastly larger than their predecessors from the 1940s, when most of the military installations in this study were established. Large areas are needed to test, evaluate and train with these systems, both to exploit their full capabilities, and to ensure that any risk of unanticipated incidents occurs over controlled ranges, rather than populated areas.

Although the effective battlespace is growing, the military's landholdings are not. Because it is unlikely that any new major military installations will be created in the region, the existing installations should be considered irreplaceable, and any degradation of their ability to perform their missions degrades both the near and long term capabilities of the military. The custodians of these installations are aware of these issues and are charged with maintaining their facilities' continuing ability to serve mission requirements. Any plan for large-scale solar development on these installations needs to acknowledge and start with that premise.

This chapter reviews the various ways that solar projects and military mission activities can conflict. There are two broad categories of conflict: ―spectrum" issues, where the conflict between solar technology and military activities occurs through interactions in the radio frequency, infrared or visual spectra; and ―physical" issues, where the conflict arises due to the potential of hazardous or destructive interaction between military vehicles, ordnance and other hardware on the one hand, and solar technology on the other. While a number of conflict types can be identified (and are further described below), it can be said that the subject of solar's mission compatibility has not been thoroughly studied. Thus, military installation staffs have to make decisions about solar development, in some cases, without solid scientific and engineering criteria but with a natural caution about any possible mission conflict.

Because the military installations support the complex scope of the Nation's military activities, the range of interactions between their activities and solar development is also complex and wide-ranging. Certain issues are more prevalent on some installations, while others are present at all of the installations. Some conflicts can be mitigated, while others cannot. It is also important to note that each installation is home to a diversity of activities, so that while mission conflicts may exclude solar development from active range areas, other areas of the installation may be free of mission conflicts.

There are no simple rules that can guide the identification of potential conflicts nor are there simple methods for conflict mitigation. Each proposed facility needs to be evaluated in the context of its specific location and the mission activities occurring there.

As discussed in greater detail in the Solar Potential Assessment chapter, mission incompatibility precludes solar development on the vast majority of the land area of the nine military installations covered by this study. The basis for this observation relates to the assumption that solar development should only be permitted on military installation range lands if the incompatibility issues can be resolved and ranges can continue their mission at 100% of their current operational tempo and training, test and evaluation output, and with sufficient allowance for future uses of the ranges. Future research may determine that some of this acreage can in fact be opened to solar development without diminishing the Nation's military capabilities. But it is also possible that in this case, as in so many others, that solar development cannot be permitted because it conflicts with the primary use of seemingly barren but exceedingly valuable real estate.

3.2 Overview of Mission Compatibility Issues

The need to train as they fight is fundamental to the U.S. armed forces. The nine military installations and range areas considered by this study are some of our most valued U.S. military assets, providing contiguous, unencumbered space to replicate, as closely as possible the operational environment of an assigned mission. These installations and ranges are considered critical to maintaining the readiness and mission effectiveness of the DoD and must be available when and where needed with the capabilities to support current and future military mission requirements.

Access to military installations, ranges, operating areas, and other lands, seaspace, airspace, and frequency spectrum is essential to providing the realistic training and testing environments to prepare soldiers, sailors, airmen, and Marines, and their associated equipment for the diverse peacetime and wartime missions they are called upon to support around the globe. These training and testing resources are being increasingly challenged by external factors that inhibit the ability of the military to use its installations, ranges, airspace, and other operating areas (DoD, 2010).

The DoD faces incompatibility and encroachment challenges that impact its ability to conduct military readiness activities, generally falling within three categories: competition for resources (e.g., access to land, water, airspace, and frequency spectrum); development on or near military training areas; and environmental enforcement and compliance issues. This chapter will specifically discuss the potential conflicts between the military mission and solar development at each of the nine installations considered by this study.

3.3 Mission Compatibility Challenges

The interaction between solar technology and mission activities can present challenges in four distinct categories: Sensitivity; Activity; Access; and, Environs and Shared-Use Space.

Table 3.1 – Mission Compatibility Challenges	
1. Sensitivity	The classification level of mission activities in these areas forbids any solar development, without exception.
2. Activity	The military activities performed in these areas severely limit any solar development or limit periodic operations and maintenance access.
3. Access	Military activities may require periodic access through an area or corridor for transit purposes, and thereby conflict with solar development.
4. Environs and Shared-Use Space	Certain areas may potentially be host to solar projects, but could be limited by mission activities in adjacent areas.

The remainder of this chapter is organized by examining mission compatibility issues and conflicts related to these four challenges. Where possible, this analysis will also include a breakdown by installation or range, within the limitations of the Unclassified sensitivity level of this report and dependant on the data made available by Service and installation representatives.

3.4 Sensitivity

Limitations and exclusions to solar development due to sensitivity of an area is the simplest exclusion to understand. These are areas that have been placed ―off limits" due to the security classification assigned by the DoD and enforced by the installation or range commander. Prohibited areas and prohibited airspace are examples of this exclusion. Such areas are established for security or other reasons associated with the national welfare, and these areas are published in the Federal Register and are depicted on aeronautical charts (Federal Aviation Administration (FAA), 2010). Another example is a restricted-access test area.

Several of the installations considered in this study, such as Nellis AFB, Edwards AFB and NAWS China Lake, host security-sensitive areas. These areas were eliminated from further consideration during the suitability reviews conducted with the representatives from each installation.

3.5 Activity

Potential direct conflicts between military activities and on-installation solar energy development are the primary limiting factor for locating solar energy facilities on the military installations analyzed in this study. The issues of these activity-related conflicts can best be examined in two broad categories, Spectrum and Physical. Section 3.5.1 will examine some of the known technical and spectrum issues related to solar technology and the military mission and the possible mitigation to resolve mission incompatibilities.

3.5.1 Technical and Spectrum Mission Conflict

Military operations rely heavily on equipment using the limited resources of the electro-magnetic (EM) spectrum. Efficient use and control of the EM spectrum is critical to national security in terms of Information Operations (IO), combat operations, and command and control warfare (C2W) (Chairman, Joint Chiefs of Staff, 2000). The rapid growth of sophisticated weapons systems, sensors, and intelligence and communications systems greatly increases the demands for slices of the EM spectrum. This section will discuss the EM spectrum in depth, outlining the uses and conflicts between solar energy technologies and military operations.

The EM spectrum is the range of all possible frequencies of electromagnetic radiation. The "EM spectrum" of an object is the characteristic distribution of electromagnetic radiation emitted or absorbed by that particular object. Generally, EM radiation is classified by wavelength into radio wave, microwave, infrared, the visible region perceived as light, ultraviolet, X-rays and gamma rays. Figure 3.1 shows the EM spectrum.

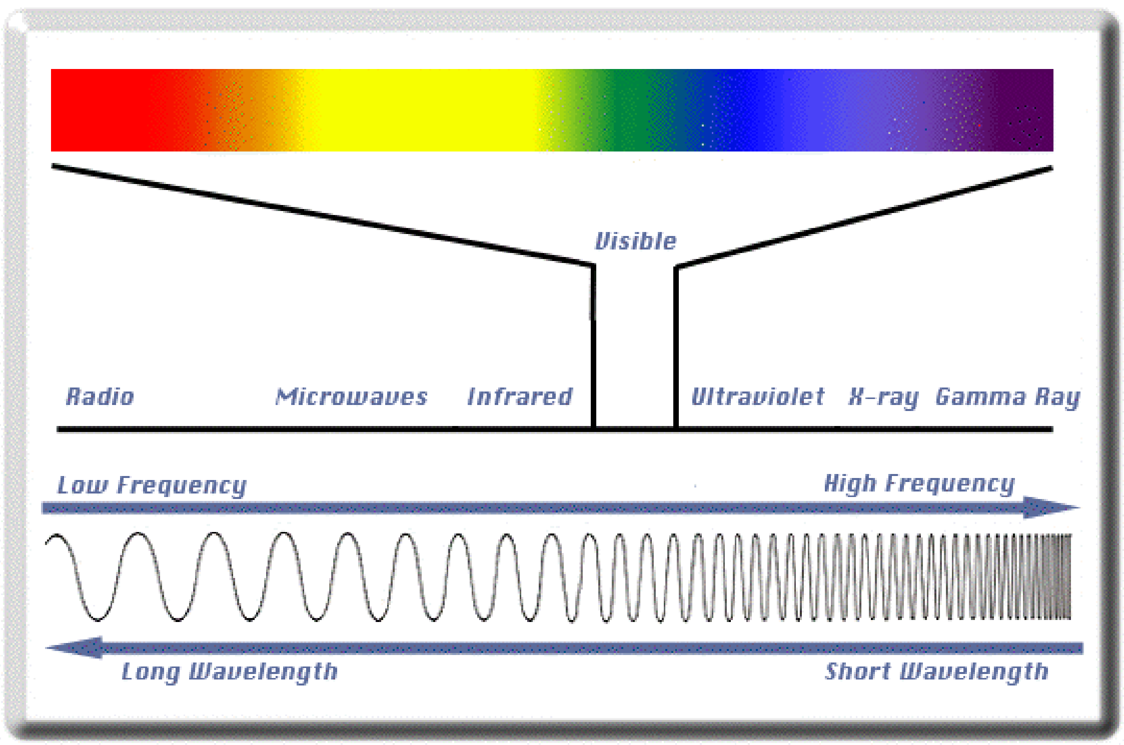


Figure 3.1 – Electromagnetic Spectrum (LCSE, 2011)

3.5.1.1 Solar Energy Systems and the EM Spectrum

Solar energy systems harvest solar energy primarily in the visible light portion of the EM spectrum. Solar arrays may be stationary linear arrays, tilted to maximize the collection of solar energy averaged throughout the day, or they may be tracking arrays that follow the sun. To increase the efficiency of the system, manufacturers strive to maximize the transmission of light to the array through the use of very low reflectivity glass or coatings. These glass compounds and coatings typically are very effective in the visible spectrum, but also may be highly reflective in portions of the infrared (IR) spectrum.

Concentrating solar thermal systems also harvest solar radiation in the visible light spectrum, but convert the energy to heat to drive electro-mechanical systems to generate electricity. The collection and concentration of the energy varies by type of system, but generally relies on a highly reflective sun tracking mirror system focusing the visible light energy onto a receiver. At the receiver the energy is absorbed and converted to heat by a ceramic or metallic heat exchanger where it is transferred to a working fluid. These receivers heat to 500° F - 1100° F, and lose some of that energy to emissions across the IR band, with the peak emissions range from 5.5 µm to 3 µm. In commercial solar thermal power plants, some of the solar thermal energy absorbed by the receiver is not converted into electricity and must be rejected to the environment. This rejected energy will take the form of a thermal plume and is also emissive in the IR spectrum, with peak emissivity around 8 µm at the source and extending to longer wavelengths as it cools and mixes with the ambient air (Kearney and Associates, 1992).

Solar thermal plants requiring manned operation can also be expected to be lit, though the light footprint can be minimized by adhering to the Illuminating Engineering Society of North America (IESNA) LZ1 protocol for lighting (State of California, 2008). Concentrating Solar Power (CSP) systems with towers exceeding 200 feet in height must be lit in accordance with Federal Aviation Administration (FAA) regulations (FAA, 2000).

Radiofrequency (RF) emissions from solar facilities fall into two primary categories, intentional and unintentional. Intentional RF emissions from a large-scale solar facility encompass RF controllers and telemetry equipment used to control the arrays and other communication electronics. Unintentional RF emission sources are those from generators, DC-AC inverters, and array control motors and power transmission equipment, including any substations and high-tension power lines associated with the solar facility. The effects these contributors have on the RF background environment vary depending on the location and the specific piece of emitting equipment (Welsh, 2011). Intentional RF emissions can be mitigated somewhat through the use of RF frequency management or other methods such as fiber optic cable control of PV arrays and other equipment (U.S. Navy, 2010). Unintentional RF emissions can be mitigated by shielding, cancellation, filtering and suppression.

3.5.1.2 Military Uses of the EM spectrum

The military is a heavy user of the EM spectrum for a wide variety of uses. For the purposes of this study, one can classify the uses by systems function and EM operating band. The three principal systems functions are Sensors, Weapons, and Communications. Sensors are used to sample the surrounding environment and enable a wide range of target detection, navigation, ranging, and measurement. Weapons systems include the guidance and fusing of explosive devices and projectiles, directed energy systems, and electronic systems that deny portions of the EM spectrum to enemies and/or create deception within enemy Command and Control systems. Communications systems include any form of data transmission from simple light signals to complex data links. Table 3.2 lists function and band of military EM spectrum use.

Table 3.2 – Function and Band of Military EM Spectrum Use			
Spectrum	**Sensors**	**Weapons**	**Communications**
UV	Threat Warning	Missile Guidance	Data Link
Visible	Optical, Telescopic sights, Night Vision Devices (NVD), Electro-Optical imaging, precision tracking	Aiming and Guidance, Fuzing	Light signals, Navigation lights
IR	Threat warning, NVD, IR Imaging, Laser warning, Laser ranging, Precision tracking	Active and passive Laser guidance, IR passive guidance, Laser Proximity fuzing, High Power Laser	IR beacons, Modulated Laser Data link, voice
Radio	Threat Warning, Electronic Support, Radar, IFF, GPS, Navigation, Telemetry, Precision measurement	High Power Microwave (HPM), Electronic Attack (Jammers), Anti-Radiation Missiles, Radar and Radio guided Missiles, Proximity Fuzing	AM, FM, HF Voice, Data Link, SATCOM, Telemetry, UAS Control

3.5.1.3 Conflicts across the EM Spectrum

The properties of large-scale solar infrastructure can conflict with military use of the EM spectrum in many ways. The magnitude and mitigation of the conflict is highly dependent upon the use of the particular range and the placement of the infrastructure relative to the sensor, weapon, or communication equipment in use by the military. There is also variability of the potential impacts between the test community and the operational forces due to the nature of their missions. In the following sections, the physical and operational conflicts will be detailed, along with generic recommendations on how to negate or mitigate the effects. Each factor will be cross-referenced to a scientific study, military reference, or Subject Matter Expert opinion.

3.5.1.4 Conflicts in the Visible Spectrum

Solar energy technology's effects in the visible spectrum are characterized as glint, the momentary flash of a reflection, and glare, a more prolonged reflection of the sun. Each can cause potentially serious interference with aircraft and ground vehicle operation, air traffic control, and other activities requiring visual reference. Reflection from the sun and moon can cause glint and glare, with the latter's effect on night vision devices. Studies of glint and glare for both CSP and PV have been completed (Ho, Clifford, Ghanbari, Cheryl, Diver, & Richard, 2009) (USAF, 2011).

CSP systems employ highly reflective mirrors to concentrate the sun's light and heat and therefore are more capable of producing potentially harmful or disruptive glint and glare than PV systems. However, the dangers to the unprotected eye from CSP systems are limited to exposures within one focal length of the concentrating mirrors, typically tens of meters (Ho, Clifford, Ghanbari, Cheryl, Diver, & Richard, 2009). One study found that moderate or severe glint extends out to ranges of three miles from a CSP Trough type system (Blow, 2010).

PV systems are far less problematic and have already been deployed close to or on airfields, including a system on the southern approach corridor to Nellis AFB. The following description is from the Nellis AFB Solar Energy Final Environmental Impact Assessment (USAF, 2011):

―The results of the study indicated that under the worst case scenario, there would be a slight potential for an afterimage or flash glare resulting from reflected direct sunlight. This afterimage or flash glare is similar to the potential for flash glare due to water and less than that due to weathered, white concrete and snow. Since this represented the worst case scenario, it would be expected that pilots would typically mitigate glare using glare shields and sunglasses; these typically reduce radiation by approximately 80 percent and would make any reflected sunlight from solar panels insignificant.

A review of FAA Regulations and completed studies determined that there are no regulations associated with reflected sunlight around airports. A study completed by the California Department of Transportation, Division of Aeronautics at the Southern California Logistics Airport in Victorville, found no objection to a proposed solar PV system based on aircraft operational safety. (State of California 2008b) Further, Denver International Airport, San Francisco International Airport, Fresno International Airport, San Jose International Airport, Buckley Air Force Base, and Luke Air Force Base all have solar panels in proximity to active runways.

The proposed PV system would not alter Nellis AFB land uses and would be a passive system that would not impact land use on adjacent properties. Solar panels are designed to absorb solar radiation; therefore, flat plate panels have little reflectivity. Because the land use change would be consistent with Nellis AFB land use plans, and the operation of the PV system would not cause a substantial increase in solar radiation reflectivity (compared to sparsely vegetated desert soils and weathered, white concrete currently present at the site), there would not be a significant impact on land use. Reflectivity of the metal stands and frames would be further subdued, if necessary, by painting the frames with a paint with low reflective properties."

Mitigation

The effects of glint and glare have the potential to deny airspace and impact mission performance and safety. Future development of CSP should be carefully planned as to not create safety hazards or deny training or test areas due to the effects of glint and glare. The effects of glint and glare are best mitigated by distance, and CSP systems should not be placed close to airfields or Landing Zones (LZ). Once developed, military operations should avoid over-flight within 3000 feet of CSP systems (Ho, Clifford, Ghanbari, Cheryl, Diver, & Richard, 2009). Trough concentrators at Kramer Junction, located on the southern border of Restricted Area 2508 (R-2508)[8]and away from low-level training and test areas, have operated for 20 years with no complaints of glare from Edwards Range Operations or General Aviation (Ho, Clifford, Ghanbari, Cheryl, Diver, & Richard, 2009).

[8] The R-2508 Complex includes all the airspace and associated land presently used and managed by the three principal military activities in the Upper Mojave Desert region, Air Force Flight Test Center, Edwards AFB; National Training Center, Fort Irwin; and Naval Air Weapons Station China Lake. (NAWC, 2011).

The experiences of Nellis AFB and other on-airport applications show PV solar to be compatible with visual operations such as flight operations and air traffic control.

System: Night Vision Devices (NVD)
Light pollution and encroachment is identified as a standing threat to military training ranges, and solar infrastructure sites can be problematic for ground and air operations using night vision devices (NVD) (State of California, 2008) (Urban Land Institute (ULI), 2006). NVD's amplify ambient light many thousand-fold and produce a representative scene to the viewer through a phosphorous ocular device. The amplification, or gain, of the device constantly and rapidly adjusts automatically in response to the amount of light sensed by the system. The visual acuity of the NVDs is affected in large part by the signal to noise ratio (S/N) of the scene within the field of view. The desired scene's light is the ―signal", while extraneous light and internal artifacts of amplification are the ―noise." In cases of moonlight glare or glint from a solar collector, the gain of the NVD will rapidly adjust downward during the event in response to an increase in received light. The effect is a momentary loss in the case of glint, or prolonged loss in the case of glare, of visual acuity as the remainder of the desired scene, the signal, is lost due to under-amplification. From the user's perspective, glint and glare will be unpredictable in nature.

The effects of the intentional lighting of solar infrastructure are much more readily identifiable and predictable. Lighting in and among other existing facility lighting will be indistinguishable from pre-existing lighting if it conforms to Dark Skies guidelines (State of California, 2008). The gains of the NVD system are already low in areas of facility lighting, and the scene is uniformly bright, so the added effect of the solar infrastructure is negligible. NVD operations, especially those of aviation, plan for this cultural lighting. Aviation units will typically avoid low-level over-flight of well-lit areas knowing there will be a decrease in their ability to see terrain and obstructions. When isolated in undeveloped areas currently free of artificial lighting, however, the effects of light will be much more disruptive. In low light conditions the NVDs operate at a very high gain to render the terrain visible. Any artificial light, no matter how Dark Skies compliant, will appear exceptionally bright to the NVDs. The effect will again be a loss in detail available to the wearer. For ground operations, vehicle drivers will need to slow their vehicles while accepting a higher chance of collision. Aviators must change course to remove the offending light from their field of view (FOV) or elevate sufficiently to remove the possibility of hitting the ground, known in aviation as controlled flight into terrain.

Mitigation
The encroachment of light onto the training ranges threatens to deny US forces the ability to train effectively in night tactics. Lighted facilities are incompatible with all of the Western training ranges except lit cantonment areas. All lighted facilities should be in strict compliance with dark skies lighting protocols. In the event that temporary lighting is required for construction or repair of normally dark facilities, coordination with the range operations and scheduling personnel is required to minimize operational conflicts.

System: Optical Telescopic Sights and Trackers
Optical telescopic sights and trackers are used extensively for test and evaluation, threat simulation, target scoring, and range safety. Thermal plumes from concentrating solar plants will

create a difficult environment for optical trackers and telescopic sights in the visible spectrum. When air parcels of dissimilar densities mix in a rapidly rising and turbulent column of hot air, light rays are distorted, creating blurring, shimmer, mirages, and reductions in the resolution and accuracy of optical systems. Unlike the transient nature of optical distortions brought about by solar heating of the desert floor, the turbulent flow of air from a CSP trough or tower facility's cooling tower(s) would be a permanent obstacle during the operation of a CSP facility. The turbulent air created by any cooling towers would be bent by the winds aloft and carried downwind a considerable distance before dissipating (U.S. Navy, 2010).

Mitigation
The test community would be most severely impacted by the thermal plume of an on-installation cooling system. Construction of CSP on or along the western (generally upwind) borders of the NAWS China Lake and Edwards AFB test ranges would degrade the pristine test environment required by the hosted test activities. Threat simulation activities at the Nevada Test and Training Range (NTTR) might also be negatively affected. Placing CSP facilities and their associated cooling towers on the leeward side of these installations, and well away from test and target ranges involving ground based trackers or air-to-ground optical sensor testing, is the only way to ensure compatibility. Because the ranges within the other installations considered by this study do not support the same level of test and evaluation operations, these negative effects are not expected to impact the other ranges considered in this study to any appreciable degree.

3.5.1.5 Conflicts in the IR Spectrum

Solar thermal plants have a large IR signature across the bands used in military operations. Glass PV panels and the mirrors of CSP plants will reflect IR lasers used in ground and airborne operations. Thermal solar plants will exhibit a strong signature in the long and mid wave bands used by IR imaging devices, and solar towers, due to their large, very high temperature collector, will emit strongly in the 2-5 μm band used by IR tracking missiles. Linear trough collector systems, with peak irradiance at 5.5 μm, will be weaker in the 2-5 micron range due to their lower collector temperature, but their large angular size may prove problematic. CSP's thermal plume, discussed above, creates shimmer and optical haze in the long wave IR regions and is particularly problematic for the test communities sharing R-2508 and the NTTR.

System: Imaging IR
IR Imagers, such as Forward Looking IR (FLIR) systems used for target acquisition, tracking, and weapon designation and guidance can be found on ground vehicles, rotary-winged aircraft, fixed-winged aircraft, unmanned aerial vehicles (UAVs), and test and target range infrastructure. These sensors give the military the ability to —see" in darkness by operating in the mid-wave (3-8 μm) or long wave (8-10 μm) region and collecting the radiated heat of an object to form an image. One negative characteristic of the current generation of IR sensors is their limited dynamic range. That is, the sensor cannot render a clear image of both a bright and dim IR source at the same time. The strong IR signals generated by objects much hotter than their background overwhelm the sensor, washing out the image of objects much closer to background temperature. An example of the effect is the white out image that results on a previously clear IR video after a bomb detonates. Thermal plumes also affect these sensors, degrading IR system performance by introducing shimmer and some obscuration of the target and affecting the resolution and contrast of the image.

The dominant effects of potential CSP IR signals on IR imaging sensors will only be problematic when the CSP is in the same FOV as the intended point or object of interest. The ability of the IR system to cope with the unwanted IR energy from CSP systems will also vary with the percentage of FOV subtended by the CSP and the properties of the particular system in use. Generally, if the IR image of the CSP takes up a smaller percentage of the IR imager (longer distances and wider FOV's) the operator will be able to tune the IR system to see the temperature ranges of interest. This adjustment takes time, practice and experience.

Mitigation
IR clutter threatens to deny the military operator use of a critical portion of the EM spectrum. IR clutter of all types must be kept clear of all target areas, as interference in this band significantly degrades training and test activities. As discussed in the optical mitigation paragraph, IR plumes can be mitigated by placing CSP facilities on the leeward side of installations and well away from IR optical devices. The Joint Mission Planning Suite (JUMPS) can be used to model current air tactics and sensor FOV to evaluate proposed sites for IR interference.

System: Imaging IR Trackers
Many IR imaging systems utilize automatic tracking systems to ease the operator's workload. Automatic tracking systems are especially important to airborne systems, where aircrew workload is already very high. Auto trackers work by comparing the IR picture frame by frame (scene trackers) or by tracking a very narrow portion of the IR picture by signal strength (gate trackers) and adjusting the system orientation appropriately. Inadvertent IR overload, such as that of the IR energy emitted by a CSP facility, increases the risk that auto-trackers will lose track of the object of interest.

Mitigation
As discussed in the Imaging IR section, the effects of competing IR signals can be mitigated by distance and careful placement of CSP facilities away from weapons and test ranges. Interference of this type is more benign in training environments not involving weapons targeting or guidance.

System: Airborne IR Search and Track
IR Search and Tracking Systems (IRST) are a class of IR sensor used for passive searching and tracking of airborne targets. IRST devices typically work in narrow slices of the IR spectrum, which aids in rejection of clutter from the IR signature of the ground and clouds. The hot metal of a CSP facility mimics the hot metal of an aircraft engine and will be visible to IRSTs as a false target. The range, capabilities, and exact spectral windows of the IRST are classified, however it is a safe assumption that the angular size and energy emitted by the CSP fields is greater than that of the intended targets (fighter sized aircraft) and therefore will be visible at ranges greater than that expected for detection of aircraft in a look-down scenario.

Mitigation
This is a pure spectral conflict and the effects on IRST are assessed as relatively benign (Ho, Clifford, Ghanbari, Cheryl, Diver, & Richard, 2009). The areas most affected are the R-2508 complex and NTTR, where test activities and fighter tactics development take place.

System: IR Homing Missile Seekers

The seeker systems on air-to-air ―heat seeking" missiles track the IR radiation from target aircraft in multiple IR bands. Seekers generally search the 2-4 µm regions looking for the heat from the propulsion systems of potential targets. Some IR seekers also look in the vicinity of 6 µm for the radiation emitted from the plume of jet engines. These systems use a variety of techniques to reject clutter from unwanted sources and IR countermeasures, such as clouds and flares. These techniques include multispectral target discrimination and angular measurements, among others. The spectral signature of CSP facilities mimics that of valid airborne targets by strongly emitting heat in the IR bands used in target tracking. Additionally, their large angular size may fool the clutter rejection methodology adopted originally to reject point-source IR countermeasures like flares. IR tracking/fuzing is also used on some types of air-to-ground and artillery delivered munitions, and the nature of operations for these weapons precludes use near any infrastructure, solar or otherwise.

Mitigation

Future development of CSP facilities in close proximity to live fire air-to-air ranges jeopardizes this critical range asset. The signature of a CSP facility is such that modern IR missiles can track the facility's heat signature, creating the possibility of a weapons impact on the solar infrastructure. This risk will deny the range for free-flight IR Missile test, and for this reason CSP technology is unsuitable for deployment near air-to-air live-fire ranges in the R-2508 complex and NTTR. For all other ranges, the effects are benign and aircrew training and awareness is a sufficient mitigation strategy.

System: Laser Designators and Pointers

Unlike the passive nature of Imaging IR systems, laser devices are active emitters of energy in the IR region. Pointers are either visible or near-IR devices used at night to transfer a visual of a target or to confirm the aiming of a weapon system. Designators are very narrow band, pulse-coded lasers used for marking, or designation, of targets and the terminal guidance of air-to-ground weapons. The power of these devices varies greatly, but generally pointers are eye-safe devices, both because radiated power is relatively low and the visible nature of the beam creates a natural aversion response if viewed directly. Laser Designators, however, are extremely hazardous as they are both powerful and, operating around 1.6µm, invisible to the naked eye. During peacetime training, lasers are never intentionally pointed at humans or animals. Lasers are used with the expectation of a diffuse reflection of energy, greatly diminishing the laser energy that reaches the unprotected eye. The chance exists, however, for the specular reflection of laser energy from smooth, glassy objects. The military manages risk in laser operations through a laser safety program. For each laser, a Nominal Ocular Hazard Distance (NOHD) is published. The NOHD is a distance at which the laser can be viewed without causing any permanent retinal damage. Nominal Hazard Zones (NHZ) are calculated for laser operations on all laser certified ranges, and take into account topography and surface composition. One requirement for laser range certification is that it be clear of specular reflectors (U.S. Navy, 2008). Standing water, due to its specular reflectance qualities, greatly increases a laser's NHZ and requires much greater safety margins. The installation of glass covered PV and all CSP heliostats to a range utilizing lasers would introduce specular reflectors to the environment and greatly complicate the certification of ranges for laser use.

Operations involving laser designators are tightly governed and controlled. A solar energy facility would never be an intentional target of high-powered laser designators if placed outside the laser operations range. However, laser spillover, the unintentional illumination of an object along the laser line of sight, is a very real possibility. Spillover may occur due to low grazing angles or unstable tracking by the target designator. Operations involving Laser Pointers are not as tightly controlled as Laser Designators. It is probable that any non-manned infrastructure on the training ranges will be subject to intentional illumination unless expressly prohibited and monitored by the range operations management.

The direction of the specular laser reflection will be very difficult to predict due to the dynamics of the operations. Ground mounted, non-tracking PV would reflect ground-based lasers up into the air, creating hazards for both participating and non-participating aircraft. Airborne illumination of non-tracking PV systems could create reflections towards either the air or ground, depending upon the angle of incidence. All other reflectors, including tracking PV systems, would reflect lasers based on their pointing angles.

Mitigation

PV and CSP systems are incompatible with laser certified ranges on all military installations. The installation of solar systems in close proximity to laser operations -- line of sight and inside a NHZ -- would serve to deny the military the ability to conduct some or all laser activities. The hazards of laser spillover on CSP systems and tracking PV may be mitigated by ensuring their arrays or heliostats are always pointing away from laser ranges. Placement of infrastructure such that intervening terrain mitigates or eliminates laser spillover is another effective option for ground-based laser activities. Small scale PV, commonly used to power remote range sensors and communications infrastructure, can be effectively masked to mitigate laser reflection concerns. Military operations policy already prohibits the intentional illumination of infrastructure and must be strictly enforced.

System: High Power Laser Weapons

High power laser (HPL) weapons differ from laser designators and pointers in function and effect. HPL are intended to transfer great amounts of energy through the coherent laser beam to burn the intended target. Power ranges for HPL are in the megawatt class and are of great danger to the unprotected eye. HPL and solar infrastructure cannot coexist where there is a chance of inadvertent laser spillover onto specular surfaces such as PV arrays or CSP heliostats. In addition to damage to the solar infrastructure, the redirected energy can cause effects well off range.

Mitigation

Placement of solar infrastructure beyond line of sight of HPL firing positions or employment airspace is the only effective strategy. Based on its size, HPL activity inside the R-2508 complex is feasible and the size of NTTR and MCAGCC Twentynine Palms may facilitate these operations as well (U.S. Navy, 2010). The R-2507 North and R-2507 South (Chocolate Mountain) restricted areas are also authorized for HPL activity and the same mitigation plan identified for R-2508 is also applicable to the R-2507 N/S (USMC, 2011i).

3.5.1.6 Conflicts in the RF Spectrum

As noted in section 3.5.1, the military is highly reliant on the radio portion of the RF spectrum for IO, C2W, and a vast array of combat operations. Within the U.S., the use of the RF spectrum on training and test ranges is carefully balanced to coexist with surrounding civil uses. The demand for RF bandwidth and the explosion in the number of RF devices in everyday life threatens to encroach upon the military ranges' use of the RF spectrum. Solar energy facilities are likely to generate both intentional and unintentional RF emissions that could directly (Radio Frequency Interference [RFI]) or indirectly (clutter) interfere with military operations. Conversely, military operations present a potential risk to solar energy facilities through high-powered emissions from electronic attack systems, radars and communications systems, as well as weapons systems such as High Powered Microwave (HPM).

System: Radar

Radar systems are ubiquitous in military operations. Radars transmit a strong radio signal and must be able to differentiate an extremely faint target echo from the relatively strong echo of the environmental clutter. Solar infrastructure differs from the natural background in its ordered construction and placement. The natural desert background is random and jumbled and offers a diffuse reflective surface to RF, while the angular, flat and uniformly curved reflective surfaces of PV arrays and CSP heliostats offer a specular reflective surface in RF. When the reflection is directed back to the radar receiver, a very strong signal may obscure other lower powered returns. Conversely, when the returns are directed away from the receiver, the effect is a lower than normal return, which can mask terrain. Some spectral smearing, or spread of the reflected frequency, can also be expected. Despite this reflectivity, solar infrastructure has a negligible effect on most military radars in the operational environment. In the test environment, however, this reflectivity may severely compromise the pristine environment needed to accurately measure radar performance.

Ground radar systems must deal with backscattered energy from the surrounding environment, which include desired signals in the form of targets and undesired signals in the form of background noise or clutter. Most ground radar systems, as part of their design, filter out the natural surrounding clutter of terrain, towers, buildings, etc by looking for the Doppler frequency shift caused by moving objects. Solar energy infrastructure is stationary, or nearly so, and does not shift the frequency of the radar returns with relation to the natural background, and therefore its returns are rejected along with the other ground clutter. For ground based systems, concern exists that an excessive amount of clutter or interference within the radar's FOV, such as that presented by a large-scale array of PV panels or heliostats, will significantly impact system performance, especially if the clutter obscures a critical range area (Welsh, 2011).

Mitigation

Due to the significant number of variables, each suggested solar energy location should be evaluated separately to ensure there are no adverse effects. Careful analysis of clutter effect and spectral smearing for infrastructure within the line of sight of ground-based radars can be accomplished in advance of approval. There are also a number of Geospatial Information System tools such as Falconview that can assist in determining radar horizons and identifying blank areas suitable for placement of arrays.

System: Airborne Radar
Airborne radars typically operate in a pulse-Doppler modality and function by sensing moving objects in backscattered signals within the radar FOV. The backscattered signals processed by the radar receiver contain both undesirable clutter and desired target skin returns. The pulse-Doppler radar receiver processor attempts to identify those Doppler-modulated backscattered signals associated with target skin returns, while rejecting all other forms of clutter backscatter and jamming interference. Solar energy arrays appear to the airborne radar as stationary clutter and have similar characteristics to ground clutter backscatter. The effective radar cross-section (RCS) of the array is a function of installation size, platform line-of-sight (LOS) geometry, and the operating frequency of the radar sensor. The variability of the RCS of the array installation will induce either a strong or weak stationary clutter response in the radar receiver signal processor.

For a pulsed-Doppler radar system operating in moving target tracking air-to-ground mode and any air-to-air mode, there is no expected impact from a PV or CSP array installation in the operational training environment. There is a potential for impact on the pulse-Doppler radar system operating in the air-to-ground imaging/mapping mode. This impact is primarily due to the possibility that the array-induced clutter may be very large due to glint. This glint condition could cause a saturation of the radar receiver or artifacts in the formed images or ground maps. However, the impact will be small because of the extremely small angular size of the glint and the small likelihood of being at the glint angle to see it for an extended period of time (Welsh, 2011). This glint artifact is also seen in radar maps of structured urban areas and aircrew are well conditioned to its temporary nature.

Mitigation
For the majority of military installations considered, there are no mitigation strategies required. However, large-scale PV and CSP facilities have the potential to deny range space to test and evaluation activities. Naval Air Warfare Center Weapons Division (NAWCWD) has expressed serious concerns for the effects of radar glint on their test mission. Unlike the training environment, where there is some acceptable level of glint-induced interference, NAWCWD relies upon the pristine environment offered within their ranges (U.S. Navy, 2010). China Lake’s North and Echo Ranges are examples of areas used for radar test activities. Further study and coordination with the test activities hosted within R-2508 and NTTR are required to identify other radar test areas.

Systems: Communications, IFF, Electronic Support (ES), Telemetry, Anti-Radiation Homing Missiles (ARM)
Solar systems’ use of intentional RF control and telemetry equipment introduces the potential for RF encroachment on the spectrum in use by the military. Despite FCC specified limitations on power and frequency, there exists the possibility that these signals can be detectable beyond 500 km by extremely sensitive airborne receivers (Welsh, 2011). Intentional emissions within FCC standard, however, do not directly compete with the intentional signals in use by the military and are of concern mainly to the test community (U.S. Navy, 2010).

Unintentional RF emission sources create RFI, sometimes also referred to as Electromagnetic Interference (EMI). RFI emanates from generators, DC-AC inverters, array control motors and power transmission equipment, including any substations and high-tension power lines associated with a solar energy facility. The effects these contributors have on the range RF background environment vary depending on the location, scale, and properties of specific pieces of equipment, as well as the sensitivity of the receiving system and degree of frequency overlap. RFI is often broadband in nature, blanketing large swaths of the RF spectrum with noise. These effects are most troublesome in the test environment, but also may affect those ISR assets that must compete with a raised noise floor, i.e., lower S/N ratio, to detect faint signals.

Mitigation
Frequency deconfliction for all intentional RF emissions with station frequency managers is necessary in order to address potential spectrum conflicts. These concerns can also be greatly mitigated by minimizing the use of RF devices for control and telemetry of sites in favor of other technologies such as fiber optics. RFI is most troublesome to the test communities inhabiting the R-2508 complex and the NTTR. The most common method of reducing unintentional RF emissions is through a combination of shielding, cancellation, filtering and suppression. However, the greatest reductions in RFI are realized either by increasing the distance between the range complex and sensitive electronic equipment and the RFI emitter or by locating the RFI emitter so that intervening terrain limits its effect.

System: Airborne Electronic Attack (EA)
Electronic attack (EA) systems can be divided into high power EA systems designed to spoof, jam or otherwise degrade or deny the enemy's use of the RF spectrum, and self protect systems designed to protect friendly systems from the effects of enemy weapons by interfering with guidance and fusing systems. Intentional RF and unintentional RFI emitted from solar energy facilities will have no effect on EA activities. However, the high-powered electronic attacks (jamming) energy reflected by the solar infrastructure may produce a significant amount of unintended broadband RFI. The geometry of the jamming platform, intended jamming target, and solar energy arrays can contribute to the scatter of a directed jamming signal to unintended ground radars and other electronic equipment. Modern radar systems can reduce, but not eliminate, broadband RFI through electronic processing. This typically results in some system degradation. It is unlikely that electronic jamming will have any detrimental effect on the solar cells of PV systems, as the received power, though strong to a very sensitive RF receiver, is very low in practical terms. But there is a possibility that the EA will interfere with RF control and telemetry devices used in CSP and PV systems, especially those in close proximity to EA activities.

Mitigation
Encroachment of solar energy development onto threat simulation, electronic attack, and test ranges threaten use of these range spaces. The most effective mitigation strategy is to ensure that the location of any solar energy arrays is not between or behind the intended target and the jamming platform. For consideration of placement of solar energy facilities, planners must take into account the placement of threat replicating RF emitters and the airspace available to the EA platforms to conduct their operations. EA activities are most prevalent within R-2508 complex, NTTR, Chocolate Mtn. AGR, and MCAGCC Twentynine Palms.

Ground Vehicle Self-Protect Systems

Ground vehicle-borne electronic self protect systems are designed to interrupt the command detonation of Improvised Explosive Devices (IED). Some of these IEDs use readily available RF transceivers as their command mechanisms, such as garage door openers, cell phones, pagers, and hand held radios. These RF transceivers share the frequency bands of FCC approved RF control devices and telemetry equipment that may be under consideration for use in solar systems. Counter IED systems (CIED), may therefore, directly interfere with the solar control and telemetry systems.

Mitigation

Ground vehicle electronic self protect systems have limited effective range and avoidance of solar facilities using RF devices is appropriate. Employment of other control and telemetry such as fiber optics is also appropriate near ground combat vehicle operation areas approved for self protect system exercise and test.

Airborne Self-Protect Systems

Active airborne electronic self protect systems do not pose a direct conflict to solar infrastructure due to low radiated power and operating frequency range. Passive RF protection material, known as chaff, may pose problems for power transmission sub systems. Chaff is composed of aluminum-coated silica glass fibers that can be spread by aircraft in flight, ships at sea, and vehicles on the ground to help them evade enemy radar. This chaff is deployed into the free stream air, where it disperses and eventually falls to the ground. Chaff can disrupt electrical power and affect electrical equipment. There have been at least two documented cases of chaff induced power outages (GAO, 2010).

Mitigation

Chaff operations are conducted throughout the R-2508 complex, R-2501 at MCAGCC Twentynine Palms NTTR, Chocolate Mtn. AGR, and NAF El Centro's R2510. Though a low probability event, the threat of chaff induced power outages could result in the loss of airspace to chaff operations and threat simulation with a corresponding degradation of readiness and test and evaluation effectiveness. If situated close to military operations, some risk of chaff-induced short-circuiting must be accepted. Shielding vulnerable electrical junctions and equipment may mitigate the probability of harmful interference from chaff. In the first power loss event, chaff infiltrated open circuitry. In the second, an extremely dense cloud of chaff inadvertently jettisoned at very low altitude caused arcing of power lines. Though the circumstances of this second event are unlikely to be replicated, proximity to military operations involving chaff raises the likelihood of occurrence.

System: Directed Energy Weapons / High Power Microwaves

High Power Microwave (HPM) Weapons can be vehicle or aircraft-mounted in the case of directed energy HPM, or in air-delivered or cruise missile warheads forms in the case of an e-bomb. HPMs operate by generating a concentration of electromagnetic waves in the microwave frequency band (hundreds of megahertz to tens of gigahertz) and whose primary objective is to overload electrical circuitry either temporarily or permanently, depending on the delivered energy level (Abrams, 2011). At lower power levels, vehicular mounted directed energy weapons can target humans and operate as a non-lethal deterrent (Siniscalchi, 1998).

Mitigation
HPM weapons are incompatible with solar infrastructure, and the presence of solar infrastructure would serve to deny airspace to HPM test activities. Since the effects of most HPM weapons are difficult to control, and may significantly damage critical parts of the surrounding infrastructure, testing is presently accomplished on various isolated facilities and range areas (USAF, 2000) (Wilson, 2004) (U.S. Navy, 2010). It is unlikely that ranges presently conducting HPM testing would be compatible with large-scale solar facilities. As the effects of HPM systems are classified and the susceptibility of an electrical system to HPM effects vary greatly, individual test facilities need to be consulted to determine the exact effects or EM footprint for each range.

3.5.1.7 Hazards to Flight Operations

This section addresses the hazards to flight operations brought about by large-scale solar infrastructure within the boundaries of military ranges, Military Operating Areas (MOA), Military Training Routes (MTR) and Restricted Areas. Hazards to flight operations can come from both spectrum and physical conflicts, but this discussion is included in the spectrum section because it affects every installation and range that supports flight operations. MOA, MTR, and Restricted Areas are set aside to separate civilian air traffic from high intensity, high speed, and or dangerous military activity. These ranges allow the military to train in activities precluded in non-protected airspace by the FAA Regulations. Two such activities potentially affected by large-scale solar infrastructure are low-level flight, which typically involves flight below 500 feet above ground level (AGL) and flight at airspeeds greater than 250 nautical miles per hour while below 10,000 feet above mean sea level. These operations are inherently more dangerous than other flight operations due to their proximity to terrain, the presence of more airborne hazards such as birds and other aircraft, minimal reaction times, and high energy of any physical impact.

Cooling Tower Induced Turbulence
Thermal plumes, as discussed in 3.5.1.1, can create a hazard to aircraft when situated close to airports and helicopter landing zones. The hazard can manifest itself as severe turbulence on the approach and departure phases of flight, where close proximity to the ground and operation close to stall speeds magnify the effects.

Mitigation
CSP cooling systems should be placed such that the rising plume of heat does not cross the airport traffic pattern and designated LZ’s. Military operations should avoid selecting and locating landing zones near CSP facilities, and be aware of the effects.

Increased Avian Hazards
Thermal plumes may also increase the chance for bird strike as raptors and scavengers take advantage of the rising air columns. The USAF Avian Hazard Advisory System was designed to predict transient thermal activity that gives rise to birds’ soaring activity to issue warnings to pilots through their Bird Avoidance Model (Kelly, 1999). Thermal plumes from CSP facilities will create permanent conditions for these birds and give rise to permanent avoidance areas. The three installations sharing the R-2508 complex are actively pursuing aviation easements to restrict bird attracting land uses (State of California, 2008).

Mitigation:
Bird activity in CSP cooling system plumes is most dangerous to high speed, low altitude aircraft on MTRs, and inside training ranges, and threatens to increase the risk of these activities or deny airspace. Pilots should be made aware of this risk and plan the avoidance of CSP during periods of bird activity.

Physical Obstructions
Any new development of solar generation facilities will require the addition of power lines to connect the facility to the electrical power distribution system. Suspended power lines are very difficult to see in flight, especially at night, and constitute a great threat to low-level flight operations. Though typically suspended less than 100 feet AGL, wires spanning valleys or traversing steep terrain can greatly exceed this height creating a higher likelihood of an aircraft impact. Aviators plan low level flight activities to avoid power lines and will elevate when uncertain of their proximity to power lines. The introduction of power lines into protected airspace used for low-level flight will increase the risk of aircraft impact, making the affected airspace less valuable for certain types of aircrew training, although at the same time, the existence of power lines may make the training range a more realistic representation of the air space where actual combat may take place.

Mitigation:
Low-level flight activities take place at all military installations except MCLB Barstow. Underground power lines eliminate any hazard to aviation; however, undergrounding of power lines is expensive. Placement of suspended power lines within existing corridors will have minimal impact on flight operations. Placement of power lines along airspace boundaries and away from MTR entry points onto military reservations will also minimize the impact to operations. Visual augmentation of power lines, typically done with brightly colored balls, may be an effective daytime strategy near helicopter landing zones and along MTR.

3.5.2 Range Utilization and Physical/Operational Mission Conflicts

Section 3.5.1 reviewed the –spectrum" interactions between mission activities and solar technology. This section will review the physical/operational conflicts. To provide context, this section will describe the military operations and activities conducted on each installation, summarize range utilization and discuss each installation's mission activity compatibility issues and concerns.

3.5.2.1 Introduction: Installation and Range Activities

For the purposes of this report, the study team developed a simplified list of the Live Training activities conducted on these installations and ranges that are relevant to all four Services' Mission Areas, described below and identified per installation in Table 3.3.

- *Live Training* - training participants operate their operational systems and platforms (including their full range of mobility and capability) in the physical environment for which they were intended.
  - *Dismounted maneuver training* - employment of forces - personnel on foot - in the range areas carrying out tactical exercises in imitation of battle.

- *Mounted maneuver training* - employment of forces - personnel in vehicles - in the range areas carrying out tactical exercises in imitation of battle.
    - Motorized (wheeled vehicle)
    - Mechanized (tracked vehicle)
- *Air operations training* (AO) - employment of aviation assets in the range area carrying out tactical exercises in imitation of battle, test and evaluation activities, logistics support activities, training support activities, range safety activities and search and rescue activities.
    - Manned Fixed Wing
    - Manned Helicopters
    - Unmanned Aircraft Systems (UAS)
- *Individual and unit live fire weapons training* - using live ammunition and/or loaded weapons or weapons systems.
- *Joint/combined arms maneuver training* - fully integrated training participants from two or more arms or elements (armor, artillery, aviation) of one military Service (Combined) or elements from two or more military Services (Joint/combined)
- *Joint/combined arms live fire and maneuver training* - using live ammunition and/or loaded weapons or weapons systems.
- *Testing and evaluation (T&E)* - [Also discussed in 4.2 Technical and Spectrum Conflicts]
    - Ground weapon systems and equipment
    - Aviation weapon systems and equipment
    - Support facilities (Maintenance and repair facilities for weapons and equipment, administrative buildings, public works, family housing, and other activities that support mission accomplishment).

Table 3.3 – Summary of Live Training Activities on Installations and Ranges

	Fort Irwin	NAWS China Lake	El Centro NAF	MCAGCC Twentynine Palms	MCLB Barstow	Chocolate Mtn. AGR	Edwards AFB	Nellis AFB & NTTR	Creech AFB
Live Training	X	X	X	X	X	X	X	X	X
Dismounted Maneuver Training	X	X		X		X			
Mounted Maneuver Training	X	X		X					
Air Operations Training	X	X	X	X		X	X	X	X
Individual & Unit Live Fire Weapons Training	X	X	X	X	X	X	X	X	
Joint/Combined Arms Maneuver Training	X	X	X	X		X			
Joint/Combined Arms Live Fire and Maneuver Training	X	X		X		X	X	X	
Test and Evaluation		X		X			X	X	X
Support Facilities	X	X	X	X	X		X	X	X

This section includes a discussion of the operating areas for each installation, beginning with a mission review, a general overview for the military installation, and lists each of the operating areas (Training areas, ranges, T&E sites and Support Facilities) associated with each installation. Each operating area is categorized by one or more of the critical capabilities it provides and the compatibility issues associated with each area. Additionally, when usage data is available, the annual number of units, personnel, and weapons and equipment the operating area supports will also be provided, presenting a more complete picture of the importance of the operating area and to better identify areas that may be compatible with solar energy projects and rule out those areas that are not.

3.5.2.2 Fort Irwin, National Training Center (NTC)

Mission

The National Training Center at Fort Irwin serves as the Army's premier training center. The installation is comprised of 754,134 total acres and is surrounded by desert hills and mountains. Much of this area is actually restricted from training due to logistical, physiographic, cultural and environmental concerns. There are 4,709 assigned military; 7,461 family members; and a civilian workforce of 5,646 personnel permanently assigned to Fort Irwin.

Fort Irwin's mission is to:

- Provide tough, realistic joint and combined arms training
- Focus at the battalion task force and brigade levels
- Assist commanders in developing trained, competent leaders and soldiers
- Identify unit training deficiencies, provide feedback to improve the force
- Prepare for success on the future joint battlefield
- Provide a venue for transformation
- Take care of soldiers, civilians, and family members

NTC trains the transformed Army by conducting force-on-force and live-fire training for ground and aviation brigades in a joint scenario across the spectrum of conflict, using a live virtual-constructive training model, as portrayed by a highly lethal and capable Opposing Force and controlled by an expert and experienced Operations Group. U.S Army and joint service units along with other governmental agencies deploy to Fort Irwin for training rotations. A typical rotation lasts several weeks and involves field training, including situational training exercises and full spectrum operations.

Land Training Areas and Range Usage

The staff, civilians and assigned units at Fort Irwin train 10 Army Brigades (a brigade consists of approximately 4,000-5,000 personnel) on a 28-35 day rotational basis each year. During the rotation, soldiers participate in challenging force-on-force and live-fire training and exercise scenarios. The land training areas and ranges for Fort Irwin are extensive. The southern half of Fort Irwin contains over 30 non-live fire TAs and numerous ranges for non-dud producing weapon systems (service rifles, machineguns, etc) depicted inside the green boundaries in Figure 3.2. The northern half of Fort Irwin contains the Live Fire (LF) Training Areas. These areas allow for the employment of dud-producing weapon systems (mortars, artillery, aviation delivered ordnance, etc.), depicted inside the red bounded areas in Figure 3.3. Between June 1, 2010 and May 31, 2011, a total of 60,751 servicemen and women utilized these facilities to train for duty in Iraq and Afghanistan (U.S. Army, 2011).

Figure 3.2 – Fort Irwin Southern Maneuver TAs and Live Fire Ranges (Halpin, June 2009-2011)

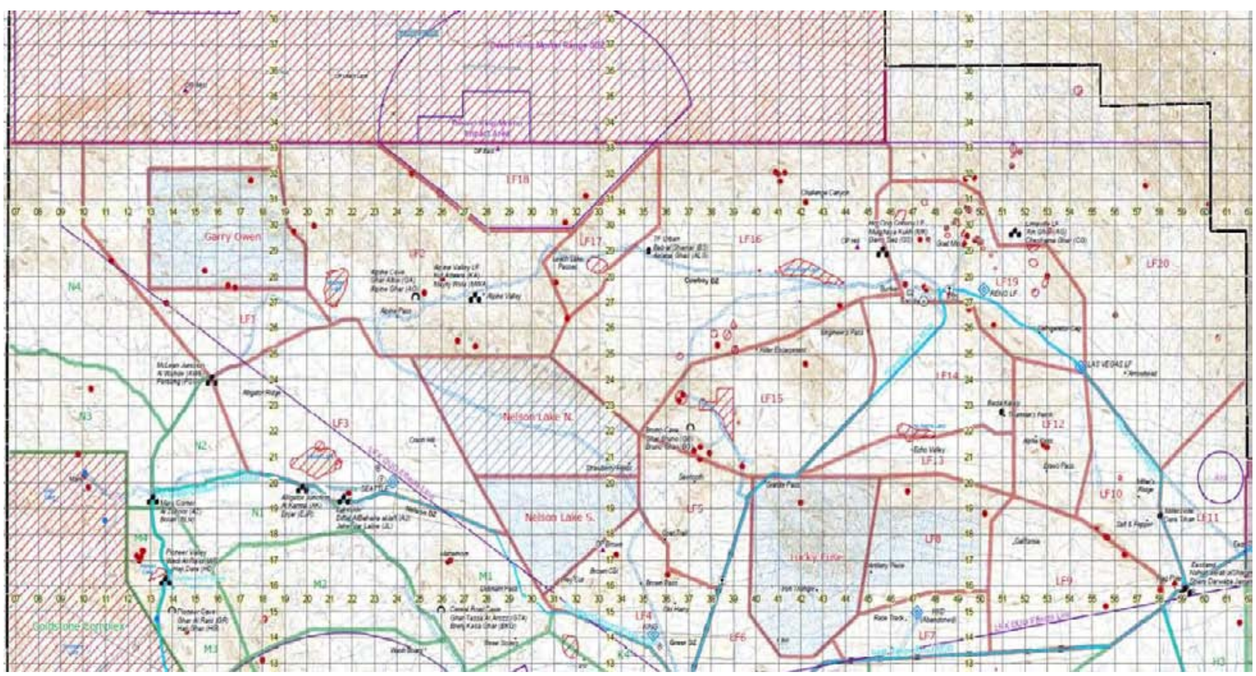


Figure 3.3 – Fort Irwin Northern Live Fire (LF) Training and Impact Areas (Halpin, June 2009-2011)

Airspace Operation Areas

The Airspace Operation Areas that support the Fort Irwin land ranges are part of the Range 2508 Complex. Range 2502N and Range 2502E are the two Airspace ranges that are used in support of Fort Irwin, NTC ground training operations. The types of operations conducted on these ranges are depicted in Table 3.4. The location where these activities occur is depicted in the accompanying schematic of the Range 2502 complex found in Figure 3.4. This airspace is controlled by the Army Airspace Information Center (AIC) Fort Irwin 24 hours a day, or NTC Airspace Control Center (NACC) when close air support activities are conducted on the ranges (USAF, 2010).

Table 3.4 – Operational Activities Conducted on Fort Irwin, NTC Range 2502 Complex

Area	Purpose
1. Southern Engagement Corridor	Force-on-Force battle simulation area
2. Central Engagement Corridor	Force-on-Force battle simulation area
3. Live Fire Exercise Corridor	Area contains computerized, pop-up, direct-fire artillery, and close-air-support (CAS) targets. During a live-fire exercise, actual battle conditions are closely simulated with artillery fire, tanks, and troops advancing against computerized arrays supported by attack helicopters and with jet aircraft CAS targets.
4. Leach Lake Air Gunnery Range (north portion of R-2502N) Beginning at 35°37’45”N/116°55’23”W, thence direct 35°37’45”N/116°29’43”W, thence direct 35°32’53”N/116°29’43”W, thence direct °32’53”N/116°55’23”W	Maneuvering by Army, Air Force, and Navy flying units providing CAS during rotational periods. During non-rotational periods, over flight of Leach Lake must be scheduled through Fort Irwin NTC Operations.
5. Goldstone Deep Space Tracking Facility (western boundary of R-2502N)	National Aeronautic and Space Administration’s (NASA) Goldstone tracking facility is used for communicating with deep space science missions. This large radio telescope not only sends high-powered RF signals, it must also detect extremely faint radio signals sent from space probes on the edge of the solar system. It was intentionally located within a bowl formed by the mountains between Fort Irwin and NAWS China Lake to shield it from RF encroachment. Over flight and spectrum use is tightly coordinated with the military. When Goldstone is making high-power transmissions or is involved in a critical/sensitive event, the area of avoidance is increased. Broadband jamming and aeronautical telemetry in the 2200–2290 MHz band are not allowed within line of sight of Goldstone without prior scheduling through the Western Area Frequency Coordinator, Point Mugu. Radio frequency emissions in the 2290–2300 MHz and 8400-8450 MHz bands are not allowed within line of sight of Goldstone. As discussed in 5.1.6.3, any solar development under consideration on the Goldstone facility will need careful study of RFI mitigation.

Source: (USAF, 2010)

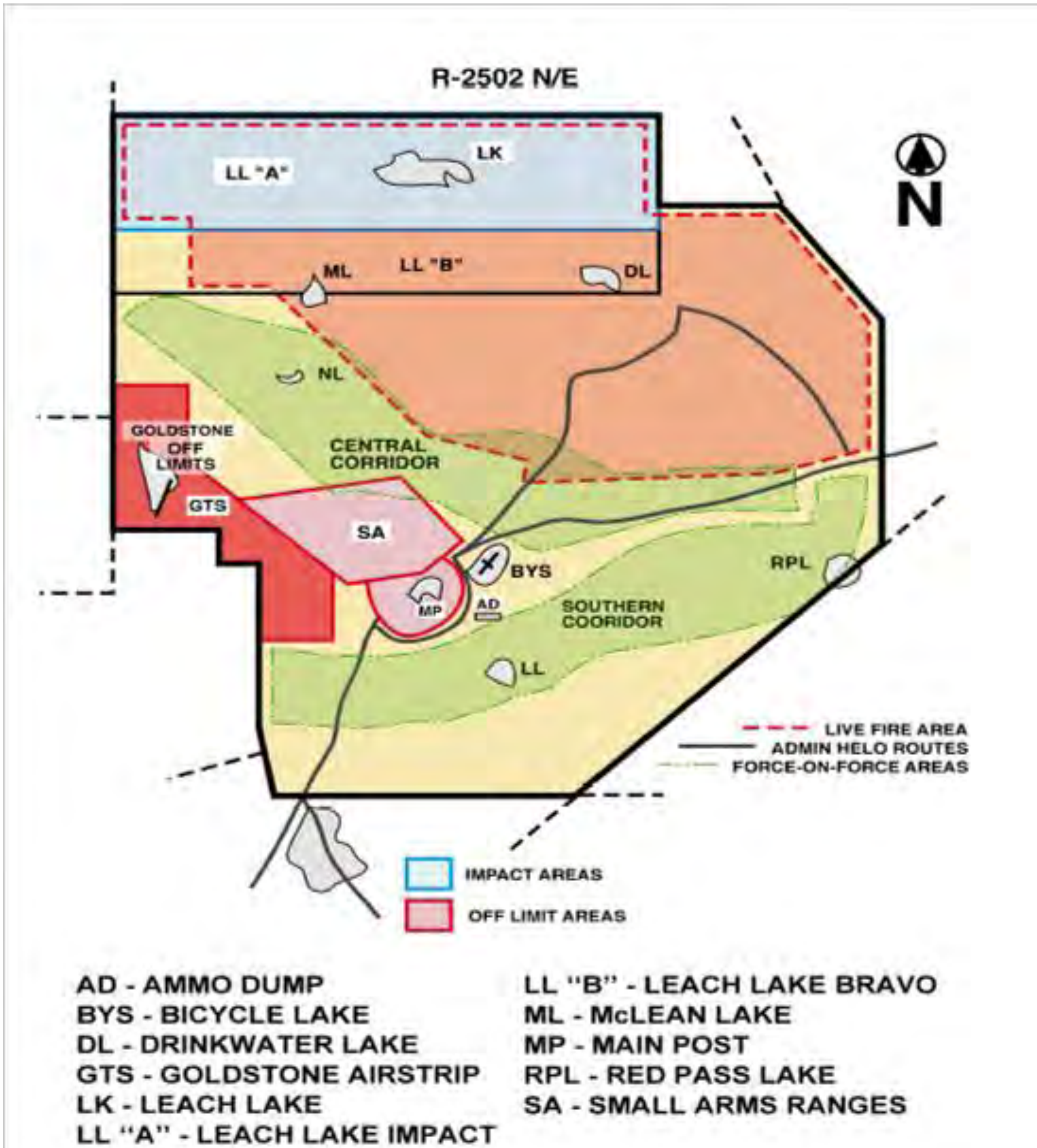


Figure 3.4 – Schematic of R-2502 Range Complex (USAF, 2010)

Compatibility Issues

Siting large solar development projects is not mission compatible with the Fort Irwin ranges. (Note that the Goldstone facility may be suitable provided spectrum conflicts can be avoided.) Live fire and maneuver activities that regularly occur in the north ranges (the live fire training area at the NTC) are incompatible with the development of solar energy projects due to the inherent hazards and risks associated with maneuvering large mechanized brigades and the employment of live ordnance. Dust created by the movement of these armored vehicles will increase the maintenance requirement on both

CSP and PV systems. Additionally solar energy projects are incompatible with the direct fire ranges and most of the maneuver ranges in the southern region of Fort Irwin. The exceptions might be any non-live fire maneuver training corridors identified by Range Operations. Access issues are another incompatibility for most of the training areas. There are limited paved or improved ground access routes into the training areas, restricted by both range regulations and existence of only a few improved surface roads. Increased use of these access routes would interfere with range operations and training requirements. A further constraint on solar energy development at Fort Irwin is the relative scarcity of water at the installation.

Mitigation
Fort Irwin is clearly working through some compatibility issues under their current Solar Energy Enhanced Use Lease (EUL) Agreement to build 500 MW of solar power facilities at Fort Irwin by the year 2022 (USACE, 2011). Fort Irwin is on the leading edge of the trend towards hosting solar energy facilities and is an ideal candidate for continued monitoring and study as this solar energy project moves forward. A detailed examination of training range usage patterns before and after the solar build-out, along with surveys of the range users' experiences, will help validate or disprove compatibility issues that may apply to future projects. In the future it may be worthwhile to reexamine range usage and modification to training after these projects take shape and more solar spectrum compatibility research has been completed.

3.5.2.3 Naval Air Weapons Station, China Lake (NAWS China Lake)

Mission
NAWS China Lake is home to approximately 4,400 civilian employees, 1,000 military personnel, and over 1,500 contractor employees. The mission of NAWS China Lake is to support the Navy's research and T&E missions to provide cutting-edge weapons systems to the warfighter. NAWS China Lake carries out the complete weapon-development process--from basic and applied research through prototype hardware fabrication, test and evaluation, documentation, and Fleet and production support. Major programs include air-to-air missiles; fuses for the Standard Missile and a wide variety of other surface-to-air and air-to-air missiles and free-fall weapons; Harpoon anti-surface weapon system; Tomahawk cruise missile; Sidearm and HARM anti-radiation-missile programs; parachute systems and subsystems for aircrews and equipment; avionics hardware and software and total-combat-system operational flight programs for most Navy fighter and attack aircraft; and tactical electronic-warfare and countermeasures systems.

NAWS China Lake's analysis and T&E capabilities and projects remain unmatched for simulation of threat weapon systems; major electronic-warfare threat-simulation facilities; and complete test and evaluation--static, live-fire, captive-carry, supersonic-track, environmental, radar cross-section--of a wide range of anti-air and anti-surface systems. The China Lake test resources comprise a portion of the DoD's Major Range and Test Facility Base (MRTFB) and is considered to be a set of critical the DoD's T&E infrastructure and associated workforce that must be preserved as a national asset to provide the T&E capability to support the DoD acquisition process (OSD RDT&E, 2011). Contributing to and complementing these projects are broad technology-based efforts, which range from basic research in physics and chemistry to applied projects in energetic materials, embedded computers, specialized semiconductor and superconductor materials, and lasers and optics.

Training Area and Range Usage Information
More than 18,000 manned and un-manned military sorties are conducted out of NAWS China Lake's Armitage Field by all U.S. services each year. The restricted airspace used by NAWS China Lake aviators includes 19,600 square miles of controlled airspace, 12 percent of California's total airspace, and provides an unprecedented venue for integrated testing and training. Figure 3.5 illustrates the location of the NAWS China Lake Ranges and R 2508 Airspace Complex. Foreign military personnel also use the airfield and ranges to conduct more than 500 test and evaluation operations each year.

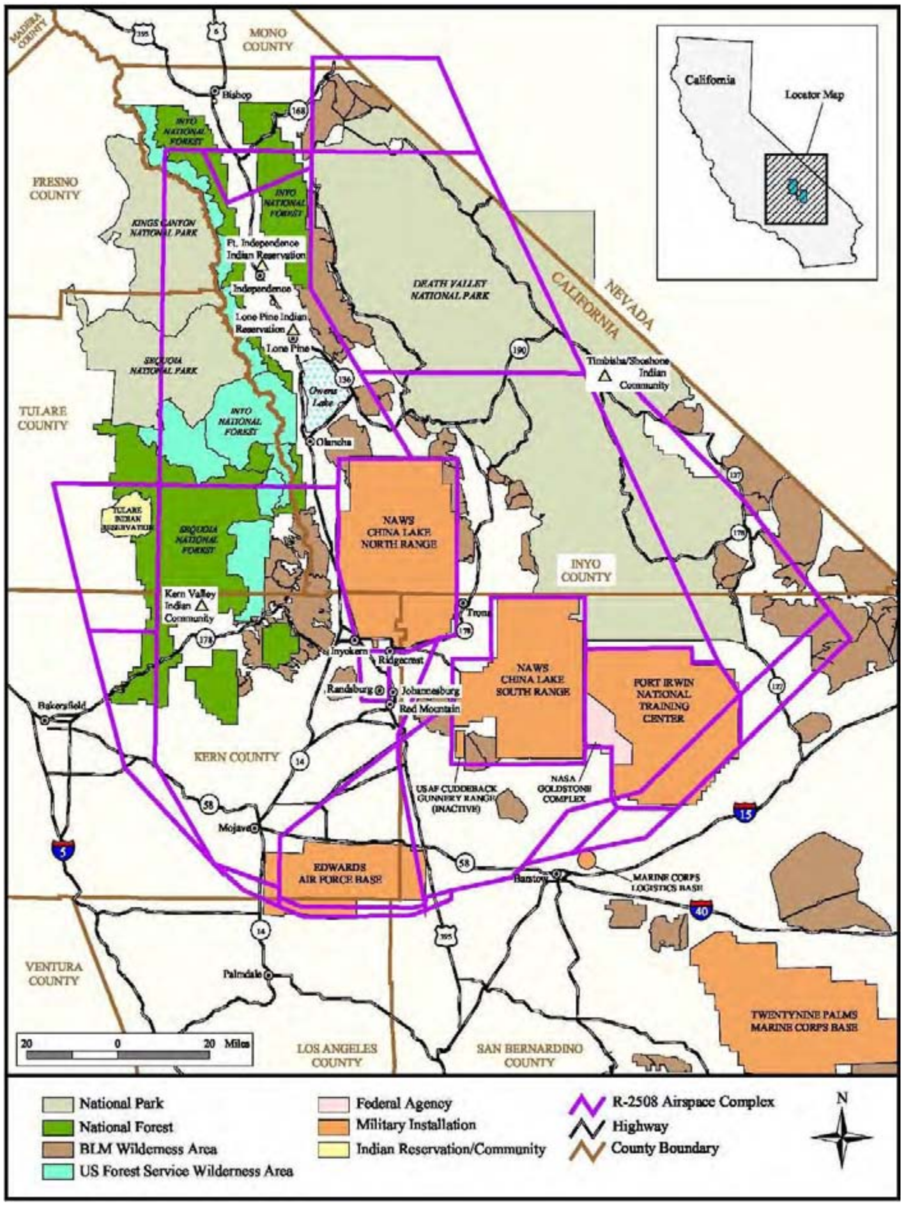


Figure 3.5 – NAWS China Lake Range Locations and Airspace Complex (BLM, 2004)

NAWS China Lake is unique in that as a testing and evaluation facility, its land and range use change depending on current test requirements. Because of the testing that occurs, the airspace required to support NAWS China Lake Operations is quite large and it includes airspace also used by Edwards AFB and Fort Irwin. This section will first cover the NAWS China Lake land/target ranges and then discuss the Range 2508 Airspace Complex that supports all three of these military installations.

Training Area and Range Usage (Land Areas)

The target and land ranges of NAWS China Lake are found in two separate tracts of land. NAWS North Range Complex and the NAWS South Range Complex. The NAWS North Range complex consists of several smaller ranges, target areas, test sites and cantonment areas, listed in Table 3.5 below and depicted on the map in Figure 3.6.

Table 3.5 – NAWS China Lake North Range Land Area Breakdown	
Coso Range	Baker Range
Coso Target Range	Armitage Airfield
Coso Geothermal	Mainside
Airport Lake	Main Magazines
George Range	Propulsion Laboratories
Charlie Range	Ordnance Test and Evaluation

Source: (BLM, 2004)

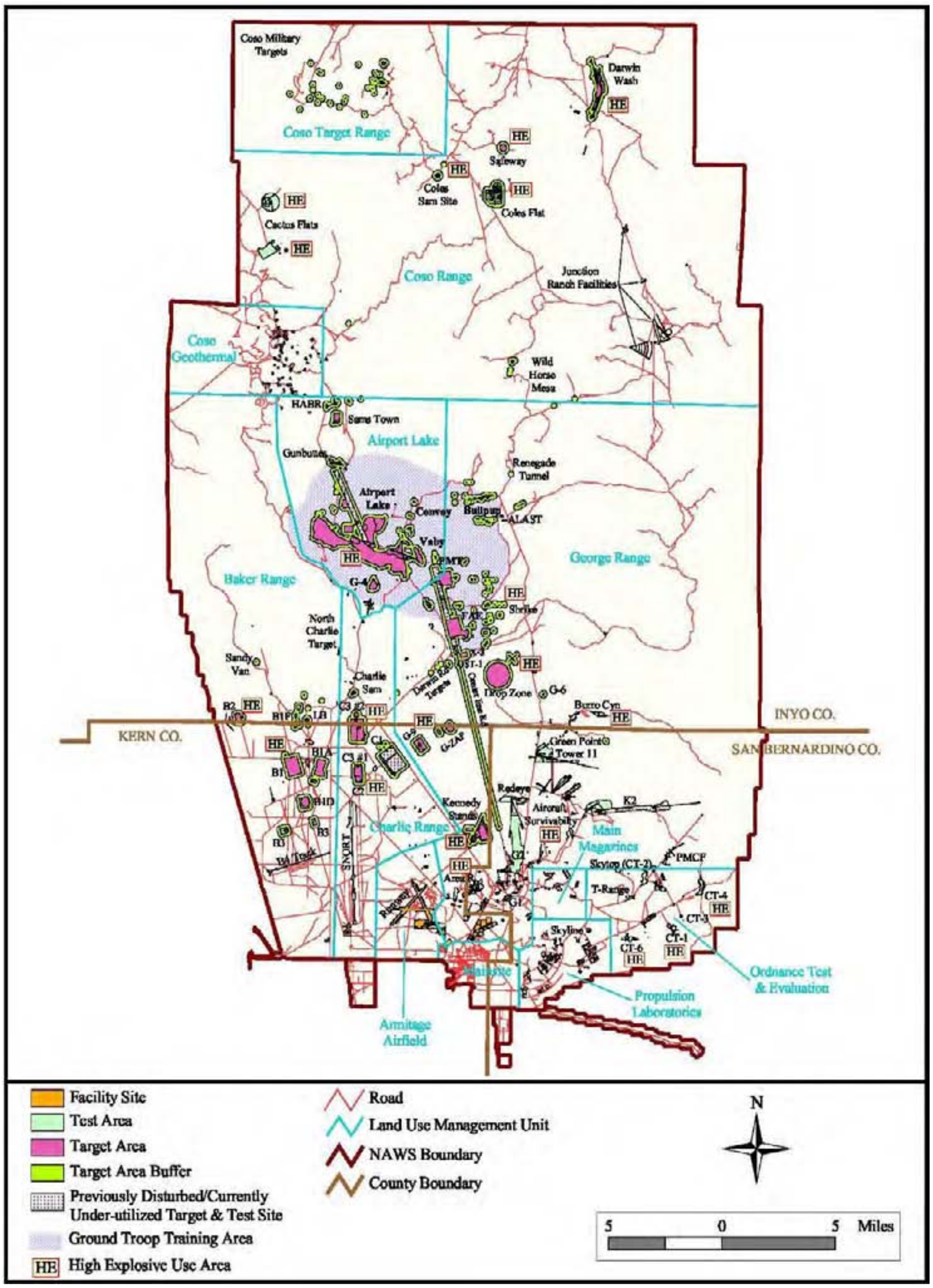


Figure 3.6 – NAWS China Lake North Range Complex Land Area Map (BLM, 2004)

The southern Range Complex consists of the ranges and target areas listed in Table 3.6 and illustrated in Figure 3.7.

Table 3.6 – NAWS China Lake North Range Land Area Breakdown	
Mojave B North	Randsburg Wash/Echo Range
Mojave B South	Superior Valley Target Range

Source: (BLM, 2004)

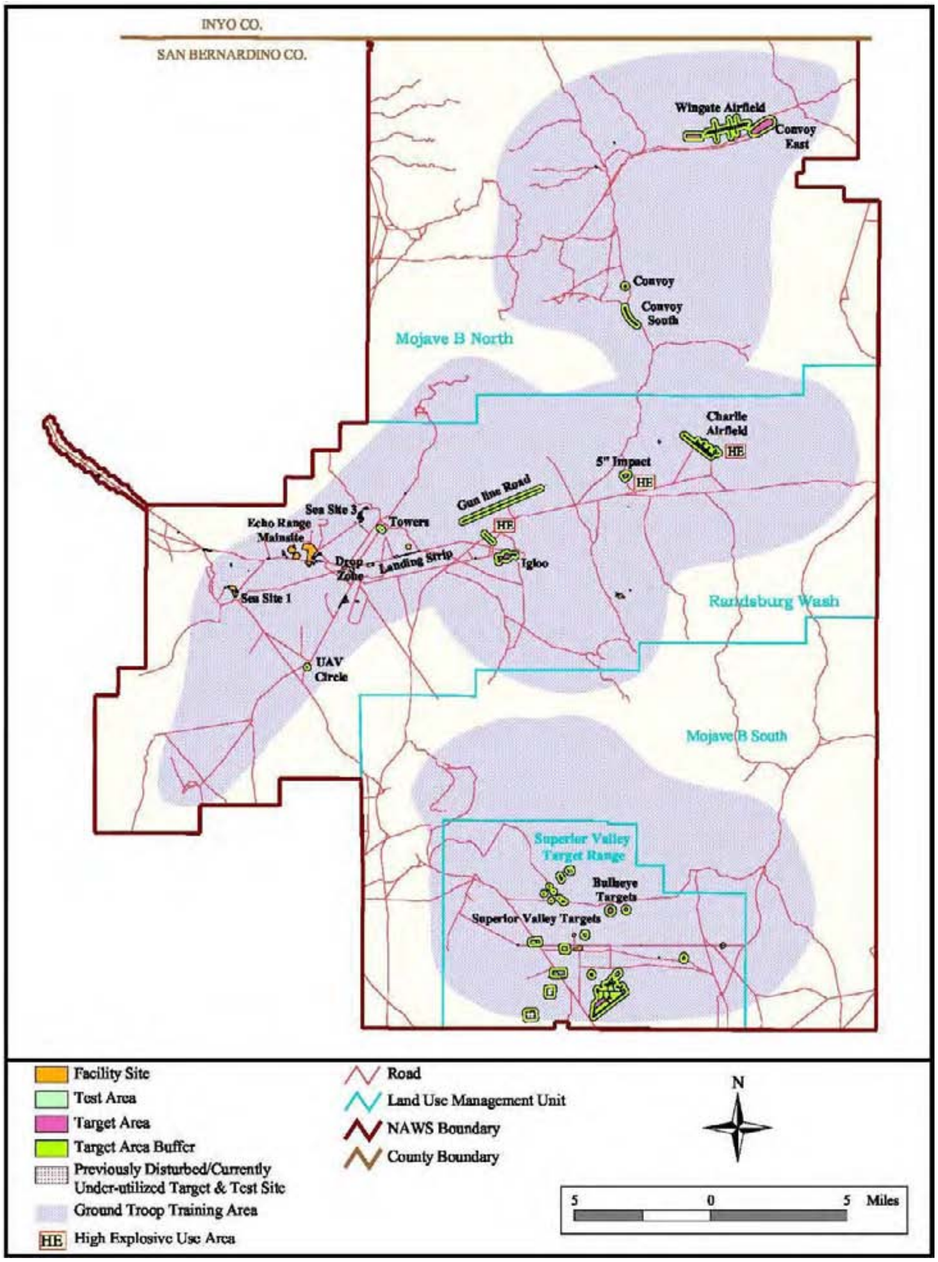


Figure 3.7 – NAWS China Lake South Range Complex Land Area Map (BLM, 2004)

Current detailed range usage data could not be obtained from NAWS China Lake because it was being compiled for an Environmental Impact Statement (EIS) that will not be ready for release until the summer of 2012 (U.S. Navy, 2011). This EIS addresses a Navy proposal to expand range usage. However, previous data compiled for a 2004 NAWS China Lake EIS Study was combined with pre-decisional information provided by NAWS China Lake Land Use managers to provide the following summary of range usage information. The proposal under consideration in the EIS, if approved, will increase range usage by approximately 25% in most categories.

Range usage at NAWS China Lake falls into 3 major categories; Research and Development (R&D), T&E, or Training (T) activities. R&D and T&E activities are the primary mission activities at NAWS China Lake. Training activities are scheduled on a not-to-interfere basis. These activities are listed in Table 3.7 and described in detail in subsequent paragraphs.

Table 3.7 – NAWS China Lake Range Usage Activities	
Air-to-Air (R&D, T&E, T)	Energetics (R&D, T&E, T)
Surface-to-Air (R&D, T&E, T)	Electromagnetics (R&D, T&E, T)
Air-to-Ground (R&D, T&E, T)	Test Track (R&D, T&E)
Surface-to-Surface (R&D, T&E, T)	Air combat, aircrew and combat skills training (T)
Ground Troop Training Type I (T)	Ground Troop Training Type II (T)

Source: (U.S. Navy, 2011)

R&D and T&E activities conducted for Air Operations also usually require the additional ground support activities defined below:

- *Pre-event/set-up activities* – Involves the installation/placement of portable/stationary instrumentation or equipment for event monitoring and data acquisition near target and test sites and at other remote locations. Also, entails shallow trenching to cover cables and instrumentation, and burying certain targets up to three meters to simulate theater conditions.
- *Target-related activities* – Includes target construction, placement/installation, maintenance, recovery, removal, clean up (including remediation of any released hazardous substances), and disposal.
- *Launch activities* – Involves the air or ground launch of a test article or target within the China Lake Range Complex (CLRC).
- *Post-event/teardown activities* – Involves test article recovery, instrumentation/equipment teardown, removal of buried targets and instrumentation, and clean up of the test site including remediation of any released hazardous substances.
- *Off-road activities* –
    - Use of vehicles or mechanical equipment in support of any above mentioned activity
    - Operation of mobile targets to simulate theater relevant threats
    - Operation/access of personnel, vehicles, and unmanned systems to unique terrain such as mines, caves, tunnels, sloped areas, vegetative areas, etc. to satisfy unique test/training requirements.
    - Removal of used targets, recovery of crashed vehicles and remediation of any released hazardous substances (U.S. Navy, 2011).

Hazard Patterns for NAWS China Lake Ranges

Because NAWS China Lake is primarily a R&D and T&E facility, it does not have standard or predetermined surface danger zones (SDZs), like most training ranges. Safety fans are calculated prior to each test, based on engineering estimates and historical data of similar tests. Figure 3.8 is a combined overlay of all the hazard fans used for the North and South Ranges for a one-year period beginning in 2009. As the figure illustrates, the hazard pattern covers almost all of the land inside the range boundaries and in some cases it even extends beyond the land boundaries.

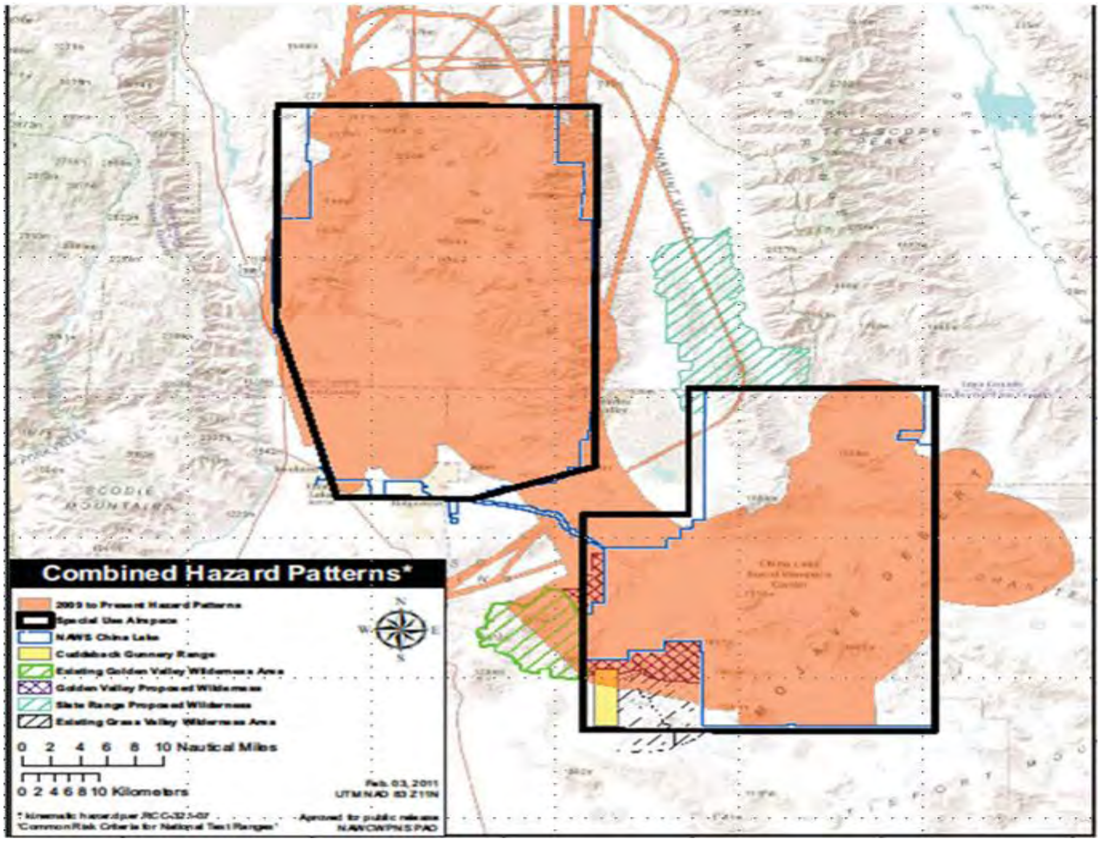


Figure 3.8 – Combined Hazard Pattern for NAWS China Lake R&D/T&E and Training (U.S. Navy, 2011)

R&D, T&E, and Training Activities that Occur on NAWS China Lake

1. Air to Air

Air to air R&D, T&E and training involves the test or actual use of an air-launched, air-intercept weapon against a variety of aerial targets. Figure 3.9 is an illustration of an air-to-air engagement. Air-to-air operations generally employ manned and/or unmanned aircraft, a kinetic or Directed Energy (DE) weapon system, a target, and countermeasure devices such as flares or chaff. Air-to-air testing assesses and evaluates weapons and weapon systems and the integration of weapon systems with the aircraft. Operations may include captive-carry inert, live motor but no warhead, or tactical all-up round for firing and warhead detonation. Examples of this type of testing might include the launch of an AIM-9X Sidewinder missile against a full-scale aerial target or the deployment of an HEL weapon from a manned platform against an unmanned aerial target.

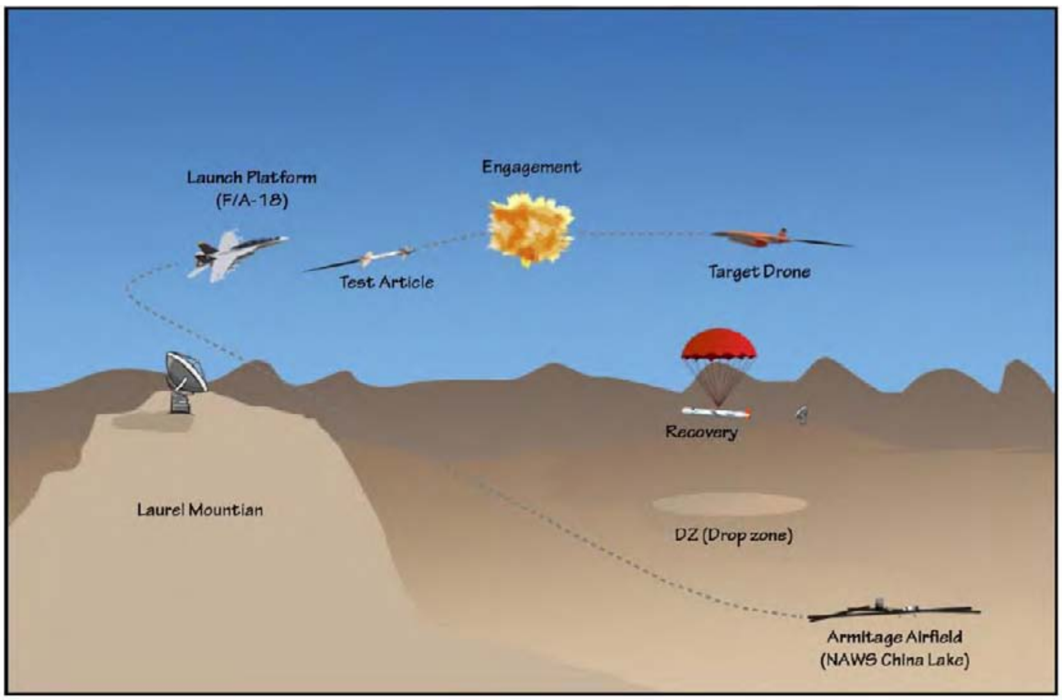


Figure 3.9 – Air-to-Air Operations (U.S. Navy, 2011)

2. Surface-to-Air

Surface-to-air operations depicted in Figure 3.10 have the same hazard patterns as air-to-air operations. This scenario involves the test of a surface launched kinetic or DE weapon against a variety of aerial targets. Surface-to-air testing evaluates overall weapon system performance, warhead effectiveness, and software/hardware modifications or upgrades of ground-based weapons systems. Operations may include inert warhead or tactical all-up round for firing and warhead detonation. Targets used in surface-to-air testing include full-scale surface launched targets, air- or surface-launched subscale targets, unmanned systems, or helicopter targets. This scenario includes the test of a ground-launch weapon from a fixed launcher. Examples of this scenario are the launch of a 2.75" HYDRA-70 rocket from a stationary launch rail or the deployment of a HEL weapon against an airborne target.

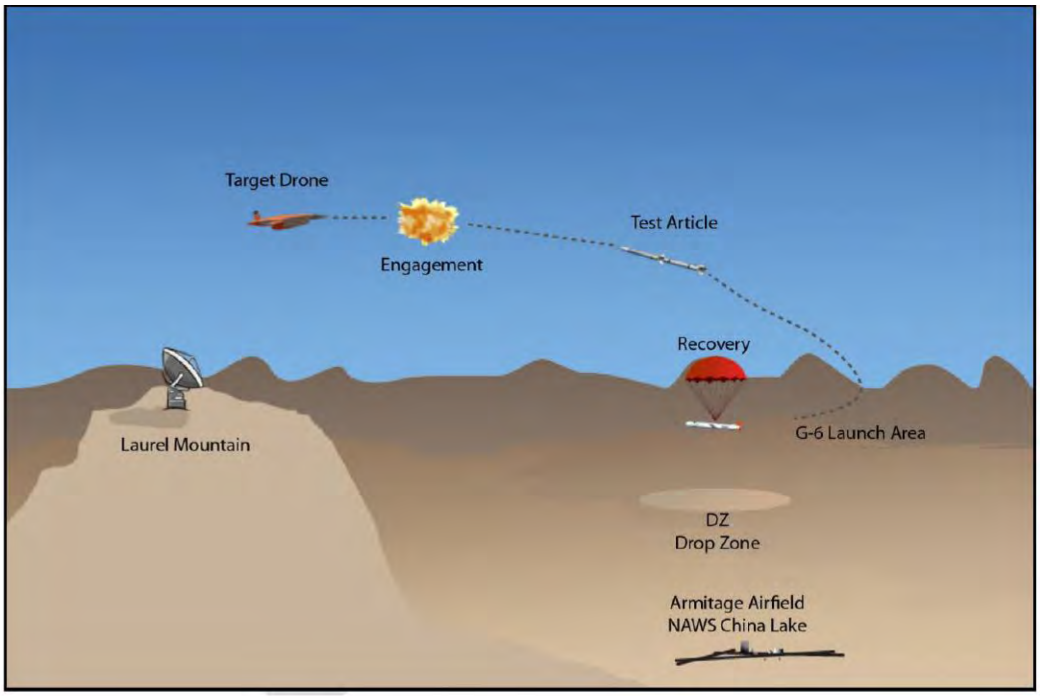


Figure 3.10 – Surface to Air Operations (U.S. Navy, 2011)

3. Air-to-Ground

Air-to-ground operations, depicted in Figure 3.11, involve the test or delivery of an air-launched, ground attack, kinetic, or DE weapon against a variety of ground-based targets. Air-to-ground testing assesses and evaluates weapon systems, the integration of air-to-ground weapons or weapon systems to the aircraft, warhead effectiveness and weapon systems and/or aircraft software and hardware modifications or upgrades. Air-to-ground tests are heavily dependent on ground targets, which can include a wide variety of vehicular, RF, and structural targets. Operations may include captive-carry inert, live motor but no warhead, or tactical all-up round for firing and warhead detonation. Examples of this scenario are the launch of a GBU-130 JDAM against a fixed, structural target or the deployment of a High Power Microwave (HPM) weapon against an electronic target.

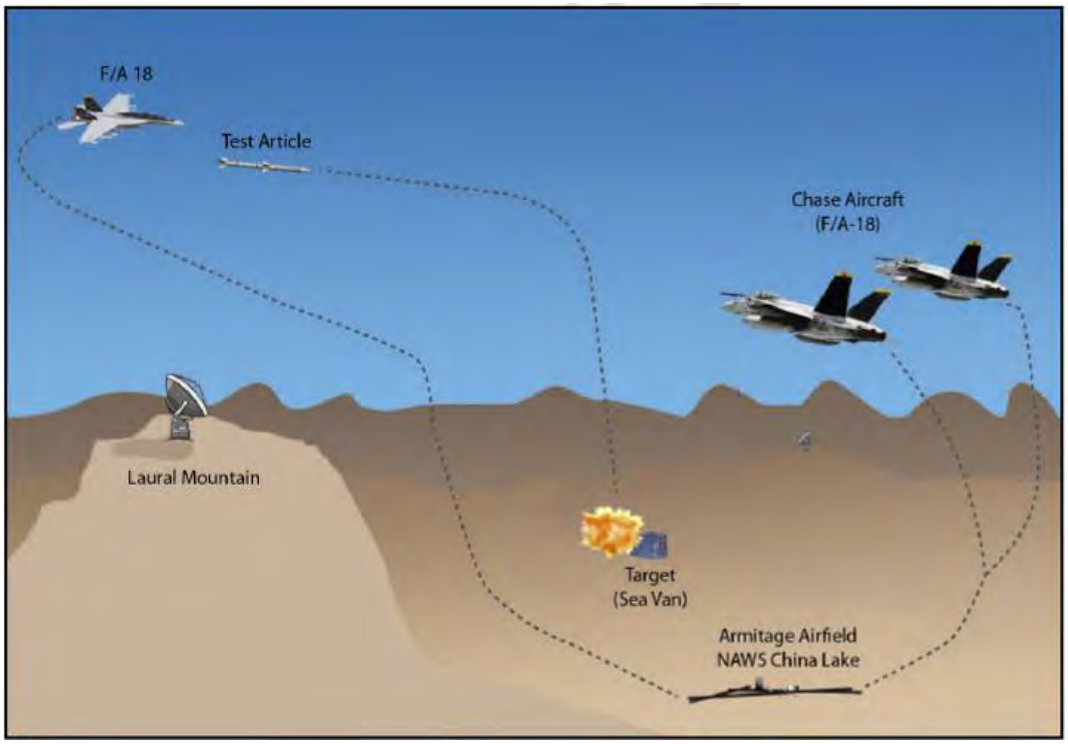


Figure 3.11 – Air-to-Ground Operations (U.S. Navy, 2011)

4. Surface-to-Surface

Surface-to-surface operations depicted in Figure 3.12, involve the test or delivery of a surface-launched, kinetic or DE weapon against a surface target. Surface-to-surface testing evaluates the overall weapon system performance, warhead effectiveness, and software/hardware modifications or upgrades of ground-based weapons systems. Operations may include inert warhead or tactical all-up round for firing and warhead detonation. Targets used in surface-to-surface testing include both fixed and mobile. This scenario includes the testing of naval guns and other types of smaller caliber guns from fixed surface sites, ground vehicles, and air platforms. Examples of surface-to-surface weapons are the 5"/54 naval guns, ground-based DE systems, and shoulder fired anti-tank/vehicle and personnel weapons.

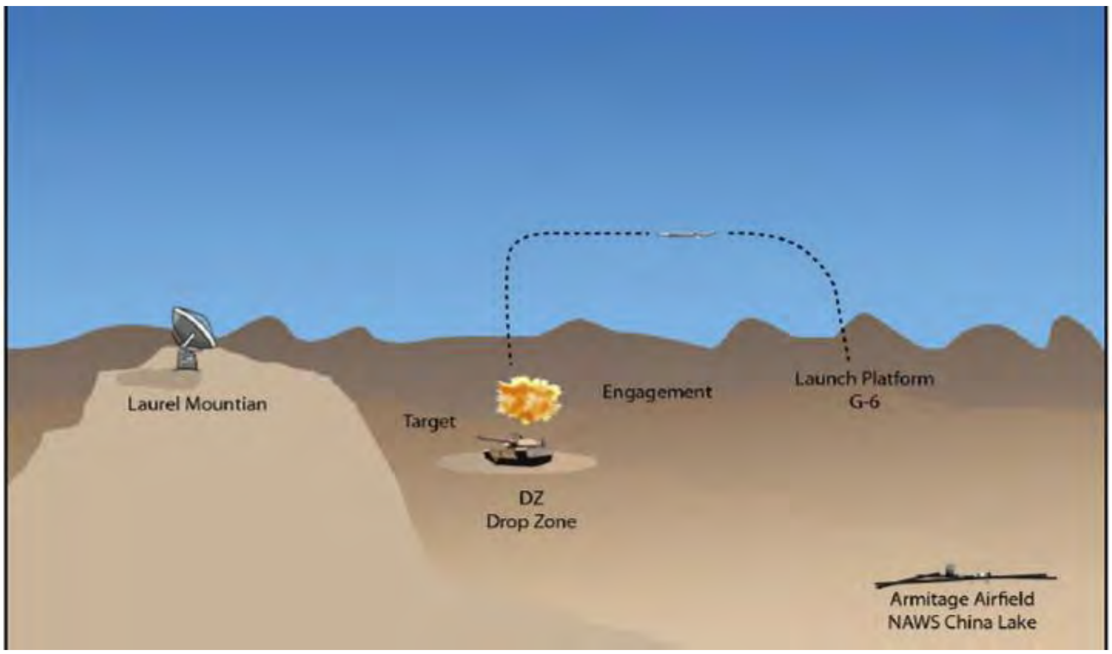


Figure 3.12 – Surface-to-surface Operations (U.S. Navy, 2011)

5. *Energetics*

Energetics is the testing, training, and disposal activities related to the use of energetic materials such as propellants and explosives. Much of the work conducted by the Energetics Research Division on explosives, propellants, and pyrotechnics is included in this category. In addition, the development and test of Counter Improvised Explosive Device (CIED) detection and neutralization systems may be considered energetics testing. Examples include:

- Propulsion testing of small and large solid fuel rocket motors.
- Environmental and safety testing for all-up rounds in accordance with military standard requirements. Environmental life cycle tests include vibration, temperature, humidity, x-ray, and final live munitions firing. Safety tests include fast and slow cook-off, bullet and fragment impact, drop tower, and sympathetic detonation.
- Treatment of energetic hazardous waste generated from R&D laboratory activities.
- Blow in place (BIP) activities to dispose of unexploded ordnance or support range operations.
- Warhead testing.

6. *Electromagnetics*
Electromagnetics involves ground and flight tests that radiate RF energy across much of the electromagnetic spectrum. These operations do not typically include the release of kinetic weapons such as missiles, rockets, bombs, and guns. However, they may involve the release of electronic warfare (EW) defensive countermeasure devices such as chaff, flares, and decoys. EM operations include antenna pattern and RCS measurements; defensive and offensive EW systems; laser systems for targeting, communication, mapping, etc.; DE weapons; experimental electromagnetics; communications; EM vulnerability of electronic systems; and other RF related testing. This category may also include the development and test of CIED detection and neutralization systems. DE weapons development and test are an important component of electromagnetics. Figure 3.13 through Figure 3.17 are examples of HEL and HPM open-air test events which may include:

- Component level tests to evaluate functionality and efficiency
- Beam characterization to measure fluence, attenuation, divergence, and other propagation effects under various atmospheric conditions
- Subscale systems to evaluate component compatibility
- System integration into air and surface platforms
- Tests to evaluate laser and HPM beam interaction with targets
- Full up system test to evaluate acquisition, and tracking performance
- Full up systems test to defeat air and/or ground targets with DE weapons mounted in air and/or ground vehicles

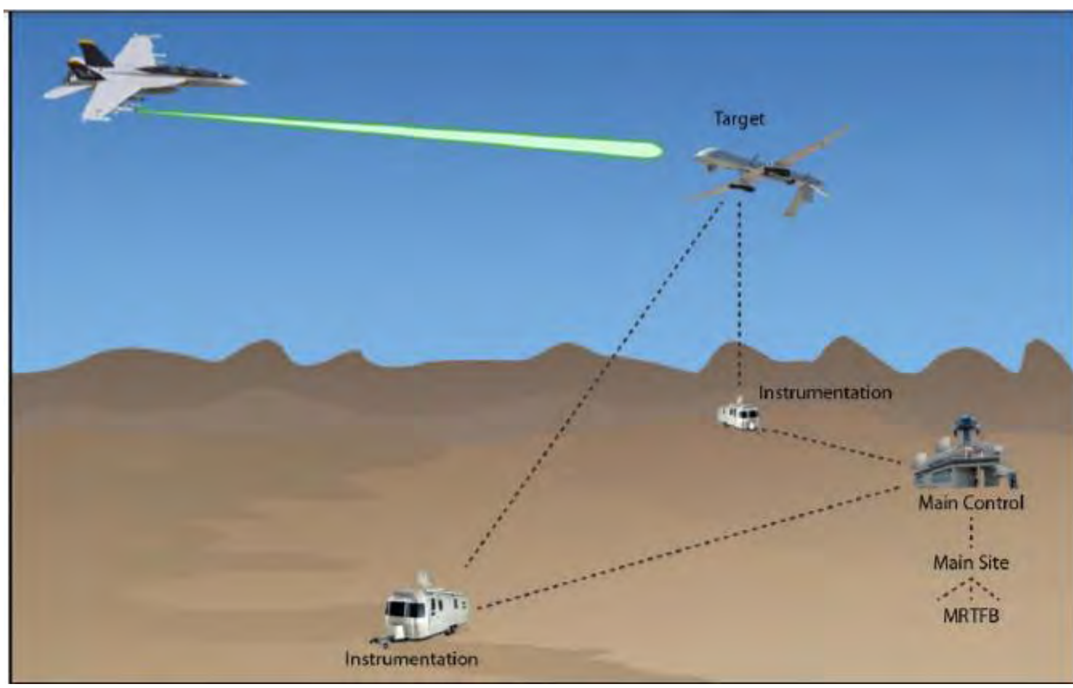


Figure 3.13 – Air-to-Air HEL Operation (U.S. Navy, 2011)

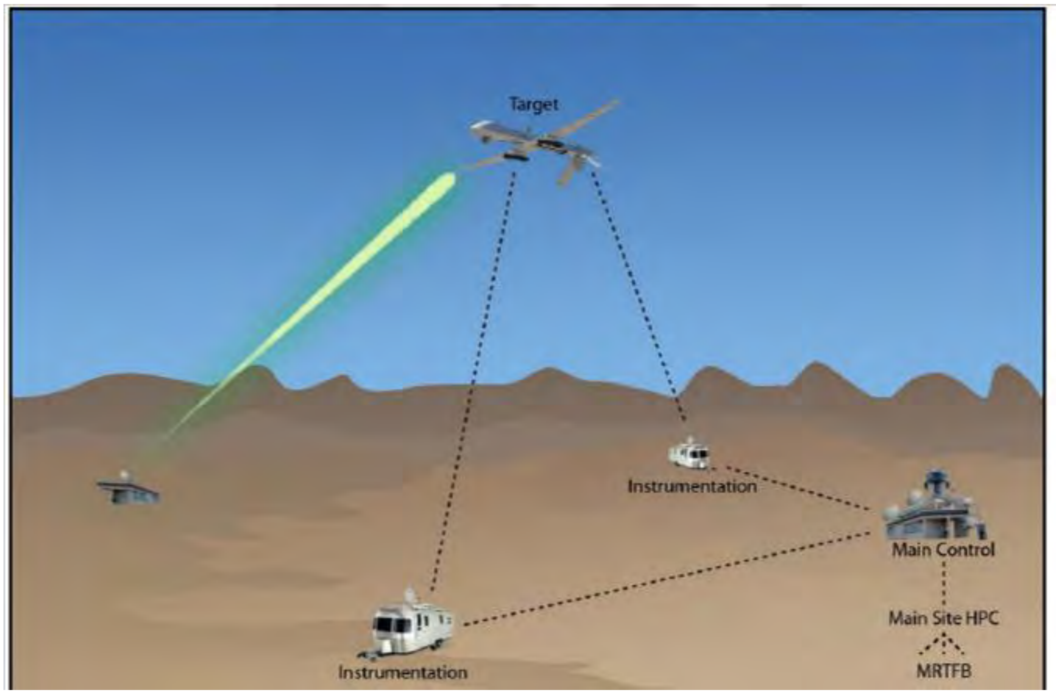


Figure 3.14 – Air-to-Ground Operation (U.S. Navy, 2011)

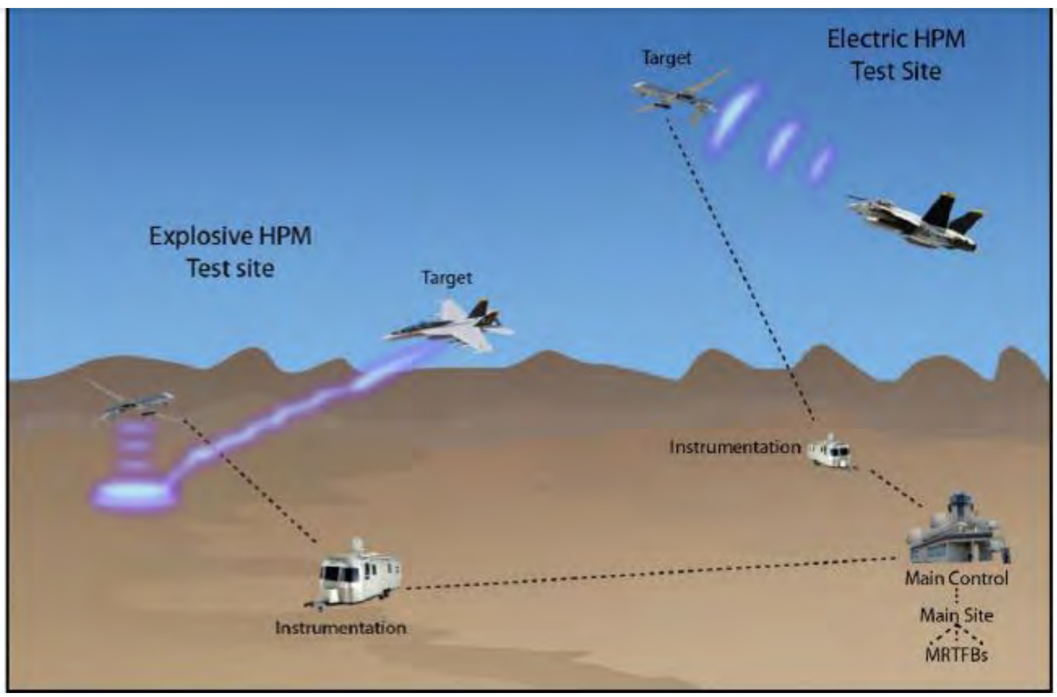


Figure 3.15 – Air-to-Air HPM Operation (U.S. Navy, 2011)

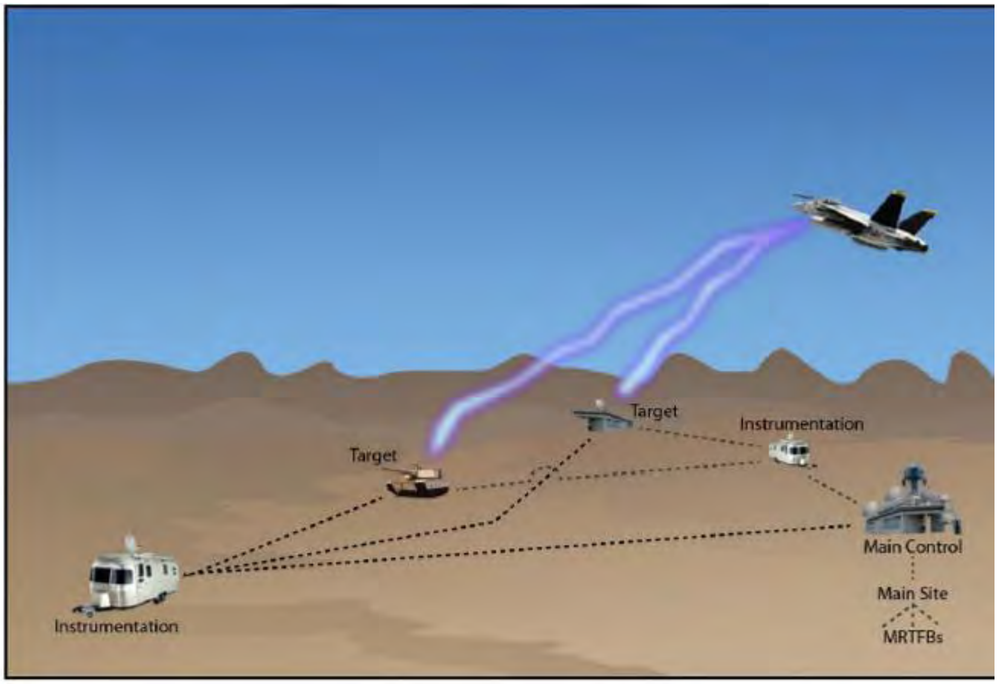


Figure 3.16 – Air-to-Ground HPM Operation (U.S. Navy, 2011)

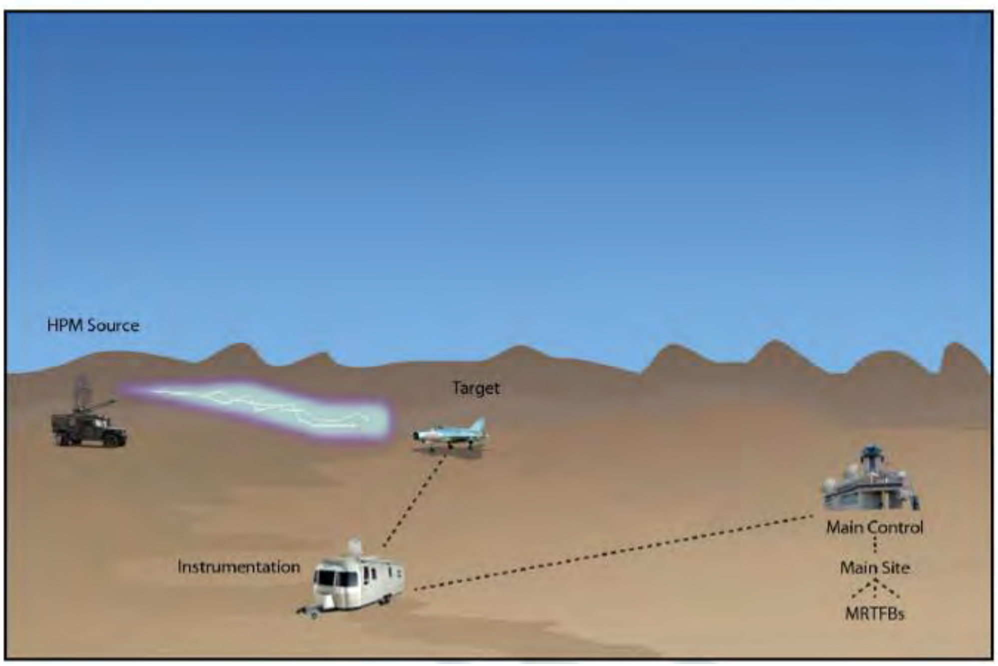


Figure 3.17 – Ground to Ground HPM Operation (U.S. Navy, 2011)

7. Test Track Operations

Test track operations involve the test of a kinetic or DE weapon system mounted on a sled capable of operating at speeds ranging from subsonic to hypersonic. A test article, often a full-scale aircraft or weapon system, is propelled down track to simulate flight conditions. Typical test track operations include target penetration using live high explosive warheads, live fuses, aircrew ejection systems, bombs, missiles, rockets, free flight terminal ballistics, environmental, soft recovery, EW and countermeasures, and vehicle and barrier testing. An example of this scenario is the test of a weapon system for target penetration capabilities against a fixed target, often a concrete block, mounted down-range of the muzzle section of the track. The weapon is separated from a propelled sled, which is retarded via water brake prior to the muzzle, and allowed to transit down-range to impact. Figure 3.18 and Figure 3.19 illustrate test track operations.

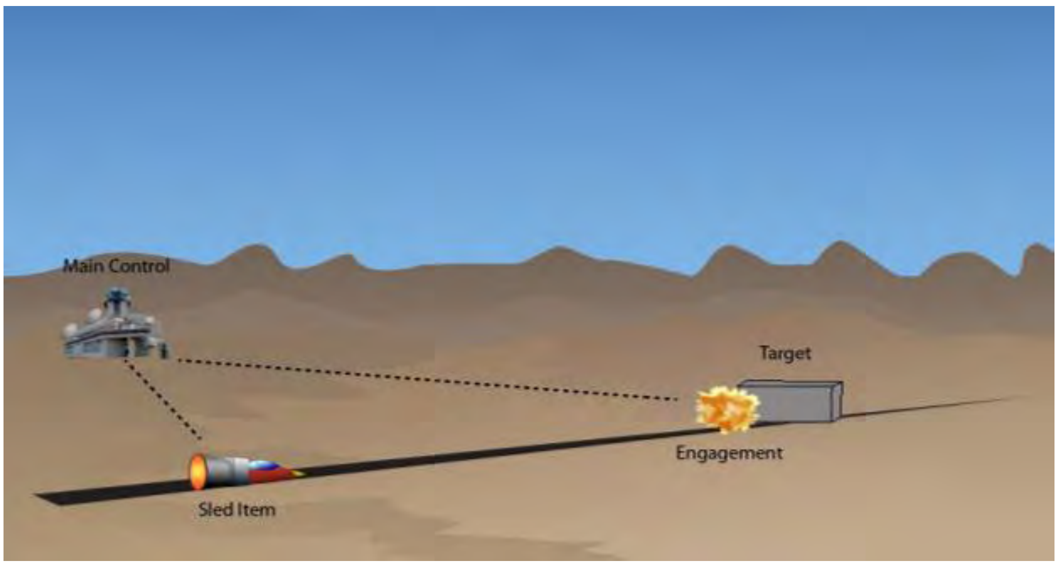


Figure 3.18 – Target Penetration Test (U.S. Navy, 2011)

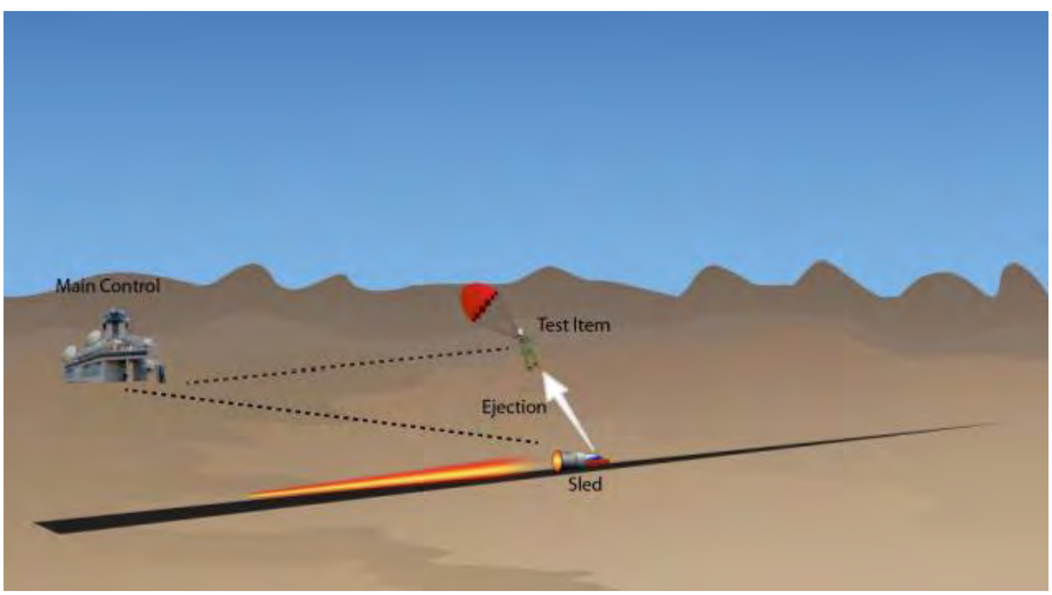


Figure 3.19 – Ejection System Test (U.S. Navy, 2011)

Air Combat, Aircrew and Combat Skills Training
This training often encompasses activities similar to some of the R&D and Testing activities in that Air-to-air and Air-to-Ground operations are part of this training. The difference is that this training is done with aircrews and actual live or inert ordnance and equipment. Training also includes navigation skills, combat maneuvering and electronic counter measures.

Ground Troop Training (GTT)
Some limited theatre relevant combat training of ground troops occurs at NAWS China Lake. Current training involves Special Forces, explosive ordnance disposal (EOD) personnel, expeditionary forces, construction battalions (SeaBees), forward deployed air controllers, and reconnaissance personnel. Examples include but are not limited to Force Reconnaissance, Insertion and Extraction, Close Air Support (CAS), Fleet Area Control and Surveillance (FASFAC), open burn/open detonation, mine clearance, and other types of tactical exercises. GTT operations may involve support aircraft (manned or unmanned; fixed or rotary wing), small- and large-caliber weapons firing, and the use of military support animals and surface vehicles. GTT may also require access to distinct terrain such as mines, caves, tunnels, sloped areas, or vegetative areas to satisfy unique training requirements. GTT events include small groups up to 60 troops or large groups up to 200 troops. Training is either focused or dispersed. Focused GTT involves the repetitive use of specific locations. Impacts are therefore concentrated in and limited to those locations. Dispersed GTT involves the intermittent use of multiple areas as troops move from one location to another and does not involve concentration of massed troops. Therefore, impacts are dispersed across locations. GTT events are explicitly constrained to not include heavy training events, such as those involving heavy brigade-sized military forces.

Airspace Operation Areas
As previously mentioned, the unique Research, Development, Testing, and Evaluation (RDTE) mission of NAWS China Lake requires extensive air space to test and evaluate weapon systems. The collective airspace is referred to as the Range 2508 Complex. The R-2508 Complex includes all the airspace and associated land presently used and managed by the three principal military activities in the Upper Mojave Desert region:

- Air Force Flight Test Center (AFFTC), Edwards AFB (AFB)
- National Training Center (NTC), Fort Irwin
- Naval Air Warfare Center Weapons Division (NAWCWD), China Lake

The R-2508 Complex is composed of internal restricted areas; Military Operations Areas (MOAs), Air Traffic Control Assigned Airspace (ATCAAs) areas; and other special airspace (see Figure 3.20). Detailed descriptions of these areas along with their management procedures can be found in the *Range 2508 Complex User's Handbook* dated January 5, 2010 (USAF, 2010).

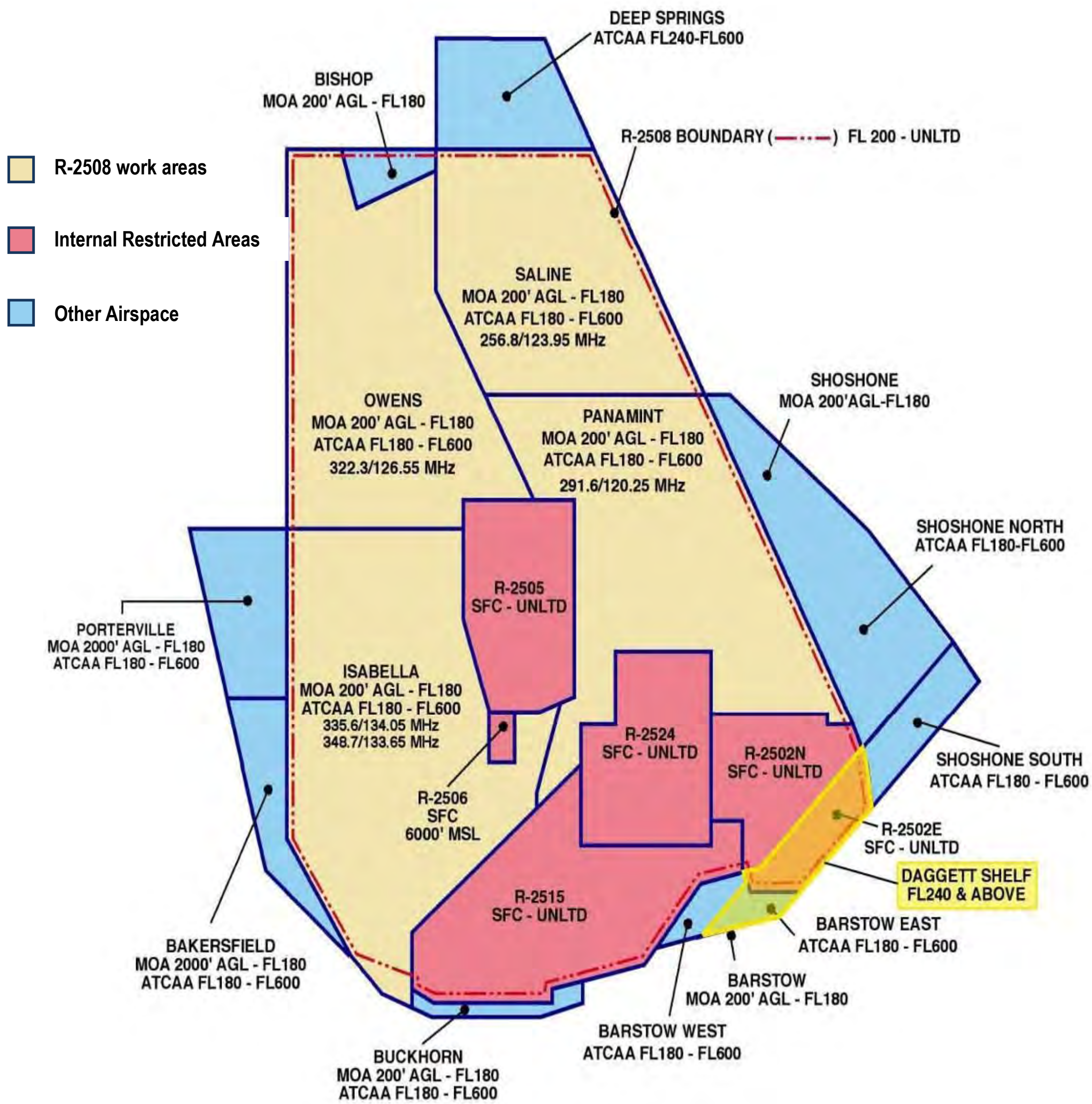


Figure 3.20 – Overview of R-2508 Complex Airspace (U.S. Navy, 2011)

The type of activity and typical operations that occur within the R-2508 Complex include:

- Aircraft research and development in all stages of flight
- Operational weapons test and evaluation flights
- Student pilot training
- Air combat maneuvering (ACM) and proficiency flights
- Civilian test aircraft in direct support of DoD and/or defense testing

Test operations must remain flexible and airspace requirements are not entirely predictable. Therefore, to best use the available airspace, participating aircraft operating in R-2508 Complex shared-use airspace are not given exclusive use of the airspace and are considered to be operating under concurrent operations. Details on the locations where these activities occur most frequently are also contained in the Range 2508 Complex User's Handbook.

Usage Data for Test Sites and Ranges
Recent annual usage data for the NAWS China Lake was made available for examination by the study team but cannot be published as a part of this report due to its sensitivity. Furthermore, this information is part of a current, pre-decisional environmental impact statement (EIS) that has not been publicly released. The most recent usage data will be released by the BLM and DoD at a future date following thorough review and in the specific order required by the EIS timeline. Annual usage of these test sites and ranges is extensive and includes flight operations, energetic testing, test track operations, directed energy operations, counter IED testing, ground and air mobile target operations, small group and large group Ground Troop Training, Explosive Ordnance Disposal training, and delivery of a wide range of weapons systems, missiles, rockets, bombs and other explosive expendables (U.S. Navy, 2011).

Compatibility Issues
NAWS China Lake's mission of weapons and systems related T&E is largely incompatible with large-scale solar development. As the overlying hazard zones (Figure 3.21) show, nearly all of the government land is within the potential impact area for weapons test activity. The spectral conflicts outlined in Section 3.5.1 also heavily negatively affect the pristine test environment currently enjoyed and required by the resident test community. Complicating the issue for NAWS China Lake is the complete envelopment of the government property by R- 2508 and its heavy use by the test community to fulfill its requirements to access the ground ranges from all directions. Therefore all of the ranges at China Lake are considered unsuitable for large-scale solar development due to mission incompatibility.

Mitigation
On most installations the negative effects of solar infrastructure on military mission can be addressed by placing the infrastructure some distance from the main operating areas, along borders, or by placing infrastructure in or near cantonment areas. For NAWS China Lake these are not options due to the envelopment of the government ranges by activities in physical and spectral conflict with large-scale solar development.

3.5.2.4 Naval Air Station, El Centro (NAF El Centro)

Mission
NAF El Centro's mission is to provide base support to aviation units from the Navy and Marine Corps, Army, and Air Force, as well as international units, and maintain target ranges for their weapons and combat air training. Squadrons visit NAF El Centro to take advantage of its ideal environment for aerial combat maneuvering, air-to-air gunnery, bombing practice and electronic warfare training. Along with its extensive range areas the facility has two operating runways, a 9,500-foot east/west runway that handles 96 percent of the traffic, equipped with a Fresnel Lens Optical Landing System at each approach end as well as lighted carrier deck landing areas at both ends so pilots can simulate carrier landings.

Land Training Areas and Range Usage
Apart from "touch and go" landings and take-offs, aircrews use NAF El Centro's two Air Operation Range complexes (Range 2510 and 2512) as well as adjacent and nearby ranges to develop their skills. The ranges have two live fire target areas each (Shade Tree 101 and Loom Lobby Target 103 for 2510 and Inky Barley 68 and Kitty Baggage 93 for Range 2512).

Additionally, 2510 has drop zones and helicopter landing zones to support parachute operations and training. Figure 3.21 depicts the air range boundaries in red and the Navy controlled land boundaries within these ranges outlined in black. In Figure 3.21, Range 2510 Target and Training Areas and Range 2512 Target Areas illustrate the target ranges for each of these training areas in greater detail. NAF El Centro controls 56,289 acres of land inside these range boundaries. These land ranges are equipped with remote controlled target areas that use Weapons Impact Scoring Systems to provide immediate verification of weapons delivery accuracy. Additionally the Display and Debriefing Subsystem (DDS) support air combat training by utilizing remote television, acoustical and laser scoring systems. The DDS is linked with Tactical Aircrew Combat Training System (TACTS) to provide a computerized record of the tactics employed by the individual aircrews and to evaluate the effectiveness of each maneuver. Figure 3.21 depicts the air range boundaries in red and the Navy controlled land boundaries within these ranges outlined in black (U.S. Navy, 2010).

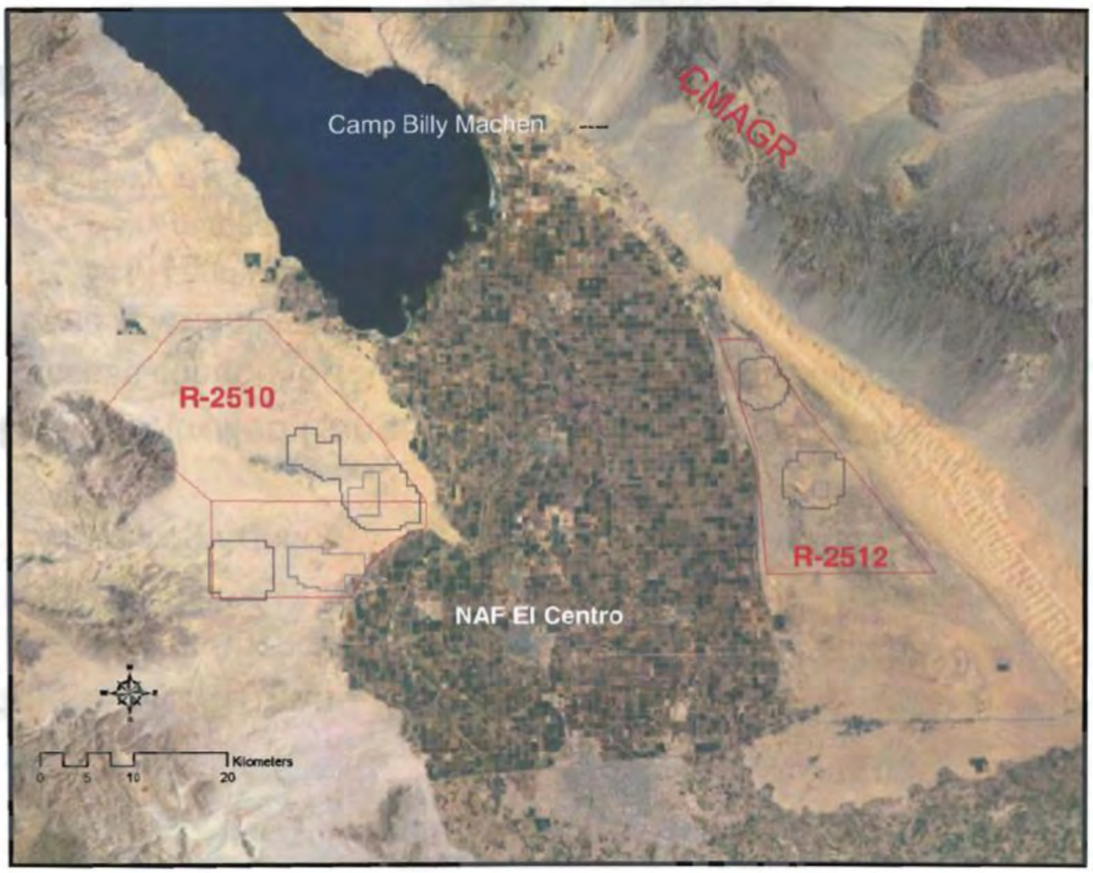


Figure 3.21 – NAF El Centro Ranges (U.S. Navy, 2010)

Variable climatic conditions and population are limiting factors at the Navy's only other facilities with similar missions – Fallon, Nevada, and Key West, Florida. As a result, NAF El Centro is very busy and in high demand. Every month, seven to 12 squadrons and up to 1,600 personnel train at NAF El Centro. Additionally, USAF parachutists, U.S. Navy SEAL's, Army Green Berets, and British, French, German, and Italian aviators visit for various phases of their training. On a typical day, flight operations reach over 450 flight hours between 7 a.m. and 11 p.m. These units conduct 7,500-8,500 sorties and deliver 25,000 to 30,000 bombs/rockets and 200,000 strafing rounds per year on the NAF El Centro Ranges (U.S. Navy, 2010).

Finally, the NAF is also the "winter home" of the Navy's Flight Demonstration Squadron, known worldwide as the Blue Angels. Starting every January, the Blue Angels conduct over two months of intense flight operations prior to the start of their air show season. Until mid-March, the officers and enlisted personnel, who are specialists in all the aviation roles required to support the squadron's maintenance, administration and public affairs requirements, hone their skills as a cohesive unit. Figure 3.22 illustrates the type of training conducted annually at NAF El Centro.

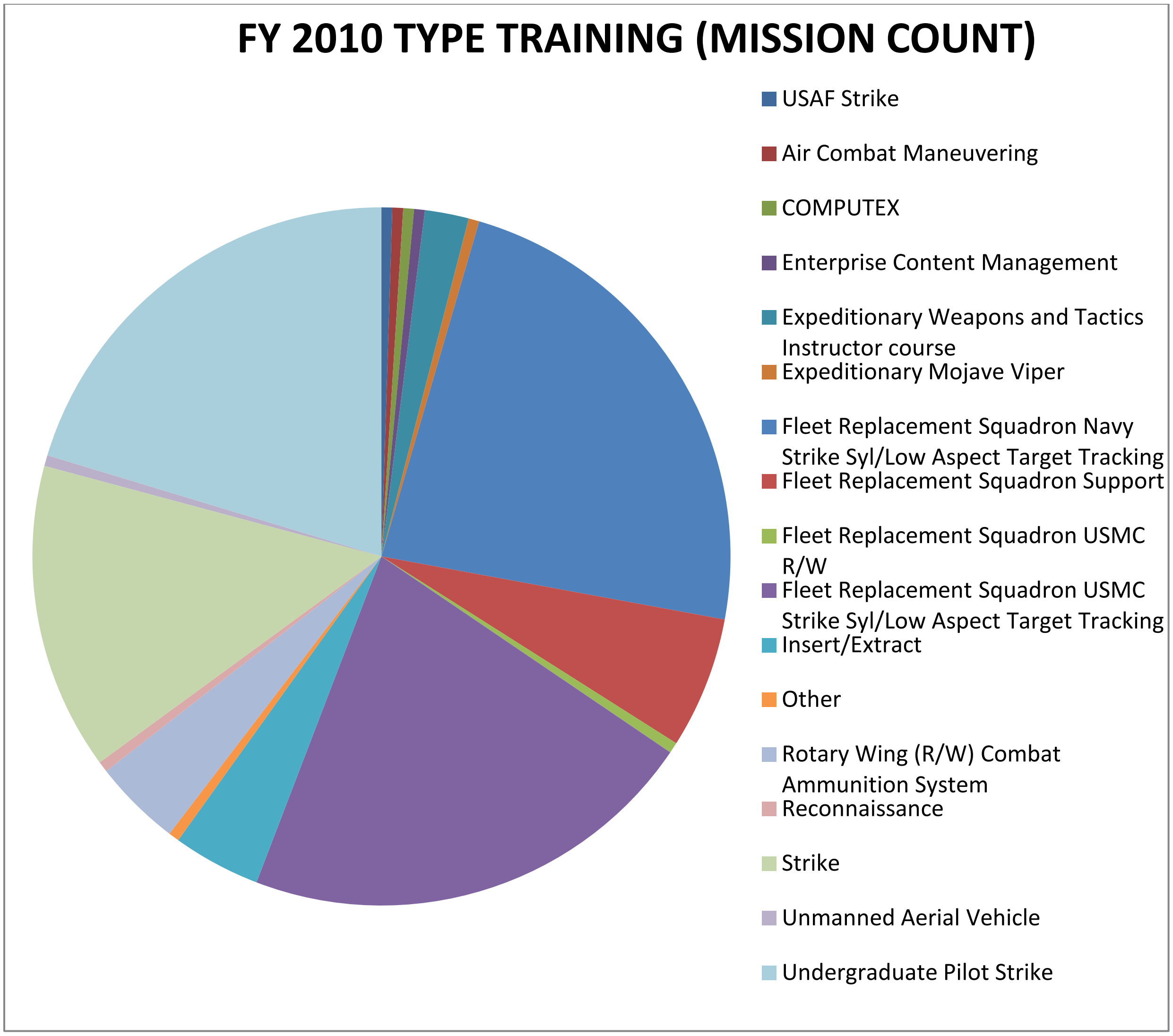


Figure 3.22 – NAF El Centro 2009 Annual Training Summary Report (U.S. Navy, 2011)

Airspace Operation Areas

The Airspace operation areas that support the training conducted at NAF El Centro is depicted in Figure 3.23. It consists of restricted airspace for ranges 2510 and 2512, and Military Operations Areas (MOA) that surround the ranges. This provides sufficient air operating space to conduct the Fleet Replacement Squadron (FRS) training required by the Chief of Naval Air Training

(CNATRA) to qualify and sustain naval aviation aircrews, support the training of the Blue Angels, the Weapons Tactics Instruction (WTI) provided by the Marine Aviation Weapons and Tactics Squadron (MAWTS), and numerous other training and exercise requirements.

3.5.2.5 Compatibility Issues

Most of the physical compatibility issues revolve around the land ranges where potential solar energy projects might be established. It is important to note that although Ranges 2510 and 2512 cover 217,830 acres of airspace this does not include all of the land beneath the airspace. NAF El Centro only controls 56,289 acres of land inside the range borders and, more importantly, the DoD only ―owns" 7,330 acres while the majority of the land on both ranges is withdrawn BLM land. The land controlled by the Navy at NAF El Centro contains the targets and assessment equipment necessary to evaluate training effectiveness. It is mission critical and the fact that live ordnance is used on these ranges makes this land incompatible with solar energy development because of the inherent danger associated with the training activities conducted there.

Mitigation
The cantonment area near the airfield offers the only possible site suitable for PV solar. CSP systems are not appropriate near the field due to spectral (glare) and safety of flight issues.

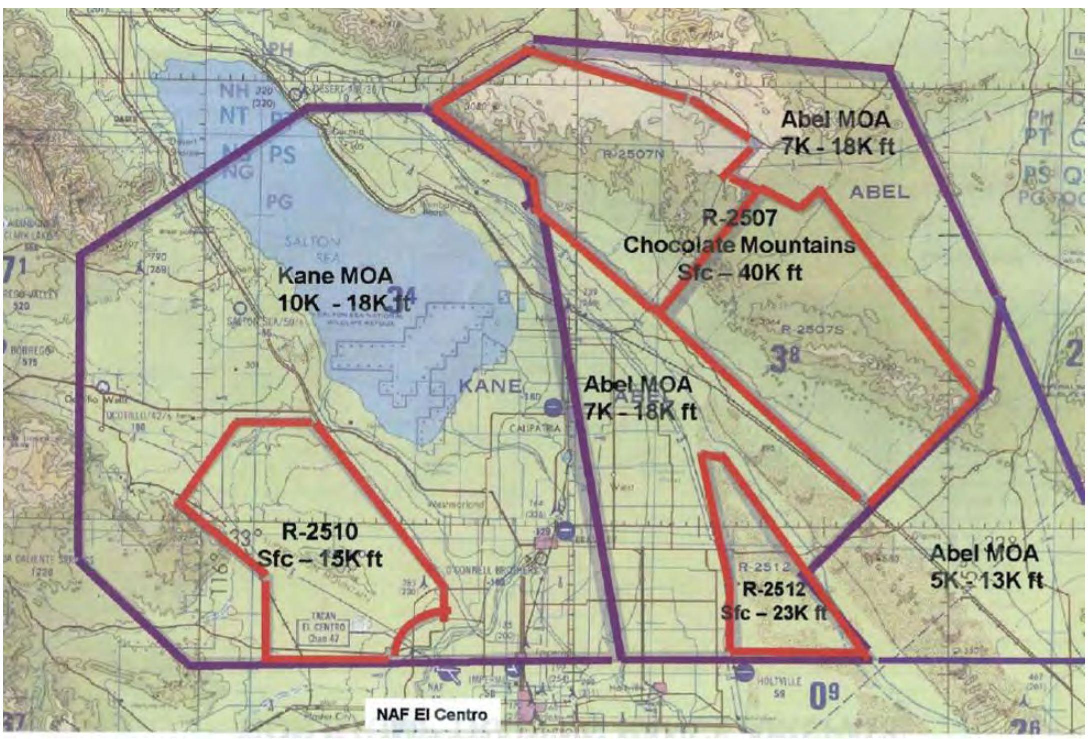


Figure 3.23 – Airspace Operation Areas for NAF El Centro (U.S. Navy, 2011)

3.5.2.6 Marine Corps Air/Ground Combat Center (MCAGCC) Twentynine Palms

Mission
The mission of MCAGCC Twentynine Palms is to conduct relevant live-fire combined arms training, urban operations, and Joint/Coalition level integration training. MCAGCC Twentynine Palms is the home to the world's largest Marine Corps Base and draws military personnel from

all over the world for Combined Arms Exercises (CAX) and specially tailored pre-deployment training and readiness exercises. Each year 50,000 Marines, roughly one-third of the Fleet Marine Force and Marine Reserve units, participate in the installation's training exercise program. These training exercises involve every weapons system in the Marine Corps' arsenal, from small arms to attack aircraft.

In addition, the installation provides facilities, services, and support to meet the needs of tenant commands, Marines, Sailors and their families. The current population of the installation includes 9,723 Active Duty members, 8,588 dependents, and approximately 1,398 civilians (USMC, 2011).

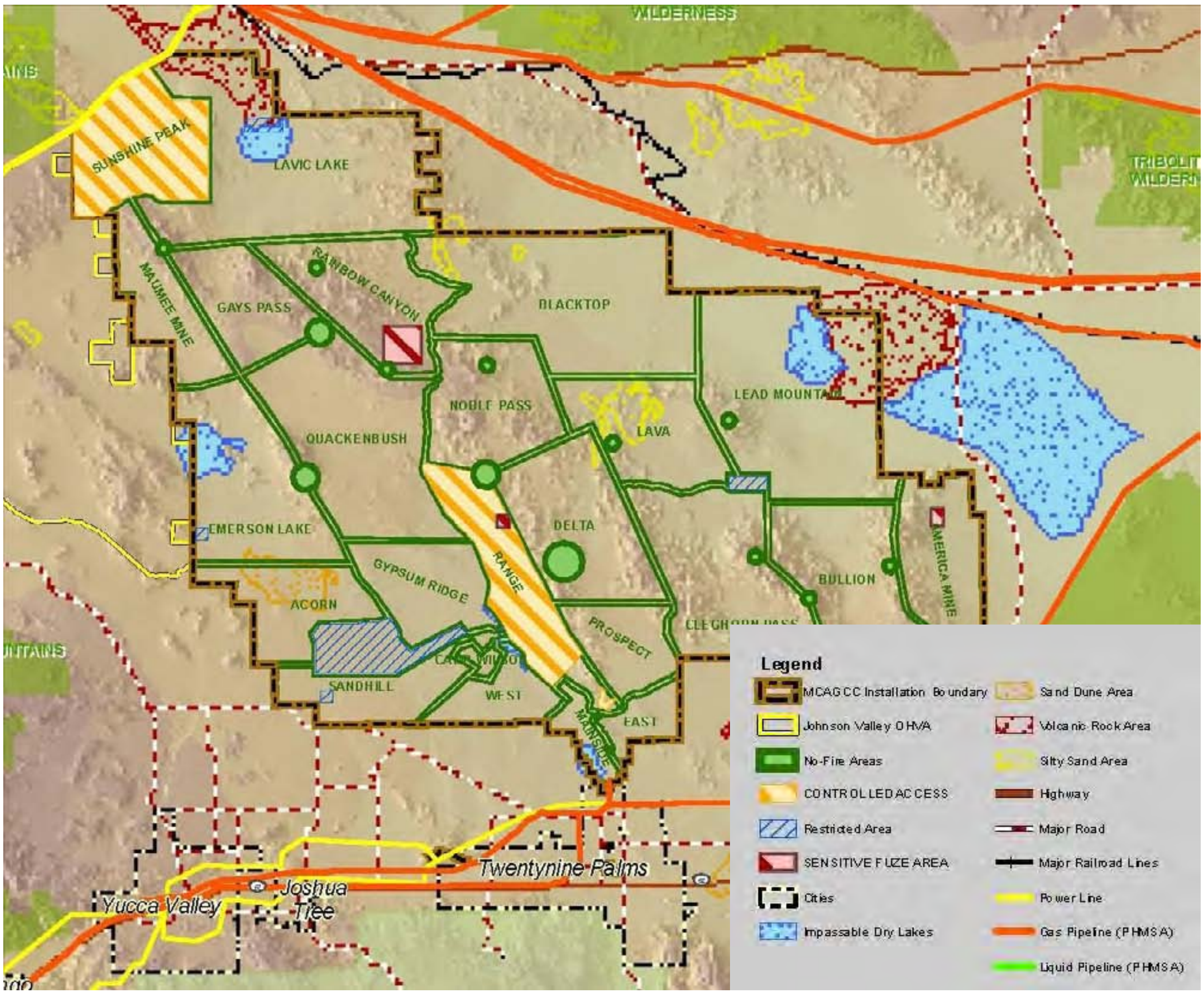


Figure 3.24 – MCAGCC Twentynine Palms Training Areas and Ranges (USMC, 2010)

Training Area and Range Usage Information

The operating areas at MCAGCC Twentynine Palms are divided into 23 integrated named Training Areas (TAs). This number includes the cantonment area (Mainside Area), which contains several non-live fire training facilities. There are 43 individual numbered ground ranges and 3 aviation ranges with numerous ground targets designated for air-delivered ordnance located throughout the TAs. These ranges are primarily live fire ranges that support the majority of the weapon systems in the Marine Corps inventory, but a few ranges are designated for non live fire maneuver training and mission rehearsals. The non-live fire ranges are designed for the use of pyrotechnics, simulated munitions and blanks. MCAGCC Twentynine Palms is unique because all but 5 of the TAs (TAs Acorn, East, West, Gypsum Ridge and Mainside) are also live fire ranges for direct, indirect and aviation delivered ordnance during large-scale Joint Combined Arms Exercises. During these training events, umpires, controllers and range safety officers shift range safety fans to support the scheme of maneuver and employment of combined arms (direct, indirect and air delivered ordnance) as units maneuver to seize assigned objectives. Direct fire weapons include rifles, machineguns, tanks, 40 mm grenades and anti-tank weapon systems. Indirect fire weapon systems include mortars and artillery. Air delivered ordnance includes rockets, guns and bombs (USMC, 2010). The TA locations are illustrated in Figure 3.24. Specific information on the weapons and ordnance fired on each range can be found in the Combat Center Order 3500.4H Standard Operating Procedures for Range, Training Areas and Airspace dated August 2010. Range usage data collected by the Base Range Control Office indicates that approximately 324,951 people are trained and 3,614,697 pieces of ordnance and ammunition are expended in these TAs and ranges each year (Chatelin, 2011).

The Marine Corps has an ongoing project to acquire additional maneuver land and air space to meet their requirement to ―train as they fight”. Figure 3.25 illustrates the recommended alternative for the Training Lands and Airspace Acquisition Project designed to provide the needed maneuver space required to train MEB-sized organizations. This proposal would increase the range and maneuver space available to units training at MCAGCC Twentynine Palms. The recommended land proposals are accompanied by recommended modifications to airspace usage to support the new land proposal. The recommended MOA and ATCAA changes that support the proposal are found in Figure 3.26.

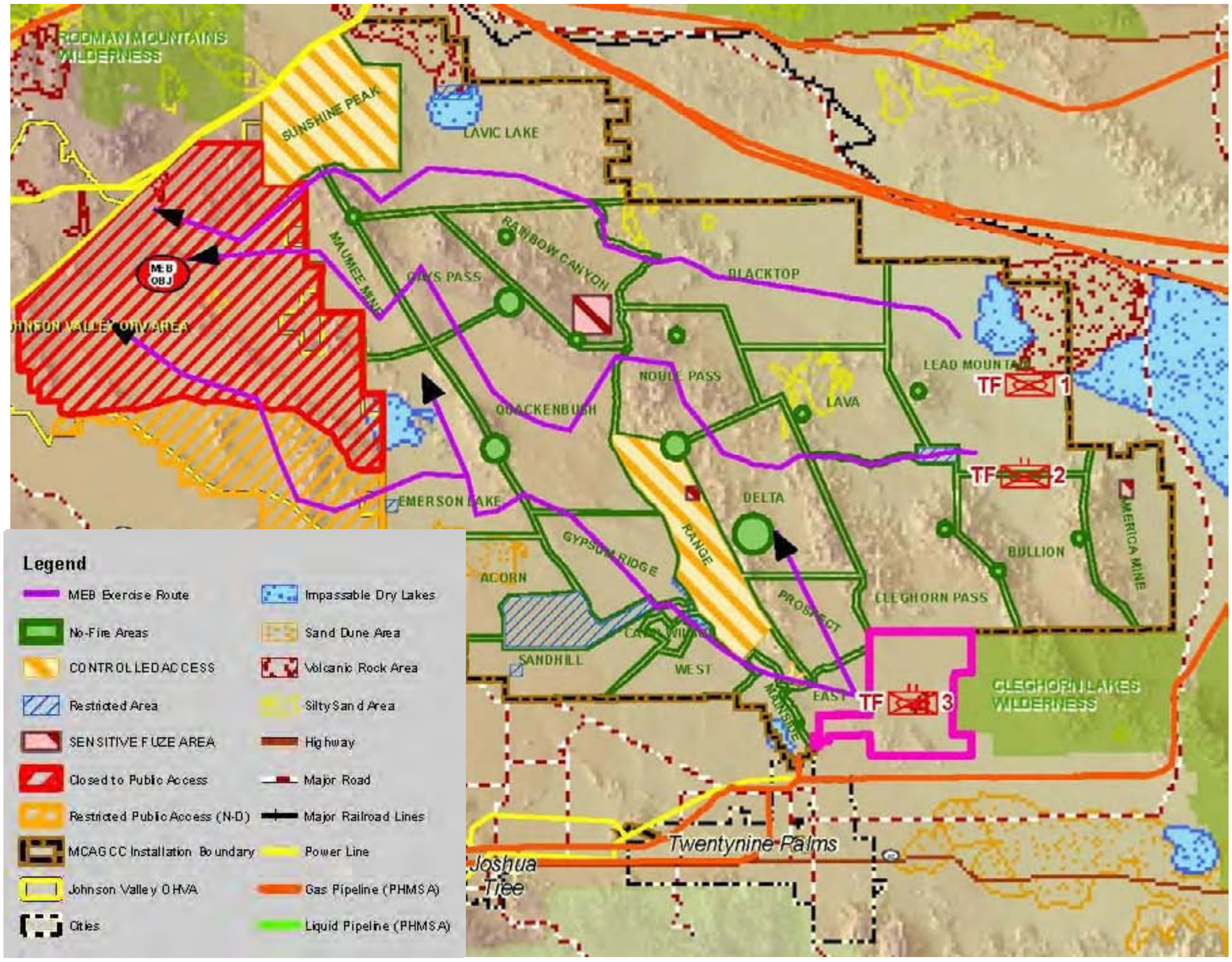


Figure 3.25 – Training Lands and Airspace Acquisition Project Proposal (USMC, 2010)

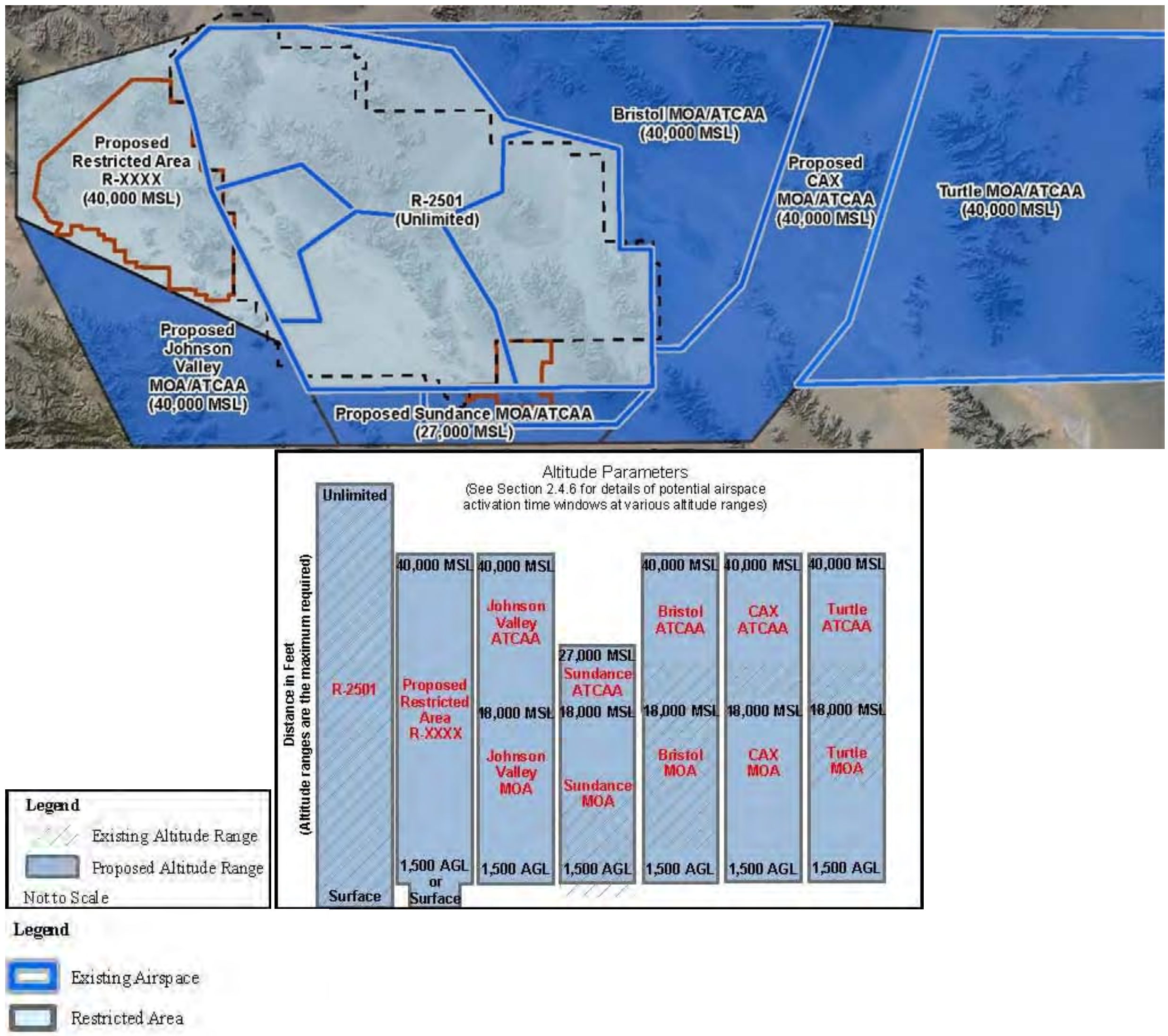


Figure 3.26 – Air Space Establishment and Modifications (USMC, 2010)

Compatibility Issues

The compatibility issues associated with the ranges at MCAGCC Twentynine Palms all relate to the activities conducted at these ranges. None of the activities are classified at a sensitivity that prevents access for solar energy projects, however, the inherent danger associated with the live fire and maneuver training conducted inside these TAs restricts consideration for co-use as sites of large solar energy projects. The exceptions might be the non-live fire maneuver TAs (Acorn, East, West, Gypsum Ridge and Mainside). However, with the exception of the Mainside area, these areas allow for the maneuver of mounted and dismounted ground units, low-level flight operations, the use of pyrotechnics, blanks and simulated munitions for direct fire weapons. Additionally, TA West contains Range 800, an EOD live-fire range, and range 705, a combat vehicle operator's course, inside its borders, making them incompatible for solar energy project usage. The Mainside TA training does not include pyrotechnics or vehicle mounted maneuver and has been used to support solar energy projects in the past, making it a potential candidate for future solar energy initiatives assuming proper coordination is conducted with installation officials. Twentynine Palms' 25 solar energy projects include an existing 1.2 MW single-axis tracking PV system funded through an Energy Saving Performance Contract ESPC), 1.7 MW of existing rooftop and sunshade solar, and plans for a 1.5 MW PV solar energy development on a dry lake that is to be privately developed through a Power Purchase Agreement (PPA). In total, Twentynine Palms is budgeted to have 10.5 MW of solar energy capacity installed on-installation by 2013.

Access issues also cause a compatibility issue for most of the training areas. Use of paved or improved ground access routes into the training areas is minimal, restricted by both range regulations and existence of only a few improved surface roads. Increased utilization of these access routes could interfere with scheduled training requirements and the movement of troops, equipment, and supplies and ammunition (See section 3.6. Access, page 3-59).

Mitigation
With the east-west expansion plans and orientation of the overlying airspace, the southern border of MCAGCC Twentynine Palms holds the most promise for potential solar development. The laser spillover spectral conflict and physical ordnance conflicts are minimized by the south-to-north orientation of firing ranges, and the range boundary road affords access. These conditions do not apply to the northern border due to the lack of any prescribed orientation of operations.

3.5.2.7 Marine Corps Logistic Base Barstow (MCLB Barstow)

Mission
MCLB Barstow is home to approximately 750 Marines, Sailors, Soldiers and their families and 2,500 civilian employees. The mission of the Logistics Base is to procure, maintain, repair and rebuild, store, and distribute supplies and equipment as assigned, and to conduct such schools and training as required by USMC needs. MCLB Barstow provides maintenance and maintenance-related products and services. It repairs, rebuilds, and modifies all types of Marine Corps ground combat equipment, and combat service support equipment. The base is comprised of three principal sites (see Figure 3.27):

- Nebo, which encompasses 1,879 acres and functions as base headquarters and is the main facility for administration, storage, recreational activities, shopping, and housing functions.
- Yermo Annex encompasses 1,859 acres and is primarily a storage and industrial complex
- The third site, 2,438 acres, for rifle and pistol ranges.

Training Area and Range Usage Information
The ranges on MCLB Barstow are all small arms ranges used for annual qualification and sustainment training for rifle, pistol and shotgun and for recreational use. They are designed to be static fire ranges, but limited live fire and maneuver can be conducted with prior coordination and permission. These ranges are not heavily used, but they are critical for conducting required qualification, and proficiency/sustainment training of the active duty personnel assigned to the facility. The range area location is illustrated in Figure 3.27 with the specific purpose and use of each range outlined in Table 3.8 below.

Table 3.8 – MCLB Barstow Training Area and Range Usage Data							
Base	**Operation Area Name**	**Use**	**Weapons**	**Ordnance**	**Usage Data People**	**Usage Data Ordnance**	**Notes**
MCLB Barstow	Pistol Range	RLF	Pistols	9mm, 12 gauge	Specific data N/A	Specific data N/A	Range supports company size units and is used periodically throughout the year
MCLB Barstow	Rifle Range	RLF	Rifles	5.56	Specific data N/A	Specific data N/A	Range supports company size units and is used periodically throughout the year
MCLB Barstow	Shotgun/ pistol	RLF/MT (LF)	Shotgun, Pistol	9mm, 12 gauge	Specific data N/A	Specific data N/A	Range supports static and Marine Corps Police Detachment Training for company size units and is used periodically throughout the year

Source: (USMC, 2009)

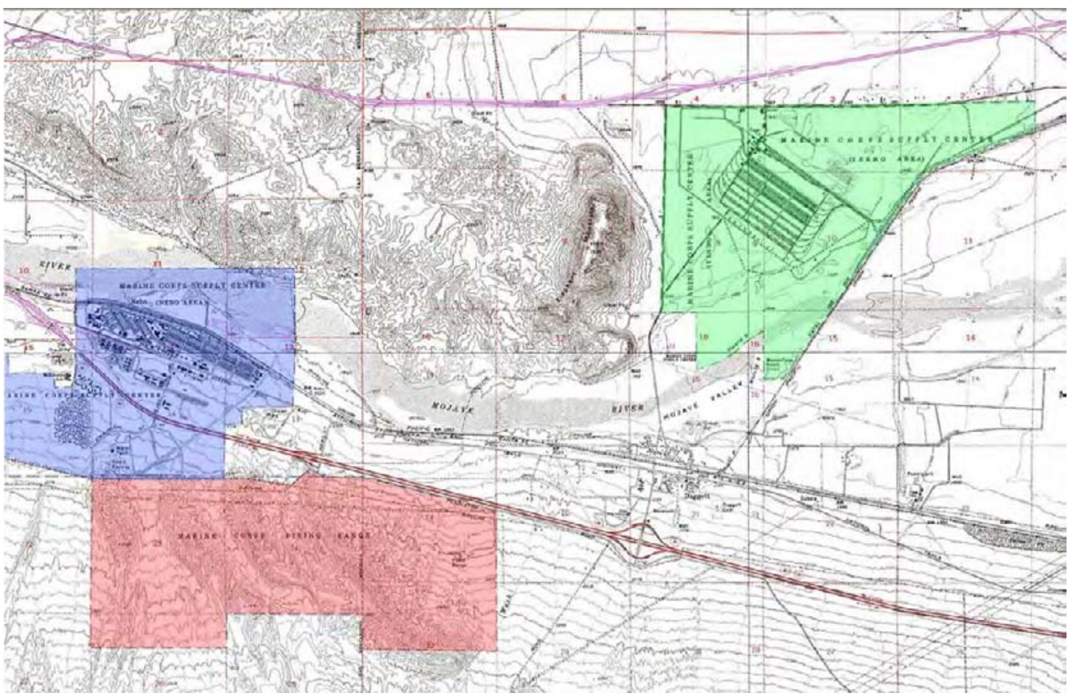


Figure 3.27 – MCLB Barstow Operation and Training Areas (USMC, 2009)

Compatibility Issues

The activity-related compatibility issues associated with the ranges at MCLB Barstow all relate to operations at these ranges. None of the activities are classified at a sensitivity level that would restrict their usage for solar projects; however, the ranges used for live fire training makes them incompatible with solar energy projects. Other operating areas at MCLB Barstow have been used to support renewable energy development and can continue to support these types of projects on a limited basis if properly coordinated with the base and regional commanders. MCLB Barstow is the site of a 1.5 MW wind turbine, but the base does not yet possess any solar energy facilities. In February 2010, the U.S. Navy (USN) awarded a $200 million IDIQ contract to five solar energy developers to construct, own, operate, and maintain up to 40 MW of solar energy capacity located on military installations in the southwestern U.S. and sell the resulting power to the Navy/Marines. As part of the IDIQ solicitation process, the Navy included a task order for a two-site solar energy facility at MCLB Barstow comprising 30 acres, 20 acres at the Yermo site and 10 acres at the Nebo site. It is expected that the 30 acre solar development at MCLB Barstow will be one of the first three solar energy projects developed as part of the larger IDIQ contract.

Mitigation
Not applicable.

3.5.2.8 Chocolate Mountain Aerial Gunnery Range (Chocolate Mtn. AGR)

Mission
The Chocolate Mtn. AGR supports training in air combat maneuvering and tactics; close air support (where air-to-ground ordnance is fired to directly support friendly forces engaged in ground combat); airborne laser system operations; air-to-air gunnery; and air-to-surface bombing, rocketry, and strafing. Artillery, demolitions, small arms, and Naval Special Warfare training are also conducted within the range. The range consists of more than 700 square miles of land and several thousand square miles of overlying and adjacent Special Use Airspace that is essential to Marine and Navy aviation readiness. The Chocolate Mtn. AGR provides a unique combination of attributes that serves this training requirement, including the proximity to existing air stations, favorable flying weather, sufficient land and airspace, diverse terrain, and developed training support facilities.

Training Area and Range Usage Information
Chocolate Mtn. AGR is subdivided into 5 major training areas; R-2507N, 2507S, 25073E and SWAT 4 and 5 (see Figure 3.28 below). The southern area, R-2507S, is designated for delivery of live and inert ordnance of all types. It contains several forward arming and refueling points and attack positions to support rotary wing operations, several target arrays, landing zones and observation points (OPs). The northern area, R-2507N, is divided approximately in half with the northern area designated for live ordnance and the southern area designated for inert ordnance only. Both halves contain assorted target arrays. However, the southern half contains several artillery firing areas, a field ammunition supply point (ASP), several OPs and helicopter and UAS landing zones. The SWAT areas are controlled firing areas to support special warfare training, including small arms, machine guns, and grenades. Figure 3.29 is an example of the types of ordnance that can be delivered by target area in R-2507S. Appendix C of MCAS Order 3710.6I, MCAS Yuma Range and Training Area SOP dated December 2, 2010 contains the complete matrix of ordnance use information for the Chocolate Mtn. AGR.

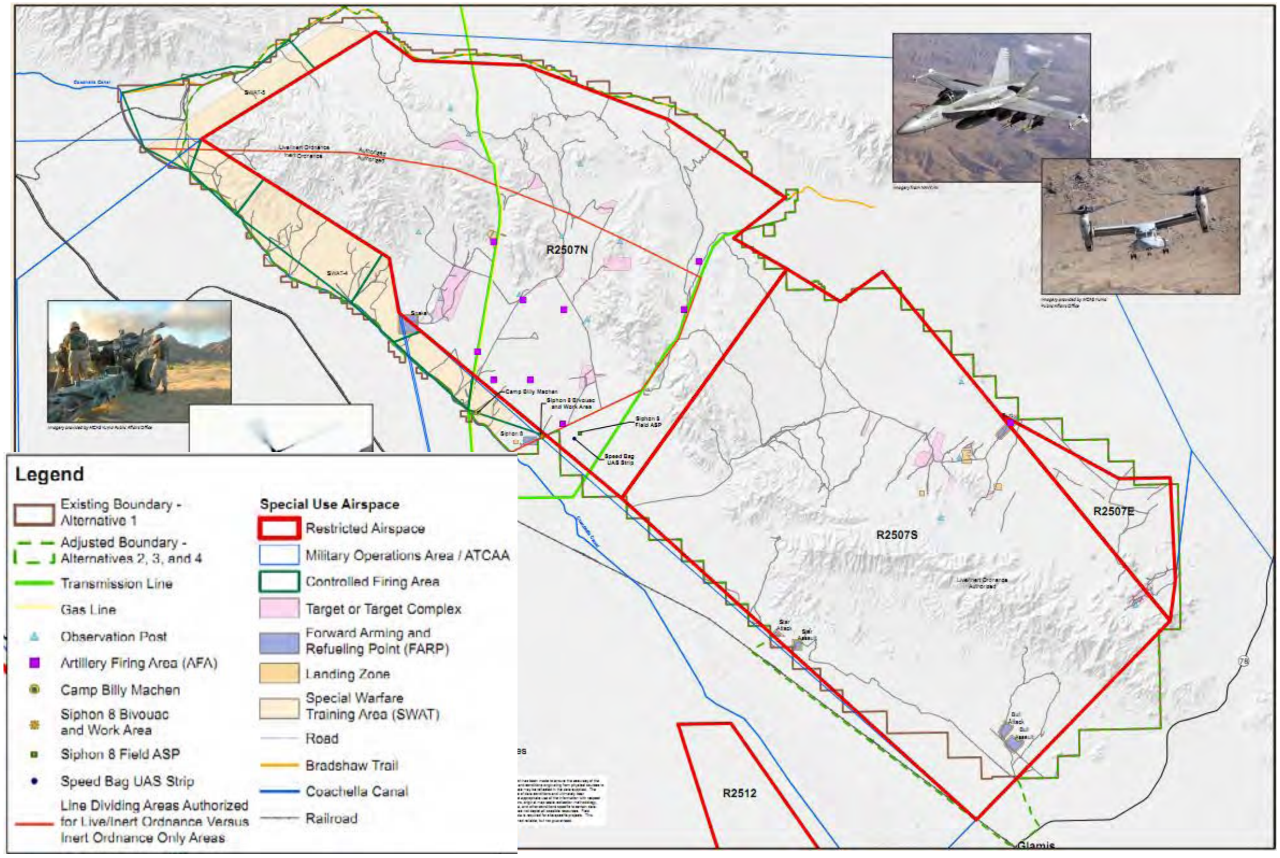


Figure 3.28 – Chocolate Mountain Aerial Gunnery Range (USMC, 2011)

Range 2507E contains restricted airspace, but does not contain target arrays for air delivered ordnance. It does contain an artillery firing area, LZ, and Forward Arming and Refueling Point (FARP) in the NW corner and it is adjacent to a target area in R-2507S.

SWAT 4 and 5 borders the NW corners of 2507N and these areas are used to support special operations training. Tactics, techniques and procedures are trained and tested here and small arms, explosives and pyrotechnics are used in this area.

R-2507 South	1 SOUTH	2 SOUTH	3 SOUTH	4 SOUTH	5 SOUTH	6 SOUTH	7 SOUTH	8 SOUTH	10 SOUTH	11 SOUTH	12 SOUTH	13 SOUTH	14 SOUTH	15 SOUTH	NOTES
CBU-99															***NOT AUTHORIZED***
CBU-100															***NOT AUTHORIZED***
CBU-103 WCMD															***NOT AUTHORIZED***
CBU-104 WCMD															***NOT AUTHORIZED***
CBU-105 WCMD															***NOT AUTHORIZED***
CBU-107 WCMD															***NOT AUTHORIZED***
CHAFF, RADAR EVASION	X	X	X	X	X	X	X	X	X	X	X	X	X	X	COMPLY WITH FAA/DOD GUIDANCE - SEE PARAGRAPH 4000.3.h (PAGE 4-5)
FLARES, IR DECOY	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
GBU-10 LGB (2,000 lb.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	INERT/TP ORDNANCE ONLY ON RUNWAY @ TGT 15 SOUTH
GBU-12 LGB (500 lb.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	INERT/TP ORDNANCE ONLY ON RUNWAY @ TGT 15 SOUTH
GBU-12 F/B DMLGB	X	X	X	X	X	X	X	X	X	X	X	X	X	X	**ONE DROP PER PASS ON AUTHORIZED TARGETS ONLY**; INERT/TP ORDNANCE ONLY ON RUNWAY @ TGT 15 SOUTH
GBU-15 OGB (1,000 lb.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	INERT/TP ORDNANCE ONLY ON RUNWAY @ TGT 15 SOUTH
GBU-16 LGB (1,000 lb.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	INERT/TP ORDNANCE ONLY ON RUNWAY @ TGT 15 SOUTH
GBU-29/30/38 JDAM (500 lb.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	**RANGE SCHEDULING APPROVAL REQUIRED 48 Hrs Prior**; INERT/TP ORDNANCE ONLY ON RUNWAY @ TGT 15 SOUTH. **SEE "JDAM ACCEPTABLE REGIONS" AT THE END OF THIS APPENDIX AND SUBMIT REQUESTS THAT FALL WITHIN THESE PARAMETERS**
GBU-31 JDAM (2,000 lb.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	**RANGE SCHEDULING APPROVAL REQUIRED 48 Hrs Prior**; INERT/TP ORDNANCE ONLY ON RUNWAY @ TGT 15 SOUTH. **SEE "JDAM ACCEPTABLE REGIONS" AT THE END OF THIS APPENDIX AND SUBMIT REQUESTS THAT FALL WITHIN THESE PARAMETERS**
GBU-32 JDAM (1,000 lb.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	**RANGE SCHEDULING APPROVAL REQUIRED 48 Hrs Prior**; INERT/TP ORDNANCE ONLY ON RUNWAY @ TGT 15 SOUTH. **SEE "JDAM ACCEPTABLE REGIONS" AT THE END OF THIS APPENDIX AND SUBMIT REQUESTS THAT FALL WITHIN THESE PARAMETERS**
GBU-54 DMLGB (500 lb.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	**ONE DROP PER PASS ON AUTHORIZED TARGETS ONLY**; INERT/TP ORDNANCE ONLY ON RUNWAY @ TGT 15 SOUTH
LGTR (89 lb.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
LUU-19 (IR)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
LUU-2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
LUU-4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
MK-20 ROCKEYE															***NOT AUTHORIZED***
MK-76 (25 lb. PB)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
MK-77 NAPALM															***NOT AUTHORIZED***
MK-81 (250 lb. GP)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	INERT/TP ORDNANCE ONLY ON RUNWAY @ TGT 15 SOUTH
MK-82 (500 lb. GP)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	INERT/TP ORDNANCE ONLY ON RUNWAY @ TGT 15 SOUTH
MK-83 (1,000 lb. GP)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	INERT/TP ORDNANCE ONLY ON RUNWAY @ TGT 15 SOUTH
MK-84 (2,000 lb. GP)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	INERT/TP ORDNANCE ONLY ON RUNWAY @ TGT 15 SOUTH

Special Restrictions: Target 15 South (Blue Mountain Airfield) has several targets of opportunity. In order to preserve the runway and taxiways for favorable visual reference, HE ordnance will be restricted to only those the targets of opportunity immediately surrounding the runway and taxiway. HE will not be authorized on the runway or taxiways.

Legend
- (shaded) = Not Authorized
- X (shaded) = Authorized under special conditions (see Notes)
- X = Authorized

Figure 3.29 – Example Ordnance Matrix for Chocolate Mtn. AGR MCAS (USMC, 2010)

Compatibility Issues

The type of training activities involving live and inert ordnance employed by aviation and ground units training at the Chocolate Mtn. AGR inside the north and south ranges are incompatible with the development of solar energy projects. The Marine Corps Training and Education Command (TECOM) Range and Training Area Management Division (RTAM) subject matter experts' input to the study stated that any development within the R2507 that is not training-related is not compatible with the range (USMC, 2011j). RTAM considers the entire surface underneath the R2507 to be a high hazard impact area and critical to the combat readiness of Marine Corps aviation specifically, and the Marine Corps generally. As such, solar energy development within almost all of the CMAGR is not compatible with the current training mission (USMC, 2011j). The air-to-surface, artillery, small arms, machinegun, low-level flight, and combined arms training conducted in these areas have inherent hazards and risks that would preclude the development of solar energy projects.

Mitigation

There are several parcels of land in the northern –beak” of the range that are not used to support military training activities that might support utility-scale solar energy development.

3.5.2.9 Edwards Air Force Base (Edwards AFB)

Mission

Edwards AFB, with approximately 11,200 military and civilian personnel, is a USAF Major Range and Test Facility Base (MRTFB). It functions primarily to enable the DoD test and evaluation support missions but also performs other missions, such as operations, training and R&D (USAF, 2010). The Air Force Flight Test Center at Edwards AFB is the Air Force Materiel Command center of excellence for conducting and supporting research, development, test and evaluation of aerospace systems from concept to combat. It operates the USAF Test Pilot School and provides considerable test activity conducted by America's commercial aerospace industry. The base consists of largely undeveloped or semi-improved land that is used predominantly for aircraft test ranges and maintained and unmaintained landing sites (i.e., Rogers and Rosamond dry lake beds). The developed portion of the Base includes approximately six percent of the total area and is concentrated on the west side of Rogers Dry Lake and includes North Base, South Base, Main Base, and Family Housing areas. As a MRTFB, the Edwards Flight Test Center test resources and associated workforce are a part of the set of critical DoD T&E infrastructure, a national asset used to provide the T&E capability to support the DoD acquisition process (OSD RDT&E, 2011).

Land Training Areas and Range Usage

Range 2515 is the main range complex used for Edwards AFB RDTE, training, and other operational activities. It is a restricted airspace range that encompasses the underlying land area to ensure the safety of personnel, structures, and the public from expended weapons, laser and electromagnetic emissions, and target debris. The range is located at the southern portion of the Range 2508 Complex (previously illustrated in Figure 3.20, page 3-40). Figure 3.30 shows where some of the key RDTE and training activities occur on the range. These activities include air-to-air, air-to-surface, surface-to-air, live air-to-air gunnery, and electronic combat and countermeasures RDTE and training. R-2515 contains various instrument ranges and special use areas (spin areas, supersonic corridors, drop zones, etc) to support these activities. The range is also used for a variety of flight test operations that require a high degree of eyes-in-the-cockpit flying and numerous UAS operations. This range has been used extensively for the RDTE of the following systems: F-22, F-35 Joint Strike Fighter, RQ-4 Global Hawk, CV-22 Osprey, YAL-A1 Airborne Laser and numerous other weapon systems such as the GBU-38 Joint Direct Attack Munitions (JDAM). A significant amount of the RDTE operations for weapons delivery testing is conducted in the Precision Impact Range Areas (PIRA) found in the East and West Ranges.

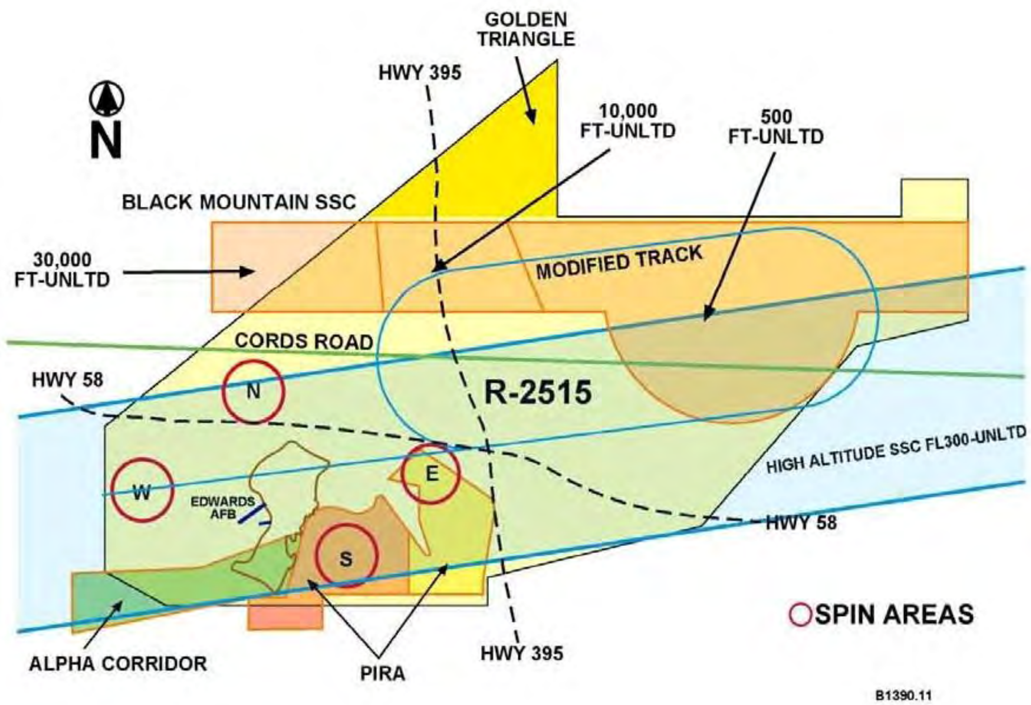


Figure 3.30 – Range 2515 Schematic of Training Activity Locations (USAF, 2010)

Mission Compatibility
As is the case with NAWS China Lake, the test mission of Edwards AFB can be negatively affected by large-scale solar development. Encroachment onto the land ranges denies Edwards the pristine test environment and important safety buffer required for aircraft test flights and test pilot training. Spectral conflicts close to the distributed sensor network in use also threatens the ability to track and control vital test programs. In spite of these issues, mission conflicts do not extend across the entire installation and Edwards AFB hosts several small solar energy projects, and is contemplating a large solar project in the northwest corner of the Base that could total as much as 500 MW. Detailed analysis of range activities and range utilization is required to fully assess which Edwards ranges and activities would be most impacted; however, range usage data and installation activity data on USAF bases was not released by USAF Headquarters at the time of this writing.

Mitigation
PV appears to be compatible within the cantonment area surrounding the base infrastructure. The range boundaries, however, are enveloped by the test airspace and any proposals for large-scale solar development in these areas will need to be carefully evaluated for mission compatibility prior to project authorization.

3.5.2.10 Creech Air Force Base (Creech AFB)

Mission
Today, Creech AFB is the home to the "Hunters" of the 432d Wing and 432d Air Expeditionary Wing, and the Joint Unmanned Aircraft System Center of Excellence. It is from Creech AFB that Predator and Reaper UAS missions are controlled daily on missions in Afghanistan and Iraq.

Creech AFB also hosts the operations of the 556th Test and Evaluation Squadron, 99th Ground Combat Training Squadron, and is still a training site for the USAF Thunderbirds.
The mission of Creech AFB, Nevada, is to train aircrews, and support, direct, and coordinate combat sorties around the world. Creech AFB is also one of two emergency-divert airfields for the 15,000 sq. mile Nevada Test and Training Range Complex.

Land Training Area and Range Usage
Creech AFB consists only of the 2,940 acre Indian Springs Auxiliary Airfield and the surrounding buildings housing the hosted units. Creech AFB flight and training operations share the NTTR and also operate in support of operations at Fort Irwin in the R-2508 Complex.

Mission Compatibility
Creech AFB cantonment is compatible with solar PV, though the available land is minimal. CSP systems would need to address glint and glare conflicts near the airfield.

Mitigation
Not Applicable

3.5.2.11 Nellis AFB and NTTR

Mission
Nellis AFB is home to the U.S. Air Force Warfare Center, the largest and most demanding advanced air combat training mission in the world. Nellis AFB provides training for composite strike forces, which include every type of aircraft in the Air Force inventory. Training is conducted in conjunction with air and ground units of the Army, Navy, Marine Corps and air forces from allied nations.

Land and Range Usage
Nellis AFB/NTTR provides a real-world environment for air and ground-based military activities, including pilot and crew training, combat exercises, and testing of new aircraft and weapons systems. NTTR hosts highly sophisticated training exercises that simulate battlefield situations such as Red Flag-Nellis, which is conducted on the Nevada Test and Training Range four times annually. It involves U.S. and allied forces from all service branches. Each Red Flag exercise normally involves a variety of interdiction, attack, air superiority, defense suppression, airlift, air refueling and reconnaissance aircraft. Within a typical 12-month period, more than 1,200 aircraft fly 20,000 plus sorties while training more than 26,750 personnel. Red Flag provides a peacetime "battlefield" within which combat air forces can train. The USAF delivers more than 45% of all its live ordnance on the Nellis AFB Range Complex. Nellis also conducts system development and operational testing; Nellis test resources are a portion of the MRTFB and are considered a critical part of the DoD T&E critical infrastructure (OSD RDT&E, 2011). The following is a list of the type of activities conducted on these ranges:

- Multi-platform testing for suppression/destruction of enemy air defenses
- F-16 AIM-9X live fire mission support
- Continuous F-15E and F-16 upgrade programs
- Range support for the first X-45 UCAV bomb drop

- Tactics development for Predator UAV Hellfire missile employment
- Integrated Air Defense System
- Live flight simulation
- Radar and threat emitter support
- Real-time feedback for mission debriefs
- Range data-link systems and networks
- Command and Control infrastructure
- Ordnance scoring, mission analysis
- Red Flag and USAF Weapons School support
- More than 1600 surface targets

The NTTR is public withdrawn lands set aside for Department of Defense missions focused on operational testing, advanced training and tactics development in support of US national interests. Over 75% of all Air Force live ordnance training is detonated within these boundaries, and the density of operations is very close to maximum capacity. Figure 3.31 shows a standard (non-RED FLAG / GREEN FLAG) operating day's schedule, reflecting its utilization/saturation. In order to keep up with demand, the NTTR stacks multiple aircraft in the same airspace, separated by varying altitudes (the lower altitude aircraft conducting the bombing). As depicted in Figure 3.31, the NTTR is broken down into separate, numbered ranges. In addition to deconflicting multiple aircraft use of a range, the Air Force must also deconflict ground parties' use of the range with aircraft.

Mission Compatibility

When a ground party is present it restricts use of the airspace, and certain operations on that range must cease. In order to construct a solar array on the NTTR, the USAF would need to shut down all military operations on that range for the duration of construction, causing an unacceptable scheduling strain on the already saturated NTTR. As a result, solar development is largely incompatible with the live ordnance target ranges, electronic warfare ranges, test ranges, and beneath the live air-to-air missile firing areas of NTTR. Most of the military-owned lands of NTTR are surrounded by special use airspace providing omni-directional access to the ground targets and test sites.

Furthermore, there is no existing electricity transmission infrastructure on the NTTR. Any solar development would therefore require the construction of additional transmission lines, creating lengthier access restraints on the numbered ranges. Additionally, any development on the NTTR would cause electromagnetic interference, degrading range capabilities.

Given these limitations, lands suitable for solar energy development would most likely be found along the boundaries of the NTTR or within the Nellis cantonment area. However, USAF range capability and encroachment assessments list renewable energy projects surrounding the NTTR as a primary interference concern with key mission areas impacted being Electronic Combat for training, test mediums and strategic attack missions (DoD, 2010). Future detailed analysis of range activities and range utilization is required to fully assess which ranges and activities are most impacted and where locations of solar developments would be compatible on the almost 3 million acres of the NTTR. Range usage data and installation activity data on USAF bases was not released by USAF Headquarters at the time of this writing.

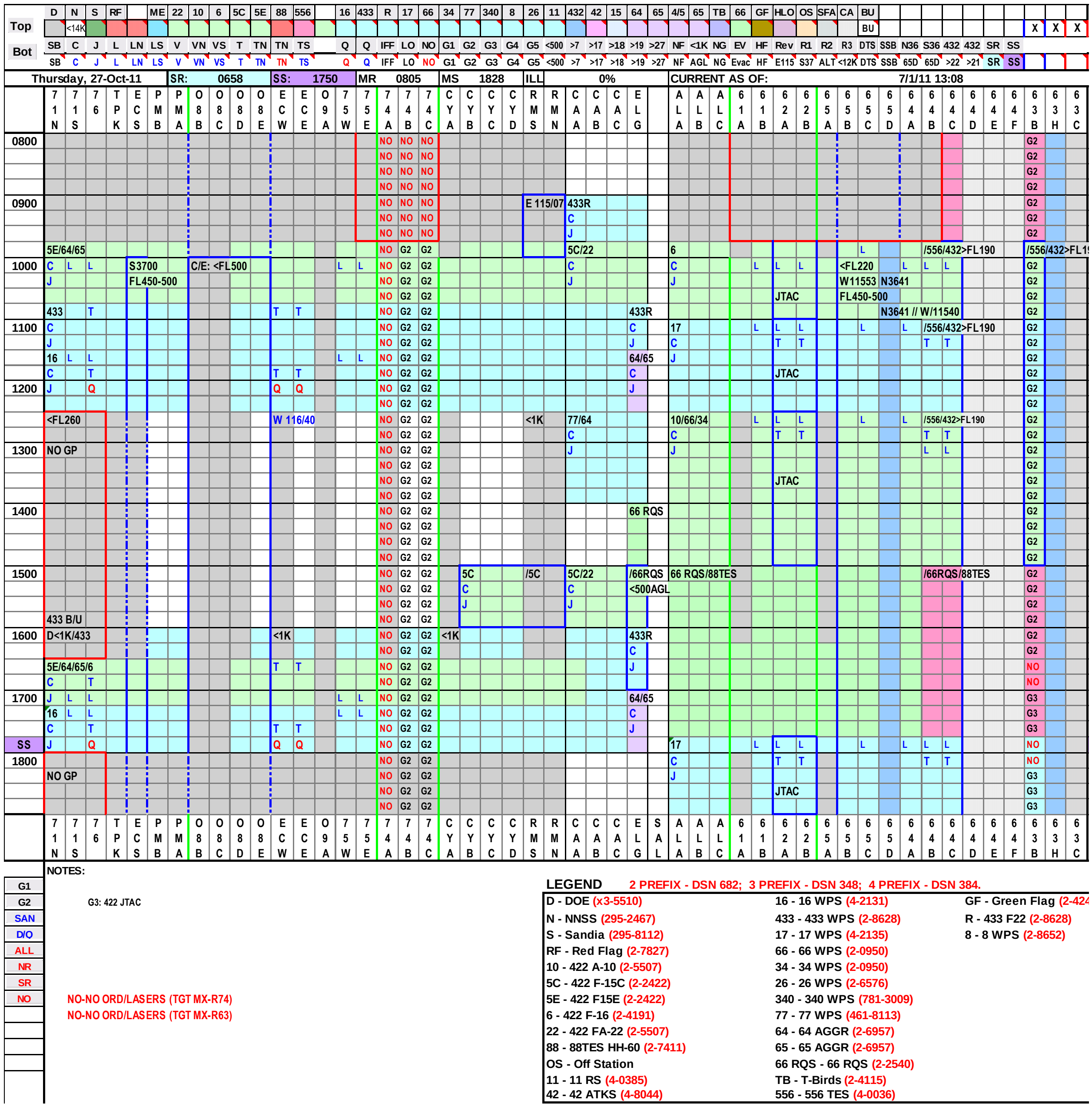


Figure 3.31 – Example of Nellis Range Operations Schedule

Mitigation

Solar PV presents the fewest challenges to the diverse mission set of NTTR. Nellis AFB has already developed one of the largest PV installations in the U.S. adjacent to the runway complex. The most likely areas suitable for new large-scale development are those adjacent to the Department of Energy (DOE) Test sites on the NTTR. CSP systems should only be considered on those areas of the NTTR already restricted from low-altitude flight and away from any test range infrastructure that would be affected by thermal emissions.

3.6 **Access**

―Access” subsumes a number of compatibility challenges between solar and mission activities. These include military security issues as well as range access issues.

Access conflicts fall into two broad categories of consideration: solar energy development restricting the military's access to range areas, and installation limitations restricting access to areas otherwise suitable for solar energy development. Because live fire weapons training requires large buffer zones for safety, restricted access through and around these areas significantly reduces transit route options for vehicle traffic in and out of potential sites for solar development and limits potential transmission line corridors. Live training, dismounted and mounted (motorized and mechanized) maneuver training activities rely heavily on the few roads and passes currently existing in the range areas. The characteristics that make these corridors a suitable location for travel are also conditions suitable for solar energy development. Similarly, aircraft conducting air operations training on the ranges enter, exit and loiter (or ―hold”) in designated areas suitable for concentrated air traffic, free from restrictions to flight and hazards to aviation, particularly low altitude flight hazards. These areas are typically the same edges and seams of the installation boundary areas identified as otherwise suitable for solar energy development or locating transmission lines.

Special consideration must be given to the avenues of approach that facilitate access to the range areas described in the Sensitivity section above. These transit routes, holding and staging areas, control points, entry and exit points may not directly involve spectrum issues or operational physical issues, but limitations or encroachment from solar energy projects still represent the same mission compatibility concern if solar energy development creates an impediment to military mission ―traffic”.

Security is another key consideration. Each installation conducts a variety of activities, some of which are classified in nature. Proposals to build solar facilities in areas where classified activities are undertaken or that require periodic transit across or adjacent to such areas are unlikely to receive favorable consideration from installation planning staff. Solar power towers – which are largely excluded from consideration in this study due to their hazard to air navigation – present an additional security challenge: there are many areas of these installations where it would be unacceptable to have a tower several hundred feet tall overlooking classified activities on the ground.

3.6.1 Fort Irwin and MCAGCC Twentynine Palms

Fort Irwin and MCAGCC Twentynine Palms share similar access compatibility considerations. Range and training area access requiring the use of paved or improved ground access routes for solar development is restricted by both range regulations and existence of only a few improved surface roads. Increased utilization of these access routes could interfere with scheduled training requirements and the movement of troops, equipment and supplies and ammunition.

3.6.2 NAWS China Lake, Edwards AFB, Nellis AFB, and Creech AFB

The discussion above described the high volume of Air Operations and T&E related operations at these installations. NAWS China Lake is home to the Coso Geothermal Field. Developed in the 1980s using the area's natural geothermic activity to generate electricity, the Coso Geothermal Plant has a capacity of 270 MW. The facility generated more 1.6 million megawatt hours (MWh) of electricity in 2010. The installation also has 12 distributed solar energy projects that have been developed in recent years totaling well over 1 MW in installed capacity. Another access consideration at these installations is a positive example of how solar energy development can address an access compatibility problem for remote range areas. China Lake has utilized solar PV arrays the largest totaling 180 kW, in several locations across its two ranges to provide power to remote, restricted testing sites. NAWS China Lake invested in these solar energy facilities because the regular shipment of diesel fuel to these remote locations was expensive and time-consuming. Installing solar energy facilities eliminated or dramatically reduced the amount of diesel fuel needed to power the facilities. In this instance, the solar energy development chosen for the task actually solved an access compatibility problem.

3.6.3 NAF El Centro and Chocolate Mtn. AGR

Access considerations at these two installations center on live fire weapons training limitations. Additionally, both already deal with significant encroachment from range transients, requiring constraints on training due to the recurring traffic of unannounced or unauthorized individuals and aircraft transiting their ranges.

3.6.4 MCLB Barstow

MCLB Barstow has minimal access limitations. The installation areas are located near major public transportation routes and the base has a well established network of roads that provide access to all areas. Special consideration must be given to MCLB Barstow's support, maintenance and repair facilities, ensuring solar development doesn't restrict access to the core mission activities or restrict any established public transportation routes to, from and through the base complex areas.

3.7 Environs and Shared-Use

An additional mission-compatibility challenge to solar development involves the surroundings or associated influences that limit solar energy development - e.g., building suitability, security issues, and proximity to other installation activities - that may make the co-location of a solar energy development unsuitable due to mission incompatibility, as well as restrictions for safety, engineering, and building or zoning guidelines. Exclusions may also include areas that are suitable in terms of policy, legal and safety concerns, but are still poor locations for solar energy development due to use-conflicts and other common-sense planning considerations.

One specific military mission area that falls into this category is explosive ordnance or munitions storage. As noted in the Introduction, the ideal site for solar is one where there are no conflicts with the primary use of the land or facility. The safety buffers around munitions storage sites are typically unused by any other activity, and thus offer potential siting for solar if the risk and regulatory compliance costs can be borne. As with other areas in this chapter, there are munitions considerations that are DoD-wide, unique to each service, or unique to each installation. All three types of munitions considerations influence mission compatibility with solar development. The remainder of this Environs and Shared-Use layer discussion will describe the mission compatibility issues, guidelines and limitations that influence any decision to locate solar development in these areas. The discussion also includes the procedures for gaining approval from the DoD, should these locations be selected for future solar development.

3.7.1 Explosive Ordnance (Munitions) Storage

Overarching guidance for all services is found in DoD Standard 6055.09-M (DoD, 2004b) *DoD Ammunition and Explosives Safety Standards*. All service regulations must comply with and reinforce the guidance in this regulation. The Navy has provided supplemental guidance for shore-based units and the Marine Corps in Navy Sea Systems Command Operations Publication – 5, Volume 1 (NAVSEA OP – 5, Vol 1), *Ammunition and Explosive Safety Ashore*. The Marine Corps further defines requirements in Marine Corps Order (MCO) P8020.10B, *Marine Corps Ammunition and Explosive Safety Program.* The Air Force further defined their policy in Air Force Manual (AFMAN) 91-201, *Explosive Safety Standards* and the Army provides more detail in Department of the Army Pamphlet (DAPAM) 385-64 *Ammunition and Explosives Safety Standards*.

Although the services have some authority to build near a potential explosive site (PES) if certain conditions are met, all new construction site plans within established explosive arcs must be reviewed and approved by the DoD Explosive Safety Board (DDESB). Not all new construction requires a waiver to established standards, but it does require review and approval of the DDESB as well as a solar energy developer willing to shoulder the risks – to life, property and capital – of developing within an explosive arc.

3.7.2 Quantity Distance Determination and Restrictions

When considering the placement of a solar energy development near a PES, two major issues will impact placement – quantity distance and siting in regard to High Occupancy Facilities/Areas.

3.7.2.1 Quantity Distance (QD)

All Services follow the standards and formulas in the DoD 6055.09-M STD when establishing quantity distance (QD). There are four standard QDs for designating explosive arcs. Each are determined by the net explosive weight (NEW) stored at the PES and a predetermined risk factor, known as the k-factor[9], based on overpressure from an explosion and the probability of hazardous fragments resulting from the explosion. The risk factor takes into account the probability for physical damage to facilities/structures and injuries to people inside one of the QDs listed below. The four standard QDs are:

- *Intermagazine Distance (IMD), Above Ground* – This is the minimum distance to be maintained between two ammunition and explosives (AE) storage locations. There are two IMDs, barricaded and unbarricaded. The unbarricaded IMD will have the greater distance from the PES.

[9] QDs discussed in this section are determined by the formula $D=KW^{1/3}$; where D=distance, K=risk factor, and W=net explosive weight.

- *Intraline Distance (ILD)* – This is the minimum distance to be maintained between two AE related buildings or sites within an AE-related operating line. As with the IMD, the ILD also has a barricaded QD and an unbarricaded QD.
- *Public Transit Route Distance (PTRD)* – The PTRD is the minimum distance that any public street, road, highway, navigable stream, or passenger railroad, including roads on a military reservation used routinely by the general public for through traffic, can be located from a potential explosion site.
- *Inhabited Building Distance (IBD)* – The minimum distance that an inhabited building can be located from a PES.

3.7.2.2 High Occupancy Facilities/Areas (HOFA)

The DoD Explosive Safety Board (DDESB) will also take into consideration the location of high occupancy facilities/areas, such as housing/shopping areas, schools, or office buildings, in relation to a solar energy development. If the solar energy development is located between the PES and a HOFA, an engineering analysis will likely be required to demonstrate that an explosion at the PES will not produce hazardous secondary fragments from the solar energy development that could impact the HOFA.

3.7.3 Waivers, Exemptions, and Secretarial Certifications/Exemptions

Although DoD 6055.09-M STD is not specific regarding what type of new construction would be allowed at which QD. It is evident that waivers or exemptions for solar projects would only be considered within the IBD and outside of the PTRD (Cotton, 2011) (Stacy, 2011). Furthermore, based on the definitions below, it is evident that the first flag officer in the installations' chain of command will usually have the authority to grant waivers and/or exemptions. However, all new construction site plans must be reviewed and approved by the DDESB (DoD, 2004). Based on previously submitted waivers and interpretation of the DoD 6055.09-M STD regulations, waivers for new construction of a solar energy facility will most likely be sent to the Service headquarters for review/approval. Finally, in reviewing the definitions of waivers and exemptions, it is evident that any new construction of a solar energy facility should request an exemption or Secretarial Certification/Exemption, instead of a waiver due to the length of time the facility will remain inside the explosive arc.

Waivers
A waiver is a written authority that permits temporary deviation from the standards as defined in DoD 6055.09-M STD for strategic or compelling operational requirements. Waivers are granted by the official with both:

- The assigned responsibilities consistent with the level of risk.
- The authority to control the resources required to accomplish the corrective action.
- Although the level for granting waivers is typically the first flag grade officer (General or Admiral) in the installations' chain of command, most waiver requests are sent to the service headquarters for review and/or approval.

Exemptions
An exemption is written authority that allows long-term noncompliance with the requirements for strategic or compelling operational requirements. Exemptions are granted by Law, Congressional review, or the official assigned responsibilities consistent with the level of risk.

Secretarial Certifications/Exemptions
The Secretary of a Military Department can authorize an Exemption or Certification to deviate from the requirements if the Secretary determines that it meets strategic or compelling operational requirements. These certifications/exemptions will be reviewed at least every five years to ensure the need still meets strategic or compelling operational requirements.

Fragments
When applying for waivers, exemptions or Secretarial Certifications/Exemptions, a hazard determination will be conducted. The potential for fragments resulting from material caught in the blast wave will be a major consideration. There are two types of fragments – primary and secondary.

- Primary fragments result from the shattering of a container (e.g., shell casings, kettles, hoppers, and other containers used in the manufacture of explosives, rocket engine housings) in direct contact with the explosive. These fragments usually are small, initially travel at thousands of feet per second and may be lethal at long distances from an explosion.
- Secondary fragments are debris from structures and other items in close proximity to the explosion. These fragments, which are somewhat larger in size than primary fragments and initially travel at hundreds of feet per second, do not normally travel as far as primary fragments.

In conducting research for this report, Explosive Safety Officers from several of the included installations were consulted and meetings were conducted with representatives from the DDESB, NOSSA, USATCES, and the AFSC/WSD. Each expressed concern that the glass or glass-like material used to construct a solar energy generating facility may exceed the common definition of secondary fragments, as defined above. Concerns revolve around the potential for glass to shatter into very small pieces and travel at least as far as primary fragments.

3.7.4 Service Issues

Based on service regulations and conversations with service level ammunition and explosives safety experts, all of the services apply the regulations and requirements in the DoD 6055.09-M STD. This means that when looking at different service installations for potential siting of solar energy projects within QDs, there should be relatively little variance in how the standards are applied. However, what information will be required in the waiver request and how the waiver process will be executed will vary slightly between the services.

3.7.4.1 Navy

The Navy is considering adding a paragraph to the NAVSEA OP-5, Volume 1 to address the increase in requests to accept renewable energy projects within an explosive arc of a PES (Stacy, 2011). The following standards are being considered for inclusion:

- All equipment involved with renewable energy production would be required to be placed outside of the PTRD.
- Siting requests must specify the energy customer and the equipment owner, and include a letter of risk acceptance from the owner for potential damage to the equipment, personnel, and power disruption (Stacy, 2011).

NOSSA will also want to see the following issues addressed in the request:

- The acceptance of risk by the property owner must be for the complete loss of equipment in case of an accidental explosion.
- If the equipment is owned by a private entity, then the owner must have written agreement with the installation on procedures for personnel access and explosive safety.
- The design must have engineering controls to isolate the project from the public and/or installation grid in the case of an accidental explosion.
- All electromagnetic radiation emitting devices/transmitters, including cellular enabled data transmitters, must be reviewed and approved in accordance with NAVSEA OP 3565, Volume 2 – *Electromagnetic Radiation Hazards*.
- If the renewable energy facility is sited between the PES and a HOFA, an engineering analysis on the equipment may be required to determine the probability of the equipment producing secondary hazardous fragments that may impact the HOFA (Stacy, 2011).

3.7.4.2 Army

Although the Army representatives did not indicate whether they were contemplating adding guidance on renewable energy generating facilities in their service regulations, they did generally agree with the same points discussed in the Navy section above. However, they also raised concerns that energetic fragmentation density of solar panels might exceed the allowable fragmentation density of one fragment per 600 square feet at the IBD (DoD, 2004). Engineering studies on the materials will have to be conducted to ensure that the solar panels do not exceed the established fragmentation density rates.

3.7.4.3 Air Force

The Air Force provides for two other types of waivers – Deviations and Event Waivers. Deviations allow for day-to-day operations to continue while corrective measures are being pursued to correct the QD violation. The Event Waiver permits a temporary exception when conditions or circumstances causing the waiver arise unexpectedly and there is not enough time to comply with the formal waiver process. The Air Force, in Chapter 1 of AFMAN 91-201, provides the greatest amount of detail in how to prepare and submit a waiver or exemption request for Air Force installations.

3.7.4.4 Marine Corps

The Marine Corps follows NAVSEA OP5, Volume 1 and MCO P8020.10B (U.S. Navy, 2007). Any request for waivers or review of site plans will go through NOSSA prior to being sent to DDESB and HQMC. The Marine Corps also provides for Event Waivers similar to the Air Force. In the Marine Corps, however, the Event Waiver is issued for temporary, non-recurring readiness or operational requirement that cannot otherwise be satisfied.

3.7.5 Explosive Ordnance (Munitions) Storage Facilities by Installation

In examining explosive arcs (Quantity Distance (QD)) around PES, it is important to understand that PESs encompass more than just explosive ordnance storage areas. A PES will also include the following:

- Air Stations and Air Force bases will have areas located near the runways for the uploading and removal of ordnance onto aircraft. Each of these areas will be identified and have established explosive arcs based on the type and quantity of ordnance that the location is designated for.
- Live fire training areas might also have –operating locations” that allow for the temporary staging of ground ammunition for use in an on-going exercise or training evolution. These areas will also be designated in local regulations and have established explosive arcs based on a pre-determined type and quantity of ammunition.
- All installations with explosive ordnance storage areas will also have designated routes coming into the installation for delivery of explosive ordnance. Sometimes these routes will also have explosive arcs designated around them. This is another Access mission compatibility limitation.

Fort Irwin
The study team was given general ordnance storage facility location information from personnel at Fort Irwin but was unable to get specific explosive arc information due to the sensitivity of weapons and training data. However, based on our research, there are several safe assumptions. As a large combined arms, live-fire, maneuver training area, it is likely that Fort Irwin will have at least one large explosive ordnance storage area and several (if not many) other PES that might include: designated Field Ammunition Storage Points (FASP), hot spots near or on an existing runway, and any potential operating areas that are used to assemble ordnance.

NAWS China Lake
NAWS China Lake has over 550 PES – 299 Explosive Ordnance Storage sites and 258 other PES.

NAF El Centro
The study team was unable to get first-hand information on ordnance storage from personnel at NAF El Centro, however the installation literature boasts the expenditure of over 25,000 to 30,000 bombs/rockets and 200,000 strafing rounds per year by units launching from the NAF (U.S. Navy, 2010). The airfield diagram denotes a Combat Aircraft Loading Area (CALA) between the junction of taxiways A and C on the east end of the field (FAA, 2010).

Chocolate Mtn. AGR
Although labeled an “air gunnery range”, this training area is also used by artillery units and other units employing indirect fire weapons. Because of this, Chocolate Mtn. AGR has designated several specific areas for Field Ammunition Supply Points (FASP). Each of these areas will have a designated explosive arc based on the maximum NEW allowed at that location.

MCAGCC Twentynine Palms
The study team was unable to get first-hand information on ordnance storage from personnel at MCAGCC Twentynine Palms, however like Fort Irwin, it is a large combined arms, live fire, maneuver training area. It too, likely has a large explosive ordnance storage point and several PES. The airfield diagram for Twentynine Palms Expeditionary Landing Facility also shows arm/de-arm spots (FAA, 2010).

MCLB Barstow
There is only one PES on MCLB Barstow and it is a small explosive ordnance storage facility that maintains six month inventory for small arms ammunition used for individual annual weapon qualification and familiarization firing (5.56, 9mm, and 12 gauge). The IBD for this one magazine does not extend past the storage area’s security perimeter fence (Korves, 2011).

Creech AFB
There are a total of 10 explosive ordnance storage locations on Creech AFB. Five are earth covered bunkers, three are above ground metal buildings, and two are operating areas in the training areas. There are 13 other PESs where explosive ordnance is handled in support of aircraft operations and runway clear zones.

Nellis AFB
The study team was unable to get first-hand information on ordnance storage from personnel at Nellis AFB.

Edwards AFB
Edwards AFB has 34 explosive ordnance storage locations and 13 other PESs that support aircraft operations. The majority of these PESs are located on or south of the main airfield on the south base (Rief, 2011).

3.7.6 The Business Case for Siting Solar Adjacent to Explosive Ordnance Storage

As noted elsewhere in this chapter, much of the land on the nine installations cannot be used for solar development because of mission conflicts. As a result, ESQD arcs have an initial attraction for solar development because there are typically no other activities conducted on this real estate, and thus there are no obvious physical compatibility challenges such as ground maneuver, live-fire exercises, etc. (Spectrum concerns may still exist.) While this ground provides great value as a safety buffer and can also provide valuable habitat or ecological services, it offers no other development value to the installation but offers a risk to the tenant. Therefore, one might reasonably assume that an installation would make ESQD arcs available to solar developers at a low price per acre.

However, even a price of zero dollars per acre may not be low enough to induce a developer to locate their project in one of these areas. Developers need to raise capital for PPA and EUL projects from investors such as pension funds and insurance companies. Given a choice between investing in a project within an explosive arc or investing in a project on BLM or private land outside the fence, an investor will need to see a higher rate of return to even consider the project within the explosive arc. Further, the investor will need to see an insurance policy that protects the investors against the loss of the project due to an explosion and against any secondary losses such as loss of income, liability suits due to secondary debris, and other claims for compensation related to loss of life, health and property. It remains to be seen whether an adventurous developer can create a satisfactory insurance package and financing package to make development within an explosive arc a successful proposition.

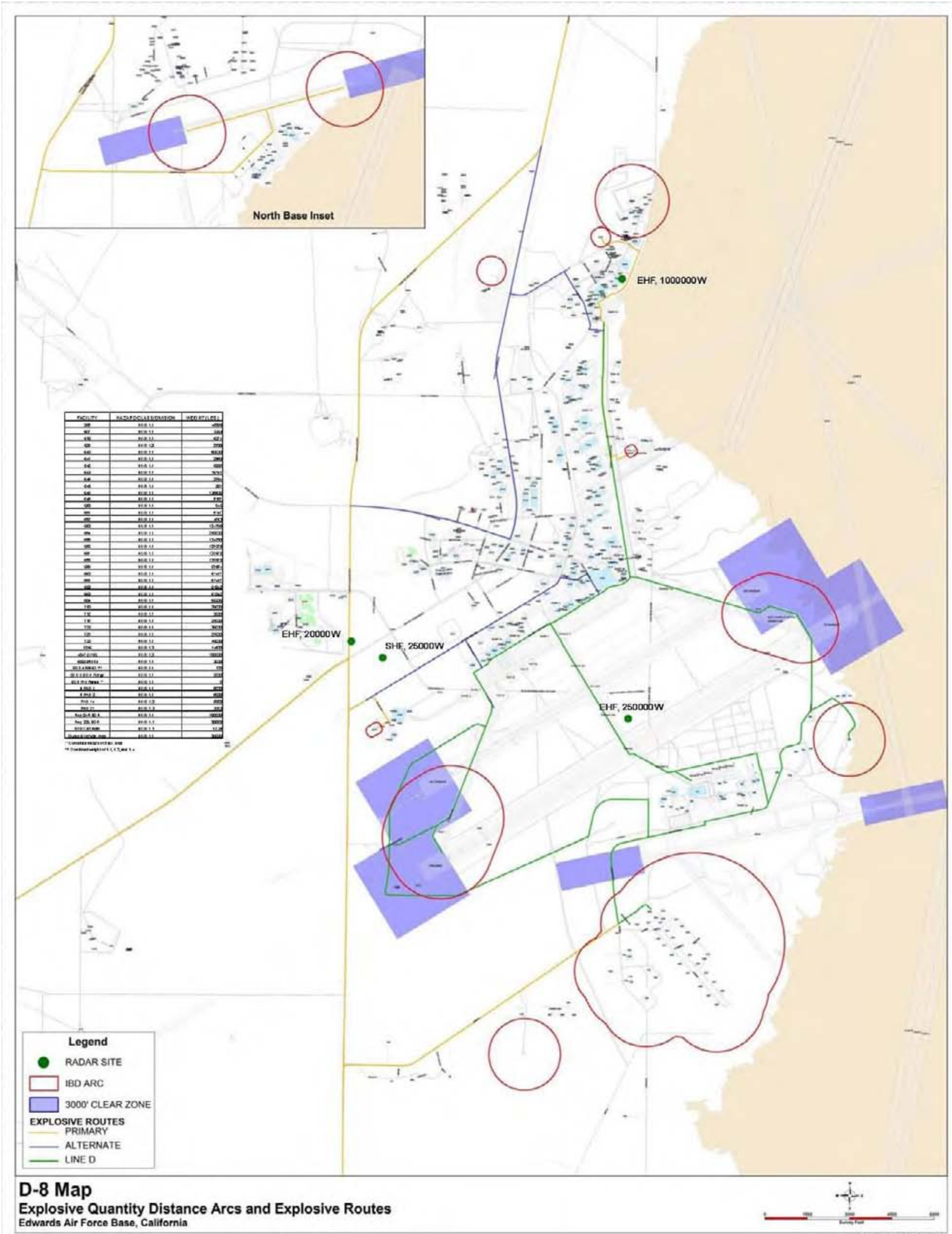


Figure 3.32 – Edwards AFB Explosive Arcs (Rief, 2011)

3.7.7 Surface Danger Zones

Section 3.5.2 of this chapter reviewed mission compatibility issues related to live fire range activities. The guidelines for proximity construction in the target areas used for explosive ordnance delivery are similar to munitions storage guidelines. Surface Danger Zones (SDZs) are the designated fixed distances, usually in a pie shape, around these live fire ranges. SDZs vary greatly depending on weapons type, munitions type, location of firing point, and location of impact area, just to name a few. Due to the large variance of munitions used on large maneuver training areas such as Marine Corps Air/Ground Combat Center and Fort Irwin, the list of ranges and related SDZs is quite extensive. These limitations were considered during the suitability reviews conducted with installation personnel, and areas affected by SDZ's were eliminated by the installation representatives.

SDZs for ground weapons systems and aviation gunnery for the Army and Marine Corps are detailed in Department of the Army Pamphlet (DA PAM) 385-63, *Range Safety* (U.S. Army, 2003). The Air Force addresses SDZ and Weapon Danger Zones (WDZ) in Air Force Instruction 13-212, *Range Planning and Operations* (USAF, 2007).

3.8 Summary

3.8.1 Mission Compatibility Screening

Spectrum and physical conflicts create incompatibilities between mission activities and solar development. Solar energy developers should understand the perspectives and mission areas of each Service and consider each installation's unique challenges, priorities, mission, guidelines and operational activities. Selecting locations for solar projects with these factors in mind will enhance the project design and improve the results. Demonstrating a thorough knowledge of the mission compatibility issues will help build a solid partnership with DoD counterparts and stakeholders.

3.8.2 Observations and Conclusions

Literature review and extensive interviews with DoD representatives on these nine installations support the following general observations and conclusions related to mission compatibility.

1. *These ranges are essential and irreplaceable* – Solar development should only be permitted on these key ranges if the incompatibility issues can be resolved and ranges can continue their mission at 100% of their current operational tempo and training, test and evaluation output, and with sufficient allowance for future uses of the ranges.

2. *Ranges are generally seen by installation personnel and the DoD as incompatible with utility-scale solar energy development* – Despite continued renewable energy development on DoD installations and support from many military leaders and DoD installation managers, the burden of proof is on solar developers to understand the concerns of and present sufficient evidence to Service leadership and range operations managers that these ranges are suitable locations for utility-scale solar energy development.

3. *Conflicts appear to be a combination of known issues and suspected issues, and more mission compatibility research is needed* – There remains significant mission compatibility data and analysis gaps. Very few studies of conflicts between mission activities and solar development have been completed, and the Services are reluctant to share existing relevant range usage and mission compatibility data due to the sensitivity of training and readiness statistics. A future study, conducted at a higher security classification level, should be able to incorporate greater detail about specific mission compatibility issues and other sensitive mission and readiness information.

4. *Mission incompatibility will remain the #1 limitation to large-scale renewable energy development at DoD installations and ranges* – The DoD and the managers of the installations and ranges support renewable energy development, recognizing the energy security benefits and potential pay-offs. But they also face incompatibility and encroachment challenges that impact their ability to conduct military readiness activities, potentially increasing mission risk due to unrealistic, segmented, curtailed, or irrelevant training. Successful communications between DoD stakeholders and solar energy development proponents will be critical to the success of any future development on these important installations.

4 Technology Characterization

4.1 Introduction

Solar technologies play an important role in helping the United States reduce greenhouse gas (GHG) emissions and stimulate the economy. Among the solar technologies currently in existence, solar PV and concentrating solar power are among the most developed. PV cells convert sunlight directly into electricity, while CSP technologies use reflective materials to concentrate the sun's rays to heat fluids that drive a generator to produce electricity.

This chapter provides a technical description of major existing concentrating solar power and PV technologies, including a discussion of important system components, efficiencies, and key projects under development. A discussion of all technical and economic assumptions used in the subsequent geographic, technical, and economic assessments is also included. Table 4.1 below shows many of the key attributes of the various solar energy technologies considered in this chapter. The table displays costs for ground-mounted solar projects only, which comprise the vast majority (over 99%) of the potential for solar development on the installations. PV systems on building roof and parking sites were also considered in the study's solar potential assessment. Cost estimates and full descriptions of methodologies used to study roof and parking sites are provided in the Solar Potential Assessment chapter.

Table 4.1 – Summary of Key Solar Energy Technology Attributes

Factor	Crystalline Silicon PV		Thin-Film PV		Tower Technology (dry cooling with no storage)	Trough Technology (dry cooling with no storage)	Dish/Stirling Engine Technology
	Fixed Axis	Single-Axis Tracker	Fixed Axis	Single-Axis Tracker			
Total Project Installation Costs[10]	$2,664/kW	$3,223/kW	$2,844/kW	$3,489/kW	$4,500/kW	$5,375/kW	$4,300/kW
Annual O&M Costs	$10/kW	$16/kW	$10/kW	$16/kW	$80/kW	$70/kW	$50/kW
Capacity Factor[11]	20-21%	25-26%	20-21%	25-27%	26%	26%	23-28%
Water Consumption (Gallons/MWh)	8	8	8	8	90	78	20
Maximum Slope[12]	5%	5%	5%	5%	5%	1%	10%
Acres/Installed MW	4.2:1	5.9:1	6.7:1	9.5:1	10.0:1	10.0:1	6.2:1
Minimum Project Size	5 acres	60 acres	7 acres	100 acres	500 acres	500 acres	70 acres

[10] The costs shown in Table 4.1 are before incentives, and do not include the costs for extensive environmental reviews or remediation nor transmission line extensions or network upgrades that may be necessary for some solar projects. The Solar Potential Assessment chapter provides background and additional detail on the cost methodologies used.

[11] The formula for ―capacity factor" is: Year 1 Annual Electricity Output (MWh_{AC})/(Installed Capacity (MW) x 8,760 hours). For photovoltaic (PV) systems, DC capacity is used in the capacity factor formula; for concentrating solar power (CSP) systems, AC capacity is used in the capacity factor formula.

[12] In the Solar Potential Assessment Chapter, a maximum slope of 5% is used for screening all technologies.

4.2 Concentrating Solar Power Technologies

4.2.1 Introduction

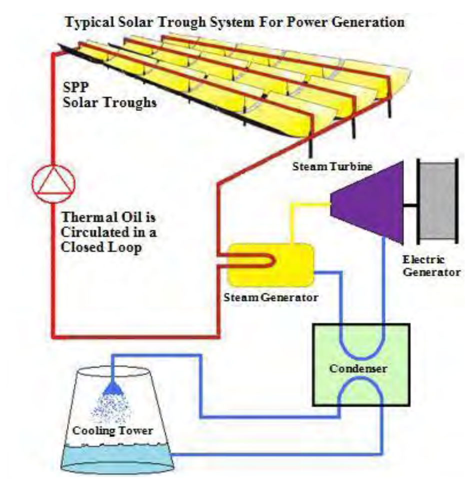
CSP systems use mirrors to reflect and concentrate sunlight into receivers. These receivers then convert the sunlight into thermal energy, typically by heating a working fluid such as oil, molten salt, hydrogen, or helium. The thermal energy captured in the high-temperature fluid is used to produce electricity either through a steam turbine or a heat engine which drives a generator (Sandia, 2009). The majority of CSP systems are grid-connected with limited battery storage, although systems using molten salt as a working fluid can incorporate thermal storage facilities that can power the steam turbines during cloudy conditions or low light and nighttime hours. These facilities can be designed to store sufficient heat in order to operate through the night or through several days of cloudy conditions (Ombello, 2010).

First in operation in California in the mid-1980s, commercial CSP plants have historically provided the lowest-cost utility-scale solar power option. There are a number of CSP systems currently in use, including solar power towers, parabolic troughs, and dish/engine systems. Markets for each type of system vary depending on the end user, storage options, concentration methods, and other design variables (SolarPACES, 2011).

4.2.2 Parabolic Trough

4.2.2.1 Description

A CSP parabolic trough system uses one or more parabolic dishes to concentrate sunlight onto a pipe filled with synthetic heat transfer oil located in the focus of the parabola. This oil is heated by the sunlight to 750°F. The superheated oil is then pumped to a nearby power block where it is used to produce high-pressure steam for a conventional steam turbine to generate electricity (Abengoa Solar, 2008). Overall, the system converts solar energy to electricity with an efficiency of about 15%. This is similar to that of PV cells, but less than Stirling dish concentrators (discussed below).



Parabolic Trough System
Image courtesy of Solar Panels Plus

4.2.2.2 System Components

Collectors and Receivers
Parabolic trough system collectors are concave mirrors made from silver-coated white glass, generally 4 to 5 mm thick and 2 to 2.8 square meters in size (Solar Millennium, 2011a). Mirrors can also be constructed from plastic film or polished metals, although these materials are less reflective (Abengoa Solar, 2008). Because of their parabolic shape, troughs focus the sun at 30-60 times its normal intensity on the receiver pipe (Fraser, 2005). The receiver pipe consists of a metal absorber surrounded by a glass envelope, which insulates the absorber

Parabolic trough power plant
Image courtesy of States Advancing Solar

from heat loss and is coated with an anti-reflective surface to maximize energy collection. For high temperature CSP applications, the space between the absorber and glass tube is evacuated (Abengoa Solar, 2008).

Mounted on a motorized base, trough systems are usually aligned on a north-south axis and follow the movement of the sun from east to west throughout the day (Abengoa Solar, 2008). If space or cost is an issue, troughs can be aligned on an east-west axis. While an east-west alignment reduces the overall efficiency of the collector due to cosine loss, it can reduce costs by removing the need for tracking motors as the trough need only be moved to adjust for seasonal changes in the sun's path through the sky (Solar Millennium, 2011b). Collectors are mounted on an aluminum structural support system that is manufactured to be extremely tolerant to weather elements and structurally rigid. Rigidity is important because the systems must be able to precisely focus sunlight on the receiver pipe, even when high winds are present. Sites also must be level, preferably with a slope of less than 1% (Fraser, 2005).

Individual parabolic trough collector modules are usually attached together to form a ―collector" that can be from 100 to 150 m long. Collectors are then configured together to form collector rows and parabolic trough plants are made up of many parallel collector rows covering large rectangular areas of land. A basic 100 MW trough plant requires roughly 475 acres of land to accommodate rows of collectors 6,167 ft long and 4,000 ft across. Adding additional collectors and storage tanks to produce energy during the evening would increase the land requirements to 940 acres for a 100 MW plant (Abengoa Solar, 2008). Plants typically store energy in a single-tank thermocline system that uses a mixture of silica sand and quartzite rock. The tank is then filled with a heat transfer fluid, typically a molten nitrate salt similar to that used in solar power tower systems.

Power Block

After being heated in the receiver pipes, the hot transfer fluid flows to the power block where a heat exchanger converts water into steam to drive a Rankine-cycle steam turbine generator, the same as in a conventional steam-powered coal or natural gas power plant. Parabolic trough systems can also be hybridized and combined with other power sources, such as natural or biogas, to meet electricity demand 24 hours a day (Solar Millennium, 2011c; DOE, 2007).

System Generator
Image courtesy of BrightSource Energy

Cooling System

Because CSP trough systems, like power tower systems, typically utilize Rankine-cycle steam turbines to generate electricity, a cooling system is required to condense the steam into water before it is ready to cycle again into the steam generator. Wet cooling systems commonly use evaporative cooling and are relatively inexpensive both in installation cost and in its impact on the net electricity generating capabilities of the power plant. But, evaporative cooling requires considerable amounts of water, as much as 800 gallons per MWh for CSP trough systems, which can be a critical issue since trough systems are typically located in arid regions in order to maximize the insolation the facility receives (DOE, 2009).

The water-conserving alternative to evaporative cooling is to utilize air-cooled condensers (ACCs), which blow air across condensing tubes to reject waste heat from the plant. The use of ACCs can reduce a CSP trough plant's water usage to 80 gallons per MWh of electricity generated or less, a 90% reduction over the water consumption of a wet cooled trough plant (Turchi *et al.,* 2010). But this water savings comes at the expense of a higher installation cost, more space required for the cooling system, and reduced net electricity generation (DOE, 2009). For a more detailed discussion of cooling system options, see the Cooling System subsection for CSP Power Towers (page 4-7).

4.2.2.3 Applications

Commercial CSP trough systems have demonstrated real net conversion rates of 24% in the summer and 15% over the course of a year. Losses due to atmosphere between the trough and its focal point are minimal, as the trough is generally designed specifically to be small enough that this factor is insignificant on a clear, sunny day (Solar Millennium, 2011c).As mentioned above, a conventional trough plant typically requires at least 4.75 acres/MW of capacity.

The levelized cost of electricity from parabolic trough systems has fallen over time. In 1985, initial plants produced power at a cost of 36 cents per kilowatt hour (kWh). Larger plants and improved operations and maintenance practices reduced costs to about 15 cents/kWh in the early 1990s (DOE, 2007). The real levelized cost of generation for a new parabolic trough system is estimated to cost in the range of 15 to 18 cents/kWh but additional cost reductions continue to be projected with renewed research and development of parabolic trough systems (SAM, 2010; NREL, 2010).

4.2.2.4 Existing and Future Projects and Trends

Commercial CSP plants with parabolic trough collector systems were first installed in the United States in the 1980s (Abengoa Solar, 2008). To date, roughly 354 MW of parabolic trough capacity has been installed in the Mojave Desert as part of the Solar Electric Generating Systems (SEGS) development plan implemented by Luz Industries. The nine SEGS plants were installed between 1984 and 1990 and collectively count as the two largest parabolic trough systems in the world with 150 MW of capacity located at the Kramer Junction, CA facility and 160 MW located at Harper Lake, CA facility (SEIA, 2011). The SEGS plants have acted as an important proving ground for parabolic trough technology. Improved maintenance of the troughs over the years has boosted the availability of each collector to greater than 99.5 percent (DOE, 2007; Fraser, 2005). In Europe, the Spanish company Solar Millennium recently installed the Andasol 1 solar power station, which uses a unique ―Eurotrough" collector and has a capacity of 49.9 MW.

SEGS III parabolic trough plant
Image courtesy of The Energy Library

In 2009, scientists at NREL developed large, curved sheets of metal that have the potential to replace glass-based collector models. These new metal sheets, coated with a layer of silver polymer, would be lighter and 30% less expensive than traditional glass collectors, allowing developers to save on production and installation costs (Tournemille, 2009; Fraser, 2005).

4.2.3 Solar Power Towers

4.2.3.1 Description

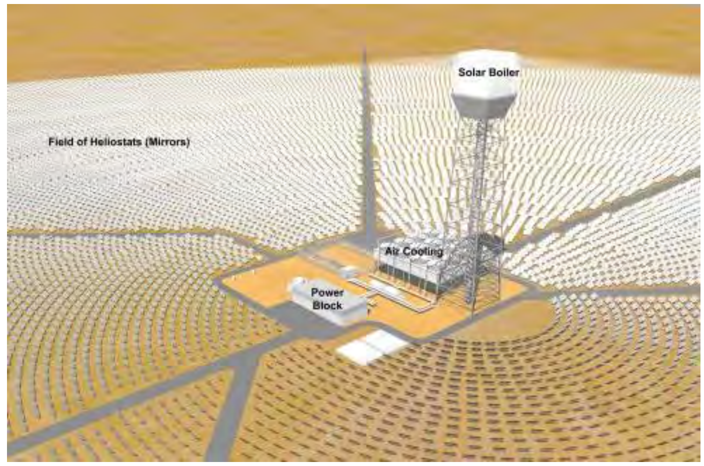


Figure 4.1 – Solar Power Tower (US Building Digest, 2011)

Solar power towers generate electric power from sunlight by focusing concentrated solar radiation on a tower-mounted heat exchanger. Arrays of flat mirrors track the sun and reflect its sunlight upon the top of the tower and heat a transfer fluid located in the tower's receiver. This heated transfer fluid is then pumped into a heat exchanger, where the heat is used to produce steam which, in turn, powers a conventional turbine generator to produce electricity (Sargent & Lundy LLC, 2003). Conventional solar power towers have either directly generated steam from water in the receiver or used a synthetic oil as a heat transfer fluid. Recently, more advanced designs use molten nitrate salt as the heat transfer fluid because of its superior heat transfer and energy storage capabilities (WIPP, 2011).

4.2.3.2 System Components

Heliostats

Heliostats
Image courtesy of BrightSource Energy

Heliostats are arrays of flat, movable mirrors that focus the sun's rays on the receiver at the top of a power tower. Mounted onto a steel pylon, a computer tracking system behind the mirror allows the array to track the sun in two dimensions, ensuring that the system correctly reflects sunlight throughout the day. Tracking software also accounts for variables such as light flux intensity, wind, air pressure, and the number of heliostats available for tracking. Because the heliostats consist of smaller, flat mirrors, they are simpler and more efficient to manufacture and install than the parabolic mirrors used in solar trough systems. This is particularly true when pylons are installed directly into the ground, eliminating concrete pads and reducing the mirrors' environmental impacts. Maintenance requirements for the mirrors are limited throughout their 35 year lifespan and the modules only require periodic cleaning with water. A 100 MW solar plant can consist of up to 50,000 heliostats and require a minimum of 5 acres per MW of power produced (Lehl Gmbh, 2010; BrightSource Energy, 2010).

Tower and Receiver

The solar power tower is the metal structure that supports a system receiver where the sunlight reflected from the heliostats is focused. Tower height can range from 300 to 600 feet and is scaled to allow the heliostats to accurately reflect sunlight from significant distances (BrightSource Energy, 2010).

For power towers that do not utilize thermal storage, the concentrated sunlight is used to heat a transfer fluid circulating in the receiver to between 800ºF and 1000ºF. The transfer fluid is then used to generate steam for use in a conventional Rankine-cycle turbine/generator to produce electricity. Electricity generated on the site is transferred to an electrical substation to be added to the electrical grid (Tribal Energy, 2011; SEIA, 2010).

Power Tower and Receiver
Image courtesy of BrightSource Energy

For solar power towers that utilize molten salt thermal storage, the heat generating process is slightly modified. In molten salt power towers, –cold” liquid salt (550ºF) is pumped from a –cold” storage tank to the receiver where it is heated to 1,050ºF and sent to a –hot” tank for storage. When electricity generation is desired, the hot salt is pumped into high-efficiency boilers with steam generation, superheating and reheating compartments to generate steam for use in the plant's Rankine-cycle power block. Once used, the cooled molten salt is returned to the –cold” liquid salt storage tank (Sandia, 2006).

Boilers and generators are typically supplied by conventional boiler and generator manufacturers and comply with standard design parameters, performance warranties, and industry best practices (BrightSource Energy, 2010). Both trough and power tower solar technologies require a single, large power block to generate electricity, although it is not uncommon for more than one generator to be used for larger facilities.[13]

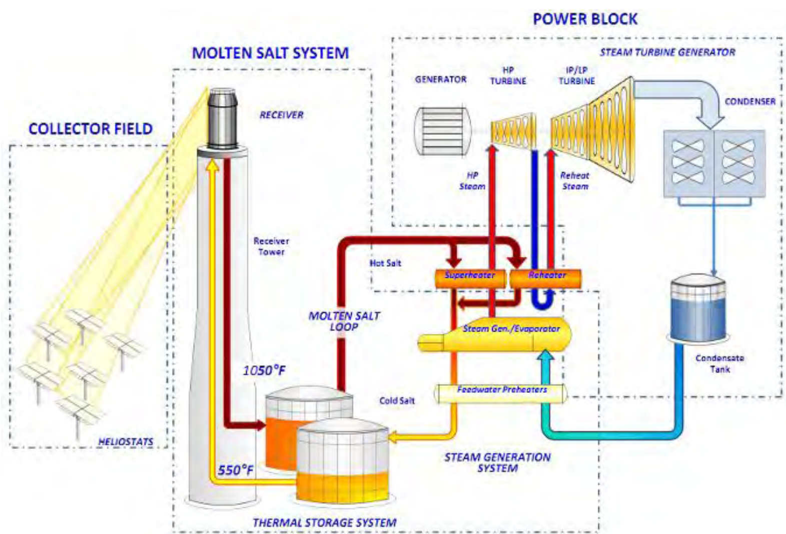


Figure 4.2 – Solar Power Tower System Components (Hunter, 2010)

Excess thermal energy, collected and stored in molten nitrate salt storage tanks during daylight, can be used to power the steam turbines during non-solar hours (Sandia, 2009). Storage tanks can be designed with sufficient capacity to power a turbine overnight or through several days of cloudy weather (Ombello, 2010).

Power tower systems typically use synthetic oils or molten salt as heat-transfer fluids because it allows the systems to operate at higher temperatures. For instance, molten salt systems operate at 1050°F, allowing them to achieve a thermal efficiency of 40% instead of the 37.6% efficiency of water-based systems. The salt is typically a mixture of 60% sodium nitrate and 40% potassium nitrate (Tribal Energy, 2011).[14]

---

[13] In contrast, dish engine and PV systems are comprised of a number of modular power block units that do not use a main power station.
[14] Mixtures of 48% calcium nitrate, 7% sodium nitrate, and 45% potassium nitrate are also being investigated.

Cooling System

Because power tower systems typically utilize Rankine-cycle steam turbines to generate electricity, a cooling system is required to condense the steam into water before it is ready to be reused in the steam generator. Typical cooling systems can generally be divided into wet and dry cooling technologies although hybrid systems have been proposed that use both types of cooling in order to capitalize on the strengths of each technology.

For power tower systems, wet cooling systems utilize evaporative water cooling to economically and efficiently condense steam in a cooling tower. This method of cooling has the advantage of being relatively inexpensive both in installation cost and in its impact on the net electricity generating capabilities of the power plant. But, evaporative cooling does utilize considerable amounts of water, 600 gallons per MWh of electricity generated or more, which can be a critical issue for solar power tower systems which are typically sited in arid regions in order to maximize the insolation the facility receives (DOE, 2009).

Increasingly common to power tower systems, dry cooling systems use the ambient air as the medium for rejecting the waste heat and condensing the system's steam back into a liquid. Typically, the steam is directed through air-cooled condensers (ACCs) which are cooled by fan blown air. Because dry cooling systems utilize the temperature difference between the system's process steam and the ambient air, high ambient air temperatures can negatively impact the performance of the cooling system and the electricity generating capacity of the CSP system, reducing the annual net electricity generation of an air-cooled plant by as much as 5% compared to a wet-cooled plant (Turchi *et al.,* 2010). In addition, ACC systems are more expensive to install than evaporative cooling systems, take more space, and have higher parasitic load requirements, which diminish the net electricity generation of the facility. But because dry cooling systems don't use water for cooling, a power tower plant's water consumption can be reduced to 90 gallons per MWh of electricity generated (DOE, 2009).

A dry cooling alternative to ACCs is to utilize an indirect air-cooling system known commonly as a Heller cycle. Heller cycle cooling typically uses less water, electricity, and space than ACCs but at the expense of visual impact. The key component of a Heller cooling system is a large convex cooling tower that draws hot air upwards and away from the condensing steam. Because of the significant visual impact of the 400 ft. tall or higher cooling tower, no CSP systems in the U.S. have utilized a Heller cycle cooling system (Climate Progress, 2009).

4.2.3.3 Applications

While smaller pilot power tower projects have been built in the 1-10 MW range, solar power tower developers are currently focusing their attention on significantly larger power tower developments with capacities of 100 MW or more (SEIA, 2011). An individual tower can be sized to produce up to 200 MW of power and developers often group multiple towers on a single site to reduce development costs. The size and layout of the tower's surrounding heliostat field depends on the location and utility's power needs. Systems generally require 10 acres per MW of power, including land area for molten salt tanks to provide 12 hours of storage (WIPP, 2011). Power towers require relatively flat terrain, with a slope of no more than five percent (BrightSource Energy, 2011).

The real levelized cost of electricity from solar power towers is currently estimated to range between 12 and 14 kWh (SAM, 2010). Additional cost reductions are expected in the future with further research and additional economies of scale from more and larger power tower developments but it is uncertain how significant these cost reductions since existing power tower developments use primarily established technologies.

4.2.3.4 Existing and Future Projects and Trends

Successful utility-scale solar power tower plants were first developed in California in the 1980s. Solar One, a 10 MW plant located near Barstow, CA, demonstrated the viability of the technology for commercial use. In 1995 Solar One was retrofitted into Solar Two, in order to demonstrate the advantages of molten salt for heat transfer and thermal storage, as well as to prove that a high-efficiency molten-salt energy storage system was a viable method to collect and store solar energy (DOE, 2011c).

After decommissioning Solar One and Solar Two in 1986 and 1999, respectively, the U.S.'s Sandia National Laboratory led an international consortium to pursue power tower plants worldwide. Particular emphasis was placed on developing plants in Spain, Egypt, Morocco, and Italy, where special solar premiums make the technology more economically attractive for developers (WIPP, 2011). In part, as a result of these efforts, utility-scale power tower systems exist in Spain, Germany, and the United States and solar towers are planned in China, Australia, and a number of U.S. states. One notable system is a 20 MW system near Seville, Spain named PS20, which consists of a solar field of 1,255 mirrored heliostats. Each heliostat has a surface area of 1,291 square feet and the tower is 531 feet high (ENS, 2009). Another system currently under construction in Sanlucar la Mayor will have an installed capacity of 300 MW. When completed in 2013 the system will supply energy to 153,000 households (Sullivan, 2009).

Currently, the only CSP tower facility operating in North America is the Sierra SunTower, a 5 MW commercial CSP plant in Lancaster, California (NREL, 2011). The world's largest solar power tower, the Ivanpah Solar Electric Generating System, is under construction in Ivanpah, CA and will produce 392 MW (NREL, 2011).

4.2.4 Dish/Engine Systems

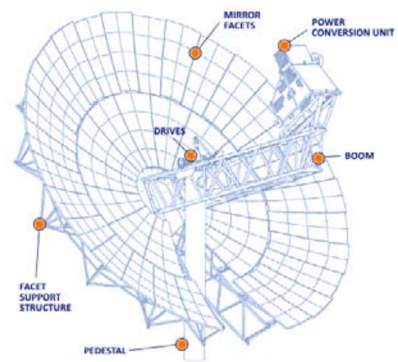
4.2.4.1 Description

Modular CSP dish/engine system use precision mirrors attached to a parabolic dish to focus the sun's rays onto a receiver located in the parabola's focus, which transmits the heat to an engine or power conversion unit. Sealed within the engine is hydrogen gas, which expands when exposed to heat. This change in pressure drives pistons inside an engine, which drives a generator to produce electricity (ScienceDaily, 2009). One popular dish/engine model is the Stirling Energy System (SES), which uses a conventional Stirling engine as the system's power conversion unit.

4.2.4.2 System Components

The major components of a SES include the solar concentrator and the power conversion unit. The solar concentrator or dish is the unit that gathers and reflects incoming sunlight onto a receiver, in order to generate heat. Concentrators are generally composed of a series of small, rectangular pieces of silver-coated white glass.

Sunlight collected by the concentrators is then directed towards a receiver. Usually consisting of a set of four sealed cylinders of hydrogen gas, the receiver acts as the heat-exchanger for the engine and generates mechanical power through pistons that rotate the engine's crankshaft. The heat transfer from solar rays to the heater head causes the hydrogen gas to expand in the piston and to be exchanged between cylinder arrangements, giving a maximum 1800 rpm speed and an output of 480 volts at 60Hz. Receivers can also contain a working fluid, such as water, that transfers heat to the engine via the boiling and condensing cycle, although water is less efficient than hydrogen gas (TheirEarth, 2008).



Stirling Engine System
Image courtesy of SES

4.2.4.3 Applications

Typical SES systems are rated at between 3 and 25 kW. While this capacity is significantly smaller than that of other commercial CSP technologies, SES are more flexible and modular, allowing installations that range from 1 MW to 1,000 MW (SES, 2011a). Systems typically generate an average efficiency of about 26%, although newer models have reached an efficiency of 31.25%. One weakness of SESs is that, because each dish generates electricity independently, rather than through a central power block, the system does not lend itself well to thermal energy storage (Bengtson, 2010).

Although water availability can be a problem for large solar thermal power plants, SESs use less water than other types of thermal electric systems (Harding, 2010). The most significant factor in the lower water consumption of SESs is their use of ambient air cooling via a radiator system to cool the gas used in the engine rather than a wet cooling system. (SES, 2011b). In addition, SESs do not use water to generate steam as is necessary in Rankine cycle steam generators commonly used for CSP tower and trough systems. Water use for washing mirrors and other miscellaneous industrial processes and sanitary uses are estimated to total 20 gallons per MWh for a utility-scale development (DOE, 2009).

Stirling CSP systems are flexible in terms of siting, because the units are modular and can be installed on sloping land up to a 10% grade (SES, 2011c). Most proposed Stirling CSP systems have been designed to use between 5 and 8 acres of land per MW of capacity.

4.2.4.4 Existing and Future Projects and Trends

While several companies have demonstration projects using Dish/Stirling-based technologies, there are currently no commercial solar parabolic dish/Stirling engine solar plants in operation in the United States, although several have been proposed in the past (Harding, 2010).

The future development prospects of this technology are uncertain. Stirling Energy Systems (SES) filed for Chapter 7 bankruptcy liquidation in late September 2011 (REW, 2011). Prior to its bankruptcy filing, the company unveiled four newly designed solar power collection dishes at

Sandia National Laboratories' National Solar Thermal Test Facility (NSTTF). Called SunCatchers™, the new dishes have a refined design that could be used in commercial-scale deployments. The new SunCatcher is about 5,000 pounds lighter than the original, is round instead of rectangular to allow for more efficient use of steel, has improved optics, and consists of 60 percent fewer engine parts. The revised design also has fewer mirrors — 40 instead of 80. Using automobile manufacturing techniques, the reflective mirrors are formed into a parabolic shape using stamped sheet metal similar to the hood of a car. The improvements facilitate high-volume production, cost reductions, and easier maintenance (Tournemille, 2009).

The DOE is also partnering with concentrating solar power companies to support their research efforts, particularly in innovations that will lower capital costs and increase system reliability through improved engine and receiver efficiency. However, the two largest dish/Stirling projects using SES technology were sold by the developer prior to construction, and the new owners intend to convert the projects to other solar technologies.

In January 2011, the DoD's Environmental Security Technology Certification Program (ESTCP), the manager of this report, announced funding for a project at Fort Carson to evaluate the dish/Stirling engine technology of Infinia Corporation. Infinia's technology is designed to produce 3.2 kW_{AC} of electricity and 7 kW_{th} of usable heat per dish/engine unit. The ESTCP evaluation project will conclude in 2013 (ESTCP, 2011).

4.3 Solar PV Systems

4.3.1 Introduction

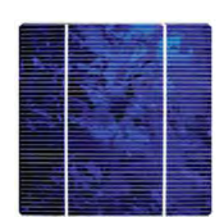
Solar cells, also known as photovoltaic (PV) cells, are solid state devices that convert sunlight into electricity via the PV effect (Dunn, 2008; NAHB, 1996). Two primary technologies dominate the PV market: crystalline silicon and thin-film. In both technologies, as light shines on a silicon crystal or a thin layer of PV material, photons strike the material and dislodge electrons. These electrons form a current that can be conducted into electrical circuits and devices (NAHB, 1996).

Crystalline Silicon Solar Cells

Crystalline silicon is the most prevalent bulk material for solar cells, with a market share of 80-90% (Solarbuzz, 2011). Silicon is categorized based on size of the crystal used within the solar module. There are two basic types of crystalline silicon applied to solar modules:

Monocrystalline silicon
Image courtesy of Best Solar

Monocrystalline silicon: Also known as single crystal modules, monocrystalline silicon modules are produced by slicing round wafers from a highly pure, single crystal structure. As a result the cells have a uniform, dark blue appearance and a life expectancy exceeding 25 years (Solarbuzz, 2011; Energy Alternatives, 2011; Wholesale Solar, 2011).



Polycrystalline silicon
Image courtesy of ShenZen Real Estate

Poly- or multicrystalline silicon: Produced by sawing a cast block of silicon into wafers, polycrystalline silicon cells are usually square and have a varied appearance (Energy Alternatives, 2011). Manufacturers generally prefer this form of silicon because it is less expensive, although the cells are also slightly less efficient (Solarbuzz, 2011). Multicrystalline silicon cells have a life expectancy of at least 25 years.

Regardless of the type of silicon used, manufacturers create a crystalline silicon module by applying phosphorus to the top surface of the silicon wafer to form a semiconductor junction. Most solar panels use a screen-printed contact pattern applied to the front and back of the cell in order to collect the electrons produced on the face of the cells.[15] The contacts also allow for the electrical current to flow to external circuits to be used by the electric load (Genpro Solar, 2011). The patterned contact overlay is also designed to direct maximum light exposure to the silicon material, while preventing electrical losses in the cell (Solarbuzz, 2011). As a result, a typical cell generates about 0.5 volts of power (Powered by Solar Panels, 2010).

Thin-film Solar Cells

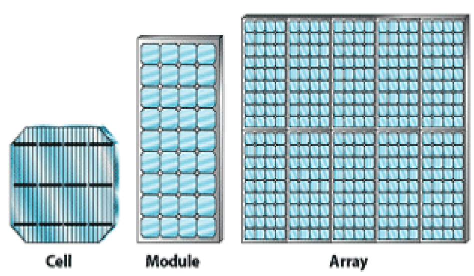
Thin-film solar cells, also called thin-film PV cells, are made by depositing one or more thin layers of PV material on a substrate. This PV material is typically amorphous silicon or a photocrystalline and nanocrystalline material such as cadmium telluride (CdTe), copper indium diselenide (CIS), or copper indium gallium diselenide (CIGS). The thickness of the material ranges from a few nanometers to tens of micrometers, making thin-film cells lighter and more flexible than traditional crystalline silicon cells (Solarbuzz, 2011; Greene, 2009).

Thin-film solar cell
Image courtesy of The Energy Blog

The thin-film semiconductor layers are deposited onto either coated glass or a stainless steel sheet. A transparent conducting oxide layer forms the front electrical contact of the cell, and a metal layer forms the rear contact. Thinner layers can be used to increase the electric field strength across the material and to provide better stability. However, the use of thinner layers reduces light absorption and reduces cell efficiency (Solarbuzz, 2011).

4.3.2 Applications

Because an individual solar cell is only capable of generating a few watts of electricity, they are normally combined into modules of dozens of cells. These modules are then assembled into PV arrays up to several square meters. For utility-scale applications, hundreds of arrays are interconnected to form a single, large system (Tribal Energy, 2011).



PV cell, module, and array
Image courtesy of Department of Energy

PV systems are generally designed in one of three ways: grid-connected without storage, grid-connected with

[15] Recent technological developments have resulted in new cell designs such as SunPower's back-contact solar cells that avoid the use of wires on the front of the cells in order to maximize the cell surface exposed to the sun and increase the overall efficiency of the cells.

emergency battery backup, and off-grid with battery storage (DOE, 2010). As of 2011, utility-scale solar projects have been designed exclusively as grid-connected facilities without storage.

Grid-connected systems without storage consist of PV arrays and a utility-interactive inverter. For ground mounted utility-scale PV systems, the inverter from each PV block interconnects to the electric distribution system. The inverter converts the array's power from direct current (DC) to alternating current (AC) that can be transferred to the grid at an interconnection point. The inverter also senses the power frequency of the utility's power and synchronizes the power produced by the solar array to that frequency (Tribal Energy; DOE, 2010). Grid-connected PV systems may use a central, string or micro inverters, depending on the type of system installed. String inverters are more common and typically used for systems sized from 1.5 kW to 500 kW. Emergency battery backup for a grid-connected system may be necessary if a site has critical loads (DOE, 2010).

Off-grid battery systems can reduce generator run times and save on operations and maintenance costs in the event that grid power is not available. An off-grid solar system would include a charge controller that manages the PV array's DC voltage and ensures that the correct voltage is sent to the batteries based on the charging requirements of the batteries (DOE, 2010). Battery storage capacity is rated in ampere hours, which is the current delivered by the battery over a set number of hours, at a normal voltage, and at a standard temperature of 25ºC. Most PV systems use lead acid batteries or conventional flooded batteries. Nickel cadmium batteries are usually the best option when a highly reliable battery is required. A charge controller or regulator is used to prevent over- and under-charging of the battery. The quality of the regulator is a key factor in the reliability of the overall system because it aligns the depth of discharge with the battery temperature and the rate of discharge. Some systems may use blocking diodes to prevent reverse discharge of the battery through the modules at times of low to no sunlight. This prevents damage to the modules from other source circuits and reduces energy loss (Solarbuzz, 2011).

Hybrid systems can be designed with an energy source other than the array or utility that supplements the solar output during periods of low solar radiation. Common energy sources include engine generators and wind turbines. Future solar systems may be integrated with existing or new combined-cycle natural gas or coal-fired plants (Tribal Energy, 2011).

Typical efficiencies of crystalline silicon modules range from 15 to 20%. They are heavily favored within the industry for distributed generation applications because they boast a higher efficiency than thin-film modules. The downside of crystalline silicon modules is they may be more expensive (Solarbuzz, 2011).

Thin-film solar modules made of amorphous silicon tend to have lower efficiencies than crystalline silicon PV (Greene, 2009). Currently, production modules boast efficiencies in the range of 9%, while prototypes have increased module efficiencies of up to 13%. Future thin-film module efficiencies are expected to rise to about 10-16%, but will not be commercially available in the near-term (NREL, 2011).

Thin-film modules are expected to cost less than fifty cents per watt to manufacture, opening new markets such as cost-effective distributed power and utility-scale production to thin-film electricity generation (NREL, 2011).

Because solar radiation has a relatively low energy density compared to other energy sources (approximately 1000 watts per square meter) it requires a relatively large total land area to generate large amounts of energy. More efficient crystalline-silicon modules have an area efficiency of about 4.5 to 10 acres per MW of energy produced (SECO, 2011). Less efficient thin-film technologies, in contrast, require about 10 to 13.5 acres to generate a MW of power (Solarbythewatt.com, 2009). Both technologies would require additional land if facilities for energy storage or hybrid systems are included. One advantage of PV systems is that the technology can be engineered to accommodate slope change across a site. However, slopes greater than five percent will generally require more complex construction (Tribal Energy, 2011).

Heat adversely affects the power output of PV modules. Crystalline silicon systems have a 0.5% decrease in power for every degree that the module temperature exceeds 25°C while typical thin-film systems lose 0.25% per °C. One advantage PV systems have over CSP tower and trough systems is that they do not require significant amounts of water for cooling. Utility-scale PV developments typically utilize 0.05 acre-feet of water per MW annually, which equals approximately 8 gallons per MWh of electricity, for the cleaning of solar panels (ANL, 2010), but even this water use is optional if the solar project utilizes more cutting-edge panel coatings and technologies to minimize the adherence of dust to the panels.

4.3.3 Existing Projects

In the past, global growth in PVs was primarily sustained by small and medium-sized installations with a capacity of less than 1 MW. PV power plants with a capacity of over 1 MW – or even more than 10 MW – were the exception. Since 2007, however, the market has changed dramatically. Falling technology prices and the rising costs of fossil fuels are making solar parks increasingly attractive for large investors. As of 2009, more than 2,600 PV power plants with an output of over 200 kW have been brought online with over half of these solar parks having a capacity of more than 1 MW, the majority of which utilized crystalline silicon technology. As of the end of 2009, large-scale PV accounted for more than a quarter of all PV power capacity or approximately 5,500 MW. Current trends indicate that a large number of PV power plants will be built, particularly in the south and southwest regions of the country, where there is ample land in the sunny deserts of California, Nevada and Arizona (Renewable Insight, 2010).

Because crystalline technologies have dominated the PV market, thin-films have historically had a niche market in low power systems (<50W) and consumer electronics applications. However, costs have fallen, making thin-film technologies more feasible for utility-scale projects, driving a growing share of the PV market. From 14 MW of global production in 2001, the thin-film industry has grown to 2,141 MW in 2009, a compound annual growth rate of 58%. In 2009, thin-film PV accounted for 25% of the larger PV market. (GBI Research, 2010). Currently, the largest thin-film installation, as well as the largest PV installation, in the US is the 48 MW Copper Mountain Solar plant developed by Sempra Generation and First Solar, Inc. in Arizona (Hughes, 2010).

4.3.4 Future Trends

Crystalline Silicon

In response to the lower prices of thin-film cells, crystalline silicon wafer manufacturers are working to reduce the silicon requirements of their modules. While current cells have a wafer thickness of about 0.200 mm, scientists envision the use of 0.08 mm wafers by 2015. Manufacturers are also working to cost-effectively grow ribbons of silicon, either as a two-dimensional strip or as an octagonal column. This would reduce the cost of growing silicon crystals for traditional wafers and reduce the need for as much expensive silicon (Solarbuzz, 2011).

Researchers are also working to increase the efficiency of crystalline silicon wafers. In January 2011 ReneSola Ltd, a global manufacturer of solar wafers, developed a new multi-crystalline wafer with a cell efficiency of 17.5%. ReneSola intends to begin pilot production of the wafer in the first half of 2011 (PRNewswire, 2011).

Thin-film

The thin-film market is also undergoing rapid change. Scaling factors, efficiency gains and new production technologies are expected to reduce thin-film module manufacturing costs in the near future. Efficiency is anticipated to rise from the current 6%-12% to 10%-15% in the coming years, with a potential of more than 20% in the longer term. Potential material developments include the development of new polymers and additional types of organic, dye-sensitive solar cells (Appleyard, 2009). As a result of this growth and development, researchers have projected that thin-film production will expand at an annual growth rate of 24% from 2009 to 2020, reaching 22,214 MW of thin-film solar capacity in 2020 (GBI Research, 2010).

5 Solar Potential Assessment

5.1 Introduction

This chapter describes complex analytic methods employed to address a very simple question:

> *How much solar generation could be developed on seven military installations in the Southern California Deserts, taking into account all of the technical and economic constraints that operate in the real world?*

In brief, across the seven California installations reviewed, 25,000 acres were found to be suitable for solar development and another 100,000+ acres were classified as likely or questionably suitable for solar. The 25,000 suitable acres would support the development of over 3,500 MW_{AC} of technically and economically feasible solar capacity. The additional 100,000 likely or questionably suitable acres would support another 3,500 MW_{AC} of technically and economically feasible solar capacity if only 25% were developed for solar. Assuming private development and ownership of this solar capacity, the Federal Government could expect to receive over $100 million of annual value, in the form of rental payments, discounted power, or both. Finally, full development of the technical and economic solar potential existing on the military installations would result in the avoided emissions of millions of tons of GHGs and criteria air pollutants.

These available acreage and solar capacity figures represent the maximum potential for solar electricity development, if one placed solar on all sites that could feasibly host it from the technical and economic perspectives. The figures, therefore, represent the outer envelope of solar potential assuming that transmission infrastructure is sufficiently available by 2015 to accommodate this solar development. In practice, the amount of solar development on the military installations, even with supportive policies and a strong military priority to pursue solar projects would fall far short of the maximum potential numbers. The reasons for the large shortfall between potential and actual construction can range from difficulties in securing transmission network upgrades and lengthy environmental reviews to lack of private developer capital, administrative and legal complexity, and competition from other generation sources.

To establish the solar potential results in this study, many issues affecting solar project viability must be navigated, on an acre-by-acre basis (and sometimes on a square foot by square foot basis), across three million acres of military lands. Those issues range from solar development conflicts with military activities and endangered species and their habitats to Native American cultural resources to slope, hillside shading, and hourly sunlight availability analyses to economic variables such as the trajectory of future power prices and land lease rates.

It is important to note that the geographical and technical aspects of this analysis were not designed to be a detailed engineering analysis of specific solar projects, nor was the economic analysis intended to be of sufficient detail for investment decision-making for any particular site. Rather, this process was intended to provide a reasonable estimate of the technical and economic potential for solar development across millions of acres of complex landscape and to complete that estimate within a constrained study schedule and budget. However, while bearing this disclaimer in mind, it is reasonable to treat the results of this study as a robust screening of potential solar development areas. Each military installation and each Service’s center of expertise for solar development (e.g., NAVFAC, AFCESA, U.S. Army Corps of Engineers (USACE), MCI, etc.) can use the outputs of this analysis as inputs to their own process of solar site selection and development.

The study organizes the many issues affecting solar viability into three categories – geographic, technological, and economic. The study analyzes these issues in a step-by-step manner, with **geographic** screening analyses occurring first. The geographic analysis first identifies potential sites for roof, parking, and ground-mounted solar projects from among the military installations’ total inventory of buildings, parking facilities, and lands.

For the ground sites that comprise the vast majority of this study, Geographic Information Systems (GIS) techniques are used to overlay 20 to 40 independent variables per military installation into composite maps displaying where solar development can and cannot occur. The GIS variables are typically in the categories of built infrastructure, construction plans, biological resources, cultural resources, environmental resources and hazards, military mission and operational activities including explosive arcs, topography, shading, and buffers around various areas. The geographic analysis calculates and locates the acres of roof, parking, and ground sites that are suitable for solar development on each military installation.

The second step – **technological** analysis – defines the characteristics for each of six solar technologies and deploys technology packages on each site that survived the geographic screening process. The technological analysis produces results for the maximum ―technical potential” for solar electricity on each site – i.e., the potential, in capacity and annual electricity output, for solar development unconstrained by project economics.

The capacity and output data from the technological analysis for up to six technology packages on each site, along with the land data from the geographic analysis, are passed on to last step in our analytic process -- **economic analysis.** The heart of the economic analysis is a financial model that calculates the 20-year investment returns for each potential solar project under private and military ownership. The economic analysis also estimates total (standard and excess) rents that may be available to the DoD if the solar projects are privately owned.

The major categories of inputs in the economic model include the performance and installation and operating costs for each solar technology, power prices, renewable energy credit (REC) prices, other solar incentive payments, land lease rates, transmission costs, and project finance rates (discount, inflation, and loan rates). The economic analysis produces, for each military installation, a matrix of results indicating which combinations of solar technology, site type (roof, parking, or ground), and ownership structure are economically viable – i.e., produce sufficiently high returns to justify solar investments. When summed across all of the military installations, this analysis indicates the total economic potential for solar development.

The study’s three-step process – **geographic, technological, and economic analysis** – is described in three separate sections of this chapter. At the end of each section, after summaries of study-wide and installation-by-installation results, the implications are discussed. The implications should help set the stage for the DoD, the U.S. Congress, and other key stakeholders to determine the goals and next steps in developing solar potential on these seven military installations in the Mojave and Colorado Deserts, beyond solar projects already operating on these installations.[16]

The results of the geographic, technological, and economic analyses are summarized in Table 5.1 below. The economically-viable results are for solar sites that yield projected investment returns in excess of the study's rate of return threshold and represent use of the solar technology (crystalline-silicon PV tracking for ground sites and crystalline-silicon fixed-axis for roof sites) with the highest rate of return on the viable sites.

Table 5.1 – Summary of Potential Solar Capacity, Output, & Acreage by Military Installation

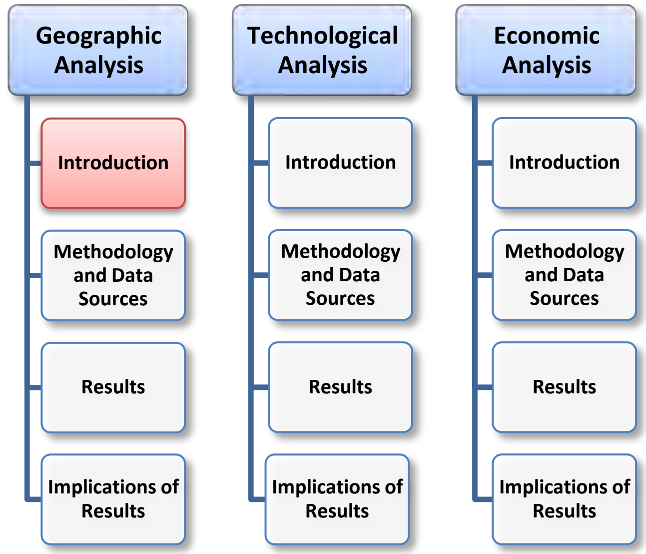
Military Installation	Economically Viable		Installation Ground Acreage[17]		
	Solar Capacity (MW_{AC})	Annual Solar Electricity Output (GWh)	Total	Technical Viability for Solar	Economic Viability for Solar
MCAGCC Twentynine Palms	80	222	595,578	829	829
MCLB Barstow	5	9	6,176	802	0
NAWS China Lake	961	2,634	1,108,956	11,302	11,302
Chocolate Mountain AGR	0	0	463,623	4,337	0
NAF El Centro	0	0	56,289	377	0
Edwards AFB	3,488	9,013	308,123	92,009	92,009
Fort Irwin	2,630	7,334	754,134	21,367	21,367
Total	**7,164**	**19,212**	**3,292,879**	**131,023**	**125,507**

[16] Table 5.69 lists and briefly describes existing and planned on-installation solar projects of 5 MW in capacity or larger in California and Nevada.

[17] The acreages shown in the right section of the Table are the simple sum of all technically-viable and economically-viable acres, respectively, with suitability ratings of 1, 2, or 3. Elsewhere in the report, for the purpose of illustrating the development potential for solar on different types of sites, suitability rating =1 sites are sometimes shown in isolation, and sites with suitability ratings of 2 (likely suitable) or 3 (questionably suitable) are multiplied by 25% to account for uncertainties about the extent of solar development potential on them.

5.2 Geographic Analysis

5.2.1 Introduction



The geographic analysis step was intended to screen the full geography of each of the seven military installations to identify sites that were not constrained for solar development. The framework for this analysis consisted of three principal elements: the military installations themselves; types of development sites; and constraint types.

The installations included in the study are listed in Table 5.2. Note that the study covered the entirety of each military installation, inclusive of built structures, training ranges, and lands owned by other Federal agencies (see ―Withdrawn Lands” in the Solar Development Context chapter) within each installation's fence line. The only areas within a military installation that were not subject to evaluation for solar development were military housing areas that have been privatized. As privately-owned structures, they are not subject to DoD decision-making for solar development.

Table 5.2 – DoD Installations Reviewed in Study

Military Installation	Service	State	Geographic Region
Marine Corps Air to Ground Combat Center (MCAGCC) Twentynine Palms	Marine Corps	CA	Mojave Desert
Marine Corps Logistics Base (MCLB) Barstow	Marine Corps	CA	Mojave Desert
Chocolate Mountain Aerial Gunnery Range (Chocolate Mtn. AGR)	Marine Corps	CA	Colorado Desert
Naval Air Weapons Station (NAWS) China Lake	Navy	CA	Mojave Desert
Naval Air Facility (NAF) El Centro	Navy	CA	Colorado Desert
Edward Air Force Base (AFB)	Air Force	CA	Mojave Desert
Fort Irwin	Army	CA	Mojave Desert

With regard to two Nevada military installations in the Mojave Desert, Creech Air Force Base and Nellis Air Force Base, the Pacific Northwest National Laboratory (PNNL) recently completed a study of on-installation opportunities for solar electricity and other renewable energy sources (PNNL, 2011). That PNNL study reviewed certain geographic, operational, utility, economic, and other factors on each installation (and on the Tonopah Auxiliary Airfield Annex) as part of its analysis and evaluated solar development zones within each installation. Because the PNNL study covered many of the same solar potential questions as this study, and did so in a serious manner, this study did not duplicate the effort and analyze Creech AFB and Nellis AFB.

The PNNL study did not review solar potential on the exceptionally large Nevada Test and Training Range (NTTR) operated by Nellis AFB. The NTTR covers approximately 3 million acres. Discussions with Service and Nellis AFB/NTTR installation-level personnel established that heavy scheduling of mission activities across the entirety of NTTR make this range unsuitable for large-scale solar development. Since the NTTR is mission incompatible with on-installation solar, it is not considered further in this study.

Within each of the seven military installations in southern California, the analysis designated five key site types for solar suitability analysis: 1) paved and 2) unpaved parking lots that might accommodate shading structures; 3) rooftops; 4) cantonment ground sites; and 5) range ground sites.

“Cantonment” is defined here as the area of an installation with built infrastructure that houses and offices military personnel, while “ranges” represent all of an installation’s land apart from the cantonment and are where military mission and operational activities occur.

The seven military installations have varying amounts of each site type; some are entirely lacking certain site types. A comprehensive review of all the geospatial data and the associated attributes must be undertaken to properly evaluate a given site type for suitability. In general, this requires a review of over 100 individual geo-referenced data layers and associated features at each facility to determine the suitability for each of the five main site types. The presence of certain features or attributes (e.g., steep slope) indicated an automatic rating of “unsuitable” while the presence of other features/attributes (e.g., moderate quality biological habitat) at a location was used as an input to models that provided a more nuanced suitability rating.

The assignment of suitability ratings to individual data layers and the development of suitability models was performed by a number of individuals that included Subject Matter Experts (SMEs) with an in-depth understanding of environmental or cultural resource issues, mission compatibility, land use compatibility, etc.; and military installation personnel who have direct experience and on-site knowledge of suitable areas for potential development. This consultation process was the primary means used to reach consensus on the relative suitability of the classes of features encountered at each facility.

The individual mapping layers and associated features available for the seven installations were uneven in terms their quality, geometric character, and the information they contained. This fact necessitated an individual approach to development and integration of all the associated sub-models into the main facility model. Following the assignment of suitability ratings to features in each source data layer, a composite map overlay of all rated layers produced a single composite suitability map for each study area. The suitable areas are mapping features, some of which may not be of a suitable size and shape to practically accommodate solar development. Therefore, each suitable mapping layer was further tested to determine whether it met several basic geometric criteria for solar suitability (geometric screening tests are further explained in the following sections). Results of the analysis, including a map that illustrates the various suitable areas on each military installation as well as tables summarizing the associated acreages are shown below.

Figure 5.1 below describes the 6-step process that the GIS Analysis followed in this study for each of the military installations.

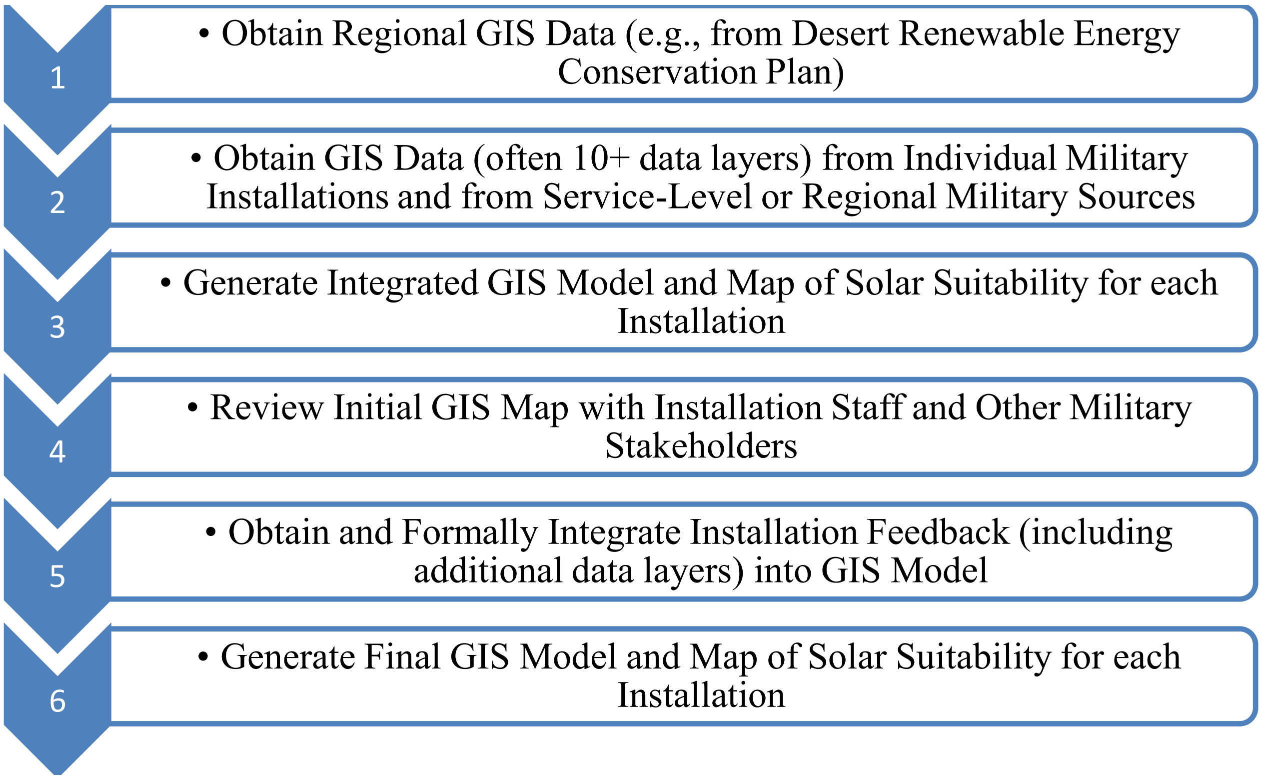
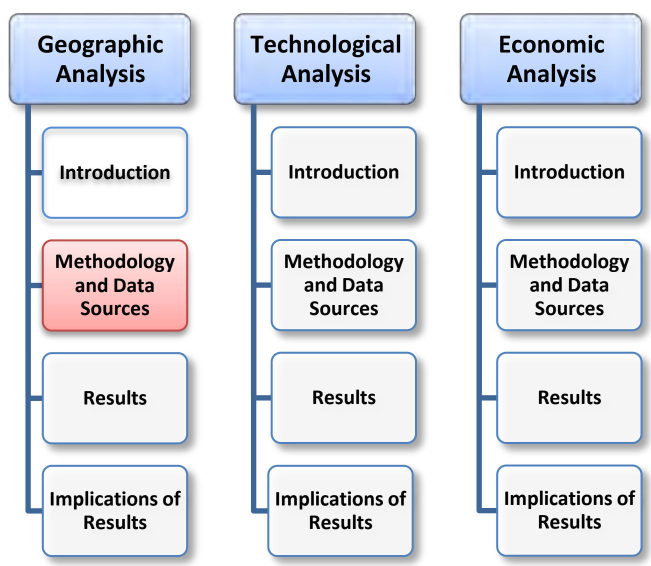


Figure 5.1 – Process for GIS Systems Analysis Followed by Study

5.3 Geospatial Database and Analysis Methodology

The solar potential assessment required a process of compilation, review, analyses, interpretation, and presentation of large amounts of geospatial information for all military installations in the study. The assessment utilized GIS-based software, tools, and methods to implement a methodology for characterizing solar potential based on the geographic distribution of several mapped evaluation criteria. This section discusses the steps that were implemented to construct the geospatial databases and to develop new map layers and reports.



5.3.1 Data Collection and Compilation

The solar potential assessment required the compilation of several geospatial data sets from various sources. In total, over 200 GB of data, comprised of over 50 geodatabases and hundreds of feature classes (data layers), were compiled for the study. For purposes of this discussion, a

–data layer” or –map layer” is a set of geographic features, stored in the GIS as a file or data table, that pertain to a given topic or theme, for example roads, land use, or habitat. All data were stored on a secure file server and managed through use of ArcGIS Rev. 9.3 software licensed by ICF from Environmental Systems Research Institute (ESRI).

5.3.2 Requirements Assessment

The compilation of data layers began with a Requirements Assessment, which was performed to identify the data needs and data collection strategies for the study. The Requirements Assessment was performed in a workshop setting and attended by subject matter experts from various disciplines: military sciences, renewable energy technologies, geospatial technologies, land use planning, biology and conservation planning, cultural resources, and visual resources. The Requirements Assessment considered a broad range of possible data needs and drew upon the collective experience of the subject matter experts, and on the results of other renewable energy projects throughout the western United States. The outcome was a list of desired data layers, a Data Request List for distribution to DoD entities, and a set of conceptual data flow diagrams that described how data would be developed through GIS geo-processing operations to identify solar potential. These products were then used as a reference to guide the data collection process.

A goal of this study was to utilize geospatial data layers that meet the following criteria:

- Fulfilled one or more of the data requirements for content and topical relevancy to the solar potential assessment
- Originated from a trusted and authoritative source
- Was judged by subject matter experts to be of suitable accuracy and detail for the study
- Was able to be obtained within the timeframe of the study
- Was in a readily usable GIS format

The compiled geospatial data sets fell into two general categories: those obtained from public (mostly government agency) sources; and those obtained from DoD entities. Data sets were obtained in a variety of GIS formats, map projection and coordinate systems, and database structures.

5.3.3 Public Agency Data Sources

Geospatial data sets were gathered from public agencies at the federal, state, and local level. These data sets generally were comprised of relevant, regionally-mapped features with geographic coverage across all installations in the study. Obtaining these data sets provided several advantages to this study -- they were readily and freely available, of reasonable quality, and provide mapping of important features that may or may not be available from the individual military installations. However, these data sets do have limitations in the spatial accuracy, detail, and resolution of mapped features, as they are typically mapped at scales between 1:24,000 and 1:100,000. For example, a data layer that has been developed at 1:100,000 mapping scale may have a spatial resolution of +/- 200 feet. Therefore, regional geospatial data sets only support broad regional planning applications, and are generally not suitable for detailed siting or engineering purposes.

The study used public data sets as a reference and visual backdrop for maps, and as a source of thematic data (e.g., habitat, roads) in cases where more detailed version of such data were not available from the military installations. Generally, data obtained from public sources fell into the following topical categories: Administration, Imagery, Biological Resources, Cultural Resources, Energy, Geophysical, Hydrology, Infrastructure, Land Use/Land Cover, Socioeconomics, and Visual Resources. In addition to these data sets, the study also used web map and imagery services such as ESRI Prime Imagery, Bing imagery, and ESRI StreetMap World 2D for map reference purposes.

5.3.4 DoD Data Sources

The geospatial data sets originating from the DoD facilities in this study were collected and compiled in a variety of ways. In each case, the standardized Data Request List spreadsheet was sent to the primary point of contact (POC) at each military installation for distribution to the appropriate on-site organizational components. The Data Request List included six broad categories, each of which included approximately a dozen GIS data layers. The broad categories were Administration, Base Infrastructure, Base Operations, Natural Resources, Cultural Resources, and Geophysical/Hydrographic. Over 60 individual geospatial data layers were requested for each facility with additional data requests for most facilities after on-site visits with military installation personnel. The ICF study communicated with each military installation- and Service-level organization through conference calls, email, secure FTP (file transfer protocol) data transfer, and site visits. The following data collection processes were employed at each military installation:

MCI – West: MCAGCC Twentynine Palms, MCLB Barstow, and Chocolate Mountain AGR

- The GIS data for all 3 MCI-West facilities were delivered by the GeoFidelis group at Camp Pendleton in mid-June 2011. A supplementary delivery of additional data was conducted in early August 2011 to account for some missing data from MCLB Barstow. The data were comprehensive and complete and some additional data were sent directly from the MCAGCC Twentynine Palms Natural Resource Officer in mid June 2011. Additional data for Chocolate Mountain was provided by GeoFidelis in late November 2011.

NAWS China Lake and NAF El Centro

- The GIS data for NAWS China Lake were supplied in two main deliveries: 1) on an external hard drive from NAVAIR in mid-April 2011 and 2) via a secure FTP session from NAWS China Lake in mid-May 2011. Combined, both data sets provided were comprehensive and complete.

- The NAF El Centro GIS data were initially delivered from NAVFAC SW via AMRDEC in early May 2011 with a supplemental delivery of additional data in late July 2011. Combined, both data sets comprise a modest degree of geospatial information, but several critical layers are not available for this project.

USAF: Edwards AFB

- The GIS data from Edwards AFB were delivered in two separate sessions: 1) via secure FTP from HAF/A3O in late June 2011, and 2) on a CD-ROM from the 95 ABW/CE Base civil engineer during a site visit in mid-July 2011. The first data delivery included the Common Installation Picture (CIP) which is a generic geospatial data set that is useful but lacks many of the facility-specific data attributes required for this project. The second delivery provided all of the remaining GIS data. Combined, both data sets provided were very comprehensive.

Fort Irwin

- GIS data were collected during a 2-day visit to the installation in early May 2011. The data were delivered on a series of DVDs provided by the Integrated Training Area Management (ITAM) GIS coordinator. The data were comprehensive and virtually complete; only the Cultural Resources data was not provided.

Figure 5.2 on the following page summarizes the data categories sought and the data actually obtained for each of the installations. With the exception of the two Air Force Bases in Nevada, sufficient data were provided to permit geographically-based screening for solar development potential for each installation. Note that many of the GIS layers listed in the table have multiple land use categories, adding further resolution and information to the modeling analysis.

Data Category	MCAGCC 29 Palms	MCLB Barstow	NAWS China Lake	Chocolate Mountain AGR	NAF El Centro	Edwards AFB	Ft. Irwin Cantonment	Ft. Irwin NASA Goldstone Range
Built Infrastructure								
Installation Area	Red	Green	Green	Green	Green	Green	Red	Green
Cantonment	Green	Red	Green	Red	Green	Red	Green	Red
Building Buffers	Red	Green	Green	Red	Green	Green	Green	Green
Parking Areas	Green	Green	Green	Red	Green	Green	Green	Red
Road Buffers	Green	Green	Green	Green	Green	Green	Green	Green
Driveways	Green	Green	Green	Red	Red	Green	Red	Red
Railroad Buffers	Red	Green	Red	Red	Green	Green	Red	Red
Slab Areas	Red	Green	Red	Red	Red	Red	Green	Red
Open Storage Ares	Red	Green	Red	Red	Red	Red	Red	Red
Canopy Pavilions	Red	Red	Red	Red	Red	Red	Red	Red
Overall Base Land Use								
Master Plan Current Land Use Areas	Red	Red	Green	Red	Green	Green	Green	Red
Future Land Use Areas	Green	Green	Red	Red	Green	Red	Green	Red
Topography & Hydrology								
Slope	Green	Green	Green	Green	Green	Green	Green	Green
Flood Zones	Green	Green	Red	Red	Green	Green	Red	Green
Playa (dry lakebeds)	Green	Red	Green	Red	Red	Green	Red	Green
Water Courses	Green	Green	Red	Red	Red	Red	Green	Red
Wetlands	Green	Green	Red	Red	Red	Red	Red	Green
Recreational Areas								
General Recreation	Green	Green	Green	Red	Green	Green	Green	Red
Parade Grounds	Green	Green	Red	Red	Red	Red	Green	Red
Hunting Areas	Red	Red	Red	Red	Red	Green	Green	Red
Environmental Hazards and Constraints								
Environmental Cleanup Site	Red	Red	Red	Red	Green	Green	Red	Red
HAZMAT Storage	Red	Green	Red	Red	Red	Red	Red	Red
Solid Waste Dump Area	Red	Green	Red	Red	Red	Red	Red	Red
Solid Waste Stockpile Area	Red	Green	Red	Red	Red	Red	Red	Red
Solid Waste Landfill	Green	Red	Red	Red	Red	Green	Green	Red
Solid Waste Recovery	Green	Red	Red	Red	Red	Red	Red	Red
Environmental Restoration Area (CERCLA Sites)	Red	Green	Green	Red	Red	Green	Green	Red
Munitions Response Program Area	Red	Red	Red	Red	Red	Green	Red	Red
Areas of Concern (AOCs)	Red	Red	Green	Red	Red	Red	Red	Red
Wastewater Treatment Areas	Green	Red	Green	Red	Green	Green	Red	Red
Biologic Resources and Habitat								
Mojave Ground Squirrel	Red	Green	Red	Red	Red	Red	Red	Green
Flora Special Species Status/Management Area	Red	Red	Red	Green	Red	Green	Red	Green
Flora Species Population	Red	Red	Red	Green	Red	Green	Red	Green
Fauna Special Species Area	Red	Green	Red	Green	Red	Green	Red	Green
Desert Tortoise Modeled Habitat	Red	Green	Green	Green	Red	Green	Red	Green
Plant Communities	Red	Green	Red	Green	Red	Green	Red	Red
Wildlife Management Areas	Red	Red	Red	Red	Red	Red	Red	Green
Cultural Resources								
Cultural Restricted & Probable Sensitive Areas	Red	Red	Red	Green	Red	Red	Red	Green
Military Mission and Operational Areas								
Airfield Surface Area	Red	Green	Green	Green	Green	Green	Red	Green
Accident Potential Zones (APZs)	Red	Red	Green	Red	Green	Green	Red	Red
Military Landing Zone	Red	Green	Red	Green	Red	Red	Red	Red
Drop Zones	Red	Red	Red	Red	Red	Green	Red	Red
Ammunition Areas	Red	Red	Green	Red	Green	Red	Green	Red
Explosives Safety Quantity Distance (ESQD) Arcs	Green	Red	Green	Red	Green	Green	Green	Red
Proving Ground	Red	Green	Red	Red	Red	Red	Red	Red
Military Range/Restricted Area	Green	Red	Red	Red	Red	Green	Green	Red
Firing Ranges	Red	Red	Red	Green	Red	Green	Red	Red
Military Surface Danger Zones (several)	Red	Red	Red	Green	Red	Red	Red	Red
Special Weapon and Training Areas (SWAT) 4	Red	Red	Red	Green	Red	Red	Red	Red
Special Weapon and Training Areas (SWAT) 5	Red	Red	Red	Green	Red	Red	Red	Red
Forward Arming and Refueling	Red	Red	Red	Green	Red	Red	Red	Red
Impact Areas	Red	Red	Red	Red	Red	Red	Red	Green
Large Dish Antennas	Red	Red	Red	Red	Red	Red	Red	Green
Miscellaneous Areas and Features								
High School	Red	Red	Green	Red	Red	Red	Red	Red
Buffer around Hangars	Red	Red	Green	Red	Red	Red	Red	Red
Safety Buffers Rocket Test Facilities	Red	Red	Red	Red	Red	Green	Red	Red
Military Exercise Service Road	Red	Red	Red	Red	Red	Red	Green	Red

Note: Green cells = information provided, Red cells = no information provided

Figure 5.2 – GIS Data Categories Obtained from Each Military Installation

5.3.5 Geospatial Analyses

Geospatial analysis was performed for selected site types for each military installation. Distinct geospatial analytical approaches were developed and applied for three groups of solar siting: building rooftops; parking lot shading structures; and cantonment and range ground sites, as described below (Figure 5.3, Table 5.3).

Military Base	Roof	Paved Parking	Unpaved Parking	Canton-ment Ground	Range Ground
U.S. Navy					
MCAGCC 29 Palms	★	★	✖	★	★
MCLB Barstow	★	★	★	★	★
NAWS China Lake	★	★	✖	★	★
Chocolate Mtn. AGR	✖	✖	✖	✖	★
NAF El Centro	★	★	✖	★	★
U.S. Air Force					
Edwards AFB	★	★	★	★	★
U.S. Army					
Ft. Irwin	★	★	★	★	★

★ Analysis complete ✖ Site Type Not Present

Figure 5.3 – Status of GIS Analysis by Installation and Solar Site Type

Table 5.3 – Minimum Size Threshold for Solar Site Types

Building Rooftop	Paved Parking	Unpaved Parking	Cantonment Ground	Range Ground
20,000 sq. ft. after a 6 ft. setback on all sides	40,000 sq. ft.	40,000 sq. ft.	5 acres	50 acres

Building Rooftops

Each military installation provided a GIS data layer representing buildings, or more generally structures, located within either cantonment or installation boundaries. In some cases, tabular information accompanied the building features – for example building name, building function, building height, and similar characteristics. Generally, specific data for rooftops such as pitch, angle, roof material type, etc. were not provided as part of the buildings data layers supplied by the military installations. Figure 5.4 provides a typical sample of building information (from Edwards AFB).

The objective of the geospatial analysis was to perform an initial screen of all mapped buildings, and to classify them into two categories: Suitable; or Unsuitable. Analysis of rooftops followed the following steps:

- Calculate area (square feet) of rooftops, based on the geometry of the building footprint
- Calculate a reduced area in square feet of rooftops, applying a 6-foot setback from the building edges

- Rate as —suitable" those buildings with a square footage of 20,000 or greater, after deduction of the 6-foot setback. (Buildings failing this criterion were rated as Unsuitable.) This minimum size criterion was applied to reflect the reality that solar developers typically seek out projects with significant roof area. Smaller roofs are much more costly to develop.
- Rate as —unsuitable” those buildings whose use or function is incompatible with solar facility installation

The output of the geospatial analysis included a map, spreadsheet, and Google Earth KML file showing the locations, characteristics, and suitability rating for each mapped building for a given military installation. The geospatial analysis of buildings was followed by further analysis and interpretation of building suitability, including visual review of aerial imagery (through tools such as Google Earth) that is described in the Technological Analysis section of this chapter.

Figure 5.4 – Sample of Buildings Data from Edwards AFB used for Rooftop GIS Analysis

Parking Lot Shading Structures

Each military installation provided a GIS data layer representing parking lots accompanied in most cases by tabular data indicating paved/unpaved condition and surface type. Figure 5.5 provides a sample of typical parking lot data that was provided from Edwards AFB. The objective of the geospatial analysis was to perform an initial screen of parking lots, and to classify them into two categories: Suitable; or Unsuitable. Analysis of parking lots followed the following steps:

- Calculate area (square feet) of parking lots, based on their geometry
- Rate as ―suitable‖ those parking lots with square footage of 40,000 or greater
- Rate as ―unsuitable" those parking lots with a square footage of less than 40,000
- Rate as ―unsuitable" those parking areas whose use or function is incompatible with solar facility installation

The geospatial analysis of parking facilities was followed by further analysis and interpretation of suitability, including visual review of aerial imagery (through tools such as Google Earth) described in the Technological Analysis section of this chapter (Figure 5.6).

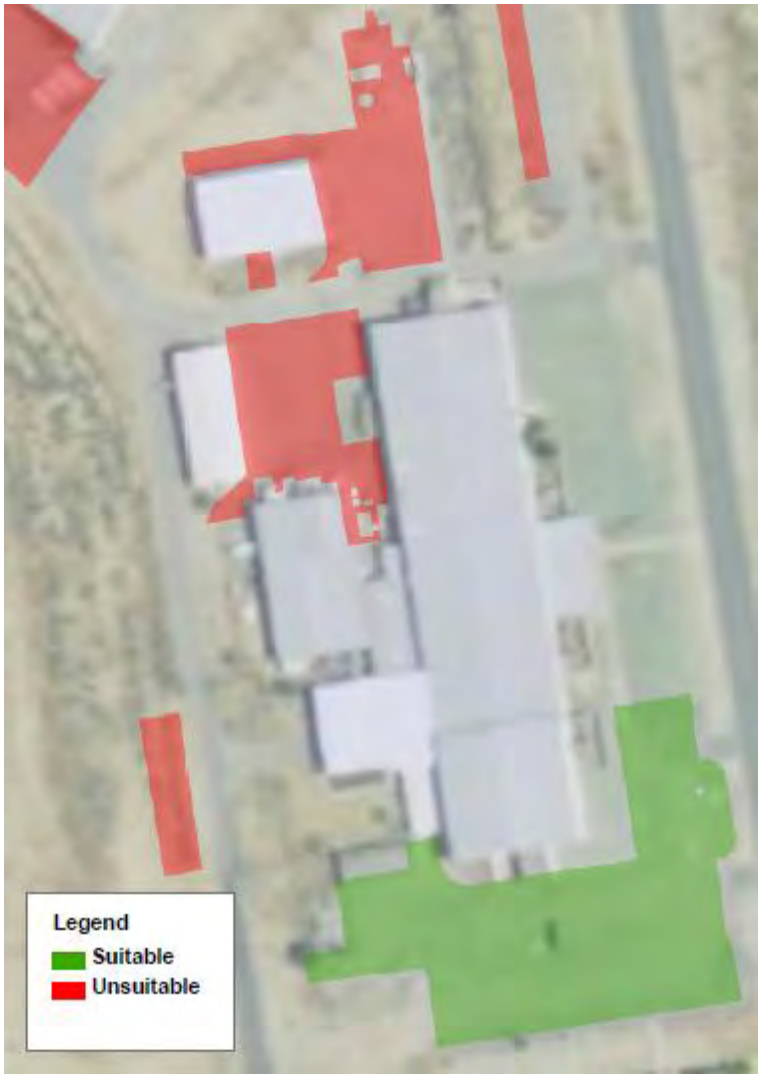


Figure 5.5 – Sample of Parking Lot Data from Edwards AFB used in the GIS Parking Lot Shading Structures Analysis

Figure 5.6 – Visual Inspection of Rooftops and Parking Areas at Edwards AFB in Tools such as Google Earth Provides Information not Available in GIS Data

Ground Sites

Geospatial analysis of ground sites involved a sequence of information processing steps for the land area at each military installation, as shown on Figure 5.7. Source data layers shown on Figure 5.7 are those essential GIS layers, drawn from both public agency sources and from DoD GIS programs, which possess both content and geographic coverage to warrant inclusion in the analysis. While each military installation possesses unique characteristics and issues, the general analysis approach can be described as follows:

- Review geospatial data layers for relevance, quality, and geographic coverage, and select a subset of source data layers for analysis.
- Perform selected preprocessing steps on source data, such as format conversion and map projection and coordinate system conversion, where necessary.
- Perform limited source data cleanup, such as geometry repair, when necessary.
- Perform intermediate geo-processing operations on source data, such as feature selection, feature merging, distance buffering, slope, etc.
- Apply a suitability rating factor to classes of features within each source data layer to produce rated data layers. The rating system is described further below.
- Perform a composite map overlay of the rated layers.
- Select the suitable areas from the composite map.
- Perform a test on area size and shape to filter out areas that do not meet geometric criteria (5-acre minimum size, and minimum 200-ft dimensions on all sides).

The geospatial analysis for ground sites was implemented through design and execution of data processing models in the ESRI Model Builder environment. These models provide a systematic, documented, and reproducible approach to performing complex geo-processing operations on large amounts of geospatial data. The data received for each installation were generally of high quality, but varied in content from installation to installation. For example, some installations had detailed GIS data that delineated specific areas of concern for special status flora and fauna, while other installations may not have had this data or only anecdotal information about these areas. In addition, some of the GIS data was not up to date; in a few cases, a military installation had recently built a new building and/or demolished and existing one, neither of which were identified in the GIS data.

Many of the data attributes for source data layers were not populated and these attributes exist in a tabular format much like a spreadsheet. For a given layer, such as a buildings layer, the data attributes would describe the building location, roof area, building ID, owner, mission purpose, etc. Similarly, these same data attributes would exist for biological layer such as species, locations, survey results, etc. These data attributes (when populated) provided essential information about the nature of the GIS data. Because of the varying nature of source data, and the different issues and conditions encountered at each military installation, it was not possible to design and adopt a ―one-size-fits-all" approach to modeling solar site suitability. Rather, an individual model had to be designed for each military installation.

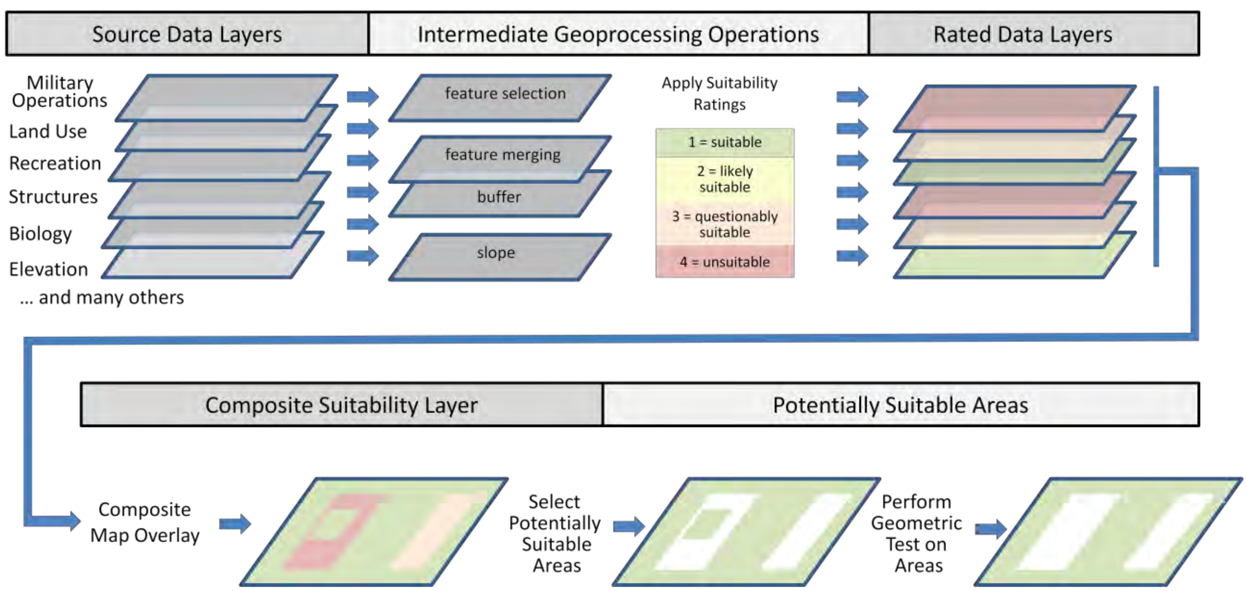


Figure 5.7 – General Data Flow of Geospatial Analysis of Ground Sites

5.3.6 Suitability Rating Scale

The application of suitability ratings to source data layer features, as shown on Figure 5.7 above, required the adoption of a standard suitability scale that would be applied to the solar potential assessment for all military installations. For all source data layers, a numeric rating on a scale of 1 to 4 was applied to each feature in the layer to indicate relative suitability of the feature to accommodate solar facility development. Other assumptions, modeling approaches, or different GIS data would not necessarily generate the same results as presented here.

The rating scale for this specific study is defined as follows:

1 = Suitable
Geospatial features that do not present any known or obvious suitability conflicts are rated in this category. The lands in each study area (cantonment or range) are initially given a rating of 1. Features from the various source data layers that are considered fully compatible with solar development are also rated at 1.

Military installation land areas with no rating worse than (i.e., above) 1 are designated in green within the installation-specific maps of solar suitability.

2 = Likely Suitable
Rating 2 describes geospatial features that may contain some minor degree of unsuitability. These features include areas that may contain sensitive (e.g., non-state or federally listed species) flora and/or fauna, may have some areas suspected of containing cultural resource sites, or areas that may require DoD personnel to make technical determinations to further verify their potential suitability. Military installation land areas with no rating worse than (i.e., above) 2 are designated in yellow within the installation-specific maps of solar suitability.

3 = Questionably Suitable
Rating 3 geospatial features that are known or suspected to confer a general lack of suitability are scored in this category. These include areas that may contain sensitive or locally protected flora and/or fauna (e.g., Mojave Spineflower, which is not state or federally listed, but is considered by the California Native Plant Society as vulnerable and threatened), may have areas containing cultural resource sites that may be protected or subject to protection, and other areas, such as floodplains, that may require the DoD to undertake more extensive technical investigations and/or be willing to pay for mitigation and monitoring costs. Military installation lands with no rating worse than 3 are designated in orange within the installation -specific maps of solar suitability.

Lands in the ―likely suitable” and ―questionably suitable” category were considered technically eligible for solar development, but the initial acreage of lands classified in these categories was reduced by 75% in the technology and economic modeling process to reflect the likelihood that much of this acreage would, in fact, be found unsuitable following onsite investigation.

4 = Unsuitable
Geospatial features that contain attributes known to render the site unsuitable for solar development are scored in this category. These include areas that contain military range operations such as bombing and gunnery activities, related activities such as ground training and maneuver exercise areas, RDTE areas where solar development would cause an unacceptable level of mission disruption, areas restricted by biological and cultural resources concerns, areas with built infrastructure such as wastewater treatment sites, etc, and all areas with a slope >5%. Each military installation narrative section below contains a table listing all areas delineated as unsuitable.

> Military installation land areas with any 4 ratings are designated as unsuitable and shown in red within the installation-specific maps of solar suitability.

The assignment of suitability ratings to individual data layers or feature classes was performed by subject matter experts, in consultation with military installation personnel, who reached consensus on the relative suitability of the classes of features encountered at each installation. At the conclusion of each installation-specific geographic results section, there is a list of source data layers and suitability ratings used on the military installation. Although the 4-point rating system was applied consistently at all military installations, in some cases the source data layer features occupied only the rating categories of 1 and 4, resulting in a binary category composite map.

The rating system described above was implemented in the GIS through geo-processing operations implemented in models within the ESRI Model Builder environment. These models resulted in an update to the geospatial databases where all land areas were assigned a final suitability rating of 1, 2, 3 or 4.

Applying Non-Binary Suitability Factors

For many data layers in the GIS analysis, a binary approach was applied in suitability scoring. Under a binary approach, a data layer indicates acreage that is either suitable (rating = 1) or has one other rating. The mission and operational data layers were all applied in a binary manner, for example. In those cases, the presence of mission or operational activity yielded a suitability score of 4 (unsuitable for solar development) and their absence indicated a score of 1 (suitable) for a given data layer.

However, for three important GIS layers, a non-binary approach was followed on certain military installations. The non-binary approach applies up to four suitability gradations to the data – suitable (rating = 1), likely suitable (rating = 2), questionably suitable (rating = 3), and unsuitable (rating = 4). The non-binary approach provides a more varied picture of solar suitability, by bringing in areas that, while not clearly suitable at present, may be found to be suitable upon additional review or with some mitigation.

The methodology used in the non-binary scoring of Desert Tortoise Habitat, Mohave Ground Squirrel Habitat, and Cultural Resources areas is described below.

Desert Tortoise and Mohave Ground Squirrel Habitat

The desert tortoise is a threatened species, and the U.S. government has designated certain portions of the deserts as critical habitat for this species. Land use restrictions apply to this critical habitat, and the restrictions can be relevant to the siting and construction of solar projects.

The Mohave ground squirrel is found only in the western Mojave Desert of California, although there is little published information regarding its current distribution and status. Although the southern portion of the range has been most intensively sampled, the only recent occurrences there are from a single core population on Edwards Air Force Base plus an additional four detections from Victor Valley. There are extensive areas within the geographic range where the status of the species is unknown, especially at NAWS China Lake and Fort Irwin. Given these facts, land use restrictions apply to this critical habitat, and the restrictions can be relevant to the siting and construction of solar projects.

The general approach taken by the habitat, solar, and geographic mapping experts involved in this study was to integrate two major data sources on desert tortoise and Mohave ground squirrel into an evaluation of the quality and status of habitat for these species on the studied military installations.

The two primary types of data sources used in the evaluation were (1) regional data such as the Desert Renewable Energy Conservation Plan (DRECP) that cover a wide land area, but at a somewhat coarser level of definition than (2) military installation-specific data where available.

The installation-specific data can have very detailed information on the location of types and subtypes of vegetation communities that the desert tortoise and the Mohave ground squirrel require or prefer. Within the installations, areas with creosote bush scrub, Joshua tree woodland, and certain other vegetation are favored desert tortoise habitat, while plant communities that exist on rocky and cement-like ground (e.g., alkali scrub) indicate areas that can prevent the tortoise from its essential burrowing activity.

The integrated regional and installation-specific data on desert tortoise were used to generate maps of high-quality tortoise habitat, moderate-quality habitat, and poor-quality habitat. This process was conducted by a subject matter expert who evaluated all of these various environmental and biological databases and then provided recommendations on which factors were selected for each habitat quality/suitability assessment. For Mohave ground squirrel, the integrated regional and installation data generated maps of core Mohave ground squirrel populations, areas where low densities of Mohave ground squirrels exist, and areas where the squirrel does not exist.

High-quality habitat for the desert tortoise was assigned a suitability rating of 4, meaning that factor alone rendered the land unsuitable for solar development. Moderate-quality tortoise habitat was assigned a rating of 3 and poor quality habitat a rating of 2. Areas with suitability ratings of 2 and 3 (whether for desert tortoise or other reasons) are distinguished on the GIS maps in this section by yellow and orange colorings. Such areas are ―likely suitable” and ―questionably suitable” for solar development, as long as they do not have suitability scores of 4 on <u>any</u> of the other 15 to 28 independent data layers analyzed for each installation. ―Likely suitable” and ―questionably suitable” acreage is reduced by 75% compared to fully ―suitable” acreage for the purposes of calculating technical and economic potential for solar, as explained in subsequent sections of this chapter.

Core Mohave ground squirrel population areas were assigned a suitability rating of 4, meaning that factor alone rendered the land unsuitable for solar development. Low-density Mohave ground squirrel areas were assigned a rating of 3 and areas where the species was extirpated a rating of 1. Areas with suitability ratings of 2 or 3 (whether for Mohave ground squirrels or other reasons) are ―likely suitable” or ―questionably suitable” for solar development (distinguished by yellow and orange colorings on subsequent GIS maps), as long as they do not have suitability scores of 4 on any of the other 15 to 28 independent data layers analyzed for each military installation.

The desert tortoise and Mohave ground squirrel GIS analyses were conducted on range areas of military installations, but not generally in cantonment areas because cantonment areas are so disturbed by built infrastructure and vehicle activity to make them inappropriate as desert tortoise and Mohave ground squirrel habitat.

Cultural Resources

Cultural resource areas with recorded sites that had either state or federal protection were assigned a suitability rating of 4, meaning that factor alone rendered the land unsuitable for solar development. Areas that contained recorded sites that were deemed potentially eligible for state or federal protection were assigned a rating of 3. Areas that contained recorded sites but required further evaluation and/or did not use field survey methods that meet state or DoD standards were assigned a rating of 2. Finally, sites that were negative for recorded sites were assigned a rating of 1. The cultural resources GIS analysis was conducted on both cantonment and range areas of military installations when the data was made available.

The installation suitability analysis and maps presented later in this section provide a composite overlay of all the binary and non-binary suitability factors studied for a given installation.

5.3.7 Composite Map Overlay

Following the assignment of ratings to features in each source data layer, a composite map overlay of all rated layers was performed to produce a single composite suitability map for each study area (cantonment/range) at each military installation, as shown on Figure 5.8. For all installations, features drawn from several source data layers overlap. For example, a military training area might overlap a floodplain, critical habitat, slope category, and land use designation. The map overlay process calculates the maximum rating value, on the 1 to 4 scale, from all input data layers. This strategy ensures that the most critical, i.e., least suitable, condition is preserved in constructing the composite suitability map. The result of this process is a new data layer where all lands within a study area are classified with a single composite rating, 1 to 4, based on the least suitable feature encountered at each location.

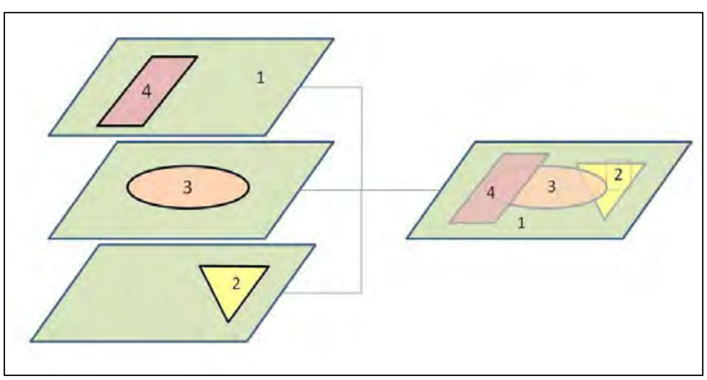


Figure 5.8 – Composite Map Overlay Preserves the Highest Rating (Least Suitable Condition) from its Inputs

5.3.8 Suitable Areas

Areas that achieved a rating of 1 following the composite map overlay process were considered Suitable and were extracted and saved as a new data layer. The suitable areas are represented as polygons, (i.e., a set of many-sided area features that represent the shape and location of homogeneous feature types such as counties, parcels of land, soil types, and land-use zones), some of which are quite irregularly shaped and may not be of a suitable size and shape to practically accommodate solar development.

Therefore, each suitable polygon from the suitable Areas layer was further tested in the GIS to determine whether it met two geometric criteria: a minimum size of five acres; and at least one dimension of a minimum of 200 ft. These criteria were applied to identify areas that would be attractive for ground-mounted solar development. The first criterion (five acres) is the minimum size parcel that would be of general interest to solar developers. The second criterion (200 foot minimum dimension) eliminated parcels of such irregular shape that they would be excessively costly to develop.

Those polygons that did not meet the geometric test were considered unsuitable and removed from the suitable Areas layer. The two figures below show the effect of the geometry test – the first figure shows MCLB Barstow suitable (green) areas before the geometry tests and the second figure shows the much smaller suitable areas remaining after the 5 acre minimum parcel and 200 feet on each side minimum were applied.

Figure 5.9 – MCLB Barstow Suitable Areas Before Geometry (Minimum Parcel Size) Tests Applied

Figure 5.10 – MCLB Barstow Suitable Areas After Geometry (Minimum Parcel Size) Tests Applied

Installation-by-installation results of the GIS analysis, including the Composite Map Overlay, and the suitable Areas, were presented in the form of maps and summary acreage reports. Overall and installation-by-installation results are presented in the next section of this chapter.

Cantonment vs. Range Areas of Installations

―Cantonment" is defined here as the area of an installation with built infrastructure that houses and offices military personnel, while ―ranges" represent all of an installation's land apart from the cantonment and are where military mission and operational activities occur. Cantonment areas tend to have relatively dense road networks and other infrastructure, many buildings and vehicle facilities, and a high degree of human activity, while ranges tend to be open areas where live-fire, instrument testing, mission simulations, training, and other military operational activities occur. The boundaries between cantonment areas can be well-defined at some installations (e.g., defined by a ring road or fence line) and less-defined at other installations.

For each installation, the study authors established cantonment boundaries in consultation with installation personnel. The division of cantonment versus range acreage is illustrated by maps for each military installation in the next section of this chapter.

Figure 5.11 illustrates cantonment versus range boundaries at Fort Irwin. Figure 5.11 further indicates which portions of the range are mission incompatible for solar development (suitability rating = 4 and shown by purple in the map), and which range areas do not have mission conflicts (shown by blue in the map). The mission compatible portions of the Fort Irwin range are within the Goldstone complex that NASA leases from Fort Irwin and that is described in more detail with Fort Irwin GIS results below.

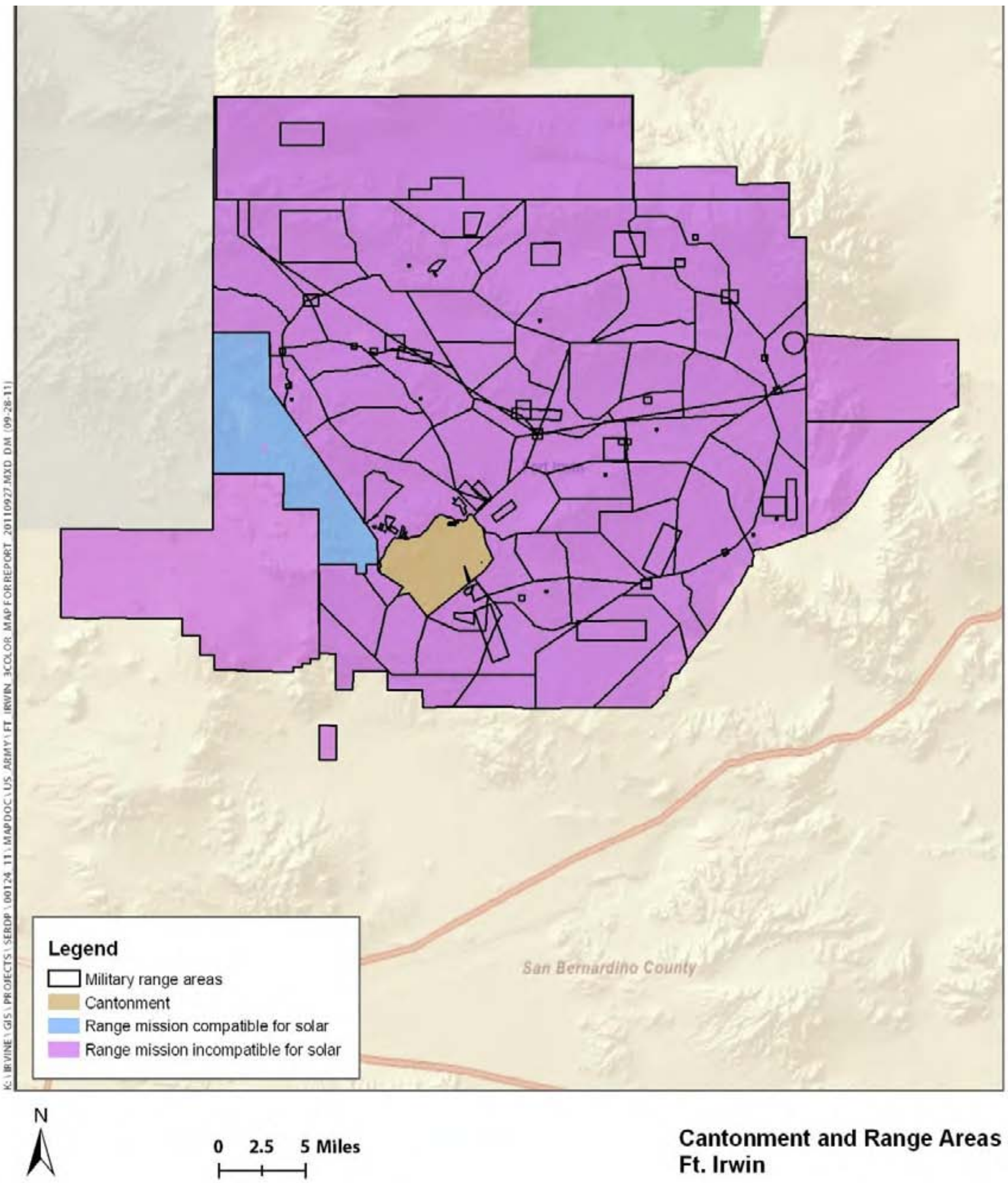
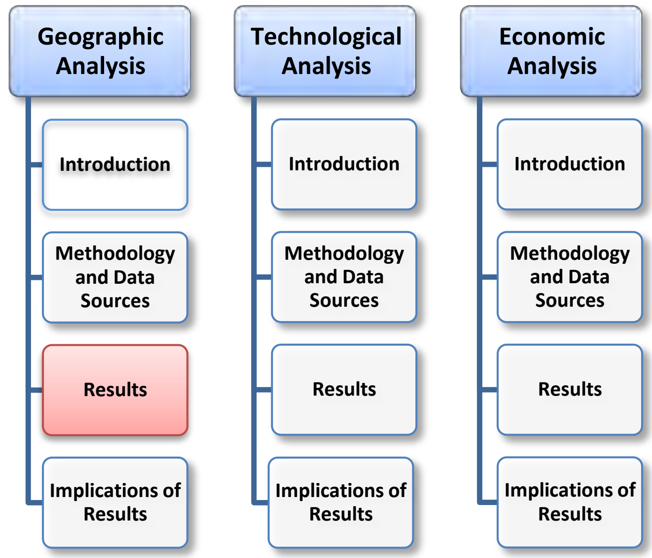


Figure 5.11 – Cantonment and Range Areas by Mission Compatibility at Fort Irwin

5.4 Results

5.4.1 Introduction



This section provides the results for each of the seven military installations that were included in this study. The results are organized around the five primary site types that could occur at each military installation: 1) paved parking lot shading structures, 2) unpaved parking lot shading structures, 3) building rooftops, 4) cantonment ground sites, and 5) range ground sites. Given the highly diverse nature of each military installation analyzed, some of these site types may not occur or be relevant. For example, the Chocolate Mountain Aerial Gunnery Range contains only range ground sites as none of the other site types exist and/or were deemed insignificant relative to the primary site type. In the end, the narratives are highly customized to accommodate the particular site types and their respective definitions for each military installation considered. The Installation and Unit Characterization Appendix provides additional details on the size, operations and unique characteristics of each installation.

Although all data sources used for each military installation have some commonality, there are some necessary differences in how the geospatial data were modeled to accommodate each facility. These differences are explained in both the military installation narrative sections.

5.4.2 Overall Results Across Seven California Installations

The total acreage rated as available for solar development across all of the military installations studied is summarized in Table 5.4, Table 5.5, and Table 5.6 below. Table 5.4 indicates the suitability rating for ground sites at each installation, before the minimum parcel size rules (at least five acres and at least 200 feet on all sides) were applied. Table 5.5 applies the minimum parcel size requirements to the acreages from Table 5.4. The acreages after the minimum size tests were applied are reflected in the military installation land suitability maps in this section and in the subsequent technological and economic analyses.

Table 5.6 presents only acres that are ―suitable” (rating = 1) for solar development for each type of solar site.

Table 5.4 – Acres of Land by Suitability Rating and Military Installation (Before Minimum Parcel Size Geometry Tests)

Military Installation	Rating 1: Suitable	Rating 2: Likely Suitable	Rating 3: Questionably Suitable	Rating 4: Unsuitable	Total Acres at Installation
MCAGCC Twentynine Palms	583	0	465	594,530	595,578
MCLB Barstow	842	0	142	5,192	6,176
NAWS China Lake	5,354	2,278	3,755	1,097,569	1,108,956
Chocolate Mountain AGR	3,879	280	392	459,072	463,623
NAF El Centro	438	0	0	55,851	56,289
Edwards AFB	1,779	19,231	72,221	214,892	308,123
Fort Irwin	6,114	0	0	714,790	754,134
Fort Irwin/NASA Goldstone Range	13,106	1,712	1,893	16,519	
Total Acres of All Installations by Suitability Rating	**32,095**	**23,501**	**78,868**	**3,158,415**	**3,292,879**
% of Total Land by Suitability Rating	**1%**	**1%**	**2%**	**96%**	**100%**

<table>
<tr><th colspan="6">Table 5.5 – Acres of Land by Suitability Rating and Military Installation
(After Minimum Parcel Size Geometry Tests Were Applied)[18]</th></tr>
<tr><th>Military Installation</th><th>Rating 1: Suitable</th><th>Rating 2: Likely Suitable</th><th>Rating 3: Questionably Suitable</th><th>Rating 4: Unsuitable</th><th>Total Acres at Installation</th></tr>
<tr><td>MCAGCC Twentynine Palms</td><td>461</td><td>0</td><td>368</td><td>594,749</td><td>595,578</td></tr>
<tr><td>MCLB Barstow</td><td>660</td><td>0</td><td>142</td><td>5,374</td><td>6,176</td></tr>
<tr><td>NAWS China Lake</td><td>5,269</td><td>2,278</td><td>3,755</td><td>1,097,654</td><td>1,108,956</td></tr>
<tr><td>Chocolate Mountain AGR</td><td>3,768</td><td>264</td><td>305</td><td>459,286</td><td>463,623</td></tr>
<tr><td>NAF El Centro</td><td>377</td><td>0</td><td>0</td><td>55,912</td><td>56,289</td></tr>
<tr><td>Edwards AFB</td><td>1,766</td><td>19,174</td><td>71,069</td><td>216,114</td><td>308,123</td></tr>
<tr><td>Fort Irwin</td><td>5,757</td><td>0</td><td>0</td><td>715,147</td><td rowspan="2">754,134</td></tr>
<tr><td>Fort Irwin NASA Goldstone Range</td><td>12,091</td><td>1,673</td><td>1,846</td><td>17,620</td></tr>
<tr><td>Total Acres of All Installations by Suitability Rating</td><td>30,149</td><td>23,389</td><td>77,485</td><td>3,161,856</td><td>3,292,879</td></tr>
<tr><td>% of Total Land by Suitability Rating</td><td>1%</td><td>1%</td><td>2%</td><td>96%</td><td>100%</td></tr>
</table>

[18] The minimum parcel size requirements for ground sites are total size of at least 5 acres and at least 200 feet on all sides. Areas failing either minimum size geometry test are re-classified as rating 4, and their acreage was excluded from the subsequent technological and economic analyses of viable sites.

Table 5.6 – Acres Suitable for Solar Development (Suitability Score = 1 after minimum parcel size test)								
Military Installation	**(A) Rooftop (acres)**	**(B) Paved Parking (acres)**	**(C) Unpaved Parking (acres)**	**(D)= (B)+(C) Subtotal – All (Paved & Unpaved) Parking (acres)**	**(E) Canton-ment Ground Sites (acres)**	**(F) Range Ground Sites (acres)**	**(G)= (E)+(F) Subtotal – All Ground Sites (acres)**	**(A) + (D) + (G) All Site Types (acres)**
MCAGCC Twentynine Palms	8	110	N/A	110	461	0	461	579
MCLB Barstow	13	17	2	19	660	0	660	692
NAWS China Lake	3	43	N/A	43	3,930	1,339	5,269	5,315
Chocolate Mountain AGR	N/A	N/A	N/A	N/A	N/A	3,768	3,768	3,768
NAF El Centro	0	14	N/A	14	377	0	377	391
Edwards AFB	17	104	38	142	6	1,760	1,766	1,925
Fort Irwin	4	121	230	351	5,757	12,091	17,848	18,203
Total Acres of All Installations by Solar Site Type	**45**	**409**	**270**	**679**	**6,140**	**18,958**	**30,149**	**30,873**

N/A = Not applicable (i.e., the site type is not present at the installation)

Edwards AFB has 92,009 acres available for solar development (70% of study-wide total) as the greatest area available at some level of suitability (rating of 1, 2, or 3) for **ground-mounted** solar, while Fort Irwin (21,367 acres or 16% of total) and NAWS China Lake (11,302acres or 9% of total) also have very sizable areas that may be suitable for solar development. Chocolate Mountain AGR is fourth with 4,337 acres with some degree of suitability. The three other California military installations studied (MCAGCC Twentynine Palms, MCLB Barstow, and NAF El Centro) combine for 2% of land at suitability ratings 1 to 3.

The rooftop and parking site acreages in Table 5.6 reflect the area available for solar development after both (a) GIS analysis of minimum sizes for individual facilities (20,000 square feet with set-back for roofs and 40,000 square feet for parking facilities), and (b) additional deductions for unavailability factors (almost 80% for roofs and 50% for parking) that are described in Section 5.6.3.

Fort Irwin has the greatest potential for parking shade structures at 351 acres, with Edwards AFB following at 142 acres, and MCAGCC Twentynine Palms at 110 acres. The Chocolate Mountain AGR has no parking shade structure potential which is consistent with its purpose as a tactical live-fire range which generally does not require any vehicle parking areas. Fort Irwin's unpaved parking areas, which are used primarily for heavy equipment, armored vehicles, tanks, and artillery offer 230 acres of solar potential, and its paved parking represents 121 acres of solar potential. Edwards AFB is the only other military installation with a relatively large unpaved parking area at 38 acres. MCAGCC Twentynine Palms presently has numerous solar-equipped shade structures over artillery storage and maintenance areas.

Edwards AFB has the highest potential for building rooftop solar projects at 17 acres. This rooftop assessment includes 68 sufficiently-large buildings such as large hangars, laboratories, and other RDTE buildings. Despite its small size MCLB Barstow also has a relatively large rooftop potential area of 13 acres which is attributed to the very large warehouses that comprise the majority of building types that could support rooftop solar. MCAGCC Twentynine Palms (8 acres), Fort Irwin (4 acres), and NAWS China Lake (3 acres) each have rooftop areas that could be used for rooftop potential. NAF El Centro and Chocolate Mountain AGR do not have any buildings that meet the solar potential assessment screening criteria.

5.4.3 Individual Military Installation Geographic Analysis Results

MCAGCC Twentynine Palms Results

The solar potential analysis for lands on MCAGCC Twentynine Palms was conducted for the cantonment area only. Although Twentynine Palms contains an extensive range, this entire area was deemed unsuitable based on mission incompatibility. Thus, the analysis was confined to rooftop, parking lot shading structures, and ground mount sites within the cantonment.

The Twentynine Palms cantonment area is relatively compact and heavily developed. It is occupied by the personnel housing areas, hundreds of administrative and operational buildings and structures, recreational fields, paved parking lots and unpaved operational areas, etc. Within the cantonment area the potential for development of solar systems on three main site types was considered: 1) parking shade structures over paved lots (generally automotive lots), 2) building roofs that had a total developable area > 20,000 square feet, and 3) ground mount sites on undeveloped land parcels larger than 5 acres. Descriptions of these minimum solar project sizes are in the following Technological Analysis portion of this chapter.

Building Rooftop and Parking Lot Sites: A total of 39 buildings that met the screening criteria were used to generate the total roof area solar potential. The buildings that met the screening criteria were a mixture of administrative, commissary, storage buildings, dining facility, operational training, retail exchange, student billeting, and multi-purpose buildings. The roof top potential was modeled to consist of 8 acres.

A total of 84 paved parking lots were considered for shading structure solar potential. Approximately 110 acres were suitable for shade structures.

Ground Sites: Figure 5.12 illustrates the suitable (illustrated in green), likely suitable (illustrated in yellow), questionably suitable (illustrated in orange), and unsuitable (illustrated in red) areas for ground mount solar development within the cantonment area. The installation's range area is not shown on Figure 5.12 because there is zero suitable acreage on the range.[19] The geospatial modeling used 19 individual GIS mapping layers and screening criteria during the suitability analysis for ground mounted solar.

[19] The same situation (large range areas with no suitable areas for solar development) applies to NAWS China Lake, NAF El Centro, and the non-Goldstone Complex portions of Fort Irwin.

A total of 461 acres within the Twentynine Palms cantonment area was deemed suitable (rating = 1) for ground mount solar.

In addition, another 368 acres was deemed questionably suitable (rating =3) for ground mount solar as these are areas within known floodplain zones. They might be suitable for ground mount solar if controls were put in place to restrict or eliminate potential seasonal flooding.

Much of this land area is located within the Mesquite dry lake bed. This area would require an appropriate flood protection engineering plan and control system to safeguard a solar system from flood damage. This could also potentially increase the cost of installing a solar array in this area.

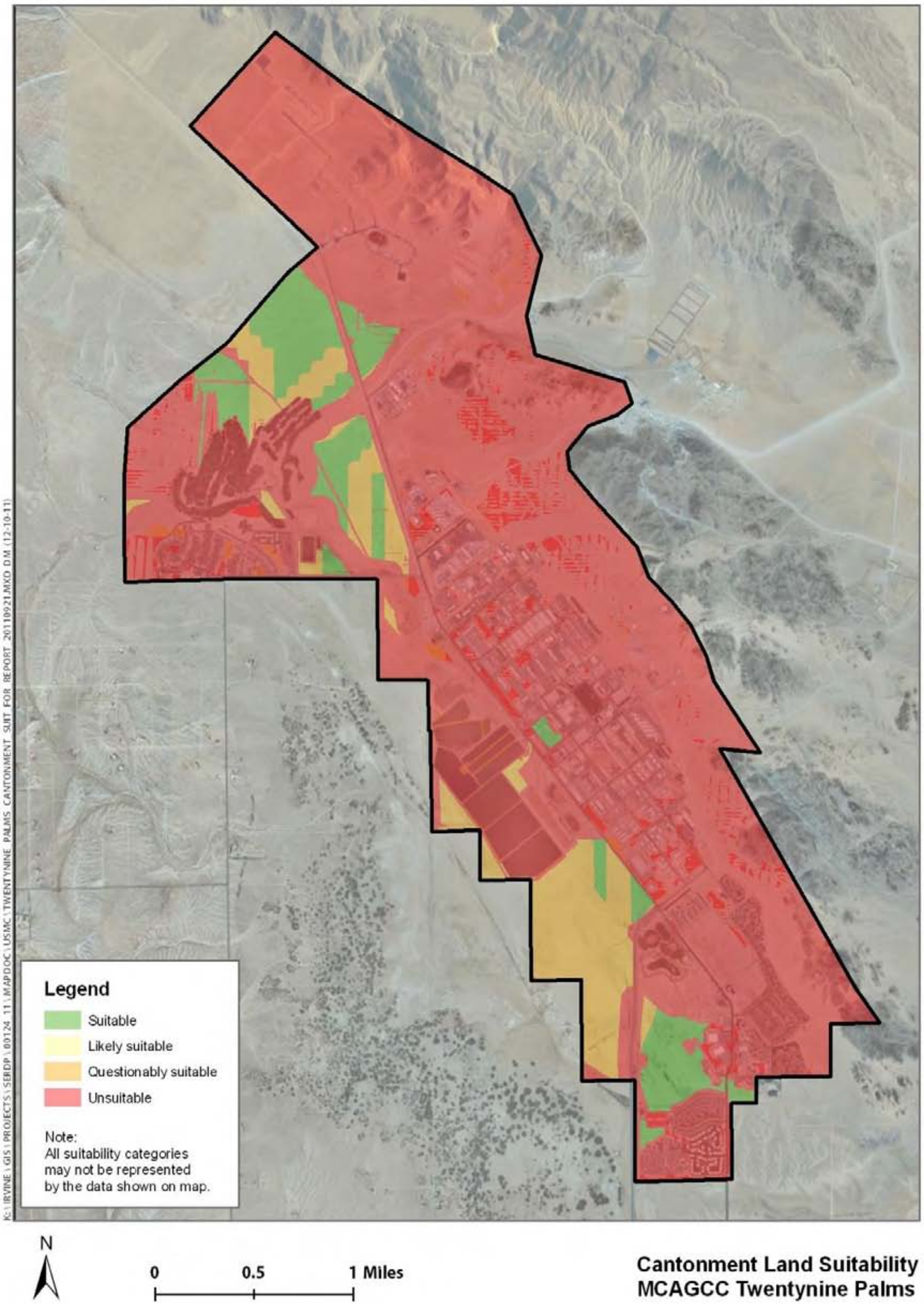


Figure 5.12 – MCAGCC Twentynine Palms Land Suitability

Conversely, a total of 594,749 acres was deemed unsuitable for solar development, largely in range areas. In addition, the cantonment area of Twentynine Palms is relatively small and the vast majority of the area is built out with a wide variety of buildings and structures. In addition, some areas such as the wastewater treatment ponds and stormwater run-off ponds occupy relatively large areas of land within the cantonment area. In addition, there are numerous recreational assets including playing fields and an 18-hole golf course. Furthermore, other areas within the cantonment area have been designated as future build-out areas, including a logistics expansion area in the northern sector of the cantonment as well as a new housing development in the southern sector.

In summary, the most significant areas deemed suitable for ground mount solar are a few contiguous areas in the northern edge of cantonment and in the southern sector of the cantonment near the family housing area. Some solar development potential exists in an additional larger area within the Mesquite dry lake bed floodplain in the southern portion of the cantonment area.

The geospatial data used for this analysis was both highly detailed and complete. This fact allowed for a robust analysis during the modeling phase and also allowed for additional fine tuning of the data during review with military installation staff.

Overall, the results of this study suggest that approximately 2% of the MCAGCC Twentynine Palms cantonment area is suitable for solar development on parking lot shading structures and on building roofs. The suitable (rating = 1) ground mount sites on undeveloped land comprise 9% of the cantonment land area. Finally, the questionably suitable (rating = 3) ground mount sites (located in the floodplain zones) comprise 7% of the cantonment land area.

Table 5.7 – GIS Data Layers Applied at MCAGCC Twentynine Palms

Description	Decision Rule	1 = Suitable 2 = Likely Suitable 3 = Questionably Suitable 4 = Unsuitable
Cantonment Boundary	All areas within the boundary presumed suitable before application of other constraints	1
Building Buffers	Areas within 100’ of any building are unsuitable	4
Parking Areas	Parking lots are unsuitable	4
Driveways	Driveways are unsuitable	4
Road Buffers	Areas within 30’ (60’ total) of the centerline of any paved and unpaved roads are unsuitable	4
Flood Zones	FEMA Special Flood Hazard Area (SFHA) Areas are questionably suitable	3
Water Courses	Areas within 150’ (300’) of the centerline of any surface water course areas are unsuitable	4
Slope	Areas >5% slope are unsuitable	4
Hillside Shading	Areas with shading at 9am or 3pm on Dec. 21, 2015, are unsuitable	4
Recreation	Athletic courts and fields, campgrounds, day-use areas, golf courses, playgrounds, parks, and swimming pool areas are unsuitable	4

Table 5.7 – GIS Data Layers Applied at MCAGCC Twentynine Palms		
Description	**Decision Rule**	**1 = Suitable 2 = Likely Suitable 3 = Questionably Suitable 4 = Unsuitable**
Environmental Cleanup Site	Environmental Cleanup areas are unsuitable	4
Landfills	Open landfill areas are unsuitable (closed landfills are suitable)	4
Solid Waste Recovery	Solid Waste Recovery areas are unsuitable	4
Explosives Safety Quantity Distance (ESQD) Arcs	ESQD Arc areas are unsuitable	4
Parade Grounds	Parade Ground areas are unsuitable	4
Military Range Area	Military Range Areas are unsuitable	4
Wastewater Treatment	Wastewater sludge, lagoon, and filtration areas are unsuitable	4
Mesquite Dry Lake Bed	Mesquite Dry Lake Bed is suitable (Note: dry lake beds are generally considered unsuitable; engineering staff at MCAGCC Twentynine Palms consider this small lake bed suitable)	1
Future Land Use Areas	Four areas delineated by DPW are reserved for future land use and are unsuitable	4

MCLB Barstow Results

The solar potential analysis for MCLB Barstow was conducted at two specific locations: 1) the Nebo cantonment area, and 2) the Yermo Annex cantonment area. These two cantonment areas are geographically separated. The Nebo site is approximately 2 miles east of Barstow along Interstate 40 which runs directly through the main part of the cantonment area of this facility. The Yermo site is approximately 8 miles east of Barstow along Interstate 15 which runs along the northern edge of the cantonment area of this facility. Both facilities serve as primary logistics, supply, and maintenance points for the USMC mission and support other services including the Navy and Army (including Fort Irwin). They are directly connected to the major hub of all west coast rail traffic for the Burlington Northern/Santa Fe and the Union Pacific railroads.

Both MCLB Barstow sites have a diverse array of infrastructure elements, however the Nebo site contains the personnel housing areas, several administrative buildings, numerous logistics buildings and structures, rail yards and connecting rail lines, former test areas, recreational fields, a former landfill, and paved and unpaved parking lots and staging areas. The Nebo site is 3,818 acres in size. There is a range area located on the southern portion of the Nebo site, but that was not considered in this study. This area contains an active gun range, is within desert tortoise critical habitat area, and contains numerous desert arroyos and areas of hilly terrain. All of these factors make the area unsuitable for solar development.

The Yermo site has fewer residential and administrative buildings than Nebo, yet has an abundance of logistics buildings and structures, rail yards and connecting rail lines, former test areas, a former landfill, several large unpaved staging areas for army and fleet support, and both paved and unpaved parking lots. The Yermo site is 1,707 acres in size.

Within the Nebo and Yermo cantonment areas the potential for development of solar systems on four main site types was considered: 1) shading structures over paved parking lots (generally automotive lots), 2) shading structures over unpaved parking lots (generally heavy and armored vehicle lots), 3) building roofs that had a total developable area > 20,000 square feet, and 4) ground mount sites on undeveloped land.

Building Rooftop and Parking Lot Sites: A total of 22 buildings that met the screening criteria were used to generate the total roof area solar potential. Thirteen of the suitable buildings were in Nebo, with the remaining nine located in the Yermo Annex.

A total of 17 acres is attributed to shade structures over paved parking lots, 2 acres is attributed to shade structures over unpaved parking lots, and an additional 13 acres attributed to eligible roof tops.

Ground Sites: The suitable ground mount solar area within both the Nebo and Yermo cantonments combined was assessed at 660 acres, and another 142 ground acres were questionably suitable. Figure 5.13 and Figure 5.14 illustrate the suitable (illustrated in green), likely suitable (illustrated in yellow), questionably suitable (illustrated in orange), and unsuitable (illustrated in red) areas for ground mount solar development within the Nebo and Yermo cantonment areas. The geospatial modeling used over 20 individual GIS mapping layers and screening criteria during the suitability analysis for ground mount solar. The primary areas with potential suitability for ground-mounted solar includes undeveloped areas at both Nebo and Yermo in and around the existing buildings and infrastructure at these sites. However, both sites have a legacy of varied use over many years and, therefore, some of the undeveloped land areas may not be fully characterized with respect to their environmental suitability for solar development. Furthermore, several areas of undeveloped land may have served (or will serve) as outdoor storage areas for a broad array of military vehicles and related assets. These undeveloped staging and storage areas could potentially continue to serve a critical military function as major changes occur with the military mission both domestically and abroad.

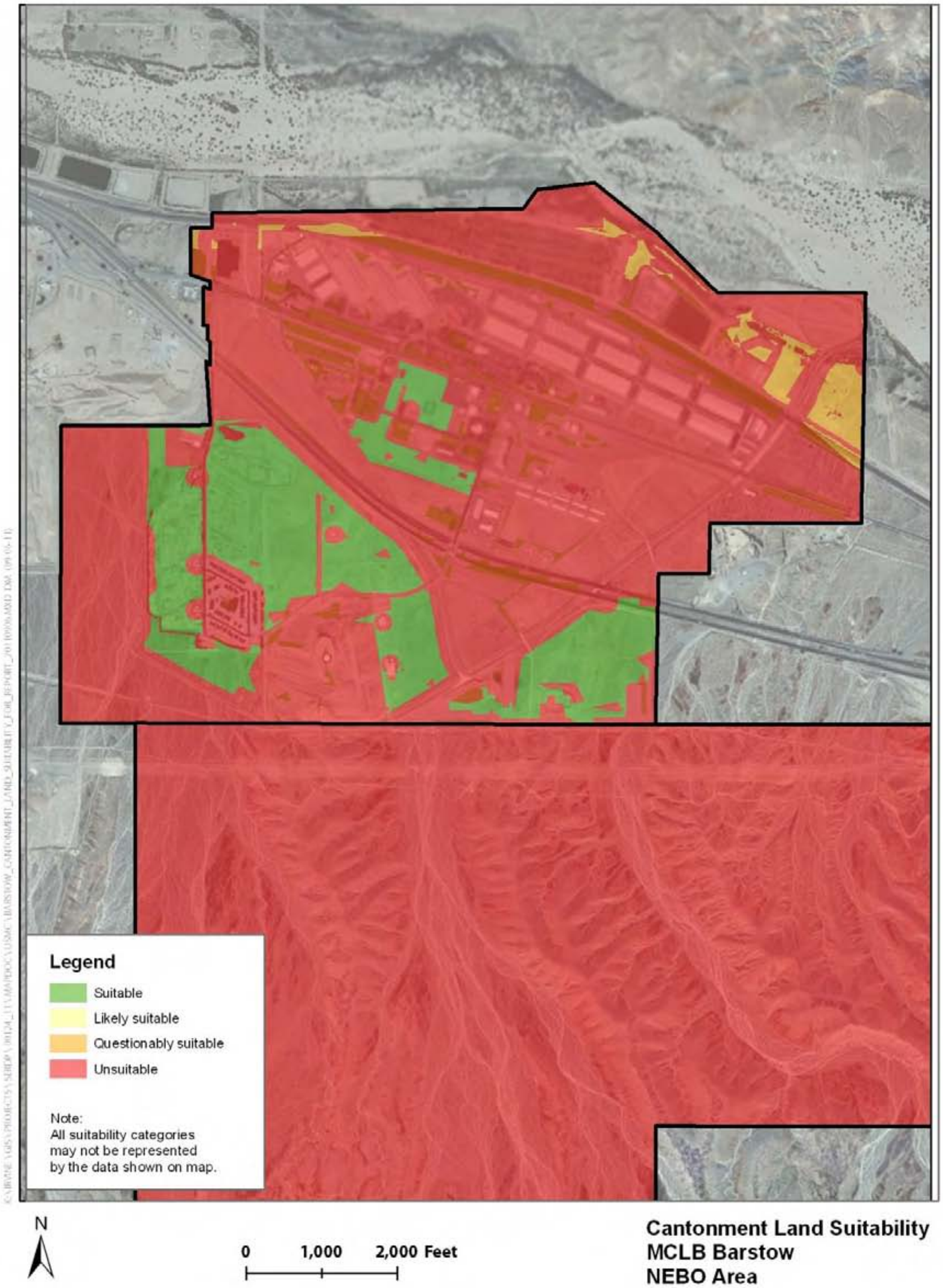


Figure 5.13 – MCLB Barstow – Nebo Area Land Suitability

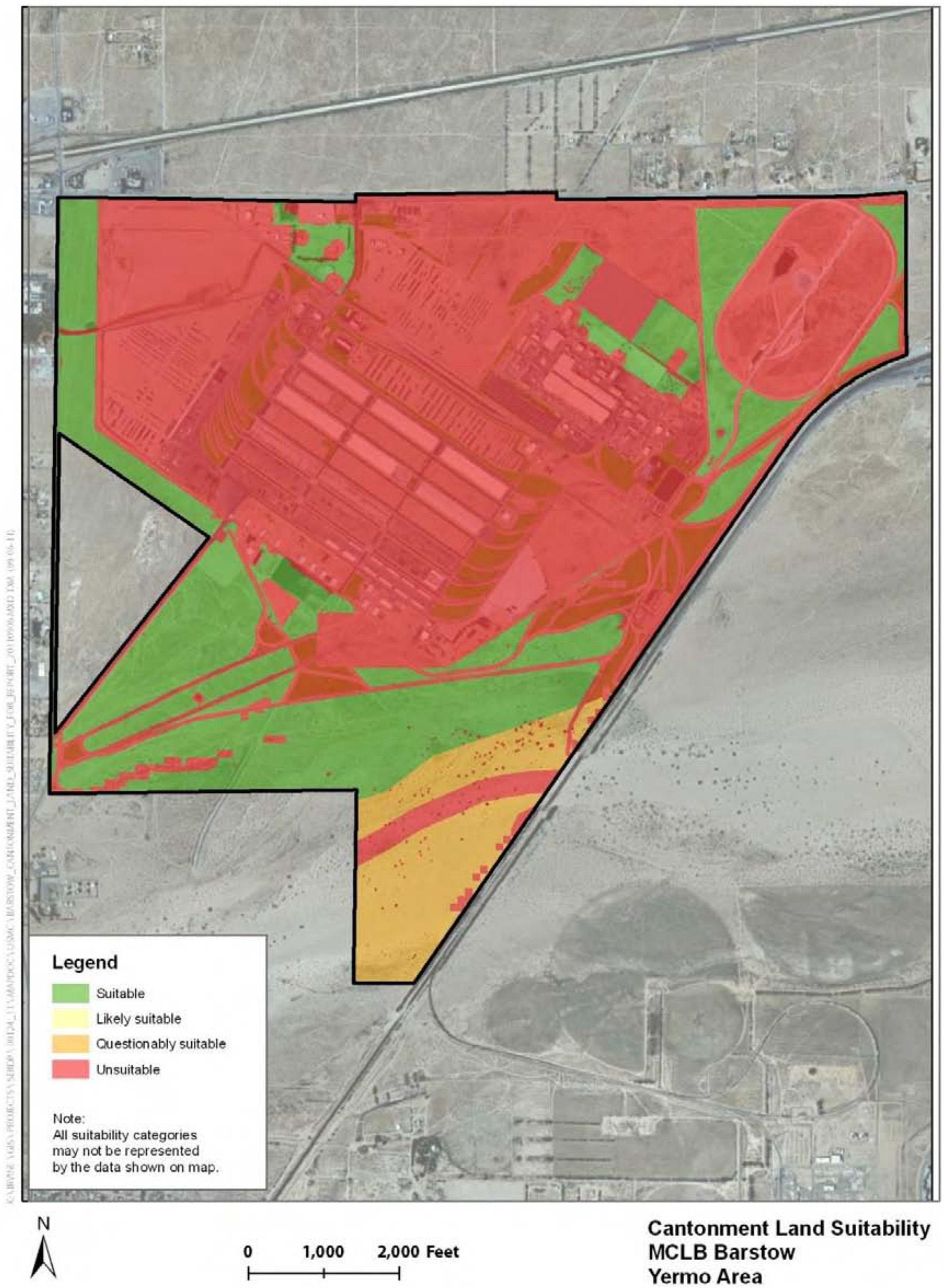


Figure 5.14 – MCLB Barstow – Yermo Annex Land Suitability

At both the Nebo and Yermo sites, some undeveloped cantonment areas reside within a known floodplain and received a questionably suitable score (3) indicating that they may not be appropriate for solar development. Most of this land area falls along the Mojave River which is known to flood during seasonal rain events. Within the Nebo cantonment area, the golf course and much of the northern edge of this site lies directly along the Mojave River and is within the floodplain area. At the Yermo cantonment site, the southern edge of the site is also directly adjacent to the Mojave River and is also within the floodplain area. Development of ground-mounted solar in either of these areas would require an appropriate flood protection engineering plan and control system which would be necessary to safeguard the solar project from flood damage. This could also potentially increase the cost of installing a solar array in this area.

A total of 4,723 acres was deemed unsuitable for solar development at the Nebo and Yermo sites combined. The cantonment areas of both Nebo and Yermo are relatively small and a substantial amount of the area is built out with large warehouses and also contains numerous undeveloped storage areas. As previously mentioned, the Nebo and Yermo cantonment sites have a legacy of varied use which has also created many fragmented parcels of land with uncertain current and future suitability. This uncertainty can be attributed to both environmental concerns as well as from future land use as it relates to potential USMC storage and logistics needs.

The geospatial data used for this analysis were both highly detailed and complete. This fact allowed for a robust analysis during the modeling phase and also allowed for additional fine tuning of the data during review with military installation staff.

Overall, the results of this study suggest that less than 1% of the MCLB Barstow area is suitable for solar development on shade structures over paved and unpaved parking lots and building roofs. The suitable ground mount sites on undeveloped land comprise 12% of the total cantonment land area. Finally, the questionably suitable ground mount sites (located in the floodplain zones) comprise 3% of the total land area.

Table 5.8 – GIS Data Layers Applied at MCLB Barstow (Applicable to Both Nebo and Yermo Annex Sides of Installation)

Description	Decision Rule	1 = Suitable 2 = Likely Suitable 3 = Questionably Suitable 4 = Unsuitable
Installation Area	All areas within the installation presumed suitable before application of other constraints	1
Building Buffers	Areas within 100’ of any building are unsuitable	4
Parking Areas	Parking lots are unsuitable	4
Driveways	Driveways are unsuitable	4
Road Buffers	Areas within 30’ (60’ total) of the centerline of any paved and unpaved roads are unsuitable	4
Railroad Buffers	Areas within 30’ (60’ total) of the centerline of any railroads are unsuitable	4
Slab Areas	Paved slab areas are unsuitable	4
Canopy Pavilions	Canopy Pavilion areas are unsuitable	4

Table 5.8 – GIS Data Layers Applied at MCLB Barstow (Applicable to Both Nebo and Yermo Annex Sides of Installation)		
Description	**Decision Rule**	**1 = Suitable 2 = Likely Suitable 3 = Questionably Suitable 4 = Unsuitable**
Flood Zones	FEMA Special Flood Hazard Areas (SFHAs) Areas are questionably suitable	3
Wetlands	Wetland areas are unsuitable	4
Water Courses	Areas within 150’ (300’) of the centerline of any surface water course areas are unsuitable	4
Recreation	Athletic courts and fields, golf courses, bleachers, swimming pools, and playgrounds areas are unsuitable	4
HAZMAT Storage	Hazardous Materials (HAZMAT) storage areas are unsuitable	4
Solid Waste Dump Area	Solid Waste Dump Areas are unsuitable	4
Solid Waste Stockpile Area	Solid Waste Stockpile Areas are unsuitable	4
Environmental Restoration Area (CERCLA Sites)	All areas are unsuitable except: RFA sites closed with no action required (based on PR/VSI/RFA results) and RFA sites fully addressed through CERCLA	4
Firing Area	Firing Range areas are unsuitable	4
Proving Ground	Proving Ground areas are unsuitable	4
Slope	Areas >5% slope are unsuitable	4
Open Storage Ares	Open Storage areas are unsuitable	4
Wastewater Treatment Areas	Wastewater sludge, lagoon, and filtration areas are unsuitable	4
Flora Species	Flora Species areas are unsuitable and commonly contain plant species that are deemed locally important to the installation	4
Flora Special Status Species	Flora Special Status Species areas are unsuitable areas and contain locally sensitive or special status plant species that are considered protected as part of the Integrated Natural Resource Management Plan (INRMP)	4
Fauna Special Status Species	Fauna (Desert Tortoise) special status areas are unsuitable	4
Cultural Restricted and Cultural Probable Sensitive Areas	Cultural Resources Restricted and Sensitive areas are unsuitable	4

Naval Air Weapons Station (NAWS) China Lake Results

The solar potential analysis for lands on NAWS China Lake was conducted at two specific locations: 1) the cantonment area (known locally as ―Mainsite”), and 2) the range area. The cantonment area at NAWS China Lake is the main developed region near the southern-most edge of the north operational range. The range area with suitability for solar tended to be adjacent to the cantonment, including parts of Armitage Field, the southernmost tip of the George Range, Corridor C, and Corridor G.

The ―range area” that tended to be wholly unsuitable was north beyond Armitage Field, such as the upper Charlie Range, upper George Range, Propulsion Laboratories, Main Magazines, Ordnance Test and Evaluation (T&E), Airport Lake, Geothermal, Coso Range, and Coso Target Range, and the Southern Range Complex that extends towards Fort Irwin. These additional range areas were deemed by NAWS staff to be too operationally sensitive to accommodate large-scale solar development.

At NAWS China Lake, the cantonment area contains the personnel housing areas, numerous administrative and operational buildings and structures, recreational fields, paved and unpaved parking lots and staging areas, etc. The range area includes the main airfield, laboratories, RDTE structures, operational range areas, etc. The land use classification system that covers both these areas includes the following function types: Administration, Community, Housing, Interim Use, Maintenance, Medical, Operations, Ordnance, RDTE, Recreation, Safety, Supply, Undeveloped and Unzoned. All of these land use classes were evaluated during the suitability analysis.

Within the cantonment area the potential for development of solar systems on three main site types was considered: 1) shade structures over paved parking lots (generally automotive lots), 2) building roofs that had a total developable area > 20,000 square feet, and 3) ground mount sites on undeveloped land.

Building Rooftop and Parking Lot Sites: A total of 31 paved parking lots were considered for shading structure solar potential during this analysis, and a total of 10 buildings that met the screening criteria were used to generate the total roof area solar potential. The buildings that met the screening criteria were a mixture of laboratories, storage warehouses, and a child development center to name a few.

Within the cantonment area, 43 acres are suitable for solar development on shading structures over paved parking lots, with an additional area of 3 acres attributed to eligible roof tops.

Ground Sites: Figure 5.15 illustrates the suitable (illustrated in green), likely suitable (illustrated in yellow), questionably suitable (illustrated in orange), and unsuitable (illustrated in red) areas for ground-mounted solar development within the cantonment and adjacent range areas. A total of 6,191 acres within the entire was deemed suitable. These areas comprise numerous parcels of undeveloped land that are greater than 5 acres in size and exist in and amongst the developed areas. One area that was identified as suitable is an old housing area that has recently been demolished and could be used for ground-mounted solar. It should be noted that ground-mounted solar development is already planned within some of the undeveloped cantonment area.

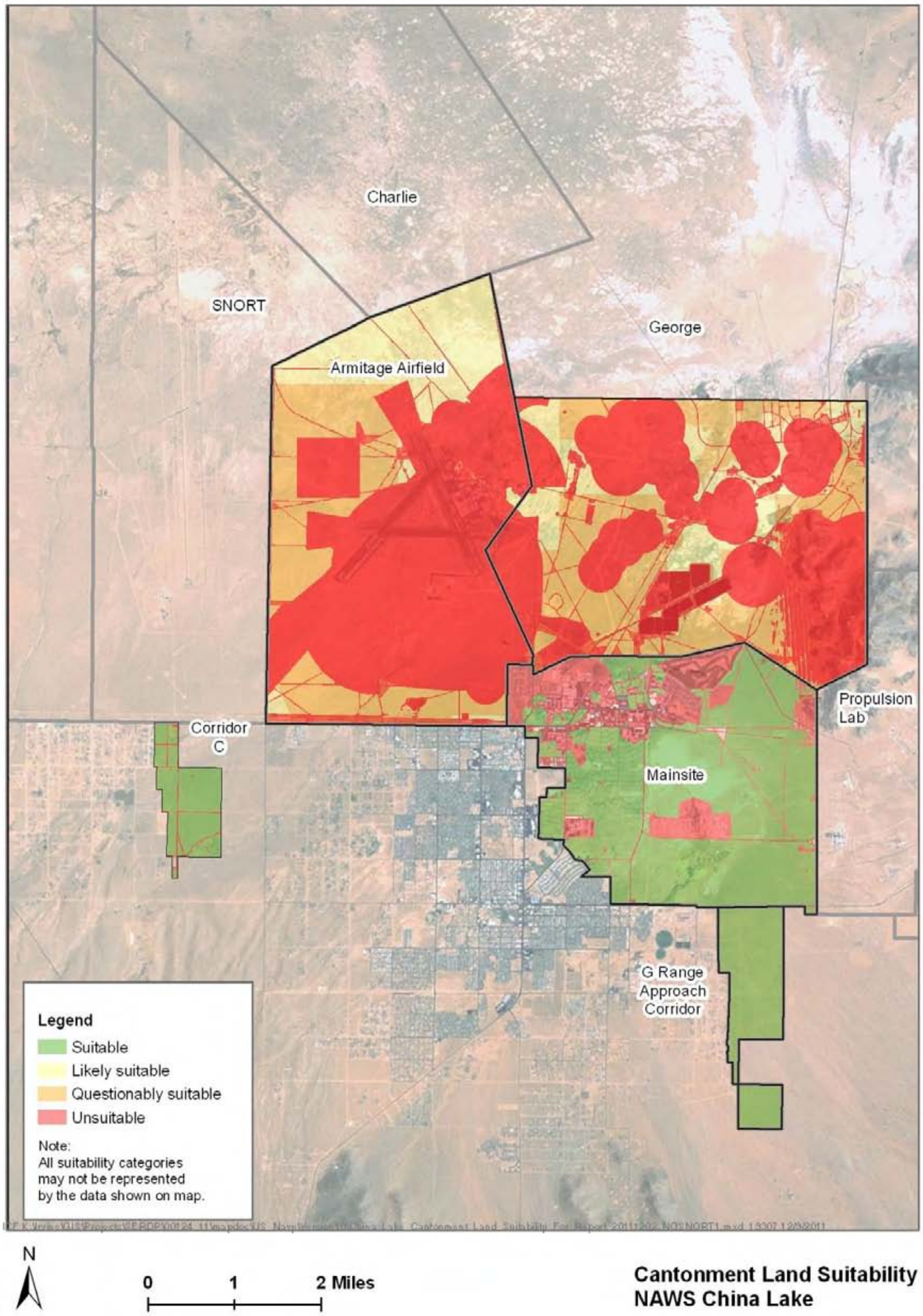


Figure 5.15 – NAWS China Lake Land Suitability

The geospatial modeling used 20 individual GIS mapping layers and screening criteria during the suitability analysis for ground mount solar. Approximately 11,300 acres of land at NAWS China Lake was rated from suitable to questionably unsuitable (e.g., rating score from 1 through 3) for solar development. The suitable (rating = 1) areas for solar development at NAWS China Lake include the cantonment area and Corridors C and G. The primary areas with at least some suitability for ground-mounted solar includes the cantonment area, Corridor C, and Corridor G. Most of the range areas has limited slope that does not exceed the 5% threshold.

Conversely, a total of 1,097,654 acres was found to be unsuitable for solar development. Several significant areas within the George Range area are unsuitable due to many Explosives Safety Quantity Distance (ESQD) Arcs around the Ammunition Storage Points (ASPs). Also, many areas around Armitage Field are deemed unsuitable as a result of aircraft safety zones and mission compatibility reasons at a few airfield hangars that conduct sensitive operations. Natural resource constraints were evaluated during the suitability modeling and no areas within the range area were rated entirely unsuitable (rating of 4) based on the geospatial mapping layers used. The area's extensive desert tortoise habitat, while not an absolute exclusion factor, did cause large areas to have their solar suitability rating downgraded (e.g., from a rating of 1 to 2 or from 2 to 3).

The geospatial data used for this analysis were both detailed and complete. This allowed for a robust analysis during the modeling phase and also allowed for additional fine tuning of the data during review with military installation staff. In a few rare cases, the NAWS China Lake GIS data depicted features on the ground that are not present today. Nonetheless, the data were considered complete and suitable for this study.

Overall, the results of this study suggest that NAWS China Lake has potential suitability for solar development on shade structures over paved parking lots, building roofs, and ground mount sites on undeveloped land.

Table 5.9 – GIS Data Layers Applied at NAWS China Lake		
Description	**Decision Rule**	**1 = Suitable 2 = Likely Suitable 3 = Questionably Suitable 4 = Unsuitable**
Cantonment/Installation Area	Mainsite, Armitage Field, Corridor G, Corridor C, and Part of George Range areas were presumed suitable prior to the application of the constraints listed below.	1
Building Buffers	Areas within 100' of any building are unsuitable	4
Parking Areas	Parking lots are unsuitable	4
Driveways	Driveways are unsuitable	4
Road Buffers	Areas within 30' (60' total) of the centerline of any paved and unpaved roads are unsuitable. Existing roads within the demolished housing area are suitable.	4
Recreation	Athletic courts and fields, campgrounds, day-use areas, golf courses, playgrounds, parks, and swimming pool areas are unsuitable	4
Land Use Areas	Operations, Ordnance, RDTE, Recreation, and Safety areas are unsuitable.	4
Environmental Restoration Site	Environmental Restoration Program (ERP) areas are unsuitable	4
High School	The High School area is unsuitable	4
Areas of Concern (AOCs)	All areas are unsuitable except: Dust Abatement, Homestead Wells, Corridor C, and Corridor G	4
Airfield Surface	Airfield surface areas, including a 1000' buffer area, are unsuitable	4
Explosives Safety Quantity Distance (ESQD) Arcs	ESQD Arc areas are unsuitable	4
Ammunition Areas	Military ammunition handling areas are unsuitable	4
Buffer around Hangars 4 & 5	Areas within 1 mile of Hangars 4 and 5 are unsuitable	4
Accident Potential Zones (APZs)	ROA Clearance, Lateral Clearance Zone, Clear Zone, and APZ 1 areas are unsuitable	4
Slope	Areas >5% slope are unsuitable	4
Hillside Shading	Areas with shading at 9am or 3pm on Dec. 21, 2015, are unsuitable	4
Playa (dry lakebeds)	Playa areas are unsuitable	4
Wastewater Treatment	Wastewater sludge, lagoon, and filtration areas are unsuitable	4
Desert Tortoise Modeled Habitat	Habitat modeling developed by a desert tortoise SME that applies two levels of suitability	2 or 3

Chocolate Mountain Aerial Gunnery Range Results

The solar potential analysis for the Chocolate Mountain Aerial Gunnery Range (Chocolate Mtn. AGR) was conducted for the entire facility. The Chocolate Mtn. AGR consists of approximately 463,623 acres of desert mountain terrain in Imperial and Riverside Counties, California. For this study the Chocolate Mtn. AGR was treated as entirely as range area (e.g., undeveloped).

The Chocolate Mtn. AGR currently supports training in air combat maneuvering and tactics; close air support (where air-to-ground ordnance is fired to directly support friendly forces engaged in ground combat); airborne laser system operations; air-to-air gunnery; and air-to-ground bombing, rocketry, and strafing. Artillery, demolitions, small arms and Navy Special Warfare training are also conducted within the range. Throughout the entire extent of the range, helicopter landing and related operations are permitted to occur anywhere. (The MV-22 Osprey has designated landing areas.) Therefore the entire Chocolate Mtn. AGR is undeveloped and does not contain any substantial buildings or other infrastructure assets as the other facilities in this study do. As a result, the analysis for Chocolate Mtn. AGR focused on ground-mounted solar development only.

The geospatial modeling process used 24 individual GIS mapping layers and screening criteria during the suitability analysis for ground mount solar. A total of 3,768 acres across the entire range area were deemed suitable (rating = 1) for solar development. The predominant exclusion layer was the combined R2507N, R2507S, and the R2507E which rendered the vast majority of the Chocolate Mtn. AGR unsuitable. This air range has a lower limit at the ground surface and extends to an unlimited altitude. Several other factors (e.g., Weapons Danger Zones (WDZ), Surface Danger Zones (SDZ), Desert Tortoise Critical Habitat Areas, etc.) also rendered much of the land area unsuitable for solar development. The suitable acreage was all located in the northwest corner of the installation. Figure 5.16 illustrates the suitable (illustrated in green), likely suitable (illustrated in yellow), questionably suitable (illustrated in orange), and unsuitable (illustrated in red) areas for ground mount solar development across the entire Chocolate Mtn. AGR area.

Overall, the geospatial modeling results for the Chocolate Mtn. AGR suggest that 1% of the land area is suitable and a further minimal amount is likely suitable (264 acres) or questionably suitable (305 acres) for ground-mounted solar development. For areas outside of the Desert Tortoise Critical Habitat Area, which was deemed unsuitable, a biological model was used to help predict desert tortoise occurrence and this generated additional screening criteria ranging from suitable (1) to questionably suitable (3).

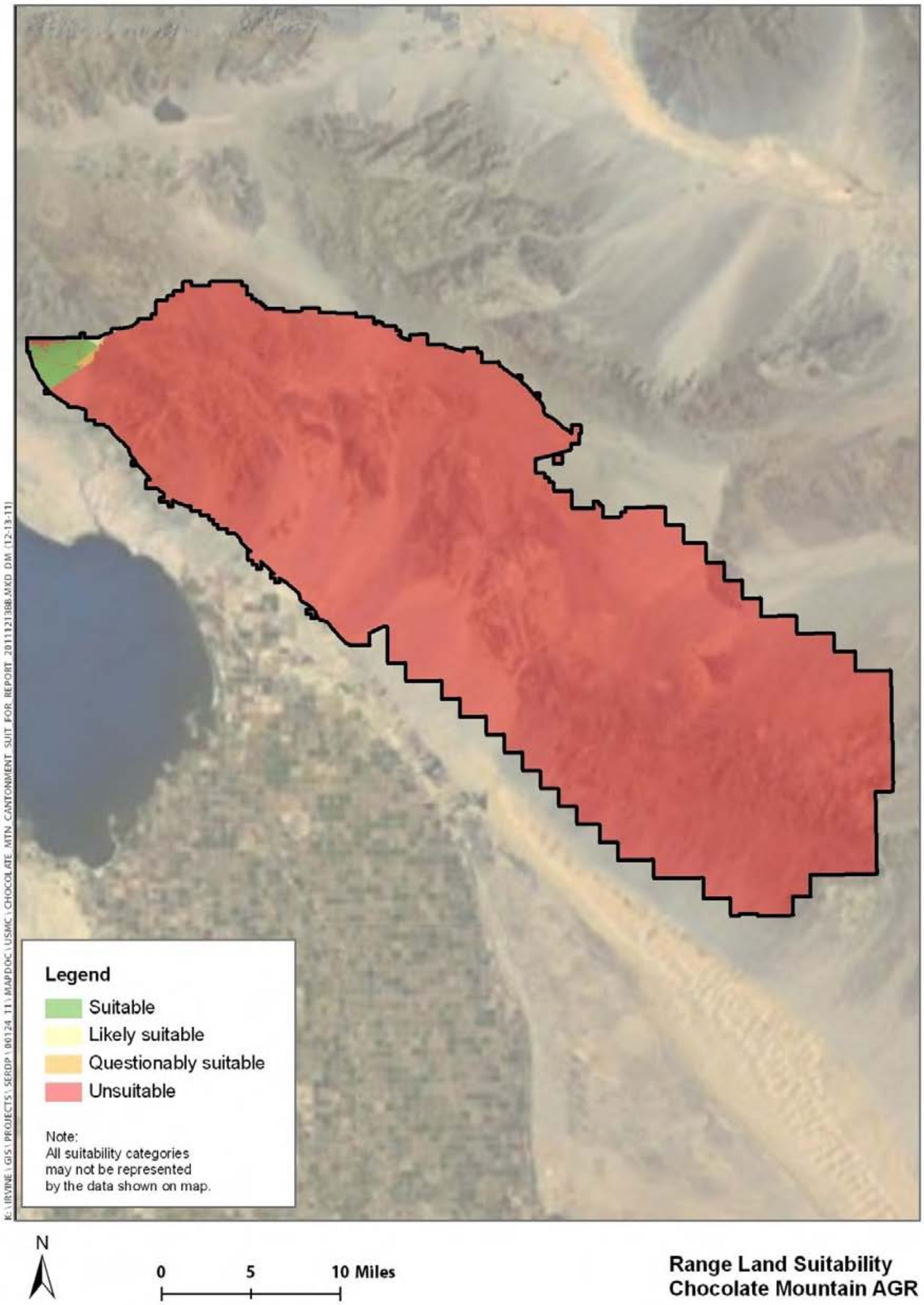


Figure 5.16 – Chocolate Mountain AGR Land Suitability

A cultural resources model was also developed for Chocolate Mtn. AGR which used actual field data to delineate those areas that are suitable (rating = 1), likely suitable (rating = 2), questionably suitable (rating = 3), and unsuitable (rating = 4). Many areas within the Chocolate Mtn. AGR had cultural resource sites that fit into each category. Based on data review, many of the sites were deemed questionably suitable as they had some degree of cultural resource presence, but needed further evaluation. A lesser number of sites where field investigations had been completed were considered either suitable or unsuitable.

Of the entire Chocolate Mtn. AGR area, 459,286 acres, or 99% of the range area was deemed unsuitable for solar development. The primary drivers for this lack of suitability were derived from the military mission and operations geospatial data layers that excluded nearly the entire Chocolate Mtn. AGR range. The geospatial data that contributed to this exclusion included the following elements: R2507 Complex, WDZs, SDZs, SWAT (Special Weapons And Training areas) 4, SWAT 5, Combined Arms Live Fire Exercise (CALFEX) areas, forward arming and refueling areas, impact areas, military landing zones, and firing ranges. Aside from the mission incompatibility, the hilly and mountainous regions within the Chocolate Mtn. AGR were often too steep (slope > 5%) to permit the installation of ground-mounted solar.

Table 5.10 – GIS Data Layers Applied at Chocolate Mountain AGR

Description	Decision Rule	1 = Suitable 2 = Likely Suitable 3 = Questionably Suitable 4 = Unsuitable
Installation Area	Any area within Chocolate Mtn. AGR was presumed to be suitable prior to the application of the constraints listed below	1
―Beak” Sub-Installation Area	Any area within ―Beak” sub-installation area was presumed to be suitable prior to the application of the constraints listed below	1
Building Buffers	Areas within 100’ of any building are unsuitable	4
Road Buffers	Areas within 30’ (60’ total) of the centerline of any paved and unpaved roads are unsuitable	4
Rail Buffers	Areas within 30’ (60’ total) of the centerline of any rail line are unsuitable	4
Slope	Areas >5% slope are unsuitable	4
Hillside Shading	Areas with shading at 9am or 3pm on Dec. 21, 2015, are unsuitable	4
Airfield Surface Area	Airfield Surface areas are unsuitable	4
Special Weapon and Training Areas (SWAT) 4	SWAT 4 areas are unsuitable	4
Special Weapon and Training Areas (SWAT) 5	SWAT 5 areas are unsuitable	4
Forward Arming and Refueling	Forward Arming and Refueling areas are unsuitable	4
Impact Area	Impact Areas are unsuitable	4
Military Landing Zone	Military Landing Zone A areas are unsuitable	4
Firing Ranges	Firing Range Areas are unsuitable	4
Aerial Laser Safety Danger Zones	Aerial LSDZ areas are unsuitable	4
Combined Arms Live Fire Exercise (CALFEX)	CALFEX areas are unsuitable	4
Military Target Area	Military target areas are unsuitable	4
Surface Danger Zone (SDZ)	SDZ areas are unsuitable	4
Weapons Danger Zone (WDZ)	WDZ areas are unsuitable	4
Restricted Airspace	R2507N, R2507S, and R2507E areas (from ground to unlimited altitude) are unsuitable	4
Desert Tortoise Modeled Habitat	Habitat modeling developed by a desert tortoise SME that applies two levels of suitability	2 or 3
Desert Tortoise Critical Habitat (DTCH)	DTCH areas (as defined by USFWS) are unsuitable	4

Table 5.10 – GIS Data Layers Applied at Chocolate Mountain AGR		
Description	**Decision Rule**	**1 = Suitable 2 = Likely Suitable 3 = Questionably Suitable 4 = Unsuitable**
Cultural Survey Areas	Areas listed as: 1) ―Negative - No Sites Recorded", 2) ―Recorded - Isolate, Not Eligible", and 3) ―Recorded - No Sites Eligible" and were designated as ―CLASS 3 – meets state and MCAS Yuma requirements, 30M or less" were each deemed suitable.	1
Cultural Survey Areas	Areas listed as: 1) ―Negative – No Sites Recorded, 2) ―Recorded - Further Evaluation Needed", and 3) ―Recorded – No Sites Eligible" and were designated as ―CLASS 2 – less intensity than required by corresponding SHPO" were each deemed questionably suitable	3
Cultural Survey Areas	Areas listed as ―Recorded - Further Evaluation Needed" and designated as ―CLASS 2 – less intensity than required by corresponding SHPO" or were designated as ―OTHER" are questionably suitable	3
Cultural Survey Areas	Areas listed as: 1) ―Recorded - All Sites Potentially Eligible", and 2) Recorded - Some Sites Potentially Eligible" were deemed unsuitable. (All sites in this category were designated as ―CLASS 3 - meets state and MCAS Yuma requirements, 30M or less")	4

Naval Air Facility (NAF) El Centro Results

The solar potential analysis for NAF El Centro initially considered two main areas: 1) the Cantonment area (i.e., main Air Station), and 2) ranges in the 2510 complex (―Shade Tree", Loom Lobby", and ―Parachute Drop Area") and the 2512 complex (―Kitty Baggage" and ―Inkey Barley"). The combined area of the 2510/1512 range complex areas is approximately 55,000 acres. After detailed review and consultation with military installation staff, these areas were deemed unsuitable due to a combination of mission incompatibility, natural resources concerns, and cultural resource concerns. Therefore, the cantonment area at NAF El Centro was the only area with any suitability for solar development.

At NAF El Centro, the cantonment area is occupied by personnel housing areas, numerous administrative and operational buildings and hangars, runways and aprons, recreational fields, paved parking lots and staging areas. The cantonment area is almost completely built-out with the exception of a number of agricultural lease areas that coincide with special safety areas around the munitions storage areas and special clearances zones immediately adjacent to the paved approach and departure areas of the main runways.

Within the cantonment area, the potential for development of solar systems on two main site types was considered: 1) shade structures over paved parking lots (generally automotive lots), and 2) ground mount sites on undeveloped land.

Building Rooftop and Parking Lot Sites: The analysis for building roofs that had a total developable area > 20,000 square feet was initially conducted for six buildings. However, all six of these buildings had roofs that were subsequently deemed unsuitable due to a variety of factors including sub-optimal pitch angles, inadequate construction condition, constraints on roof geometry, and unavoidable roof obstructions.

The analysis for shade structures over unpaved parking lots was not conducted as they do not exist on site.

The potential suitability for solar development of 14 acres that can be attributed to shade structures over paved parking lots. All of this suitable shade structure solar development is within central cantonment area. A total of 15 paved (i.e., asphalt) parking lots were considered for shading structure solar potential during this analysis.

Ground Sites: Although some small patches of undeveloped land in the central area of NAF El Centro could be likely or questionably suitable for ground mount solar sites, these areas were deemed unsuitable for solar development by the military installation planning office. The goal for future land development at NAF El Centro is to consolidate all buildings and infrastructure within a small and densely packed area to avoid potential future land use conflicts with the airfield, hangars and potential build-out in that area. This consolidation and planning action will eventually occupy all undeveloped lands within this central area.

Figure 5.17 illustrates the suitable (illustrated in green) and unsuitable (illustrated in red) areas for ground-mounted solar development within the remainder of the NAF El Centro cantonment area. This mainly includes the areas of NAF El Centro that are immediately along the southern boundary to the east and west of the main entrance and a small area in the northwest corner that is near the wastewater treatment facility.

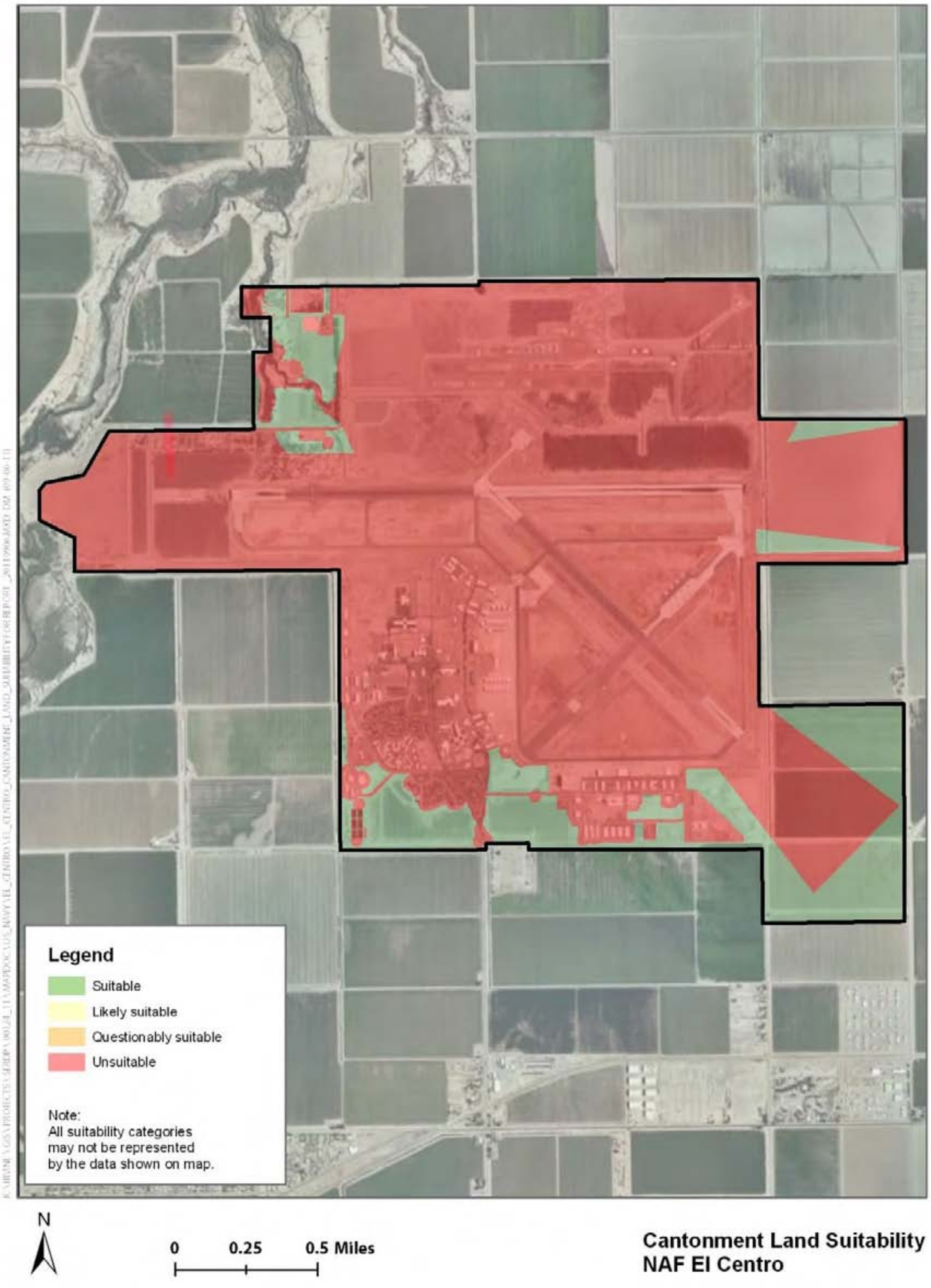


Figure 5.17 – NAF El Centro Land Suitability

The geospatial modeling used 16 individual GIS mapping layers and screening criteria during the potential suitability analysis for ground mount solar. A total of 377 acres within the entire cantonment area was deemed suitable for solar development.

Conversely, a total of 55,912 acres was deemed unsuitable for solar development. Significant open land areas within NAF El Centro are currently leased out for agricultural purposes. There are two primary factors that dictate the unsuitability of these agricultural land areas for potential use as solar ground mount sites. The first is the large ESQD arcs that surround the munitions bunkers on the northern edge of the facility rendering these sites unsuitable for development due to safety concerns. The second is the existence of –clear zones" located at the ends of runways 8/26 and 12/30 also due to safety concerns. According to OPNAVINST 11010.36C, of the 93 land use categories evaluated for these clear zones the only two compatible land uses are 1) undeveloped land, and 2) agriculture that excludes both livestock and placement of any above-ground features.

The geospatial analysis and modeling of the NAF El Centro cantonment (as well as the original assessment of the 2510/2512 range complexes) was problematic because many of the GIS datasets that are common to most DoD installations simply did not exist for NAF El Centro. This was particularly the case during the initial screening of the range complexes.

Table 5.11 – GIS Data Layers Applied at NAF El Centro		
Description	**Decision Rule**	**1 = Suitable 2 = Likely Suitable 3 = Questionably Suitable 4 = Unsuitable**
Installation Area	All areas were assumed to be suitable prior to the application of other constraints	1
Building Buffers	Areas within 100' of any building are unsuitable	4
Parking Areas	Parking lots are unsuitable	4
Road Buffers	Areas within 30' (60' total) of the centerline of any paved and unpaved roads are unsuitable	4
Railroad Buffers	Areas within 30' (60' total) of the centerline of any railroads are unsuitable	4
Recreation	Athletic courts and fields, golf courses, and playground areas are unsuitable	4
Current Land Use Areas	Aircraft Operations/Maintenance, Base Officer Quarters, Base Enlisted Quarters, Medical, Ordnance, Recreational Family, Maintenance/Production areas are unsuitable	4
Interior Cantonment Areas	Undeveloped lands within inner cantonment area are unsuitable	4
Flood Zones	FEMA Special Flood Hazard Areas (SFHAs) are questionably suitable	3
Environmental Restoration Site (Hazardous Waste)	Environmental Restoration Program (ERP) areas are unsuitable	4
Airfield Surface	Airfield surface areas, including a 1000' buffer area, are unsuitable	4
Accident Potential Zones (APZs)	ROA Clearance, Lateral Clearance Zone, Clear Zone, and APZ 1 areas are unsuitable	4
Explosives Safety Quantity Distance (ESQD) Arcs	ESQD Arc areas are unsuitable	4
Ammunition Storage	Ammunition Storage areas are unsuitable	4
Wastewater Pond Areas	Wastewater sludge, lagoon, and filtration areas are unsuitable	4
Slope	Areas >5% slope are unsuitable	4

Edwards Air Force Base Results

Edwards AFB is different from some of the other large installations addressed by this study in that it does not have a single compact developed area surrounded by a large area of open range land. Instead, there are several developed areas on the military installation separated from one another by several miles of open country. What follows is a description of some of the key areas within the installation fence line.

The cantonment at Edwards AFB is primarily the main developed region within the central part of the military installation adjacent to Rogers dry lakebed. Other facilities include the PIRA (Precision Impact Range Area), the AFRL (Air Force Research Laboratory), bombing range, and the remaining open space.

At Edwards AFB, the cantonment area contains the personnel housing areas, main airfield and hangars, hundreds of administrative and operational buildings and structures, recreational fields, paved and unpaved parking lots and staging areas, etc. The remaining areas outside the cantonment include numerous research laboratories, RDTE structures, operational range areas, etc. The land use classification system that covers these areas includes the following functional types: Airfield, Communications System, Housing, Miscellaneous Military Land, Institutional, Navigation and Traffic Aids, Office Building Locations, Other, Parks and Historic Sites, Post Office, Storage, Research and Development, Training Land, Vacant, and Recreation. All of these land use classes were evaluated during the suitability analysis (See Section 5.3.5).

Four main site types were evaluated for solar development at Edwards AFB: 1) shade structures over paved parking lots (generally automotive lots); 2) shade structures over unpaved parking lots (generally heavy and armored vehicles lots); 3) building roofs that had a total developable area > 20,000 square feet; and 4) ground mount sites on undeveloped land.

Building Rooftop and Parking Lot Sites: Edwards AFB has a total of 68 buildings that met the screening criteria used to generate the total roof area solar potential. The buildings that met the screening criteria were a mixture of aircraft hangar, test facilities, laboratories, storage warehouses, and the installation exchange and commissary to name a few. The military installation has 17 acres of solar development potential on eligible roof tops.

A total of 111 paved (i.e., asphalt and concrete) and 21 unpaved (i.e., bare earth) parking lots were considered for shading structure solar potential during this analysis. By size, 104 acres of solar development potential can be attributed to shade structures over paved parking lots, and an additional 38 acres can be attributed to shade structures over unpaved parking lots.

Ground Sites: The geospatial modeling process used 30 individual GIS mapping layers and screening criteria during the suitability analysis for ground-mounted solar.

A total of 1,739 acres across the entire facility area was deemed –suitable” (rating = 1) for solar development.

Approximately 92,000 acres of land at Edwards AFB was rated from suitable, likely suitable, or questionably suitable (e.g., rating score from 1 through 3). Figure 5.18 illustrates the suitable (illustrated in green), likely suitable (illustrated in yellow), questionably suitable (illustrated in orange) and unsuitable (illustrated in red) areas for ground mount solar development across the entire Edwards AFB area. Virtually all of the land available for solar development (88,294 acres, or 96% of the total) is in ranges areas, with the remaining 4% (3,715 acres) in cantonment areas of the installation.

The 92,000 acres includes several large hunting areas that were rated as ―likely suitable.” However, these areas have relatively low current use and their designation may change with future changes in the base master plan. If these areas were deemed to be fully suitable (rating = 1), this would increase the acreage in this category greatly as these hunting areas occupy a rather large footprint, especially in the northwest corner of the installation. Additional areas of Edwards AFB were deemed likely or questionably suitable as a result of natural resource concerns, such as those raised by the desert tortoise.

Of the entire Edwards AFB area, 216,114 acres, or 70% of the Edwards AFB area, was deemed unsuitable for solar development because of mission, operations, master planning, and other constraints. Some hilly and mountainous areas contributed to these unsuitable site conditions for ground- mounted solar development due to excessive slope (e.g. > 5%). Two large operational areas of Edwards AFB that are deemed unsuitable include the PIRA (Precision Impact Range Area) and three main dry lake beds (playas), of which Rosamond and Rogers occupy a significant portion of the entire military installation. All three playas serve an operational role, most notably Rogers Dry Lakebed which is a critical feature of the Air Force Flight Test Center (AFFTC) mission.

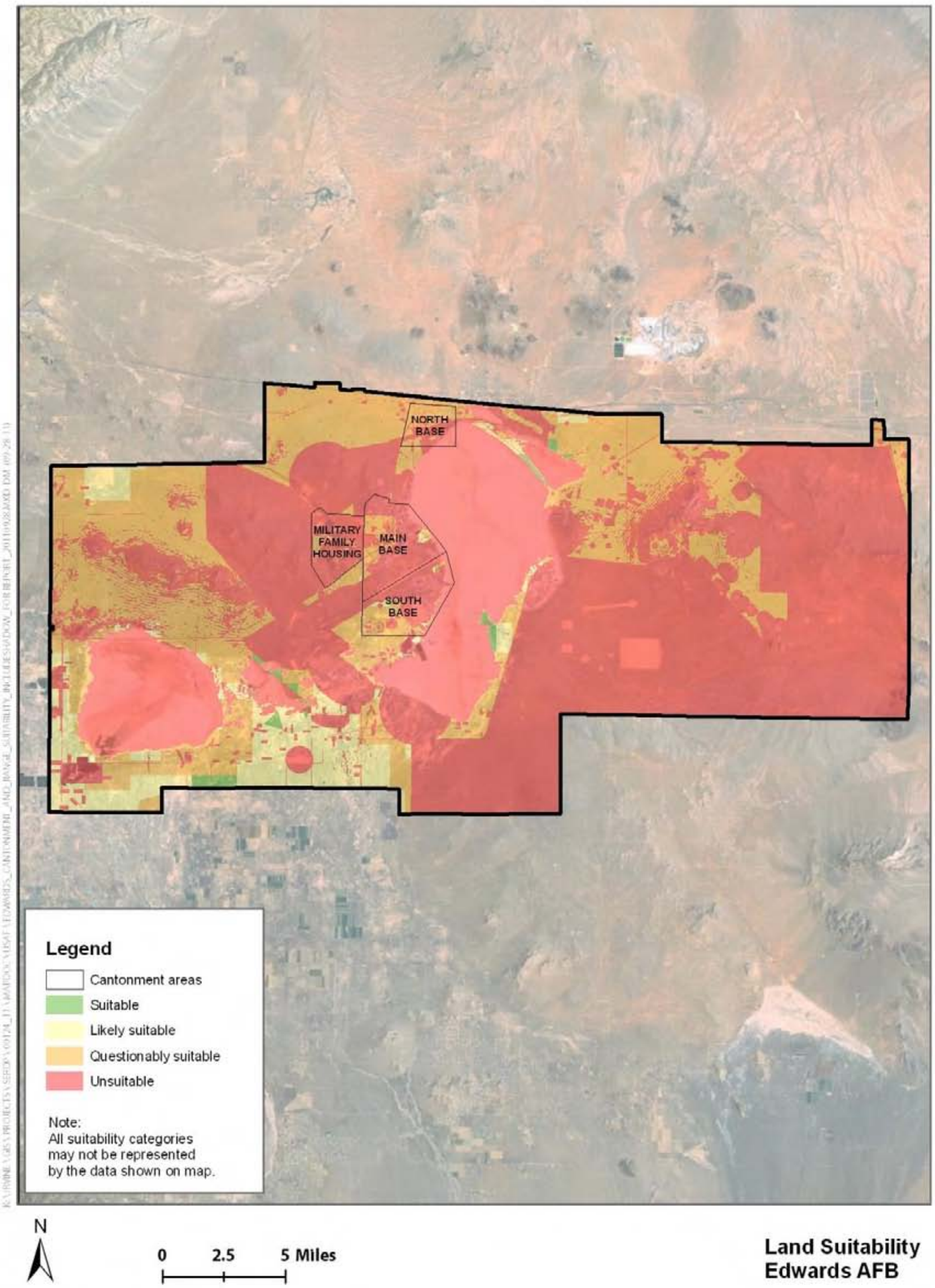


Figure 5.18 – Edwards AFB Land Suitability

The geospatial data used for this analysis was detailed, complete and of excellent quality for this study. This fact allowed for a robust analysis during the modeling phase and also allowed for additional fine tuning of the data during review with installation staff.

Overall, the results of this study suggest that approximately 0.05% (159 acres) of the entire Edwards AFB land area has potentially suitability for solar development on parking shade structures over paved lots, unpaved lots, and building roofs combined. Approximately 30% of the land surface of Edwards AFB has some suitability for solar on ground mount sites.

Table 5.12 – GIS Data Layers Applied at Edwards AFB

Description	Decision Rule	1 = Suitable 2 = Likely Suitable 3 = Questionably Suitable 4 = Unsuitable
Installation Area	All areas were deemed suitable before the application of other constraints	1
Munitions Response Program Area	Farm Drop Zone, PIRA; Jettison Area 1; Jettison Area 2; Small Arm Combat Range areas are unsuitable	4
Building Buffers	Areas within 100’ of any building are unsuitable	4
Parking Areas	Parking lots are unsuitable	4
Driveways	Driveways are unsuitable	4
Road Buffers	Areas within 30’ (60’ total) of the centerline of any paved and unpaved roads are unsuitable	4
Railroad Buffers	Areas within 30’ (60’ total) of the centerline of any railroads are unsuitable	4
Recreation	Athletic courts and fields, campgrounds, day-use areas, golf courses, playgrounds, parks, and swimming pools areas are unsuitable	4
Hunting Areas	All hunting areas are likely suitable	2
Slope	Areas >5% slope are unsuitable	4
Hillside Shading	Areas with shading at 9am or 3pm on Dec. 21, 2015, are unsuitable	4
Master Plan Current Land Use Areas	Airfields, Forest and Wildlife, Navigation and Traffic Aids, Parks and Historic Sites, and Training Land areas are unsuitable	4
Flood Zones	FEMA Special Flood Hazard Areas (SFHAs) ―AE” and ―AO” are questionably suitable	3
Playa (dry lakebeds)	Playa areas are unsuitable	4
Wastewater Treatment	Wastewater sludge, lagoon, and filtration areas are unsuitable	4
Environmental Restoration Site	Environmental Restoration Program (ERP) areas are unsuitable	4
Solid Waste Landfill	Landfills areas (except those listed as ―abandoned”) are unsuitable	4
Explosives Safety Quantity Distance (ESQD) Arcs	ESQD Arc areas are unsuitable	4
Drop Zones	Military Drop Zone areas are unsuitable	4

Table 5.12 – GIS Data Layers Applied at Edwards AFB		
Description	**Decision Rule**	**1 = Suitable 2 = Likely Suitable 3 = Questionably Suitable 4 = Unsuitable**
Firing Range	Firing Range areas are unsuitable	4
Military Range Area	Military Range areas are unsuitable	4
Airfield Surface	Airfield surface areas, including a 1000' buffer area, are unsuitable	4
Safety Buffers within Air Force Research Laboratory (AFRL)	Buffer areas around test facilities within the AFRL are unsuitable	4
Accident Potential Zones (APZs)	ROA Clearance, Lateral Clearance Zone, Clear Zone, and APZ 1 areas are unsuitable	4
Flora Study Area	Flora Study Areas are unsuitable and commonly contain plant species that are deemed locally important to the installation	4
Flora Special Status Species	Flora Special Status Species areas are unsuitable and contain locally sensitive or special status plant species that are considered protected as part of the Integrated Natural Resource Management Plan (INRMP)	4
Plant Communities	Mesquite Tree Woodland areas are unsuitable	4
Plant Communities	Joshua Tree Woodland areas are likely suitable	2
Desert Tortoise Modeled Habitat	Habitat modeling developed by a desert tortoise SME that applies two levels of suitability	2 or 3
Desert Tortoise Critical Habitat Area (DTCHA)	The Freemont-Kramer Desert Tortoise area is likely suitable	2

Fort Irwin Results

The solar potential for Fort Irwin was analyzed for two specific locations: 1) the cantonment area, and 2) the NASA Goldstone Deep Space Communications Complex. The cantonment area at Fort Irwin is the main developed region near the southwestern edge of the military installation just inside the main gate and is surrounded by several operational range areas. The NASA Goldstone facility lies northwest of the cantonment and contains largely undeveloped land that is similar in nature to the adjacent operational ranges. NASA is considered a tenant to the Department of the Army and must manage and administer the lands in accordance with both Army and NASA policies and procedures. For the purposes of this study, the NASA Goldstone facility was treated as ―range area" to conform to this study's two principal land classifications types: cantonment area (e.g., generally developed with infrastructure) or range area (e.g., largely undeveloped).

The principal range areas of Fort Irwin (i.e., the areas used for National Training Center activities) were found to be unsuitable for ground-mounted solar development because of conflicts with mission activities. Refer to the Mission Compatibility chapter for a description of the nature and tempo of mission activities conducted at Fort Irwin.

At Fort Irwin, the inner portion of the cantonment area is occupied by the installation village containing the personnel housing areas, hundreds of administrative and operational buildings and structures, recreational fields, paved and unpaved parking lots and staging areas. This inner cantonment area is generally delineated by the perimeter road that encircles this village.

Four main site types were evaluated within the cantonment area for solar development: 1) shade structures over paved parking lots (generally automotive lots); 2) shade structures over unpaved parking lots (generally heavy and armored vehicle lots); 3) building roofs that had a total developable area > 20,000 square feet; and, 4) ground mount sites on undeveloped land.

Building Rooftop and Parking Lot Sites: A total of 23 buildings met the study's screening criteria and were used to generate the total roof area solar potential of 4 acres. The buildings that met the screening criteria were a mixture of administrative, vehicle maintenance, warehouses, and the installation commissary, to name a few.

A total of 67 paved (i.e., asphalt and concrete) and 35 unpaved (i.e., bare earth) parking lots were considered for shading structure solar potential during this analysis. Solar development could be sited on 121 acres of shade structures over paved parking lots, and an additional 230 acres on shade structures over unpaved parking lots.

Ground Sites: Although some land within the inner village area is undeveloped and could support ground mount solar, it was deemed unsuitable for future development. These areas comprise numerous parcels of undeveloped land that are greater than 5 acres in size between the developed areas. However, the installation Master Planning staff indicated that most of these potential ground mount sites are already earmarked for future development. In some cases, the future development activities planned within this inner village area will include both ground mount and rooftop solar installation. One such example is the planned construction of a new hospital which will employ both roof and ground mount solar systems.

Additional areas adjacent to this inner village area were also deemed unsuitable due to future development as specified by the master planning office. This includes future installation build-out areas extending south of the main village, waste water treatment areas, and other operational build out areas. An additional feature within the cantonment that was deemed unsuitable is a military ground transport route that connects a staging area near the main village to the ranges located just outside the main gate area to the southwest. This transport route was buffered on either side of this road in order to avoid mission conflict with the movement of heavy and armored vehicles between the inner cantonment the southwest range and maneuver areas.

Figure 5.19 illustrates the suitable (illustrated in green) and unsuitable (illustrated in red) areas for ground mount solar development within the cantonment area. The geospatial modeling used over 16 individual GIS mapping layers and screening criteria during the suitability analysis for ground mount solar. A total of 5,757 acres within the entire cantonment area was deemed suitable for solar development. The primary areas with potential suitability for ground mount solar include the large area between the main gate and the inner village as well as some lands on the eastern and western edge of cantonment area.

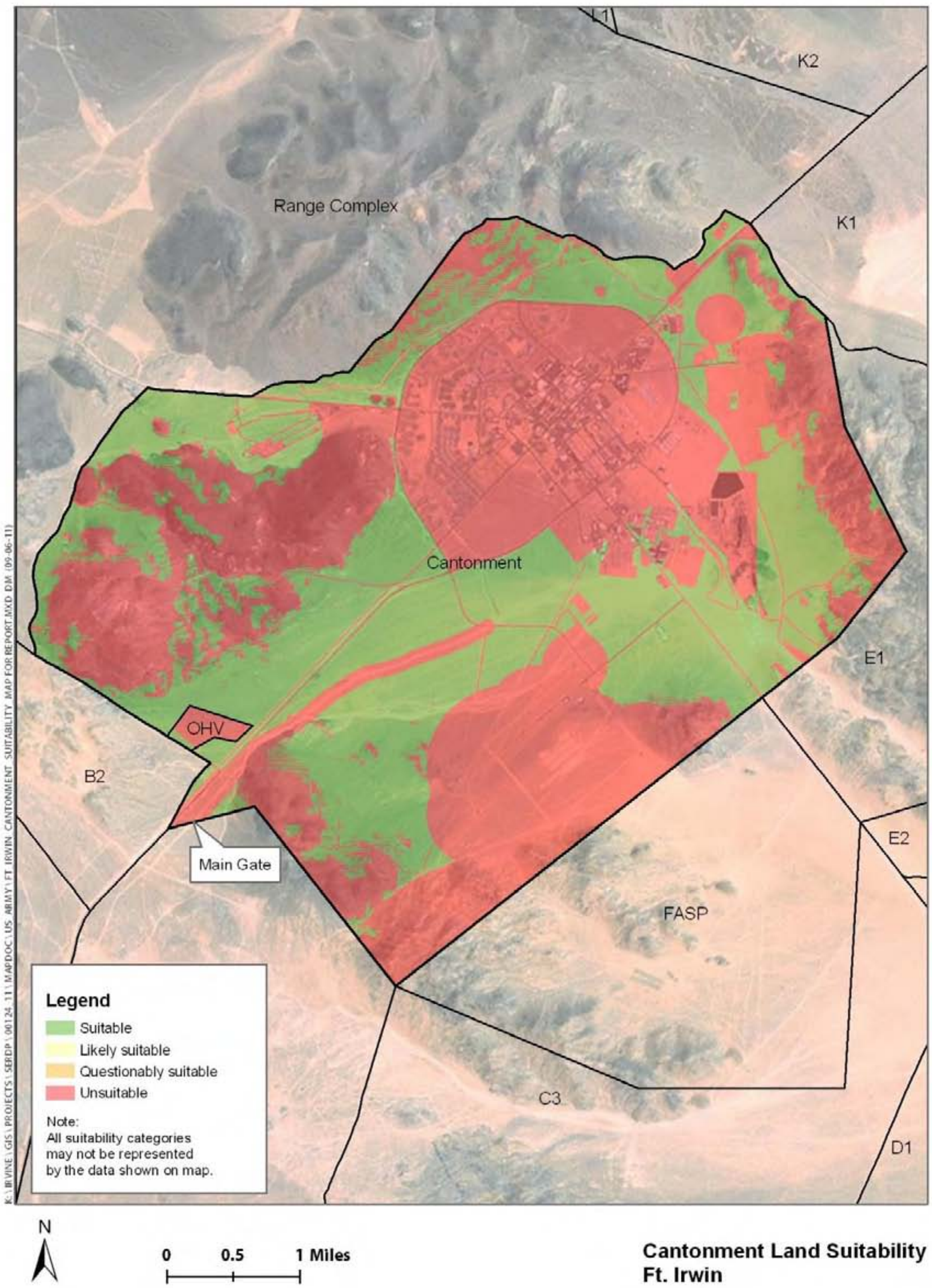


Figure 5.19 – Fort Irwin Cantonment Land Suitability

Table 5.13 – GIS Data Layers Applied at Fort Irwin Cantonment		
Description	**Decision Rule**	**1 = Suitable 2 = Likely Suitable 3 = Questionably Suitable 4 = Unsuitable**
Cantonment Area	All areas were deemed suitable prior to the application of other constraints	1
Building Buffers	Areas within 100' of any building are unsuitable	4
Parking Areas	Parking lots are unsuitable	4
Slab Areas	Slab Areas are unsuitable	4
Road Buffers	Areas within 30' (60' total) of the centerline of any paved and unpaved roads are unsuitable	4
Villages	Areas within the RCI village are unsuitable; these residential units are privately-owned	4
Future Zoning	Future Zoning areas for Troops and Residential are unsuitable	4
Slope	Areas >5% slope are unsuitable	4
Recreation	Athletic courts and fields, bleachers, golf courses, playgrounds, recreation parks, miscellaneous recreation, and swimming pool areas are unsuitable	4
Environmental Cleanup Site	Environmental Cleanup areas are unsuitable	4
Landfills	Solid Waste Landfill areas are unsuitable	4
Wastewater Treatment	Wastewater sludge, lagoon, and filtration areas are unsuitable	4
Ammunition Storage	Ammunition Storage areas are unsuitable	4
Military Restricted Access Areas	Military Restricted Access areas are unsuitable	4
Military Exercise Service Road	Areas within 300' (600' total) of the centerline of the Military Exercise Service Road that parallels main entrance road are unsuitable	4
Future Land Use Areas	Three areas delineated by installation's Department of Public Works are reserved for future land use and are unsuitable	4

A total of 715,147 acres was deemed unsuitable for solar development at Fort Irwin, the vast majority of which was on the ranges. Within the cantonment, a significant portion of the western side is unsuitable due to the hilly terrain where the slope exceeds 5%. Also a significant portion of the southeastern side of the cantonment is unsuitable due to the safety buffer zone around a large Ammunition Storage Point (ASP). Within the cantonment area the primary environmental and geographic factors that were deemed unsuitable were the environmental clean-up sites and the areas with a slope exceeding 5%. Although natural and cultural resources constraints were evaluated during the suitability modeling discussion with the military installation, no areas within the cantonment were identified with these characteristics and, therefore, they could not be formally applied to the GIS modeling analysis. In summary, the most significant contiguous area deemed suitable for ground-mounted solar was the area between the main gate and the inner village area.

Fort Irwin Range Site: NASA Goldstone Results

As previously noted, the NASA Goldstone facility was analyzed as a range area, which is the fifth and final site type that is considered as part of this study. Figure 5.19 illustrates the suitable (illustrated in green), likely suitable (illustrated in yellow), questionably suitable (illustrated in orange), and unsuitable (illustrated in red) areas for ground mount solar development within the NASA Goldstone facility.

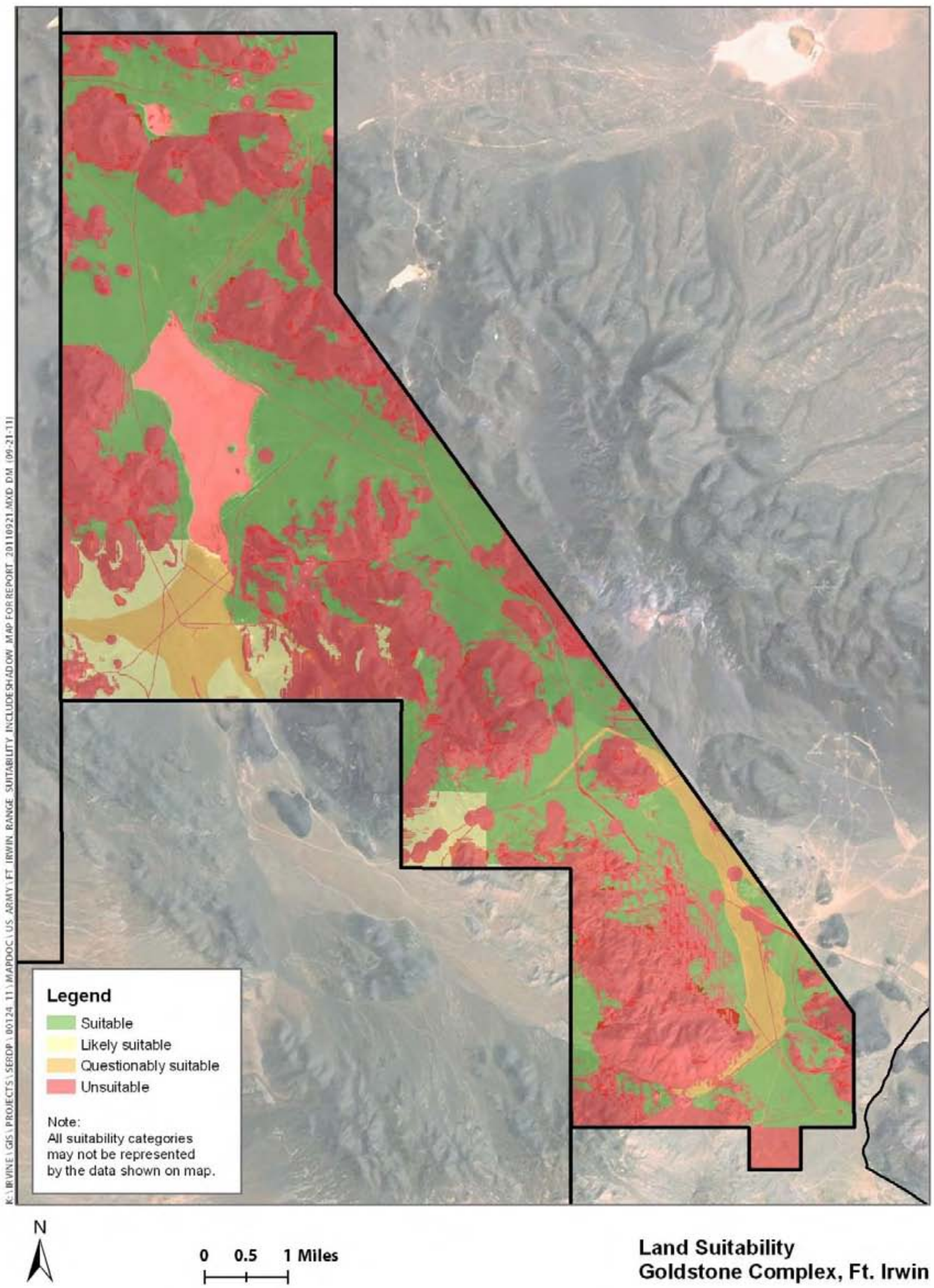


Figure 5.20 – NASA Goldstone Range at Fort Irwin Land Suitability

The geospatial modeling for Goldstone used over 18 individual GIS mapping layers and screening criteria during the suitability analysis for ground-mounted solar. A total of 12,091 acres within the entire Goldstone facility was deemed suitable for solar development, 1,673 were likely suitable, and 1,846 were questionably suitable. The likely and questionably suitable areas generally occur along both sides of the road that extends from the southeast facility entrance point towards the northwest border of the facility.

In contrast, sites deemed unsuitable comprised a total of 17,620 acres primarily in the central and northern regions of the facility. A primary driver for the unsuitability is the steep and mountainous terrain that exceeds 5% slope. In addition, environmental data was assessed in the GIS suitability modeling which included several biological geospatial mapping layers. This geospatial data included flora special species management areas, potentially sensitive flora and fauna species areas, and Federal wildlife management areas; these indicators rendered some areas unsuitable.

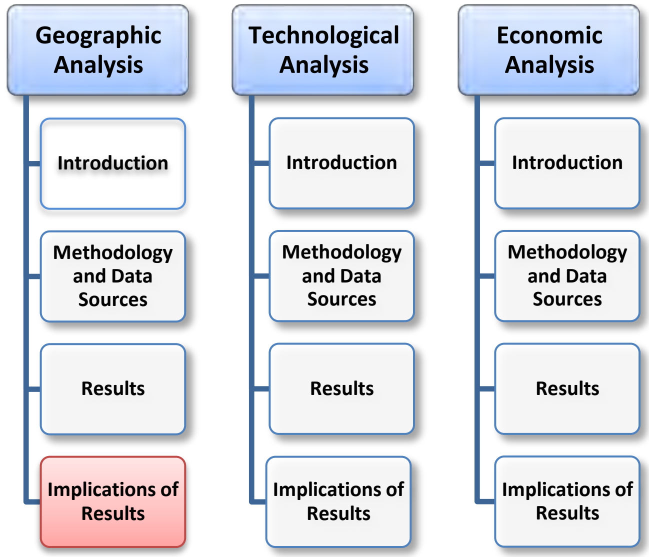
Approximately 47% of the land surface of the NASA Goldstone facility has some suitability for ground-mounted solar.

Table 5.14 – GIS Data Layers Applied at NASA Goldstone Range at Fort Irwin

Description	Decision Rule	1 = Suitable 2 = Likely Suitable 3 = Questionably Suitable 4 = Unsuitable
Goldstone Range Area	All areas deemed suitable prior to the application of other constraints	1
Slope	Areas >5% slope are unsuitable	4
Hillside Shading	Areas with shading at 9am or 3pm on Dec. 21, 2015, are unsuitable	4
Road Buffers	Areas within 30' (60' total) of the centerline of any paved and unpaved roads are unsuitable	4
Building Buffers	Areas within 100' of any building are unsuitable	4
Flood Zones	Flood Zone Wash Areas are unsuitable	4
Playas	Playa Areas are unsuitable	4
Impact Areas	Impact Areas are unsuitable	4
Goldstone Antennas	Areas within 500' of NASA Goldstone Deep Space Antennas are unsuitable	4
Flora Special Species Management Area	Flora Special Species areas are unsuitable and contain locally sensitive or special status plant species that are considered protected as part of the Integrated Natural Resource Management Plan (INRMP)	4
Flora Species Population	Flora Species areas are unsuitable and commonly contain plant species that are deemed locally important to the installation	4
Fauna Special Species	Fauna Special Species areas are unsuitable	4
Wildlife Management Areas	Wildlife Management areas are unsuitable	4
Mohave Ground Squirrel	Mohave Ground Squirrel areas that are shown to be extinct, unknown, or unclassified are suitable	1
Mohave Ground Squirrel	Mohave Ground Squirrel areas that are shown to be present in relatively low density (from field surveys and recent studies) are likely suitable. (―Density" is defined by installation-provided biologic information).	2
Mohave Ground Squirrel	Mohave Ground Squirrel areas that are shown to be core areas (from field surveys and recent studies) are unsuitable (―Core" areas are those with routine occurrence of the Mohave ground squirrel).	4
Cultural Survey Areas	Areas within 500' of point locations listed as positive for a cultural resources concern are unsuitable	4
Wetlands	Wetlands areas are unsuitable	4

5.5 Implications of Results

The key implications of the solar potential analysis can be grouped into several categories:



1. Large portions of the ranges at many military installations were found to be ―unsuitable" due to potential conflicts between solar development and military mission activities. This reduced the acreage available for solar development.
2. The GIS modeling results indicated that solar development potential exists within or around nearly all military installation cantonment areas, and the cantonment areas alone can offer significant acreage suitable for solar projects even before considering the installation ranges.
3. These results will require additional field validation prior to commitment to the solar development process.
4. Rooftop installations are familiar and are seen by many people, but ground sites offer the vast majority of the acreage available for solar development.

Each of these implications is described in greater detail below.

Implication #1: The ranges of most military installations are "unsuitable" for solar development.

Across all military installations evaluated in this study, the open range land initially offered great potential for solar development purposes. However, during the briefings and subsequent meetings and data analysis with Fort Irwin, MCAGCC Twentynine Palms, MCLB Barstow, NAWS China Lake,[20] and MCAS Yuma on behalf of Chocolate Mtn. AGR much or all of the range areas were found to be unsuitable for large-scale solar development, chiefly because of mission compatibility conflicts. For these military installations, the various combinations of training and readiness, test and evaluation, and military security negated any potential for large-scale solar development potential on the ranges. For NAF El Centro there was a significant lack of both operational and environmental geospatial data that ultimately resulted in the range areas being found unsuitable for solar projects. It is still possible that some edges and corners of the various ranges (R2510 and R2512) at NAF El Centro could be used for smaller-scale solar development if appropriate additional data became available for analysis.

---

[20] NAWS China Lake and NAVAIR staff ruled out the vast majority of the north range as unsuitable for solar primarily because of mission conflicts but not its entirety. The results of this study do consider some of the southernmost areas of the northern range area. The entire south range at NAWS China Lake was determined to be unsuitable.

For Edwards AFB, and for the NASA Goldstone Complex at Fort Irwin, larger portions of the ranges were free of obvious mission conflicts. The results from Edwards AFB, and to a lesser extent NAWS China Lake and Chocolate Mountain AGR, indicate that certain ranges may have areas that could be suitable for solar development while maintaining mission function.

An interesting aspect of the range analyses that were conducted as part of this study relates to the concept of “edges and corners”. The study team focused on edges and corners of the ranges with the goal of identifying areas that would have minimal or no mission conflict. The edges and corners contained suitable acreage at several installations. However, at Fort Irwin, the edges and corners of the NTC range were considered unsuitable due to their status as desert tortoise protection areas with the possible exception of the Red Pass Lake area. Thus, range areas may not always have non-operational edges and corners that are suitable for solar development.

Implication #2: Solar development potential exists within or around nearly all installation cantonment areas.

Six of the seven military installations contain a centralized cantonment area where solar potential was generally found to be technically feasible. Vacant land area around buildings that is either un-zoned or unoccupied occur on essentially every military installation except Chocolate Mtn. AGR, which has no defined cantonment, and these areas vary in size from relatively small parcels of land at NAF El Centro and MCLB Barstow to much larger areas at Fort Irwin and NAWS China Lake. In addition to vacant land, roof top and parking shade structures were also found to be common features that could also be considered for solar development. Similar to the ground mount sites, the area available in the rooftop and parking categories also ranged from low to quite abundant. The rooftop area potential at MCLB Barstow is impressive given the military installation’s relatively small size.

Implication #3: These results will require additional field validation prior to commitment to the solar development process.

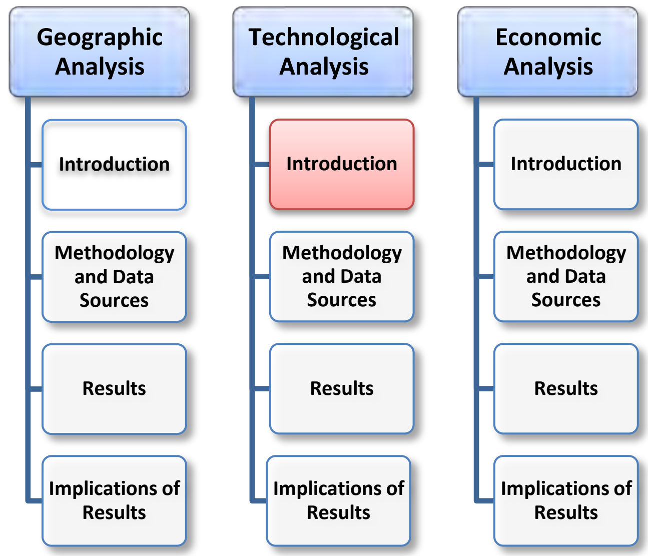
The GIS data available to the study team varied in terms of completeness and quality. Even sites deemed suitable as part of this study could be incompatible because of unknown or undocumented land development plans. Furthermore, since some military installations did not have complete data, and other data were not made available, the results presented here need additional verification prior to commitment to any solar development project. Finally, although this analysis included several on-site visits and the use of Google Earth imagery and other means to identify and evaluate surface features, ground truthing is necessary to fully advance a project from the planning to the development phase.

Implication #4: Rooftop installations are familiar and are seen by many people, but ground sites offer the vast majority of the acreage available for solar development.

As shown in Table 5.6, the appropriate rooftops and parking lot shading structures across the seven military installations offer hundreds of acres of technically suitable area for solar development. Potential ground mount sites, however, are measured in the tens of thousands of acres. This 100:1 ratio suggests that the installations and the Services should be focusing on ground mount sites as the site type with the largest aggregate potential (and the lowest cost and greatest profitability, as will be discussed in later sections of this chapter).

5.6 Solar Technology Analysis

5.6.1 Introduction

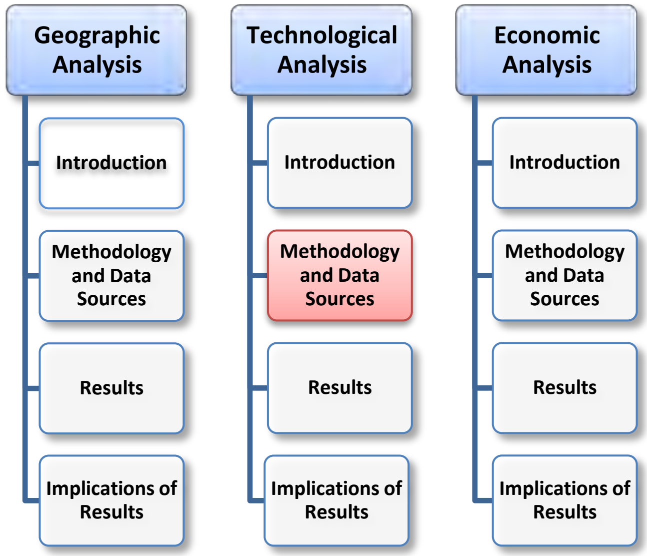


A key objective of this study was to assess the solar energy potential for seven major military installations located in the Mojave and Colorado Deserts in California. The second step in the analytical sequence takes the suitable, likely suitable, and questionably suitable sites for solar development identified through the Geographic Analysis described in the prior section and configures appropriate solar installations on those sites. It configures the solar equipment, space utilization, angle towards the Sun, and other factors separately for roof, parking, and ground-mounted solar projects and for the different solar technologies considered in this study. These factors drive the solar peak capacity and hourly solar electricity output for each combination of military installation, site type and solar technology evaluated in this study. The solar electricity capacity and output information computed during this process defines the **technical potential,** that is**,** the maximum solar development possible on suitable, likely suitable, and questionably suitable sites expressed in kW of capacity and kWh of annual energy production As will be discussed in greater detail in the Economic Analysis section, not all of the technical potential is financially viable; the financially-viable subset constitutes the **economic potential**.

The remainder of this section addresses the following aspects of the Solar Technology Analysis:

- Solar Technologies Applied
- Configuration of Solar Projects on Suitable Military Installation Sites
- Solar Electricity Output Calculations
- Summary of Results: Technical Potential for Solar on Military Installations
- Implications of Results

5.6.2 Methodology



5.6.2.1 Solar Technologies Applied in Study

This study applied six separate solar technology packages:

- Crystalline-silicon PV fixed-axis
- Thin-film PV fixed-axis
- Crystalline silicon PV single-axis tracking
- Thin-film PV single-axis tracking
- CSP Dish/Stirling
- CSP Trough.

Additional information about each solar technology may be found in the Solar Technology Characterization chapter.

Some technology packages are more appropriate than others in specific situations, depending on the site type. A matrix showing which technologies were applied to each site type and size is below in Table 5.15. That matrix reflects pairings of technologies to site types that are assumed to be the most technically and commercially reasonable in the year 2015 (the reference year for solar projects in this study).

Table 5.15 – Solar Technology Package Size Minimums Applied to Each Site Type

Solar Technology	Building Roof	Parking Shading Structures	Ground Mounted
Crystalline-Silicon PV Fixed-Axis	20,000 square feet (~ ½ acre)	40,000 square feet (~ 1 acre)	5 acres in cantonment; 50 acres on ranges[21]
Thin-Film PV Fixed-Axis	20,000 square feet (~ ½ acre)	N/A	7 acres in cantonment; 70 acres on ranges
Crystalline-Silicon PV Single-Axis Tracking	N/A	N/A	60 acres
Thin-Film PV Single-Axis Tracking	N/A	N/A	100 acres
CSP Dish/Stirling	N/A	N/A	140 acres
CSP Trough (dry system)	N/A	N/A	500 acres

[21] The minimum size for installations on cantonment and range sites reflect that five acre (1 MW) systems are the smallest commercially-feasible minimum size when developed near installation electrical infrastructure but range sites are much better suited for utility-scale developments (50 acre/10 MW) because of the typically higher costs (e.g., additional transmission, environmental compliance) and lower revenues (wholesale electricity rates) associated with range sites. However, because no suitable range sites were between 5 and 50 acres, this limitation had no practical implications on the analysis.

5.6.2.2 Solar PV

Solar PV is the most common solar technology used today and is applied in residential, small and large commercial, and utility-scale installations. The modularity of the systems allows greater flexibility in design and installation. PV technology and has already been used on a number of military installations as described in Appendix A to this report. For this analysis, two PV technologies were evaluated: crystalline-silicon and thin- film. Both PV technologies were evaluated without any supplemental energy storage (e.g., batteries).

Crystalline-silicon PV technology is more widely used than thin-film. It is available from multiple manufacturers, and has a higher rated capacity and greater energy production per unit area than thin film, which makes this technology more appealing in many scenarios. Crystalline-silicon module prices tend to be higher than those of thin-film modules, but the entire system costs can be very similar.[22]

Thin-film PV technology is most commonly found in large-scale PV installations but is also used in other types of installations (e.g., roofs). The power density for these products is significantly less (~ 40%) than for crystalline-silicon modules, therefore thin-film products require substantially more area to offer equal power values. In scenarios where there is ample and inexpensive land available, this may not be a significant disadvantage.

Both PV technologies were considered using tracking and fixed **racking systems**. A tracking system pivots the PV array along an axis to follow the sun's apparent path through the sky each day. A fixed mount keeps the array in a stationary position. Only fixed racking systems were considered for rooftop arrays as tracking systems on rooftops are difficult to install and maintain. A tracking system will increase the energy yield from a solar array compared with a fixed-mounted system, but it will add capital and operation and maintenance (O&M) costs to the system as a whole. All fixed ground mounts in this study were assumed to use a module tilt angle of 20° from the horizontal to maximize the ratio of energy produced to land area used. Tracking arrays were assumed to track the sun along a single axis.

5.6.2.3 Concentrating Solar Power

CSP was the other category of solar technology evaluated. There are three principal types of CSP in use today, but for this study, only two – Dish/Stirling Engine and parabolic trough -- were evaluated, and they were only applied to large ground sites. In both cases, the systems were configured without energy storage.

Using a two-axis tracker to follow the sun's apparent path, Dish/Stirling system uses a parabolic dish reflector to concentrate the Sun's energy on a focal point, where the focused energy is used to drive a heat engine. The commercially available **Dish/Stirling** systems are typically 25 kW per dish, and individual units are placed together to form a large array. These projects are most applicable for large-scale, utility sized projects. Therefore this study only considered Dish/Stirling applications for large-scale, ground-mounted projects.

---

[22] Table 5.25, Table 5.26, and Table 5.27 in the Economic Analysis section of this chapter describe the cost components applied in the study for each solar technology-site type combination.

Parabolic trough systems are applicable for utility scale projects and were only considered on areas with large land areas available. Due to the scarcity and cost of long-term water resources on the desert military installations, this analysis assumed the use of a “dry” trough system, which uses far less water than “wet” trough systems and relies on air and other mechanisms for its primary system cooling.

The study did not apply a third CSP technology – power tower – which uses a field of mirrors surrounding a central tower to concentrate the Sun’s energy. Because these towers can be hundreds of feet tall and are likely to pose a range of mission conflicts, they do not appear viable on the military installations addressed in this study. CPV technology was also not evaluated in the study due to its lack of widespread application.[23]

5.6.3 Configuration of Solar Installations

To begin the technology analysis for each military installation in this study, a set of fundamental criteria were established for all solar installations. The solar installations were first characterized by the site type: rooftops within cantonment areas, shading structures above parking lots within cantonment, ground mounts within cantonment and ground mounts in range areas. The requirements for each site type outlined here were made in addition to the GIS criteria discussed in the previous section. These criteria were established to ensure that only sites appropriate for solar development were modeled.

Rooftop Site & Project Considerations

Minimum Roof Area: Solar developers evaluating the potential to install solar technology at a large military installation will typically focus on larger-scale sub-projects within the overall program at the military installation. To reflect this reality, the analysis required that any building being evaluated for a rooftop solar installation have a minimum roof area of 20,000 ft^2, which would accommodate an approximate 200 kW_{DC} crystalline-silicon PV array. This was done to establish a minimum PV array size that would consistently make economic sense and be attractive to larger-scale solar developers. To determine whether a building met this criterion, it was first assumed that the building’s roof area (data not provided to the study team) was equal to the building’s ground footprint (data which were provided to the study team). This initial roof area was reduced by six feet along the entire perimeter to represent required setbacks from building edges during the solar array installation. The resulting area, equal to the building footprint minus the six foot setback, was used to determine if the building met the required 20,000 ft^2 requirement.

The roof size minimum had the effect of eliminating the vast majority of installation structures from further consideration; taking Fort Irwin as an example, of the 1,152 distinct “non-home” structures represented in the building inventory GIS layer, only 23 (2%) survived the application of this criterion. However, this 2% of structures represented 24% of the total building footprint at Fort Irwin, indicating that a large proportion of the rooftop solar development opportunity is atop a small minority of the military installation buildings.

---

[23] CSP Power Tower technology is described in the Solar Technology Characterization section in this report.

Rooftop Restrictions: After the buildings were sorted by size and the smaller buildings were eliminated, the remaining roof area was reduced to reflect the many factors that limit solar development on actual rooftops: some space is typically unavailable due to shading; other space is unavailable due to roof penetrations and obstructions (HVAC units, elevators, etc.); a building's roof pitch may be too steep (or too curved) for solar installation; and a building may be oriented with a poor southern exposure. In the absence of actual data for these factors for each building, the study team applied percentage reduction factors to the building rooftop area, based on estimates from the team's inspection of selected buildings and aerial imagery for Fort Irwin and MCAGCC Twentynine Palms. Because the building stocks at the military installations appeared quite similar, the study team applied these results to the cantonment areas of all of the military installations. As a further check, the team evaluated Edwards AFB, which, despite a greater degree of curvature on some roofs, also had quite similar aggregate solar-readiness of its roofs based on satellite image inspection.

The roof areas that remained after the 20,000 ft^2 cut-off were reduced by a total of 39% to account for the different roof obstructions and features:

- Rooftop obstructions (HVAC, elevator penthouses, etc.) - 4%
- Rooftop geometry - 4%
- Rooftop pitch and orientation - 26%
- Mechanical screens - 1%
- Structural integrity of building - 4%

This estimate resulted in an amount of roof area that can be considered available for PV installations.

Area Reduction for Roof Maintenance and Replacement: In general, it does not make technical or economic sense to install a solar system on a roof that will need replacement before the end of the solar system's lifetime. PV systems can have useful lives of over 20 years, and removing and then replacing an intact solar system if the roof needs to be replaced creates unnecessary costs (system removal, storage, re-installation, as well as the opportunity cost of lost solar output).

Roof replacement and maintenance schedules were requested for each military installation, but those data were largely unavailable. In the absence of specific data, the study assumed a 30-year average roof life. This means that, at any point in time, one-third of the military installation roofs will have 20+ years of useful life remaining. Thus, at any given time, only one-third of suitable building roofs, after all other exclusions discussed above, would be able to accommodate a 20-year-lifetime solar system without an intervening roof replacement. Because this study attempts to estimate the technical and economic potential for solar assuming that all projects are undertaken in 2015, the total rooftop solar capacity reported per military installation reflects this rooftop maintenance reduction (i.e., only one third of the otherwise suitable roof area), and thus understates the solar technical potential over a longer time horizon. Over a span of 20-30 years, all otherwise-suitable roofs should be available to host solar projects, and can be scheduled into the installation’s roof replacement schedule. The DoD’s initiative to encourage all replacement roofs to be solar-ready and individual Service-level policies mandating that ―green”, ―white” or solar roofs be installed during roof replacements should facilitate this outcome.

In summary, only a small percentage of each military installation’s buildings was deemed suitable for solar development, and of those, only a small fraction of their collective roof area survived the two reduction steps (rooftop restrictions and area reduction for roof replacement) discussed above. Once this ―developable area” was established, the study team moved to the next step, designing PV arrays that would fit.

Rooftop PV Array Layout: Both crystalline-silicon and thin-film modules were drawn in Auto CAD at a 10° tilt. This resulted in specific array configurations and power density value (W/ft^2) per PV technology. These technology specific array configurations were then used in conjunction with the rooftop data discussed above to determine the technical potential for rooftop solar capacity at each military installation.

Based on the technology-specific inputs discussed above and the PV array layout assumptions, the following power densities were calculated:

- 10.01 W_{DC}/ft^2 for crystalline-silicon installations
- 6.24 W_{DC}/ft^2 for thin-film installations

To determine the solar capacity for the cantonment roofs, ICF first aggregated the total roof area for all suitable roofs on each military installation. That value was reduced by 39% to account for roof areas unavailable due to roof top obstructions, shading, orientation and pitch. Then, one third of that value was taken as the estimated amount of rooftop area that will be available for solar installations in 2015 without a roof replacement scheduled within 20 years. This roof area was then multiplied by the appropriate power density value to determine the total PV technical potential, in MW, for each military installation.

As an example, the aggregate roof area (after accounting for six foot setbacks) for large buildings within the Fort Irwin cantonment is 782,522 ft^2. To obtain the final rooftop array potential the following factors, as described above, were used:

- 782,522 ft^2 x 61% = 477,388 ft^2
- 477,388 ft^2 x 33% = 159,113 ft^2
- 159,113 ft^2 x 10.01 W/ft^2 for crystalline silicon = 1592.7 kW = 1.59 MW_{DC} of technical potential for crystalline silicon

Parking Site and Project Considerations

Paved and unpaved parking areas were considered for crystalline-silicon PV shading structure installations. These are structures elevated above parking areas, acting as both a shade structure as well as an energy producing structure. Only crystalline-silicon PV was modeled to maximize energy production and minimize the size of the structure. Thin-film was not considered based on the additional area required for equivalent energy values. The study included separate analysis of both paved (standard 9' vehicle clearance) and unpaved parking areas (14' vehicle clearance). The two kinds of parking areas were treated in this technical analysis step, but had different installation cost values associated with them in the subsequent economic analysis step. For both types of parking areas, the solar array was modeled to cover half of the parking lot. This allows for driving lanes as well as a perimeter around the entire lot. The array was then reduced by another half to account for expected (but undocumented) difficulties with solar suitability and the potential for re-deployment of some parking areas for other purposes over the study's 2015-2034 timeframe.

Parking PV Array Layout: The parking areas within cantonment were evaluated in a fashion very similar to the cantonment rooftops. To determine the array configuration, a typical parking canopy design at a vehicle clearance height of 9 feet for paved parking and 14 feet for unpaved parking (to allow for taller military vehicles, as high as tractor-trailers) was evaluated. The array tilt angle was assumed at 7° and the array coverage of the parking area was approximately 50%.[24] This resulted in an array power density of 7.14 W/ft^2.

When available, the parking areas were categorized as paved and unpaved. The minimum parking area considered was 40,000 ft^2 and all the parking areas were aggregated. The aggregate area was then multiplied by the array power density value, and divided by 50% to account for general facility unavailability, to determine the total PV technical potential for the paved and unpaved parking areas.

Ground Site and Project Considerations

Ground mounted solar installations were considered for both cantonment and range areas for each military installation where suitable, likely suitable, and questionably suitable sites[25] survived the GIS screening process. A number of criteria were established to help clearly define locations appropriate for solar installations.

Area: The minimum site acreage values used for solar projects were as outlined above in Table 5.15. As with rooftop installations, it makes economic sense to focus on larger project opportunities within each military installation.

Minimum Dimensions: In addition to the minimum size of 5 acres, a minimum plot dimension of at least 200 feet on all sides was also established. This was done to eliminate oddly-shaped parcels that have dimensions that would not allow for a productive solar installation. (Contrast the construction and operational challenges between, for example, a perfectly square 10 acre parcel – 660 feet on a side -- with a 10 acre parcel that is one mile long but only 82.5 feet wide.) Within the cantonment, another minimum dimension was established, a minimum distance from

[24] These values for parking installations were obtained from analyzing the layout of solar canopy projects and discussion with solar parking experts.

[25] ―Suitable" sites are those surviving the study's GIS with a suitability rating of 1 and no conflicts for solar development. ―Likely suitable" and ―questionably suitable" sites have at least one conflict for solar development, but a conflict that is not prohibitive. ―Likely suitable" and ―questionably suitable" sites have GIS suitability ratings of 2 and 3, respectively, and some percentage of them should be ultimately suitable for solar development with further investigation and/or modest mitigation of the conflicting factor. ―Unsuitable" areas have a suitability rating of 4. The suitability ratings on ground sites are explained at length in the prior section of this chapter.

buildings of 100 feet. This was done to ensure that the solar installation would not interfere with building operations and to keep the solar installation out of the shadow of nearby buildings.

Slope: A maximum slope of 5% was also established to minimize the cost associated with grading and other major construction costs to make the site suitable for solar. This also allowed for the consideration of ground ballast racking, where the solar installation, particularly PV, is held in place by concrete weight, reducing and potentially eliminating the installation of permanent posts and associated penetration of the desert ground that could have adverse habitat consequences.

A number of other GIS screening factors for biological, cultural, environmental, flood zone, recreational, military mission and operational, built infrastructure, land use planning, and other issues were applied installation-by-installation to potential ground sites, and are described in the GIS section above.

Solar Field Layout: As with the rooftop and parking arrays, Auto CAD drawings were utilized to model the solar plants' physical sizes at the military installation locations. The array tilt angle was assumed at 20° for the fixed-axis systems. Once the ground area criteria for each military installation identified and the minimum acreage values were applied as shown in Table 5.15, each of the technologies was assigned a power per unit area to establish the potential solar plant size at each military installation. The following power density values were used in the study:

- Crystalline-silicon PV fixed racking, 238 kW_{DC}/acre (~ 201 kW_{AC}/acre)
- Crystalline-silicon PV tracking, 169 kW_{DC}/acre (~ 140 kW_{AC}/acre)
- Thin-film PV fixed racking, 148 kW_{DC}/acre (~ 125 kW_{AC}/acre)
- Thin-film PV tracking, 106 kW_{DC}/acre (~ 88 kW_{AC}/acre)
- Dish/Stirling, 161.29 kW_{AC}/acre
- Concentrating trough, 100 kW_{AC}/acre

5.6.4 Solar Electricity Output Calculations for PV Systems

The electricity outputs for all of the solar technologies considered in this report were modeled in the System Advisor Model (SAM), a renewable energy software program available from the National Renewable Energy Laboratory (NREL) (NREL, 2011). This program allows the user to model a variety of solar technologies using local weather files and specific equipment. SAM also requires the user to input certain installation- and site-specific parameters. The information below outlines the values used within the SAM modeling program for this study.

NREL Systems Advisor Model (SAM) Calculations – PV Systems
All PV arrays were modeled using the same basic principles in SAM. The PV modules used in the model are both representative samples from their respective technologies as well as being products manufactured in the US. Table 5.16 shows the products chosen for each of the PV models.

Table 5.16 – Solar Product Selections for Study			
Solar Technology Component	**Manufacturer**	**Model**	**Rating**
Crystalline-Silicon Modules	Sharp	NUU240F1	240W
Thin-Film Modules	Abound Solar	AB1-65-B	66W
Inverter - rooftop arrays	Satcon	PVS-100	100 kW
Inverter - parking arrays	Satcon	PVS-250	250 kW
Inverter - ground mount arrays	Satcon	PVS-1000 MVT	1,000 kW
Fixed Racking	Schletter	PV Max	
Single-Axis Tracking	Array Technologies	DuraTrack	

The inverters chosen for the modeling were also U.S. manufactured. In addition, the inverters used in each simulation were chosen based on the assumed capacity that would actually be installed. For example, for the cantonment rooftop model, inverters with a capacity of 100 kW were modeled since it is reasonable to assume that a similar sized inverter would be used at each location. At the time of the study, there is not a good industry selection for 200kW inverters. In addition, for the roof sizes used in this study, multiple100kW inverters could be utilized on even the smallest roofs. However, using multiple 100 kW inverters results in lower annual energy production compared with fewer larger inverters.

5.6.5 Array Size based on Given Area and Assumed Array Layout

For each simulation, an estimated array size was input into SAM as the starting point. This power value was calculated for each array location as outlined above.

5.6.6 Array Tilt and Orientation

The tilt angle of the PV array from the horizontal has an impact on space usage and on energy production values. For the purpose of this study, for each site type, a tilt angle was chosen to maximize both the energy production of the array as well as maximizing the use of the available area. This resulted in the following tilt angles:

- Rooftop - 10°
- Parking structures - 7°
- Ground fixed mounts - 20°
- Ground tracking mounts - 0°

The azimuth or the orientation of the array with respect to south is also a consideration for energy production. The steeper the tilt angle, the more critical the azimuth angle becomes. All the azimuth angles were modeled at true south.

5.6.7 Input Derates

SAM also accounts for a number of system deratings. PV modules' reported outputs are given for laboratory conditions. The expected module outputs are reduced within the modeling program to accurately represent the true power output values. Other unavoidable losses occur within the system due to losses across conductors and the because of the inefficiency of transformers and associated electrical equipment. SAM uses algorithms based on weather data and field data to estimate the PV arrays' power output to the utility. The following derating values were used consistently for this study:

Pre-inverter derate = 87.12% for fixed mounts and 85.38% for tracking systems
This pre-inverter value includes losses and inefficiencies from the PV array to the inverter including wiring losses, the mismatch effect between modules and the module manufacturers' rated power tolerance. The pre-inverter derate differs between fixed mounts and tracking systems because of the small amount of time a tracking system is not actually pointing the PV array directly at the sun. This amount of time can vary based on tracking manufacturer but is relatively low universally.

Post inverter derate = 97.02%
This value represents the losses associated with the transmission of the AC power from the inverter to the utility and includes losses from transformers and AC wiring. SAM takes into account actual inverter efficiency values when calculating energy output values from the array.

The result of these two input derates immediately reduces the PV array's AC output to 84.5% of the rated value for fixed-mount systems, for example:

1. 1,000 kW (rated PV system) x 0.8712 (pre-inverter) x 0.9702 (post-inverter) = 845.2 kW

5.6.8 Shading

The losses due to shading were assumed to be negligible given the site locations in the deserts and the generally low-rise nature of most military installation buildings. The available rooftop area was already reduced to account for potential shading from rooftop-located obstructions. Ground mount locations within the cantonment were required to be at least 100 feet from the nearest building. All potential ground-mount locations – within the cantonments and on the ranges on the five California military installation [26] with hilly terrain-- were evaluated for shading from nearby hills, ridges and mountains using the shading analysis module within ESRI ArcGIS. Sites needed to be shade-free at both 9 am and 3 pm on December 21, 2015, in order to be further evaluated in this study. Sites that failed this test were deemed unsuitable and were not further considered. This was the most conservative date for shading analysis, since it is the day of the year with the shortest period of daylight.

[26] The five military installations on which shading analysis was performed were MCAGCC Twentynine Palms, NAWS China Lake, Chocolate Mountain AGR, Edwards AFB, and Fort Irwin (cantonment and NASA Goldstone range). Shading analysis was not performed at MCLB Barstow and NAF El Centro, because the areas available for solar development were typically on very flat terrain. Both MCLB Barstow and NAF El Centro had less than 700 acres each available for solar development.

5.6.9 Weather Data

SAM is pre-loaded with over 1,000 of weather files[27] for different locations in the U.S., as well as methods to incorporate more external weather files from NREL's website. The data sets are listed as typical meteorological year (TMY) data and come in TMY2 and TMY3 data sets. The TMY3 data sets are considered to be statistically superior, therefore when available, these data set were used. The weather file was changed for each military installation to most accurately reflect the solar resource (sunlight) available for each technology. This produces different solar electricity output between military installation s for the same solar technology configurations.

5.6.10 Solar Electricity Output Calculations for Dish/Stirling Systems

The Dish/Stirling model was approached in a fashion similar to that of the PV systems. An industry standard dish was utilized for the models, the 25 kW dish manufactured by Stirling Engine Systems. The design of the dish allows for some modularity for the solar arrays since each unit is limited to an output of 25kW, making it relatively small and easier to configure into irregularly shaped parcels.

Solar Plant Layout and Power Rating

The dish systems were first modeled by drawing a typical dish field to establish required distances between units. This resulted in a field that could host 161.29 kW/acre.[28] Using this value, ICF was able to evaluate the available suitable land area and populate that area with the maximum Dish/Stirling plant.

Solar Plant Output

Standard efficiency and performance parameters for the Dish/Stirling technology (not any specific Dish/Stirling equipment models) were utilized within SAM to model the expected plant output. This is because there is such a limited number of sizable, operating Dish/Stirling systems presently from which to choose equipment.

5.6.11 Solar Electricity Output Calculations for Parabolic Trough Systems

The NREL SAM program was also utilized to model the output for the trough systems in this report. Standard collectors and system components available in the SAM program were used.

Solar Plant Layout and Power Rating

An industry standard value of 100 kW/acre was applied to the trough systems when estimating the solar power output potential. After GIS data identified suitable land areas within each military installation, this value was used to establish the potential trough system at each

---

[27] The NREL SAM model has 1,018 TMY3 weather files and 202 TMY2 weather files. The geography in some of the TMY3 files may overlap with geography in some of the TMY2 files, so the number of unique locations may be less than the 1,220 sum of the two file totals.

[28] While Dish/Stirling systems are modular, their modularity is less granular than PV technologies for which the module can be a single 280 watt panel. Therefore, the 161.29 kW/acre average power density would only be realized over several large parcels of land. This study has a minimum Dish/Stirling system size of 11,290 kW (70 acres), which should be adequate to avoid this complication. However, for smaller Dish/Stirling systems (e.g., 2,000 to 5,000 kW), the power densities may be somewhat lower due to module granularity.

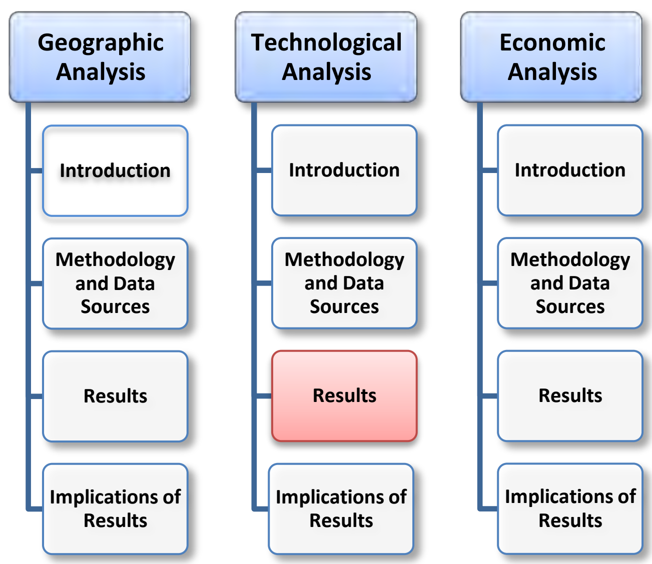
installation. The solar field aperture value was adjusted within SAM to maximize the available land area with the trough system's power output. The majority of the standard SAM values were left in place in an attempt to effectively model each system. Based on the different solar field physical sizes, the number of field subsections was varied to maximize the energy production at each site.

This study did not incorporate energy storage facilities in conjunction with the trough systems. In addition, the trough systems were assumed to be air-cooled to minimize the water usage by these plants. There is a water requirement assumed within the system to account for washing the mirrors used within the system.

Solar Plant Output

The estimated plant output was run through SAM by applying the site specific weather conditions for each appropriate land area. Standard SAM efficiency and system specific parameters were used within the model. The system was assumed to have a 90% gross rated output to net power output. Therefore, a plant rated at 80MW would have an assumed 72MW net output.

5.7 Summary of Results: Technical Potential for Solar on Military Installations



The following tables summarize the **technical solar potential** if all ―suitable" sites are developed and 25% of all ―likely suitable" and ―questionably suitable" sites are developed. Technical potential is shown for all seven California military installations combined and then individually by installation. The solar technical potential results are also separated by site type and solar technology. These results show the maximum capacity and output for sites passing the GIS screening process, but do not account for the economic viability of the solar projects (i.e., these results assume all technically-feasible solar projects can be developed). Please note that capacity factors differ by technology (due to system physical properties) and by military installation (due to differing sunlight patterns).

The subsequent Economic Analysis section of the report refines the technical potential results further by running them through a complex economic model to gauge solar project viability. The Economic Analysis section identifies the subset of technically feasible projects that are also estimated to be economically viable (i.e., delivering above-threshold investment returns) under the study's assumptions.

Table 5.17 –Technical Potential[29] for Solar Development (All California Installations)				
Solar Technology	**Peak Capacity (MW_{DC})**	**Peak Capacity (MW_{AC})**	**Year 1 Energy Production (MWh_{AC})**	**Capacity Factor[30]**
Cantonment Rooftop Sites				
Crystalline-Silicon PV	19.9	17.1	33,039	18.9%
Thin-Film PV	12.5	10.7	21,153	19.3%
Cantonment Paved Parking Sites				
Crystalline-Silicon PV	127.3	109.3	208,433	18.7%
Cantonment Unpaved Parking Sites				
Crystalline-Silicon PV	83.9	71.6	136,471	18.6%
Cantonment Ground Sites				
Crystalline-Silicon PV Fixed	2,915	2,583	5,212,379	20.4%
Thin-Film PV Fixed	1,813	1,605	3,291,413	20.7%
Crystalline-Silicon PV Tracking	2,070	1,721	4,747,851	26.2%
Thin-Film PV Tracking	1,298	1,081	3,012,983	26.5%
Dish/Stirling	N/A	1,329	3,090,598	26.5%
Trough	N/A	1,062	2,409,632	25.9%
Range Ground Sites				
Crystalline-Silicon PV fixed	10,263	9,200	18,009,999	20.0%
Thin-Film PV Fixed	6,382	5,715	11,375,971	20.3%

---

[29] The technical potential is based upon building solar plants on 100% of the suitable (rating = 1) acreage at each installation plus 25% of the ―likely suitable" (rating = 2) and 25% of the ―questionably suitable" (rating = 3) acreage identified during the prior geographic analysis. This is the solar development potential on each installation as defined by this study.

[30] Capacity factor represents the percentage of time that the solar generation facility is operating at peak capacity. The formula for capacity factor is: annual output (MWh)/(rated capacity in $MW_{DC\ or\ AC}$ x 8760 hours). There are 8760 hours in a non-leap year. Here, we present capacity factors for PV technologies versus DC capacity (the industry norm) and AC capacity for CSP technologies. The capacity factor for a given solar technology (e.g., crystalline-silicon PV) may differ across site types, even within the same installation, because tilt angles and other factors affecting performance differ by mount type (roof, parking, and ground). These factors are described in the prior Methodology section of this chapter. Differences in capacity factors between installations are driven by differences in hourly solar resources (sunlight) at the installations.

Table 5.17 –Technical Potential[29] for Solar Development (All California Installations)				
Solar Technology	**Peak Capacity (MW_{DC})**	**Peak Capacity (MW_{AC})**	**Year 1 Energy Production (MWh_{AC})**	**Capacity Factor[30]**
Crystalline-Silicon PV Tracking	7,288	6,086	16,310,390	25.5%
Thin-Film PV Tracking	4,571	3,821	10,356,208	25.9%
Dish/Stirling	N/A	6,459	13,740,003	24.3%
Trough	N/A	4,312	9,783,692	25.9%
All Site Types Combined				
Crystalline-Silicon PV fixed	13,409	11,981	23,600,321	20.1%
Thin-Film PV fixed	8,208	7,331	14,688,537	20.4%
Crystalline-Silicon PV tracking	9,358	7,807	21,058,241	25.7%
Thin-Film PV tracking	5,869	4,902	13,369,191	26.0%
Dish/Stirling	N/A	7,788	16,830,601	24.7%
Trough	N/A	5,374	12,193,324	25.9%

Table 5.18 – MCAGCC Twentynine Palms Technical Potential for Solar Development				
Solar Technology	**Peak DC Capacity (MW)**	**Peak AC Capacity (MW)**	**Year 1 AC Energy Production (MWh)**	**Capacity Factor**
Cantonment Rooftop Sites				
Crystalline-silicon PV	3.6	3.0	5,838	18.7%
Thin-Film PV	2.2	1.9	3,738	19.0%
Cantonment Paved Parking Sites				
Crystalline-Silicon PV	34.1	29.8	56,341	18.8%
Cantonment Unpaved Parking Sites				
Crystalline-Silicon PV	N/A	N/A	N/A	N/A
Cantonment Ground Sites (including Dry Lake Bed)				
Crystalline-Silicon PV fixed	132	113	235,830	20.5%
Thin-Film PV fixed	82	70	148,903	20.8%
Crystalline-Silicon PV tracking	93	77	216,348	26.4%
Thin-Film PV tracking	59	49	137,281	26.7%
Dish/Stirling	N/A	88	211,637	27.5%
Trough	N/A	N/A	N/A	N/A
Range Sites – N/A at this Installation				
Capacity factor = MWh Production per year / (Rated Capacity x 8760 hrs/yr)				

Table 5.19 – MCLB Barstow Technical Potential for Solar Development				
Solar Technology	**Peak DC Capacity (MW)**	**Peak AC Capacity (MW)**	**Year 1 AC Energy Production (MWh)**	**Capacity Factor**
Cantonment Rooftop Sites				
Crystalline-Silicon PV	5.7	4.8	9,401	18.9%
Thin-Film PV	3.6	3.1	6,020	19.2%
Cantonment Paved Parking Sites				
Crystalline-Silicon PV	5.4	4.6	8,911	19.0%
Cantonment Unpaved Parking Sites				
Crystalline-Silicon PV	0.7	0.6	1,199	19.0%
Cantonment Ground Sites				
Crystalline-Silicon PV fixed	166	145	296,236	20.4%
Thin-Film PV fixed	103	90	187,026	20.7%
Crystalline-Silicon PV tracking	117	96	268,304	26.0%
Thin-Film PV tracking	73	61	170,249	26.3%
Dish/Stirling	N/A	111	266,988	27.5%
Trough	N/A	N/A	N/A	N/A
Range Ground Sites – N/A at this Installation				
Capacity factor = MWh Production per year / (Rated Capacity x 8760 hrs/yr)				

Table 5.20 – NAWS China Lake Technical Potential for Solar Development				
Solar Technology	**Peak DC Capacity (MW)**	**Peak AC Capacity (MW)**	**Year 1 AC Energy Production (MWh)**	**Capacity Factor**
Cantonment Rooftop Sites				
Crystalline-Silicon PV	1.5	1.3	2,505	19.6%
Thin-Film PV	0.9	0.8	1,603	19.9%
Cantonment Paved Parking Sites				
Crystalline-Silicon PV	13.3	11.3	22,324	19.1%
Cantonment Unpaved Parking Sites				
Crystalline-Silicon PV	N/A	N/A	N/A	N/A
Cantonment (Mainsite) Ground Sites				
Crystalline-Silicon PV fixed	935	841	1,675,753	20.5%
Thin-Film PV fixed	582	522	1,058,075	20.8%
Crystalline-Silicon PV tracking	664	557	1,525,783	26.2%
Thin-Film PV tracking	417	349	967,980	26.5%
Dish/Stirling[31]	N/A	N/A	N/A	N/A
Trough	N/A	393	891,654	25.9%
Range Ground Sites				
Crystalline-Silicon PV fixed	678	610	1,214,071	20.5%
Thin-Film PV fixed	421	378	766,568	20.8%
Crystalline-Silicon PV tracking	481	403	1,105,421	26.2%
Thin-Film PV tracking	302	253	701,294	26.5%
Dish/Stirling	N/A	N/A	N/A	N/A
Trough	N/A	285	645,995	25.9%
Capacity factor = MWh Production per year / (Rated Capacity x 8760 hrs/yr)				

[31] Based on reviews with installation personnel, it was determined that the Dish/Stirling technology produces too much heat to be compatible with NAWS China Lake's IR research, development, test, and evaluation activities.

Table 5.21 – Chocolate Mountain AGR Technical Potential for Solar Development				
Solar Technology	**Peak DC Capacity (MW)**	**Peak AC Capacity (MW)**	**Year 1 AC Energy Production (MWh)**	**Capacity Factor**
Cantonment Rooftop Sites				
Crystalline-Silicon PV	N/A	N/A	N/A	N/A
Thin-Film PV	N/A	N/A	N/A	N/A
Cantonment Paved Parking Sites				
Crystalline-Silicon PV	N/A	N/A	N/A	N/A
Cantonment Unpaved Parking Sites				
Crystalline-Silicon PV	N/A	N/A	N/A	N/A
Cantonment Ground Sites – N/A at this Installation				
Range Ground Sites				
Crystalline-Silicon PV fixed	931	772	1,632,800	20.0%
Thin-Film PV fixed	579	480	1,031,533	20.3%
Crystalline-Silicon PV tracking	661	514	1,471,959	25.4%
Thin-Film PV tracking	414	324	934,944	25.7%
Dish/Stirling	N/A	630	1,392,873	25.3%
Trough	N/A	391	887,173	25.9%
Capacity factor = MWh Production per year / (Rated Capacity x 8760 hrs/yr)				

Table 5.22 – NAF El Centro: Technical Potential for Solar Development				
Solar Technology	**Peak DC Capacity (MW)**	**Peak AC Capacity (MW)**	**Year 1 AC Energy Production (MWh)**	**Capacity Factor**
Cantonment Rooftop Sites				
Crystalline-Silicon PV	N/A	N/A	N/A	N/A
Thin-Film PV	N/A	N/A	N/A	N/A
Cantonment Paved Parking Sites				
Crystalline-Silicon PV	4.4	3.6	6,930	18.1%
Cantonment Unpaved Parking Sites				
Crystalline-Silicon PV	N/A	N/A	N/A	N/A
Cantonment Ground Sites				
Crystalline-Silicon PV fixed	90	73	154,061	19.6%
Thin-Film PV fixed	56	45	97,367	19.9%
Crystalline-Silicon PV tracking	64	49	138,279	24.8%
Thin-Film PV tracking	40	31	87,864	25.1%
Dish/Stirling	N/A	59	130,563	25.4%
Trough	N/A	N/A	N/A	N/A
Range Ground Sites – N/A at this Installation				
Capacity factor = MWh Production per year / (Rated Capacity x 8760 hrs/yr)				

Table 5.23 – Edwards AFB Technical Potential for Solar Development				
Solar Technology	**Peak DC Capacity (MW)**	**Peak AC Capacity (MW)**	**Year 1 AC Energy Production (MWh)**	**Capacity Factor**
Cantonment Rooftop Sites				
Crystalline-Silicon PV	7.6	6.6	12,644	18.9%
Thin-Film PV	4.8	4.2	8,096	19.3%
Cantonment Paved Parking Sites				
Crystalline-Silicon PV	32.4	27.8	52,572	18.5%
Cantonment Unpaved Parking Sites				
Crystalline-Silicon PV	11.7	10.1	19,053	18.5%
Cantonment Ground Sites				
Crystalline-Silicon PV fixed	222	203	383,148	19.7%
Thin-Film PV fixed	138	126	242,066	20.0%
Crystalline-Silicon PV tracking	158	134	345,285	25.0%
Thin-Film PV tracking	99	84	219,318	25.3%
Dish/Stirling	N/A	149	295,121	22.6%
Trough	N/A	93	211,739	25.9%
Range Ground Sites				
Crystalline-Silicon PV fixed	5,568	5,098	9,604,265	19.7%
Thin-Film PV fixed	3,462	3,165	6,067,801	20.0%
Crystalline-Silicon PV tracking	3,954	3,347	8,655,160	25.0%
Thin-Film PV tracking	2,480	2,101	5,497,567	25.3%
Dish/Stirling	N/A	3,741	7,397,715	22.6%
Trough	N/A	2,339	5,307,611	25.9%
Capacity factor = MWh Production per year / (Rated Capacity x 8760 hrs/yr)				

Table 5.24 – Fort Irwin Technical Potential for Solar Development				
Solar Technology	**Peak DC Capacity (MW)**	**Peak AC Capacity (MW)**	**Year 1 AC Energy Production (MWh)**	**Capacity Factor**
Cantonment Rooftop Sites				
Crystalline-Silicon PV	1.6	1.3	2,651	18.9%
Thin-Film PV	1.0	0.8	1,696	19.4%
Cantonment Paved Parking Sites				
Crystalline-Silicon PV	37.7	32.2	61,355	18.6%
Cantonment Unpaved Parking Sites				
Crystalline-Silicon PV	71.4	60.9	116,219	18.6%
Cantonment (Main Gate Areas Outside of Ring Road) Ground Sites				
Crystalline-Silicon PV fixed	1,370	1,208	2,467,351	20.6%
Thin-Film PV fixed	852	751	1,557,975	20.9%
Crystalline-Silicon PV tracking	973	808	2,253,851	26.4%
Thin-Film PV tracking	610	508	1,430,291	26.8%
Dish/Stirling	N/A	923	2,186,289	27.0%
Trough	N/A	576	1,306,239	25.9%
Range (NASA Goldstone) Ground Sites				
Crystalline-Silicon PV fixed	3,087	2,721	5,558,864	20.6%
Thin-Film PV fixed	1,920	1,693	3,510,070	20.9%
Crystalline-Silicon PV tracking	2,192	1,821	5,077,850	26.4%
Thin-Film PV tracking	1,375	1,144	3,222,402	26.8%
Dish/Stirling	N/A	2,088	4,949,416	27.1%
Trough	N/A	1,297	2,942,912	25.9%
Capacity factor = MWh Production per year / (Rated Capacity x 8760 hrs/yr)				

5.8 Implications of Technical Potential Results

The key implications of the solar potential analysis can be grouped into six categories:

1. Significant solar development potential exists across the grounds of the seven California military installations.
2. Cantonment ground sites alone offer substantial solar development potential, even before range areas are considered.
3. Parking canopies offer the ability for military installations to technically meet much of their on-site electricity demand.
4. Building rooftop opportunities for solar development are very limited in 2015, due largely to roof replacement issues.
5. Even though the military installations are all in Deserts, sunlight differs among installations and results in different electricity output levels across military installations.
6. The choice of solar technologies is important, even before economics are considered, due to meaningful differences in the land requirements and electricity output levels.

Each of these implications is described in greater detail below.

Implication #1: Significant solar development potential exists across the grounds of the seven California military installations.

There is the **technical** potential for at least 90 MW_{DC} of solar plants on each military installation. Edwards AFB alone has a maximum technical solar development potential of 5,346 MW_{AC} and study-wide there is almost 12,000 MW_{AC} of potential capacity **if crystalline-silicon fixed-axis systems are installed**. On an annual output basis, this potential can translate into over 23,000,000 MWh (or over $2.3 billion in annual electricity revenue at current rates). This potential solar electricity output is equivalent to over 75% of DoD's annual, total electricity consumption of 29,861,334 MWh (DoD, 2010d) and more than 40 times as large as the combined annual electricity consumption (approximately 560,000 MWh) of the seven California military installations in this study.

The technical potential of the other technologies studied was lower than for crystalline-silicon fixed-axis. However, there is the technical potential for substantial (approximately 5,000 MW_{AC} or more) development for each of the six solar technologies studied.

Implication #2: Cantonment ground sites alone offer substantial solar development potential, even before range areas are considered.

While the range areas of the military installations comprise the vast majority of all land surveyed and contribute about 63% of the ―suitable" (suitability rating = 1) acreage for solar development in this study, the much smaller cantonment areas still offer sizable solar potential. The cantonment areas have the technical potential for utility-scale projects on six of the seven installations studied (Chocolate Mountain AGR has no cantonment area). Across the six cantonment areas, there is the technical potential for 2,583 MW_{AC} from the crystalline-silicon PV fixed-axis systems and 1,721 MW_{AC} from crystalline-silicon tracking systems. These cantonment solar projects, with 5,212 gigawatt hours (GWh) and 4,748 GWh of annual electricity output, depending on the PV technology, could meet over half of the DoD's agency-wide goal of 25% renewable energy (equivalent to about 7,465 GWh annually). Overall, across all suitability ratings, cantonment areas represent 22% of the technical potential for ground-based solar capacity in this study.

Implication #3: Parking canopies offer the ability for military installations to technically meet much of their on-site electricity demand.

All but one military installation had parking facilities that could be used for the installation of solar canopies. The total capacity of parking-sited solar is estimated at 211 MW_{DC}, or 181 MW_{AC}, which would be roughly equivalent to the total peak demand across the military installations. This total is for paved and unpaved parking facilities combined.

In addition to electricity generation for military installations, placing solar PV arrays above parking areas can provide shaded parking for vehicles and equipment maintenance activities and the ability to incorporate electrical vehicle charging stations.

While solar parking canopies are technically feasible, and have been implemented on some military installations at a more modest scale, they carry much higher installed costs than roof or ground-mounted solar PV and must be located near electrical load to capture maximum electricity revenue.

Implication #4: Building rooftop opportunities for solar development are very limited in 2015, due largely to roof replacement issues.

There were only 20 MW_{DC}, or 17 MW_{AC}, of building rooftop solar potential across all seven military installations combined. This result was driven by reviewing only suitably large roofs (20,000 square feet after setback). The primary reason for the low total is that roof replacement schedules were considered. In 2015, the reference year for this study, it is estimated that only one-third of suitable roofs would have 20 or more years left on their roof life and be able to host solar projects without interruption.

Over time, most roofs can be made solar-ready when they are replaced as the DoD is encouraging. Eventually, this replacement activity will render the solar rooftop potential at the military installations to be close to triple the level estimated in the study.

Implication #5: Even though the military installations are all in Deserts, sunlight differs among installations and results in different electricity output levels across installations.

Though the military installations are all in the Mojave or Colorado Deserts, their sunlight patterns are somewhat different. Drawing from the solar weather files for each location, capacity factors (the % of a solar project's maximum capacity that is being utilized) for the military installations varied by up to 1% to 2% depending on the solar technology. This can make a meaningful difference in solar electricity output and revenue for the large-scale ground-mount systems in the study. NAWS China Lake tended to have the strongest solar resource (and capacity factors), while NAF El Centro had the lowest solar resources among the installations.

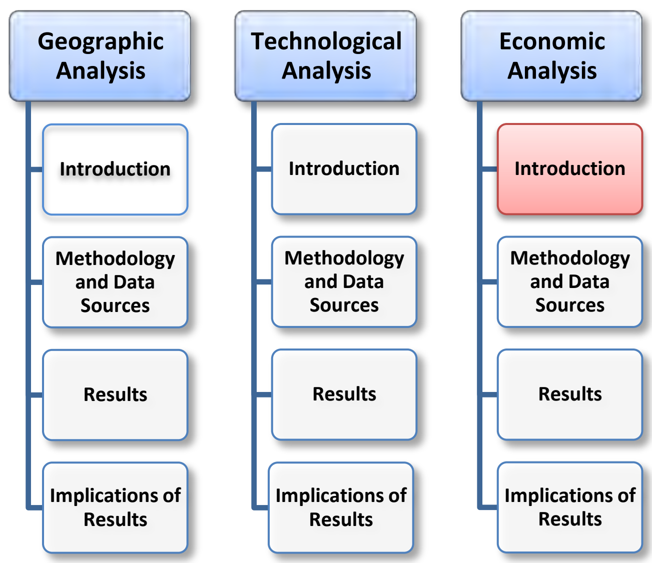
Because they are all in the Deserts, though, these military installations tend to have much higher capacity factors than military installations in most other locations in the U.S.

Implication #6: The choice of solar technologies is important, even before economics are considered, due to meaningful differences in the land requirements and electricity output levels.

The economic differences between the six solar technologies studied are described in the next section of this chapter. However, apart from project economics, there are other differences between the solar technologies to consider. For example, the land requirements for the technologies vary from 4.2 acres/MW for crystalline-silicon PV fixed-axis to 9.5 acres/MW for thin-film PV single-axis tracking and 10 acres/MW for the Trough CSP technology. The capacity factors for the technologies also vary widely from about 20% for the fixed-axis PV technologies to 25% to 28% for the tracking PV and the CSP technologies. Depending on what the DoD would be seeking to optimize in addition to economics (e.g., minimum land requirement or maximum output from environmental perspective), the differences between the technologies could be important to consider.

5.9 Economic Analysis

5.9.1 Introduction



The economic analysis is the last step in this solar electricity potential review. While the prior technology analysis section describes the technical solar potential, unconstrained by current cost and revenue factors, this section describes how much of that technical potential can be achieved with viable economics. Therefore, the results of this economic analysis section are, in all cases, a subset of the technical analysis results. The economic analysis results show where solar projects can be sited with financial returns exceeding the military's and/or private owners' minimum investment thresholds. At the conclusion of this section after the economic implications of solar development are described, solar projects' environmental effects are summarized.

In performing the economic analysis, we have integrated information obtained from the prior GIS and technology analyses with many other economic factors including transmission costs, technology costs, O&M costs, electricity prices, REC values, the values of other solar incentives, and project finance factors. Taken together, these factors can be used to establish 20-year investment pro-formas for each site and solar technology considered suitable for solar development. These investment pro-formas are calculated for two ownership scenarios --

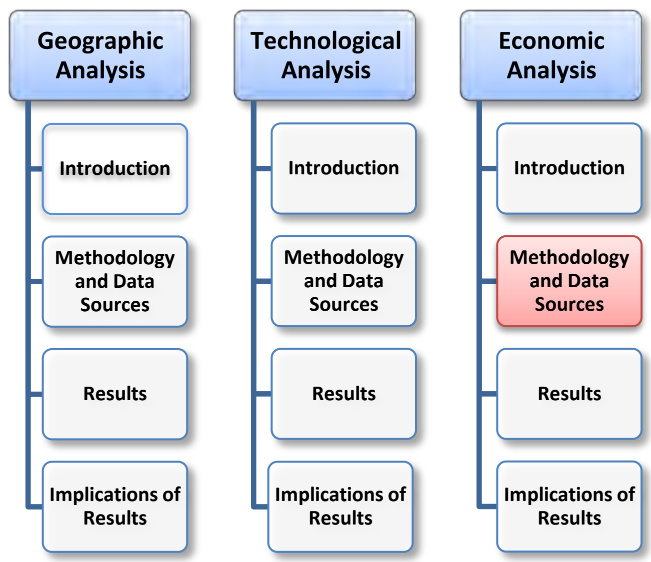
MILCON (direct military ownership) and private ownership.[32] [33] The site and technology combinations exceeding the respective MILCON and private ownership investment return thresholds over the total 20-year (2015 through 2034) period are reported as the economically-viable projects at the end of this section. Taken as a whole, the economically-viable projects establish an estimate of the maximum potential for solar development on the military installations given the study's constraints and assumptions.

In the following section, we describe how the economic analysis methodology links with the preceding GIS and technology analyses in a stepwise manner and detail the variables, assumptions, and techniques particular to economic analysis. The study has taken a relatively detailed approach to its economic modeling of solar project returns and has estimated many variables that affect the potential investment returns of solar projects. It has done so both to attempt to add precision to its projections of the military installations' solar potential and to allow readers to evaluate the range of factors applied.

5.9.2 Methodology

This methodology section describes the nine categories of inputs and processes used in the study's economic analysis in turn. Those nine categories are:

1. Solar technology costs
2. Electricity prices
3. REC prices
4. Other federal, state, and utility solar incentives
5. Land lease rates
6. Transmission costs
7. Economic and project finance rates (e.g., inflation, discount rates, debt terms)
8. Project ownership
9. 20-year investment return calculation



5.9.3 Solar Technology Costs

For each of the solar technology packages applied in this study, estimates of their fully-installed, pre-incentive costs were established and utilized in the study's economic model. These cost estimates were for project construction in 2015 and were based upon secondary and primary source research into current solar costs and assessments of cost trends over the next four years.

---

[32] For the private ownership model, it is assumed that the physical power and RECs will be sold by the owner through a power purchase agreement (PPA) or similar off-take arrangement. PPA models are very common for commercial- and utility-scale solar projects.

[33] In a separate part of this section, we also describe returns under – energy joint ventures between (a) the U.S. Department of Defense or its Services or installations, and (b) private owners, whereby the Defense entity receives all excess profit above a threshold as a rent payment for the solar project land.

The cost estimates were determined to cover the specific solar project sizes considered in this study.

Below are three tables describing the cost factors applied for crystalline-silicon PV, thin-film PV, and CSP technologies, respectively. Footnotes with descriptions of the sources for the cost estimates are provided with each table.

Table 5.25 – Cost Elements for Crystalline-Silicon PV Projects

Factor	Fixed Axis Roof & Parking Sites	Fixed-Axis Ground Sites	Single-Axis Trackers
Modules[34]	$1,480/kW	$1,320/kW	$1,320/kW
Racking	$280/kW	$280/kW	$160/kW
Trackers	N/A	N/A	$640/kW
Inverters	$300/kW	$200/kW	$200/kW
Balance of System	$280/kW	$240/kW	$240/kW
Installation Labor[35]	$1,313/kW	$438/kW	$438/kW
Project Development and Integration[36]	7.5% of total equipment and labor	7.5% of total equipment and labor	7.5% of total equipment and labor
Total Project Installation Costs (sum of above costs; pre-incentive)[37]	$3,927/kW	$2,664/kW	$3,223/kW
Premium to Baseline Roof Cost for Paved Parking Sites[38]	30% (= $5,105/kW)	N/A	N/A
Premium to Baseline Roof Cost for Unpaved Parking Sites[39]	34% (= $5,262/kW)	N/A	N/A
Annual O&M Costs	$14/kW/year[40]	$10/kW/year[41]	$16/kW/year[42]

---

[34] Data on equipment costs are obtained from the National Renewable Energy Laboratory (NREL) System Advisor Model and competitive bids as of March 2011, with an assumed approximate 20% cost reduction between 2011 and 2015 due to solar efficiency and scale improvements consistent with the methodology and orders of magnitude in a recent ICF report (ICF International, 2010). For an alternate source on installed costs per category, see Pletka, Ryan, Black & Veatch (Pletka, 2010).
[35] The labor rates applied in this study are $43.75/hour from the Southern California District Council of Laborers. The study assumes 30 labor hours per installed kW for distributed (roof and parking) projects and 10 labor hours per installed kW for ground projects.
[36] Utilized midpoint of range from large-scale PV project bids and verified with solar consultancy Optony for reasonableness.
[37] For comparison, Energy and Environmental Economics, Inc. projects solar installed costs to be $4,700/kW (100 to 500 kW capacity) to $4,820/kW (> 500kW capacity) in 2015 nominal dollars in its *California Solar Initiative Cost Effectiveness Evaluation* (California Public Utilities Commission, 2011).
[38] Derived from bids on equivalent building roof and parking canopy projects and verified with outside firm.
[39] The additional installation costs for unpaved parking projects primarily reflect the material (e.g., steel or aluminum) and construction cost of taller canopies than those applied for paving parking areas. The study's assumption is that unpaved areas will need to accommodate taller vehicles than paved areas over the 20 year asset life of the solar projects.
[40] (NREL, 2011). For relevant range of solar PV O&M costs, see also Electric Power Research Institute (Nadav, 2010).
[41] (NREL, 2011), (Moore, 2011)

Table 5.25 – Cost Elements for Crystalline-Silicon PV Projects			
Factor	**Fixed Axis Roof & Parking Sites**	**Fixed-Axis Ground Sites**	**Single-Axis Trackers**
Insurance[43]	$10/kW/year	$10/kW/year	$10/kW/year
Inverter Replacement Accrual[44]	$10/kW/year	$10/kW/year	$10/kW/year
Inflation Rate Applied to Annual Expenses (O&M, Insurance, & Inverter Replacement Costs)[45]	3.66%	3.66%	3.66%
Net Decommissioning Cost[46]	$80/kW	$60/kW	$60/kW
Acres/ Installed MW[47]	4.4:1 (Roof) 3.3:1 (Parking)	4.2:1	5.9:1
Minimum Project Size (building roofs and parking lots)	20,000 solar-ready square feet (= 0.46 acres)	5 acres	60 acres

[42] (Prior, 2009). Note that this study breaks out ongoing operating costs for PVs into three categories (O&M, inverter replacement accrual, and insurance), while certain sources such as GTM may combine them under the ―O&M" category.

[43] While the federal government tends not to purchase outside insurance to cover losses, insurance costs have been included for the MILCON scenario to reflect the self-insurance costs (risk of losses) that the federal government would bear in the absence of an insurance policy. However, the economic viability of solar projects under MILCON would not be affected, even if one aggressively assumed no insurance costs (zero risk of loss) for the federal government. This is because insurance costs are a minor overall system cost.

[44] (Nadav, 2010)

[45] The inflation rate used in the study is the average, compounded inflation rate from the U.S. Bureau of Labor Statistics' Consumer Price Index-All Urban Consumers (CPI-U) over the period 1979-2009. While this inflation rate is higher than rates typical over the past few years, it represents a longer-run calculation deemed appropriate for the time horizon (2015 to 2034) in the study's economic calculations.

[46] Value estimated by outside solar consulting firm with strong life-cycle solar PV experience.

[47] For parking canopies, a ratio of 7.14 watts per square foot (of parking lot, not parking canopy) was used based on computer-assisted design modeling of a representative, actual solar parking project. This translates into approximately 310 kW per acre of parking lot.

Table 5.26 – Cost Elements for Thin-Film PV Projects (2015 $ Values in MW_{DC} Capacity)			
Factor	**Fixed Axis Roof Sites**	**Fixed-Axis Ground Sites**	**Single-Axis Trackers**
Modules[48]	$1,250/kW	$1,150/kW	$1,150/kW
Racking	$400/kW	$400/kW	$240/kW
Trackers	N/A	N/A	$760/kW
Inverters	$300/kW	$200/kW	$200/kW
Balance of System	$280/kW	$240/kW	$240/kW
Installation Labor[49]	$1,313/kW	$656/kW	$656/kW
Project Development and Integration[50]	7.5% of total equipment & labor	7.5% of total equipment & labor	7.5% of total equipment & labor
Total Project Installation Costs (sum of above costs; pre-incentive)	$3,809/kW	$2,844/kW	$3,489/kW
Annual O&M Costs[51]	$14/kW/year	$10/kW/year	$16/kW/year
Insurance	$10/kW/year	$10/kW/year	$10/kW/year
Inverter Replacement Accrual[52]	$10/kW/year	$10/kW/year	$10/kW/year
Inflation Rate Applied to Annual Expenses (O&M, Insurance, & Inverter Replacement Costs)	3.66%	3.66%	3.66%
Net Decommissioning Cost[53]	$100/kW	$80/kW	$80/kW
Acres/Installed MW[54]	7.0:1 (Roof)	6.7:1	9.5:1
Minimum Project Size (building roofs)	20,000 solar-ready square feet (= 0.46 acres)	7 acres	100 acres

[48] Data on equipment costs are obtained from the National Renewable Energy Laboratory (NREL) System Advisor Model and competitive bids as of March 2011, with an assumed approximate 20% cost reduction between 2011 and 2015 due to solar efficiency and scale improvements consistent with the methodology and orders of magnitude (ICF International, 2010). For an alternate source on installed costs per category, see Pletka, Ryan, Black & Veatch (Pletka, 2010).

[49] The labor rates applied in this study are $43.75/hour from the Southern California District Council of Laborers. The study assumes 30 labor hours per installed kW for distributed (roof and parking) projects and 15 labor hours per installed kW for ground projects.

[50] Utilized midpoint of range from large-scale PV project bids and verified with outside firm.

[51] (NREL, 2011). For relevant range of solar PV O&M costs, see also Nadav (Nadav, 2010) and Prior (Prior, 2009). Note that this study breaks out ongoing operating costs for PVs into three categories (O&M, inverter replacement accrual, and insurance), while certain sources such as GTM may combine them under the ―O&M" category.

[52] (Nadav, 2010).

[53] Value estimated by outside solar consulting firm with strong life-cycle solar PV experience.

[54] Thin-film technologies take more space per installed MW than crystalline-silicon.

Table 5.27 – Cost Elements for CSP Projects (2015 $ Values in AC Capacity)		
Factor	**Dish/Stirling Engine Technology**	**Trough Technology (dry cooling with no storage)**
Total Installation Equipment & Labor[55]	$4,000/kW	$5,000/kW
Project Development and Integration[56]	7.5% of total equipment & labor	7.5% of total equipment & labor
Total Project Installation Costs (sum of above costs; pre-incentive)	$4,300/kW	$5,375/kW
Annual O&M Costs[57]	$50/kW/year	$70/kW/year
Insurance	$10/kW/year	$10/kW/year
Water consumption[58]	20 gallons/MWh	78 gallons/MWh
Water Cost[59]	$4/1,000 gallons	$4/1,000 gallons
Inflation Rate Applied to Annual Expenses (O&M, Insurance, and Water Costs)	3.66%	3.66%
Net Decommissioning Cost	$0; assume re-commissioning	$0; assume re-commissioning
Acres/Installed MW	6.2:1	10.0:1
Minimum Project Size (ground sites)	70 acres	500 acres

The inflation rate applied to the variable costs for the solar technologies is explained in the economic and project finance rates section 5.9.9 below.

The minimum project sizes are set so that individual building roofs or parking facilities would have solar-ready space sufficient to accommodate 200 kW_{DC} systems, cantonment ground sites would be at least 1 MW_{DC} in capacity, and range sites would be at least 10 MW in capacity. The minimums for PV tracking systems and Dish/Stirling CSP systems are set at 10 MW in all ground locations. The minimum for Trough CSP systems is set at 50 MW. In this study, systems of 10 MW and above in capacity are viewed as utility-scale systems.

---

55 Installed costs for CSP systems are difficult to estimate due to the low number of operational CSP systems in the U.S. and the unique characteristics and histories of many of the operational systems. NREL System Advisor Model data provided cost ranges for each technology, and the values applied in this study are within those ranges. It is estimated that 20% of total project installation costs are for labor for the purpose of calculating state sales taxes (labor is not considered taxable in this study).

56 Utilized midpoint of range from large-scale PV project bids and verified with outside firm. The same value was applied to CSP systems which have a more limited record of actual project bids than PV systems.

57 (NREL, 2011) (Prior, 2009).

58 (DOE, 2011).

59 The water use for the Trough technology is based on a ―dry" system (using methods other than water for much of its cooling), rather than the much more water-intensive ―wet" system. Because the water use for PV (PV) technologies (crystalline-silicon and thin-film) would likely be so modest, the PV technologies are not assessed water charges in this study. Only the CSP technologies are assessed water charges. The Solar Technology Characterization chapter describes water use for the CSP technologies in greater detail. For water costs, a typical municipal rate was used from U.S. Department of Energy, Report to Congress (DOE, 2011).

This study focuses only on solar electricity generation – it does not review the potential for solar water heating projects, which can be a useful and cost-effective form of solar energy conversion. The DoD has a goal that 30% of water heating be provided by solar collectors, as discussed in the Solar Development Context chapter of this report.

5.9.4 Electricity Prices

Wholesale Electricity Prices Applied to Ground Sites

There are conceptually two revenue sources for the solar projects in this study – sales of the physical electricity generated from the projects and sales of their RECs. Both types of revenue are performance-based – the project receives the price of physical power and of RECs for each unit (MWh) of AC power it produces. As the only two revenue sources for the solar projects in this study, estimates of these prices over the 20-year economic model period have a substantial impact on the study results. For that reason, the study team relied on a careful forecasting program that accounts for every electricity generation unit in the United States in establishing the price projections. These wholesale price projections apply to the ground-mounted solar projects in this study, which comprise 99% of the technical utility-scale potential for solar development in this study as described in Table 5.6 in the prior section. (Roof- and parking-mounted solar jointly account for the remaining 1% of technical utility scale potential, and the self-generation electricity pricing applicable to those site types is discussed in the Self-Generation Electricity Prices Applied to Roof and Parking Sites section below).

In California, physical power and RECs are bundled together into single delivered products. For analytic clarity, though, we have broken out the physical power and REC price projections. Physical power prices are discussed below and REC prices are discussed in the following section.

For this project, we provided forward on-peak and off-peak energy prices for the Southern California market in both real 2010 and nominal dollars. ICF International's (ICF's) economic modeling tool, Integrated Planning Model (IPM®), was used to project the forward energy prices, using assumptions taken from the Environmental Protection Agency's (EPA's) latest base case (EPA, 2010a). EPA uses IPM to analyze the economic impacts of proposed regulations, and develops assumptions about future fuel costs, load growth, and other factors to drive the model for its scenario runs.

IPM® simulates the entire energy market of both the United States and Canada. The market is broken into over 100 regions and sub-regions to capture commercially significant transmission congestion. IPM® is a production cost simulation model that focuses on analyzing wholesale power markets and assessing competitive market prices of electrical energy, based on an analysis of supply and demand fundamentals. The model also projects plant generation levels, new power plant construction, fuel consumption, and inter-regional power flows. The model determines generation, and therefore production costs and prices, using a linear programming optimization routine with dynamic effects (i.e., it looks ahead at future years and simultaneously evaluates decisions over specified years). All major factors affecting wholesale electricity prices are explicitly modeled, including detailed modeling of existing and planned units, with careful consideration of fuel prices, environmental allowance and compliance costs, and operating constraints. Based on looking at the supply/demand balance in the context of the various factors discussed above, IPM® projects hourly spot prices of electric energy within a larger wholesale power market. IPM® also projects the annual ―pure” capacity price.

ICF utilized EPA's Base Case 4.10 power sector modeling assumptions for new generation capital costs, retrofit capital costs, and energy demand growth. Fuel prices, such as for coal and natural gas, were also derived from EPA 4.10 (EPA, 2010). ICF used the model, focusing specifically on the Southern California power market, to provide forward pricing projections.

To add accuracy to the wholesale revenue estimates in the study, distinct on-peak and off-peak revenue streams were calculated for each potential solar project. The on-peak revenue for a given year is equal to the solar project's on-peak electricity output for that year multiplied by the region's on-peak electricity price for that year. The off-peak revenue is, likewise, equal to off-peak electricity output multiplied by the off-peak price. Capacity scarcity values, together with ―energy” prices, are included in the on-peak and off-peak electricity prices. The electricity output going into these calculations was taken from the detailed electricity output profiles covering each of the 8,760 hours in a non-leap year that are calculated for each potential solar project. ICF bundled the value of capacity scarcity and energy together to establish all-hours firm energy prices in the Southern California market. See the previous Solar Technology Analysis section of this chapter for more detail on electricity output calculation methods.

The two next tables display the combined **"all hours" ("round-the-clock") wholesale physical electricity price projections** (including energy and capacity scarcity values) for Southern California and the bundled physical power (including energy, capacity scarcity, and REC values), respectively, arising from the detailed IPM® modeling exercise. Details on the on-peak and off-peak division of physical power prices are provided in Table 5.70.

Table 5.28 – Wholesale California Physical Electricity Price Projections (including capacity scarcity value)		
Year	**Firm Wholesale Electricity Price (Real 2010 $/MWh)**	**Firm Wholesale Electricity Price (Nominal $/MWh)[60]**
2015	$55.67	$66.63
2016	$55.91	$69.37
2017	$54.45	$70.02
2018	$53.05	$70.73
2019	$55.30	$76.43
2020	$57.76	$82.74
2021	$60.48	$89.81
2022	$64.78	$99.71
2023	$72.27	$115.32
2024	$73.60	$121.74
2025	$74.96	$128.53
2026	$76.18	$135.39
2027	$77.41	$142.62
2028	$78.66	$150.24
2029	$79.94	$158.26
2030	$81.24	$166.71
2031	$82.84	$176.24
2032	$84.49	$186.33
2033	$86.19	$197.01
2034	$87.92	$208.34

Projections for bundled electricity prices (physical electricity combined with RECs) are provided in the Table 5.29. These bundled prices simply reflect the sum of the physical electricity prices from Table 5.28 above and the REC prices from Table 5.31 in the next section that describes the REC price estimate methodology.

[60] The annual inflation rate used to convert 2010 real (or constant) dollars into nominal dollars here is 3.66%, which is the rate generally used for annual revenues and costs in this study only. That inflation rate reflects the annualized increase of the CPI-U consumer price index over the period 1979-2009 inclusive. As a general principle, receivers of ICF's IPM® price projections (such as the study authors in this case) apply their own inflation assumptions. IPM® generates pricing in real dollars to allow users flexibility in their conversion to nominal dollars.

Table 5.29 – Wholesale California Physical Electricity and REC Price Projections (Bundled)		
Year	**Bundled Wholesale Physical Electricity & REC Price (Real 2010 $/MWh)**	**Bundled Wholesale Physical Electricity & REC Price (Nominal $/MWh)[61]**
2015	$99.29	$118.84
2016	$93.86	$116.45
2017	$95.13	$122.35
2018	$96.67	$128.88
2019	$102.07	$141.05
2020	$107.89	$154.56
2021	$106.07	$157.52
2022	$106.24	$163.55
2023	$109.98	$175.50
2024	$107.90	$178.48
2025	$106.16	$182.02
2026	$98.90	$175.77
2027	$93.96	$173.11
2028	$90.71	$173.25
2029	$88.72	$175.64
2030	$87.63	$179.83
2031	$88.56	$188.39
2032	$89.60	$197.59
2033	$90.75	$207.45
2034	$92.00	$218.01

The bundled (energy, capacity, and REC), firm wholesale electricity prices listed in Table 5.29 above were applied to all potential ground-mounted solar projects.

Self-Generation Electricity Prices Applied to Roof and Parking Sites

A ―self-generation" price is applied to all roof and parking solar installations because it is assumed that, in practice, they would be completed in relatively smaller capacity groupings[62] and would not be interconnected directly to the transmission system.

The principal reasons for the application of self-generation prices to roof and parking sites are:

---

[61] The annual inflation rate used to convert 2010 real (or constant) dollars into nominal dollars here is 3.66%, which is the rate generally used for annual revenues and costs in this study only. Additional explanation is in the subsequent economic and project finance rates section of this chapter.

[62] While the roof, paved parking, and unpaved parking solar projects are aggregated within each installation for ease of display and other purposes in this report, the underlying solar technology cost and performance data modeled for roof and parking projects are based on individual commercial-scale installations of approximately 200 to 500 kW each.

1. First, there is little possibility that new solar generation would receive full retail electricity price treatment (i.e., above self-generation rates) under the current net metering caps (e.g., 1 MW per meter in California). The net metering rules establish limitations on the military installations because they tend to be served by only one to three main utility meters[63] and several military installations already have renewable energy facilities connected on their side of the utility meter(s) meeting or exceeding the net metering caps.[64]

2. Second, a reasonable proxy of what the military installations might receive for solar self-generation in excess of net metering caps (but well below the military installation's peak electricity demand) projects to be somewhat higher than the study's estimated wholesale rates for 2015 and, therefore, would be preferable to the wholesale rates for the project owner. This proxy for self-generation unit revenue is calculated as the price the military installations pay for the generation portion of their electricity supply in a competitive market, plus some compensation for reduced distribution charges that are driven by usage and demand measurement.

   Multiple military installations in Southern California take competitive generation supply from the Western Area Power Administration (WAPA), and their average, annualized WAPA price is approximate $80/MWh, excluding Edwards AFB, which has a negotiated lower rate with WAPA. When $35.25/MWh in estimated avoided distribution charges are added to the $80/MWh generation price for self-generation, the total self-generation 2010 price for Southern California becomes $115.25/MWh, which is used in the study. [65]

---

[63] See the Installation and Unit Characterization Appendix for information on the utilities and metering of the installations.

[64] In the Solar Development Context chapter, the study authors describe how raising the net metering caps may encourage more distributed (behind-the-meter) solar generation.

[65] The distribution charges are based on the utility SCE's TOU-8 rate class. Based on review of the SCE TOU-8 rate with Direct Access charges at the installations in the study, the team found that several installations paid approximately $50/MWh in average distribution charges in 2010. This $50/MWh charge was driven by usage-based factors, counted in kWh (43%), demand-based factors, denominated in kW (55%) and fixed charges, which did not vary based on usage or demand (2%). Of these three factors, solar self-generation offsets usage based charges on a 1:1 basis, i.e., every kWh of solar generation reduces utility bill charges by a kWh. Demand-driven charges are more complex; although solar generating plants are typically operating at full capacity during the same period when the utility measures an installation's peak demand, a period of cloudiness can cause the array's output to plummet and significantly reduce its ability to mitigate peak demand charges. To account for this uncertainty, the study assumed that 1/2 of demand-based charges could be offset by self-generation. Finally, the 2% of distribution charges that are either fixed fees or power factor charges were assumed to be unaffected by the presence of solar self-generation. The 2010 combined distribution charge offset then becomes (43% x $50/MWh) + (50% x 55% x $50/MWh) = $35.25/MWh. SCE serves the great majority of the California installation electricity load considered in this study, and versions of the TOU-8 rate apply to the main meters at MCAGCC Twentynine Palms, MCLB Barstow, NAWS China Lake, Edwards AFB, and Fort Irwin. To avoid having two sets of California self-generation price estimates in this study, the Chocolate Mountain AGR and NAF El Centro installations in the Imperial Irrigation District (IID) utility territory also used the SCE self-generation assumptions, though IID's rate structure is more usage-based than SCE, with only about 5% of IID charges being demand-based for the installations. Appendix A of this study describes the electricity supply costs, including the separation of the generation and distribution portions of those costs, for each installation.

Because there is no distinct modeling engine available to forecast Southern California retail prices, the study assumed that retail prices would change year-to-year in the same direction and by the same percentages as the bundled prices for wholesale electricity plus RECs. Thus, the 2010 self-generation value was converted to a 2015 value using the study's 3.66% annual inflation rate and, then, changed at the same annual percentage rate as the study's bundled wholesale electricity and REC prices between 2015 and 2034. This assumption is reasonable in that changes in the self-generation price are driven to a significant degree by changes in the wholesale electricity market, where electricity marketers such as WAPA buy and sell bulk electricity.

3. The third reason for the application of self-generation prices for roof and parking solar projects is that multiple military installations have electricity export restrictions with their utilities that prevent and/or value at zero behind-the-meter installation electricity self-generation that exceeds the military installation's electricity usage. These restrictions mean that installing self-generation that exceeds any month's peak demand could result in zero payment from the wholesale market, no value in the form of avoided utility purchases and/or a notice of utility contract violation for a portion of the self-generation electricity output. This risk is particularly pronounced for solar generation (without storage) because its output cannot be controlled by the owner, unlike natural gas-fueled cogeneration units. To control for this risk, the study authors have set a maximum self-generation capacity at half of annual peak demand.

Annual self-generation rates estimated for the California military installations are listed in Table 5.30 below.

Table 5.30 –Retail Self-Generation Physical Electricity and REC Price Projections for California Installations (Bundled)

Year	Bundled Self-Generation Physical Electricity & REC Price (Real 2010 $/MWh)	Bundled Self-Generation Physical Electricity & REC Price (Nominal $/MWh)[66]
2015	$115.25	$137.94
2016	$108.95	$135.18
2017	$110.43	$142.02
2018	$112.21	$149.60
2019	$118.48	$163.73
2020	$125.23	$179.41
2021	$123.13	$182.84
2022	$123.33	$189.84
2023	$127.67	$203.71
2024	$125.25	$207.17
2025	$123.22	$211.28

[66] The annual inflation rate used to convert 2010 real (or constant) dollars into nominal dollars here is 3.66%, which is the rate generally used for annual revenues and costs in this study only. Additional explanation is in the subsequent economic and project finance rates section of this chapter.

Table 5.30 –Retail Self-Generation Physical Electricity and REC Price Projections for California Installations (Bundled)		
Year	Bundled Self-Generation Physical Electricity & REC Price (Real 2010 $/MWh)	Bundled Self-Generation Physical Electricity & REC Price (Nominal $/MWh)[66]
2026	$114.79	$204.03
2027	$109.06	$200.94
2028	$105.30	$201.11
2029	$102.98	$203.87
2030	$101.71	$208.74
2031	$102.79	$218.68
2032	$104.01	$229.35
2033	$105.34	$240.80
2034	$106.80	$253.06

5.9.5 REC Prices

RECs are certificates representing the electricity output from eligible renewable energy generation sources and are used to track compliance with a state's Renewable Portfolio Standards (minimum requirements for production of renewable power), among other environmental purposes. RECs are very important in California, as the state has an aggressive Renewable Portfolio Standard (RPS) that electricity suppliers in the state must meet.

Though RECs are bundled together with physical power deliveries in California, we have broken out the price projections in this study into physical power (see above) and REC categories for greater analytic clarity. We have done so because the process of price formation and the drivers of physical power and REC prices are somewhat different. Immediately below is a brief description of the issues and variables driving the REC price projections. These price projections represent the green premium, over and above the physical commodity power price, a generator could expect to receive for RECs delivered to an off-taker through a bundled (RECs + power) sales agreement.

The study assumes in its baseline economic calculations that all solar project RECs are sold (not retained) by the project owner, whether MILCON or privately-owned. Policy issues associated with substituting RECs in this manner to meet military green energy or other goals are described in the Solar Development Context chapter of this report.

ICF projects that the green premium available to renewable energy projects that meet California's deliverability requirement[67] will remain robust through the early 2020s. Upward pressure on pricing is driven by the state's rapidly growing renewable energy requirements and the assumed phase-out of key federal incentives, including the production tax credit (PTC) and

[67] California has recently adopted a 33 percent by 2020 renewable portfolio standard (RPS) that categorizes renewable resources as dynamically scheduled, firmed and shaped, or tradable RECs (TRECs) depending upon how they are effectively generated in, or delivered into, the state. For modeling purposes, ICF merges the dynamically-scheduled and firmed and shaped categories together and treats them as one product requiring deliverability.

investment tax credit (ITC), and the assumption that state-based green premiums will have to rise to offset the reduction in federal-level incentives. In the longer term, ICF expects green premiums will fall steadily from the 2020s through the 2030s as renewable energy technology costs improve and as commodity power prices rise due to costs associated with assumed environmental regulations such as California's AB 32 GHG emission reduction program. AB 32 is built into ICF's IPM® power market modeling.

New wind, solar, and geothermal capacity will provide the majority of new generation required to meet the California RPS through 2035. ICF's modeling of California accounts for ―firmly" planned renewable capacity additions. Firm additions, particularly those in the Tehachapi area in southern California, should play a key role in helping California meet its renewable energy requirements. By 2020, new geothermal, solar, and wind capacity additions will supply roughly equivalent amounts of deliverable generation.

Table 5.31 –REC Price Projections in $/MWh

Year	California REC Price (Real 2010 $)	California REC Price (Nominal $)[68]
2015	$43.62	$52.21
2016	$37.95	$47.08
2017	$40.68	$52.32
2018	$43.62	$58.15
2019	$46.76	$64.62
2020	$50.13	$71.82
2021	$45.60	$67.71
2022	$41.47	$63.83
2023	$37.72	$60.18
2024	$34.30	$56.74
2025	$31.20	$53.49
2026	$22.72	$40.38
2027	$16.55	$30.49
2028	$12.05	$23.01
2029	$8.78	$17.37
2030	$6.39	$13.12
2031	$5.71	$12.15
2032	$5.11	$11.26
2033	$4.57	$10.44
2034	$4.08	$9.67

[68] The annual inflation rate used to convert 2010 real (or constant) dollars into nominal dollars here is 3.66%, which is the rate generally used for annual revenues and costs in this study only. Additional explanation is in the subsequent economic and project finance rates section of this chapter.

5.9.6 Other Federal, State, and Utility Incentives

Beyond REC, which are projected to provide substantial support to solar development in California, there are a number of other solar incentive programs included in the study.

At the Federal level, the major solar incentives (the ITC and modified accelerated cost-recovery system depreciation (MACRS)) are embedded in the tax code. Therefore, government agencies and non-profit organizations that have no tax liability cannot generally access these incentives if they own solar projects themselves. Private owners can access the tax-based incentives and that is one of the reasons for the frequency of private ownership of solar projects on public lands and buildings, using partnership models such PPAs.

In this study, it is assumed that a project built by the military using MILCON funds, for example, would not have access to Federal incentives, but ownership privately-owned project on a military installation would have access to these incentives. The study assumes that the Federal ITC equal to 30% of the fully-capitalized (equipment, labor, and development/integration) installation cost of solar projects, enshrined in law through the end of 2016, will be in full effect in 2015 and that the full benefit (30% tax credit) would be utilized in the first year of solar project operation.

Also, the longstanding MACRS depreciation schedule for solar projects is also applied for private owners in this study, but not for MILCON-funded projects. MACRS is applied to 85% of fully-capitalized project costs (i.e., deducting half of the 30% ITC benefit from 100% of costs, as is common practice). MACRS is calculated over the first six years of system operation and does not include the temporary bonus depreciation now in effect (NCSC, 2009). For both MACRS and the ITC, the study assumes sufficient private-owner tax liability to take full advantage of these tax provisions.

At the state and utility levels, **beyond** the substantial REC revenue stream discussed in the prior section, the availability of incentives for large-scale solar projects on military lands is projected to be somewhat limited. In the Southern California Edison (SCE) utility territory[69], the substantial initial funding for California Solar initiative (CSI)[70] incentives for non-residential projects has almost been exhausted at present and, therefore, is unlikely to be available for the 2015 start date of solar projects in this study. While there are additional solar incentive programs in SCE's territory, they tend to be focused on residential and other applications quite different from the large commercial-scale and utility-scale systems that are modeled in this study. The property tax exclusions for solar producers in California are not taken as applicable here, since military lands, and project located on military lands, typically do not pay property taxes.

In the Imperial Irrigation District utility that serves Chocolate Mountain AGR and NAF El Centro, there is a strong Performance Based Incentive (PBI) program that provides $0.24/kWh ($240/MWh) for solar output from systems up to 400 kW (0.4 MW) in capacity for government and non-profit solar projects for a five-year period. Such payments are capped at $650,000 over

[69] SCE is the utility serving MCAGCC Twentynine Palms, MCLB Barstow, NAWS China Lake, Edwards AFB, and Fort Irwin, which is the majority of installations in this study.
[70] The background and outlook for the California Solar Initiative and other solar incentive programs is described in more detail in the Solar Development Context chapter.

the five-year period, and systems larger than the maximum capacity have their payments prorated down to the maximum size. As NAF El Centro already has 250 kW of solar projects installed, the study's assumption is that NAF El Centro will reach the 400 kW maximum for the PBI program before 2015 and, therefore, no additional PBI is assumed in the study's modeling of its solar sites. Chocolate Mountain AGR has no solar sites at present, so the PBI is applied for that military installation up to the 400 kW program maximum.

Guaranteed solar loan programs were not incorporated into this analysis at the Federal, State, or utility level. The lending assumptions applied in the study are described in the subsequent Economic and Project Finance Rates section.

5.9.7 Land Lease Rates

When a private developer builds a solar project on public land, it typically pays an implicit or explicit rental payment to the public agency controlling the land. No lease payments are made in association with building roof and parking[71] solar sites, as such projects would not remove any usable land from alternate uses by the military.

For all ground-based (both cantonment and range area) solar projects in this study using the private ownership model, we have applied a two-pronged lease calculation. The lease payments would be made from the private project owner to an agency of the U.S. government[72]. The two prongs of the lease payments are (1) a county-based[73] per-acre rent for the land itself, and (2) a separate and additional, technology-based rent proportional to expected solar capacity. This is based on a DOI/BLM Methodology (BLM, 2010e). The associated data for each County and solar technology are described in the tables below.

---

[71] The solar parking installations are comprised of metal canopies, under which vehicles can park, with solar panels and equipment on top of the canopies. No parking spaces are projected to be removed from service, except briefly during solar system installation, so there would be no long-term land loss or cost.

[72] The question of which government agency receiving payment for land rents is not always simply answered. The study assumes that the identity of the government agency taking receipt of the rental payments -- BLM or a military department – is immaterial for the purpose of analyzing whether a project will be economically viable. The Solar Development Context contains a fuller discussion of the complex issues associated with withdrawn lands located within the installations addressed by this study.

[73] The counties in which the seven installations in this study are located are: MCAGCC Twentynine Palms (San Bernardino County); MCLB Barstow (San Bernardino); NAWS China Lake (Inyo, Kern, San Bernardino); Chocolate Mountain AGR (Imperial, Riverside); NAF El Centro (Imperial); Edwards AFB (Kern, Los Angeles, San Bernardino); and Fort Irwin (San Bernardino). For those installations crossing into multiple Counties, the study authors have identified the County with the majority of a suitable ground solar site in it and assigned the site exclusively to that County for the purposes of lease calculations to the extent practical.

Table 5.32 –Solar Land Lease Rates for Ground Sites by County		
County	State	Acreage Portion of Starting Annual Lease Rate (2015$/Acre)[74]
Imperial	CA	$225.42
Inyo	CA	$68.98
Kern	CA	$112.70
Los Angeles	CA	$1,379.44
Riverside	CA	$375.68
San Bernardino	CA	$150.28

Table 5.33 – Technology Portion Only of Solar Land Lease Rates for Ground Sites	
Technology	Technology Portion of Starting Annual Lease Rate (2015$/MW)[75]
Crystalline-Silicon Fixed-Axis PV	$5,256
Crystalline-Silicon Tracking PV	$5,256
Thin-Film Fixed-Axis PV	$5,256
Thin-Film Tracking PV	$5,256
Dish/Stirling CSP	$6,570
Trough CSP	$6,570

The tables in this section imply that thin-film solar PV installations have higher lease payments than crystalline-silicon PV because thin-film requires considerably more space (acreage) per installed MW of capacity than the crystalline-silicon technology. The tables also show that Dish/Stirling and Trough installations have higher technology-fee lease components than PV because CSP technologies tend to have higher capacity factors.[76] Trough has the highest lease rates of the six technologies, as it combines relatively high acreage requirements per MW with a high capacity factor per MW.

The study also has an additional ―excess" land lease payment (above the standard payment described above) that it calculates. That scenario evaluates whether the U.S. military could capture excess returns from privately-owned solar projects above the private owners' investment return threshold. The excess rent calculations are described in more detail in the subsequent Project Ownership section. Table 5.71 displays the combination of the annual standard rents

---

[74] The acreage portion of the lease rates from the Bureau of Land Management are in 2010 dollars, and have been escalated to 2015 dollars (the starting year for the study's economic analysis) by applying the annual inflation rate of 3.66% used in the study. They are inflated annually after 2015 by 3.66% as well.
[75] The technology, or ―megawatt capacity fee," portion of the BLM lease rate used in this study is for CSP technologies with no energy storage. This is consistent with the study's use of CSP without storage throughout the study. BLM has higher megawatt capacity fees for CSP with storage. No inflation adjustment has been performed on the technology (per megawatt) portion of the lease rate. The technology portion of the lease rate is phased in over the first five years per BLM protocol, with 20% applied in the first year, 40% in the second year, 60% in the third year, 80% in the fourth year, and 100% in the fifth year and thereafter.
[76] Capacity factor measures the percentage of generation unit's actual output versus its output if it was operating at its peak output during 100% of a period. For solar projects over a 1-year (non leap year) period, the formula for capacity factor is: Actual Output/(8,760 hours x Maximum Hourly Rated Capacity).

described here and the ―excess rents" that may potentially arise and be captured under the energy joint venture statute, enhanced use lease, or other DoD contracting arrangements.

5.9.8 Transmission Costs

Though this study does not consider existing 2011 transmission system limitations to be binding constraints for the purpose of estimating longer-term solar potential on the military installations, it does include a basic mechanism for projecting military installation transmission line extension costs for ground-sited solar projects to connect to the transmission system. Stated otherwise, lack of current access to transmission capacity (a) does not eliminate an otherwise available solar ground site in this study from being counted towards the study's total of **technically-viable** solar potential, but (b) basic cost estimates of connecting military installation solar projects to the nearest substation are included in the calculation of the **economically-viable** solar potential and, therefore, transmission costs may render certain technically-viable sites unviable from an economic perspective. This description applies to ground sites only.[77]

The only transmission cost estimates applied in this study are for lines between the potential ground-mounted solar projects identified in this study to a nearby Point of Interconnection (POI) with a significant (230 kV or 500 kV) operational transmission substation. Network upgrade costs on the existing transmission infrastructure, including upgrading substations, are not modeled here. Further, the POI costs that are included in this study, though derived from published utility transmission cost schedules, should just be seen as gross estimates. In practice, there are many factors such as regulatory and environmental review complexity, the lack of straight paths between solar projects and substations, and long-range utility planning on its network supply and demand needs that can cause transmission line extensions to vary widely in their cost or even their fundamental feasibility.

The inclusion of POI transmission costs in this study are meant to notify the reader to the importance of such costs in solar development and to capture some of the real projects costs that transmission constraints pose to utility-scale solar development in the study's economic model. POI costs are taken in the first year of the solar project investment, are not capitalized for purposes of establishing loan balances in this study, and are not taken as eligible for the Federal ITC or MACRS depreciation allowance when privately owned.

Table 5.34lists the 2015 POI transmission cost factors assigned to each military installation. The ongoing O&M costs of transmission line extensions are very small relative to POI construction, and are assumed to be zero in this study.

[77] For building roof and parking sites, which are typically much smaller in aggregate than ground sites and adjacent to installation electrical distribution systems, this study assigns no transmission cost. The statistical screening process used to identify suitable roof and parking sites is explained in the prior Solar Technology Analysis section of this chapter.

Table 5.34 – Summary of Transmission Factors for Expanding Solar Development at Installations				
Military Installation	**Distance to Reference Substation (Miles)**[78]	**Voltage of Transmission Line Extension**	**Maximum AC Capacity of Transmission Line Extension (kV)**[79]	**Projected Transmission Costs per Line Extension Mile at Reference Voltage (2015$)**[80]
MCAGCC Twentynine Palms	N/A	N/A	N/A	$0[81]
MCLB Barstow	44.5[82]	500	1,500	$5,022,663
NAWS China Lake – Mainsite Cantonment	7.4	230	400	$5,542,249
NAWS China Lake – Range	7.4	230	400	$5,542,249
Chocolate Mountain AGR	53.5	500	1,500	$7,268,660
NAF El Centro	7.7	500	1,500	$7,268,660
Edwards AFB	30.0	500	1,500	$5,022,663
Fort Irwin - Cantonment	71.6	500	1,500	$5,022,663
Fort Irwin – NASA Goldstone Range	72.9	500	1,500	$5,022,663

The pure range areas with suitable lands (e.g., Chocolate Mountain AGR and the NASA Goldstone complex in Fort Irwin), not surprisingly, tended to have the longest POI distances. To

---

[78] The distance to the reference transmission substation was measured as a straight line from the center of the installation area with solar suitability. The transmission substations and their maximum voltages applied to each installation were: Lugo 500 kV (MCLB Barstow), Inyokern 230 kV (NAWS China Lake), Imperial Valley 500 kV (Chocolate Mountain AGR), Imperial Valley 500 kV (NAF El Centro), Vincent 500 kV (Edwards AFB), and Lugo 500 kV (Fort Irwin).

[79] The relationship between transmission line type and transfer capability (maximum AC capacity) was obtained from Western Electricity Coordinating Council (WECC) estimates. The WECC figures associate a transfer capability of 400 MW with a 230 kV AC single line, and 1,500 MW with a 500 kV single line (WECC, 2011).

[80] Transmission line extension costs per mile to the ―Point of Interconnection" were determined by (a) using 2011 costs from the SCE Generator Interconnection Unit Cost Guide (revised as of 1/12/2011) for single circuit, tubular steel pole lines at 230 kV and single circuit, lattice tower lines at 500 kV for the installations served by SCE (MCAGCC Twentynine Palms, MCLB Barstow, NAWS China Lake, Edwards AFB, and Fort Irwin) and applying the 1.5 X multiplier that SCE provides for hilly terrain, or (b) using 2011 costs from the San Diego Gas and Electric (SDG&E) Draft Unit Cost Guide (1/24/2011) for single circuit, anchor-bolted steel pole lines at 230 kV and single circuit, lattice tower lines at 500 kV and applying the 1.2 X multiplier that SCE provides for hilly terrain for the installations that are closest to an SDG&E substation (Chocolate Mountain AGR and NAF El Centro), and (c) inflating the 2011 cost figures to 2015 dollars by using the standard 3.66% annual inflation rate applied in the economic section of this study.

[81] MCAGCC Twentynine Palms is already planning to install two new 115kV electrical lines at its installation that should be sufficient to carry the solar potential projected for the installation in this study. Therefore, the marginal transmission cost applied for MCAGCC Twentynine Palms is zero in this study.

[82] The distance to the relevant 500 kV transmission substation was calculated from the weighted-average of the centers of the Nebo and Yermo portions of MCLB Barstow. The weighting factor among the two sides of the installation was the acreage available for solar development on each side of the installation. As was the case with certain other installations, there are smaller capacity transmission substations closer to MCLB Barstow than the 500 kV substation applied here.

the extent that additional range areas, especially in isolated desert regions, become suitable, such sites would generally have longer distances to transmission interconnections and higher transmission costs.

5.9.9 Economic and Project Finance Rates

There are several financial rates included in the study and, in many cases they have sizable effects on the study's outcomes (i.e., projections on the magnitude and location of economically-viable solar sites). For example, if the study's discount rates (minimum investment return thresholds) or loan rates are lowered meaningfully and other factors stayed equal, the overall solar potential assumed in the study would increase. The economic and project finance factors for this study are summarized in the Table 5.35.

Table 5.35 – Economic and Project Finance Rates Included in Study for MILCON and Private Ownership

Factor	Value Applied in Model for MILCON Ownership	Factor	Value Applied in Model for Private Ownership
Discount Rate[83]	7% Real (Pre-Inflation)	Discount Rate[84]	12% Nominal (Post-Inflation)
Annual Inflation Rate[85],[86] (applied to electricity & REC prices, O&M, insurance, and water costs)	3.66%	Annual Inflation Rate (applied to electricity & REC prices, O&M, insurance, and water costs)	3.66%
Federal Corporate Income Tax Rate	0% (tax-exempt)	Federal Corporate Income Tax Rate	35%[87]
State Income Tax Rates	0% (tax-exempt)	State Income Tax Rates[88]	8.84%
State Sales Tax Rates	0% (tax-exempt)	State Sales Tax Rates[89]	8.25%

[83] The MILCON discount rate is obtained from the U.S. Office of Management and Budget's Circular on *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs* (OMB, 1992). Under that OMB guidance, ―some Federal activities provide a mix of both Federal cost savings and external social benefits … The net present value of such investments should be evaluated with the 7 percent real discount rate discussed in Section 8.b. (of the OMB Circular) unless the analysis is able to allocate the investment's costs between provision of Federal cost savings and external social benefits." The solar projects in this study represent integrated investments, with the potential for intertwined Federal cost savings, social/environmental benefits, and national and military-level energy security benefits.

[84] See ―cost of equity" from Prior (Prior, 2009). The GTM Research study also uses a 50/50 debt equity percentage and a 7% loan rate, just as in this study. GTM uses a 20-year loan term and a 25-year economic life for solar projects, compared to a 15-year loan term and a 20-year economic life in this study.

[85] The inflation rate used in the study is the average, compounded inflation rate from the U.S. Bureau of Labor Statistics' Consumer Price Index-All Urban Consumers (CPI-U) over the period 1979-2009. While this inflation rate is higher than rates typical over the past few years, it represents a longer-run calculation deemed appropriate for the time horizon (2015 to 2034) in the study's economic calculations.

[86] The annual inflation rate is applied annually, beginning in year 2 of the economic analysis (2016), to electricity prices, REC prices, O&M, insurance, water costs, inverter replacement accruals, and scheduled lease payments. Depending on the solar technology and site type (ground, roof, or parking), some of the above factors do not apply at all as described elsewhere in this chapter, but where they are applicable, the annual inflation rate is utilized.

[87] The current maximum federal corporate income tax rate is 35%, and that is applied to all income for privately-owned solar projects in this study.

[88] (FTA, 2011a)

Table 5.35 – Economic and Project Finance Rates Included in Study for MILCON and Private Ownership			
Factor	**Value Applied in Model for MILCON Ownership**	**Factor**	**Value Applied in Model for Private Ownership**
Property Tax Rate[90]	0%	Property Tax Rate	0%
Equity Ownership	100%	Equity Ownership	50%
Loan Interest Rate[91]	N/A	Loan Rate	7% Nominal (Pre-Inflation)
Loan Term	N/A	Loan Term[92]	15 years

5.9.10 Project Ownership

The two baseline ownership options included in this study are MILCON (construction funded by the military budget) and private ownership. The private ownership model involves private developers owning the solar projects on military lands and selling the solar output through a PPA or similar arrangement to an off-taker. The study does not specify the nature of the off-takers[93] or off-take agreements for either the MILCON or private ownership models.

The differing economic factors applied to MILCON and private ownership are described in the sections above. Some of the primary differences are that MILCON is sales and income tax-exempt and has a lower discount (investment hurdle) rate than private owners, but MILCON cannot access the substantial Federal solar incentives embedded in the tax code. The Federal ITC and MACRS depreciation that substantially offset the installed cost of solar projects can be claimed by private owners with sufficient tax liability, but not by direct government or non-profit owners of solar projects.

In addition to MILCON and private ownership, the study also calculates excess rents that may be available to the DoD in addition to the standard BLM-scheduled solar rents discussed above if the project generates sufficient projected profit for a private owner or financier. The DoD may be able to obtain these excess rents, whether as direct lease payments, reduced power costs, or via other means under the energy joint venture statute giving the military authority to sell electricity or a contractor to sell electricity to the military.[94] Under this concept, the DoD would receive all excess solar project returns above a given investment hurdle rate established for a private solar owner. Those excess returns would be transferred from the private owner to the DoD via excess lease payments (above the project's standard lease payments). This structure allows the

---

[89] (FTA, 2011b) State sales tax is applied to the installed equipment costs of each technology (not to the labor or project development & integration costs). State sales tax is not capitalized into the basis for the federal investment tax credit or modified accelerated cost-recovery system depreciation.
[90] Military properties are typically exempt from state and local property taxes.
[91] (FTA, 2011a). The loan balance calculation (Microsoft Excel's PMT function) applied in this study assumes annual payments and a constant loan interest rate. The loan payments include principal and interest, but no reserve payments, taxes, or other loan fees.
[92] The loan rate and loan term used are consistent with the Black & Veatch study (Black and Veatch, 2011).
[93] In general, the economic returns of potential solar projects vary positively with the creditworthiness of off-takers of the project output.
[94] Refer to the Solar Development Context chapter of this report for additional information about the energy joint venture contracting method, authorized through 10 U.S.C. 2916.

government to essentially charge rent in correlation with project returns, as long as the private owner can achieve its benchmark return. If the solar project does not generate excess returns, there would be no extra rent payments to the military (the military would just receive the standard, scheduled rent payments).

The excess return calculation is made for ground sites in this study, as those tend to be the utility-scale projects on which this type of military-private contracting would be most likely to occur. Excess rents are not calculated for building roof and parking sites on the military installations. Table 5.71 describes results from the excess rent calculations.[95] Table 5.72 combines the excess rents that may be available with standard rent payments for the use of military lands for solar under the energy joint venture, enhanced use lease, and/or other contracting authorities.

5.9.11 20-Year Investment Return Calculation

The economic model inputs and processes described above, together with the installed capacity (MW) and electricity output (MWh) established by the Technology analysis and the acreage and other site characteristics established by the GIS analysis, are all integrated into 20-year pro-forma investment return calculations for each combination of solar technology, potentially-suitable sites, and project ownership options. Those investment returns are the economic results in the study – they show which combinations of solar technologies, sites, and ownership options generate positive net present value[96] investment returns. The technology-site-ownership combinations with positive (above zero) net present values demonstrate the economically-viable solar potential at each military installation and, when summed, across all of the military installations studied.

The investment return calculation contains 20 individual years of revenues (physical power and REC sales proceeds) and expenses (one-time installation, transmission, and de-commissioning costs; ongoing annual costs including land lease and loan payments; and tax payments and credits) for each potential solar project combination. The net, post-tax earnings from each of the 20 years are converted into a single net present value[97] (NPV) by (a) applying the appropriate discount rate to earnings for each future year, and (b) summing the discounted earnings into a single NPV.

---

[95] The energy joint venture analysis uses a 16% investment hurdle rate; i.e., the U.S. Department of Defense would receive excess rent from the private owner's solar project returns above 16%, thus providing a negotiating cushion to private owners above their minimum investment decision rate (discount rate) of 12%. The 12% discount rate is used in determining the general economic viability of privately owned solar projects in this study.

[96] Net present value (NPV) is a common financial analysis mechanism for converting long-term investment cash flows, like those for a renewable energy project, into a single value in current dollars. An annualized percentage ―discount rate" is the mechanism for reducing future-year cash flows into current dollars. A project with an NPV above zero is one whose investment rate of return exceeds the discount rate and which is considered economically-successful. At an NPV of zero, a project's investment rate of return would exactly equal its discount rate.

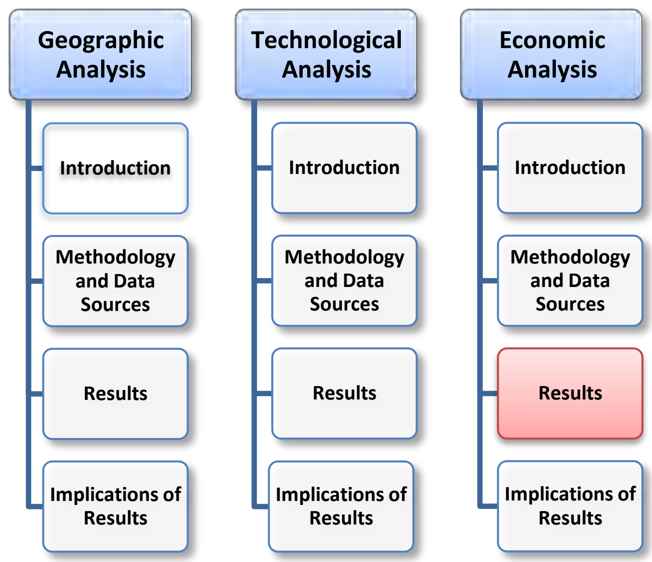
[97] As described in the prior Project Economic and Finance Rates section, the discount rate for MILCON-owned projects is 7% real (before annual inflation) or 10.66% nominal (after inflation), and the discount rate for privately-owned projects is 12% nominal (after inflation). Higher discount rates represent higher thresholds for what is considered a profitable investment and, other factors equal, lead to lower NPV estimates and thus fewer economically-successful projects.

The investment pro-formas assume that the project owner (private or MILCON) sells all solar RECs. The projected economic returns would be significantly lower if all of the solar RECs were retained, or bought back, by the system owner because RECs are estimated to represent about 25% of total solar revenue.

As mentioned in the Solar Development Context chapter of this study, some portions of the DoD may implement a program of substituting the purchase of national, non-technology-specific RECs for the RECs produced and sold from projects on military installations. Such a program would be expected to have a modest cost (deducting only about 1% from total solar project revenue over 20 years) since substitute, national RECs are readily available and valued at about $1/MWh. Due to this low cost, implementing a substitute REC purchase program should not change this study's results in any meaningful way and is not modeled separately.

5.10 Economic Analysis Results

5.10.1 Overall Economic Results



Overall, it is estimated that the **economic potential** for solar development across all seven military installations is 7,164 MW_{AC}.[98] This total is derived from the study's research processes and assumptions and applies to all solar locations reviewed (ground, building roof, and parking sites) and represents 99% of the technical solar potential at the military installations.

The economic potential total (7,164 MW_{AC}) highlighted here is for the solar technologies with the greatest investment rates of return on ground and roof sites, respectively. The economically-viable solar capacity would be approximately 50% higher (10,811 MW_{AC}) and annual electricity generation about 10% higher, if the goal was to maximize installed solar capacity, as opposed to

[98] When displaying the combined solar capacity of all the technologies reviewed, we use MWAC, reflecting their peak rated AC (alternating current) capacity. This is the most consistent way to join PV (PV) and concentrating solar power (CSP) technologies, since CSP technologies do not typically produce direct current (DC), as PV systems do. In addition, AC capacity figures better reflect the financial and environmental effects of solar electricity projects because system output in AC power is what is ultimately consumed and sold, as opposed to DC power generated upstream at the panels. Data on the economic variables (installed cost, O&M costs, etc.) of PV systems are expressed on the basis of DC capacity, which is the industry standard. The DC data are then converted to AC capacity on the basis of the peak hourly output of the system. The total capacity show here is for the sum of 7,147 MW of ground site crystalline-silicon tracking and 17 MW of roof-mounted crystalline-silicon fixed-axis. Those technologies had the highest internal rates of return on investment at ground sites and roof sites, respectively, and, therefore, would be the most likely technologies to be developed.

project rate of return. The higher capacity figure would reflect the use of crystalline-silicon fixed axis systems on ground sites, rather than crystalline-silicon tracking systems that offer higher projected investment returns on ground sites. Capacity and electricity output data for up to six solar technologies at each military installation are displayed in the results section of this chapter.

For ground locations, the total capacity represents the economic potential for developing solar projects on 100% of sites deemed “suitable” (i.e., with no conflicting land uses of any kind), plus 25% of sites deemed “likely suitable” or “questionably suitable” (i.e., with land conflicts that could be ameliorated with additional military installation review).[99]

Table 5.36 shows the economically-viable potential by suitability rating. The table uses the solar technology (crystalline-silicon tracking) with the highest investment returns.

Table 5.36 – Economically-Viable Solar Potential on Ground Sites by Suitability Rating

Row #	Suitability Rating	Ground Site Potential Solar Capacity (MW_{AC})
1	100% of Suitable Acreage (rating = 1)	3,595
2	100% of Likely & Questionably Suitable Acreage (ratings = 2 & 3)	14,208
3	25% of Likely & Questionably Suitable Acreage (ratings = 2 & 3)	3,552
4	Unsuitable Acreage (rating = 4)	0

The sum of rows 1 and 3 in Table 5.36 is the 7,147 MW_{AC} of ground-based solar potential cited as the viable total under this study’s methodologies. If only ―suitable” sites were considered, the solar potential would drop to 3,595 MW. If all areas with any degree of suitability (rating of 1, 2, or 3) were combined, the solar potential would rise to 17,803 MW (the sum of rows 1 and 2).

As mentioned above, there are 17 MW_{AC} of roof-based solar potential in addition to the ground site potential in Table 5.36.

The ―unsuitable” category comprised the great majority of the land at most military installations and represented acreage that had one or more clear conflicts with solar development. ―Unsuitable” sites did not enter the Technology or Economic Analyses because they are not appropriate locations for solar development. ―Suitable”; ―likely suitable” and ―questionably

[99] Definitions for ―suitable,” ―likely suitable,” ―questionably suitable,” and ―unsuitable” land sites are provided in the GIS Analysis section of this chapter. Table 5.36 divides the economically-viable acreage into the ―suitable”, ―likely suitable”, and ―questionably suitable” classifications for all seven California installations combined. In the subsequent results summaries for each installation, ――sitable” ground acres are distinguished from ―likely suitable” and ―questionably suitable” ground acres.

suitable” together; and ―unsuitable” locations can be analogized to traffic lights as green (go), yellow (proceed with caution), and red (stop), respectively.

For building roof and parking locations, there were only two classifications applied – ―suitable” or ―unsuitable” – i.e., there was no middle ―likely suitable” or ―questionably suitable” category for roof and parking sites.

Further, the reported total is for private ownership of the solar projects. The study reviewed both private and MILCON ownership but, in all cases, private ownership yielded superior projected economic returns to MILCON under the study assumptions.[100]

Economic results are not reported for projects with estimated zero or negative NPVs. Such projects, in total, represent the difference between the ―technical” potential for solar development on the military installations and the ―economic” potential. They are technically-feasible (i.e., have potentially valid site characteristics), but are not deemed economically-feasible under the study's assumptions due to some combination of relatively high costs and low revenues.

The total, study-wide capacity (MW_{AC}) data presented below in Table 5.37 are obtained from the technology with the highest IRR at each site. For example, if all six solar technologies were economically successful at a site, but crystalline-silicon tracking had the highest IRR of the six technologies, then its capacity would be reported.[101]

---

[100] The higher projected economic results for private ownership than for MILCON are largely attributable to the fact that private owners can access tax-based federal solar incentives (the 30% investment tax credit and MACRS accelerated depreciation) which can jointly reduce installed projects costs by well over 40%. In addition, private owners are assumed to leverage their returns with project debt. The effect of these federal tax incentives and the project debt for private ownership exceeded the financial benefits of MILCON (avoidance of federal and state income tax, avoidance of state sales tax, and a lower discount rate). The MILCON ownership scenario does not assume any direct government grants supporting solar development. Such grants (e.g., past American Recovery and Reinvestment Act grants) would improve MILCON returns and could cause them to exceed the returns from private ownership. In addition, there are possible scenarios not modeled here (e.g., special operational or environmental risks, contractual complexities, or unavailability of outside capital) wherein MILCON may be the preferable or only ownership option for a given installation solar project.

[101] Alternatively, one could use other benchmarks for total solar potential. If one selected the solar technology with the highest electricity output (and, thereby, the greatest environmental benefit), crystalline-silicon fixed-axis would be the choice for ground sites and the figures reported in this section's tables would change. Likewise, if one sought to maximize installed (or peak) capacity, crystalline-silicon fixed-axis results would be reported and the total potential solar AC capacity across the seven installations would rise by approximately 50% from the 7,164 MW for crystalline-silicon trackers on ground sites (including 17 MW of crystalline-silicon fixed-axis on roofs) to 10,811 MW for crystalline-silicon fixed axis on ground and roof sites. On sufficiently-large ground sites, the economic results for all six solar technologies considered in this study were calculated. For building roof sites, only crystalline-silicon fixed-axis and thin-film fixed-axis results were calculated and, for parking sites, only crystalline-silicon fixed-axis results were calculated as explained in the Methodology portion of this chapter.

Table 5.37 – Capacity of Solar Technology with Highest IRR for Economically-Viable Solar Development Sites, under Private Project Ownership (MW_{AC} in Installed Solar Capacity)						
Military Installation	**Cantonment Ground Sites**[102]	**Range Ground Sites**	**Building Roofs**[103]	**Paved Parking Canopies**	**Unpaved Parking Canopies**	**Total (All Site Types)**
MCAGCC Twentynine Palms	77	0	3	0	N/A	**80**
MCLB Barstow	0	0	5	0	0	**5**
NAWS China Lake	557	403	1	0	N/A	**961**
Chocolate Mountain AGR	N/A	0	N/A	N/A	N/A	**0**
NAF El Centro	0	0	N/A	0	N/A	**0**
Edwards AFB	134	3,347	7	0	0	**3,488**
Fort Irwin	808	1,821	1	0	0	**2,630**
Total	**942**	**5,571**	**17**	**0**	**0**	**7,164**

While the paved and unpaved parking projects were not economically-viable under study assumptions due to the incremental costs of purchasing and installing steel solar canopies, this analysis did not account for possible ancillary benefits of solar parking installations. For example, such parking structures could allow for electric vehicle charging during the day, could embed advanced smart metering to use electric vehicles as sources of stored electricity, and/or could offer benefits by providing shade for mechanical work on military vehicles. In addition, shading structures can extend the life of equipment parked beneath them, and also increase driver comfort compared with leaving a vehicle exposed to the desert sun.

Currently, the parking canopies add approximately 30% (paved with 9’ clearance) and 34% (unpaved with 14’ clearance) to installed project costs compared to similarly-sized roof-mounted projects. That price increment is sensitive to steel material prices, which comprise a large portion of the incremental costs.

Table 5.38 – Capacity for Economically-Viable Solar Development Across Installations, by Solar Technology under Private Project Ownership (MW_{AC})						
	PV Technologies				**CSP Technologies**	
Military Installation	**Crystalline-Silicon Fixed-Mount**	**Thin-Film Fixed-Mount**	**Crystalline-Silicon Tracking**	**Thin-Film Tracking**	**Dish/Stirling**	**Trough**
MCAGCC Twentynine Palms	116	72	77	49	88	0
MCLB Barstow	5	3	0	0	0	0
NAWS China Lake	1,452	901	960	602	0	0

[102] Crystalline-silicon PV single-axis tracking had the highest overall internal rate of return (IRR) among the six solar technologies evaluated on large ground sites. Crystalline-silicon tracking capacity results are reported uniformly in this table for economically-viable sites. However, there was one site at which a different technology had the highest IRR – at the NASA Goldstone range at Fort Irwin, thin-film tracking had a slightly higher IRR than crystalline-tracking and the highest IRR among the three technologies that were economically-viable on the Goldstone range.

[103] Crystalline-silicon PV fixed-axis had the higher internal rate of return among the two solar technologies evaluated on building roofs.

Table 5.38 – Capacity for Economically-Viable Solar Development Across Installations, by Solar Technology under Private Project Ownership (MW_{AC})						
	PV Technologies				CSP Technologies	
Military Installation	**Crystalline-Silicon Fixed-Mount**	**Thin-Film Fixed-Mount**	**Crystalline-Silicon Tracking**	**Thin-Film Tracking**	**Dish/Stirling**	**Trough**
Chocolate Mountain AGR	0	0	0	0	0	0
NAF El Centro	0	0	0	0	0	0
Edwards AFB	5,308	3,295	3,481	2,184	0	0
Fort Irwin	3,930	1	2,629	1,144	0	0
Total	**10,811**	**4,272**	**7,147**	**3,979**	**88**	**0**

Table 5.39 – Annual Electricity Output for Economically-Viable Solar Development Across Installations, by Solar Technology under Private Project Ownership (Year 1 Electricity Output in *GWh = 1,000 MWh*)						
	PV Technologies				CSP Technologies	
Military Installation	**Crystalline-Silicon Fixed-Mount**	**Thin-Film Fixed-Mount**	**Crystalline-Silicon Tracking**	**Thin-Film Tracking**	**Dish/Stirling**	**Trough**
MCAGCC Twentynine Palms	242	153	216	137	212	0
MCLB Barstow	9	6	0	0	0	0
NAWS China Lake	2,892	1,826	2,631	1,669	0	0
Chocolate Mountain AGR	0	0	0	0	0	0
NAF El Centro	0	0	0	0	0	0
Edwards AFB	10,000	6,318	9,000	5,717	0	0
Fort Irwin	8,029	2	7,332	3,222	0	0
Total	**21,172**	**8,305**	**19,179**	**10,745**	**212**	**0**

The total annual solar electricity output for the two thin-film PV technologies is equal to approximately one-quarter to one-third of total, DoD-wide electricity consumption, which is 29,861 GWh (DoD, 2010d). Annual output from the two crystalline-silicon PV technologies would be equal to about two-thirds of DoD-wide electricity use.

The totals in Table 5.38 and Table 5.39 above for solar potential should not be summed across technologies. This is because the study allows for multiple technologies to be built on ground sites (all six technologies, subject to their different minimum sizes per site) and building roof sites (crystalline-silicon and thin-film fixed-mount). Therefore, summing the capacity (MW) or output (MWh) would result in an over-estimation of total solar potential since multiple technologies cannot be simultaneously built on the same site.

Table 5.40 – Capacity for Economically-Viable Solar Development Across Installations, by Site Type under MILCON Project Ownership (MW_{AC} in Installed Solar Capacity)

Military Installation	Cantonment Ground Sites	Range Ground Sites	Building Roofs	Paved Parking Canopies	Unpaved Parking Canopies	Total (All Site Types)
MCAGCC Twentynine Palms	0	0	0	0	0	0
MCLB Barstow	0	0	0	0	0	0
NAWS China Lake	0	0	0	0	0	0
Chocolate Mountain AGR	0	0	0	0	0	0
NAF El Centro	0	0	0	0	0	0
Edwards AFB	0	0	0	0	0	0
Fort Irwin	0	0	0	0	0	0
Total	0	0	0	0	0	0

Table 5.41 – Capacity for Economically-Viable Solar Development Across Installations, by Solar Technology under MILCON Project Ownership (MW_{AC} in Installed Solar Capacity)

	PV Technologies				CSP Technologies	
Military Installation	Crystalline-Silicon Fixed-Mount	Crystalline-Silicon Tracking	Thin-Film Fixed-Mount	Thin-Film Tracking	Dish/Stirling	Trough
MCAGCC Twentynine Palms	0	0	0	0	0	0
MCLB Barstow	0	0	0	0	0	0
NAWS China Lake	0	0	0	0	0	0
Chocolate Mountain AGR	0	0	0	0	0	0
NAF El Centro	0	0	0	0	0	0
Edwards AFB	0	0	0	0	0	0
Fort Irwin	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**	**0**

A matrix connecting the solar technologies with the site type to which they are applied in this study is provided in Table 5.42. Background on why the technologies were connected to different site types is provided in the prior Technology section. For example, Concentrating Solar Power technologies can only generally be installed on the ground. The same restriction applies to PV tracking systems.

Table 5.42 – Matrix of Solar Technologies Applied to Solar Site Types in Study

	PV Technologies				CSP Technologies	
Site Type	**Crystalline-Silicon Fixed-Mount**	**Thin-Film Fixed-Mount**	**Crystalline-Silicon Tracking**	**Thin-Film Tracking**	**Dish/Stirling**	**Trough**
Ground[104] (Cantonment or Range Areas)	**X**	**X**	**X**	**X**	**X**	**X**
Building Roof	**X**	**X**				
Paved Parking Canopies	**X**					
Unpaved Parking Canopies	**X**					

For reference, Table 5.43 and Table 5.44 indicate the **economically-viable** acreage available for solar development on each military installation. These acreage data are a subset of the acreages reported in the earlier Geographic Analysis section of this chapter. The economically-viable acreages here reflect the areas on which utility-scale solar could be deployed with projected investment rates of return exceeding the study’s threshold. They also incorporate the study’s assumption that 100% of suitable acreage and only 25% of ―likely suitable” and ―questionably suitable” acreage would be considered in the economic analysis.

The two tables indicate that just over 500,000 acres of military installation ground sites are economically-viable. While 78% of this ground acreage is on range areas of the installations, a still-large figure of over 11,000 acres is on cantonment sites.

The economically-viable acreages parallel the solar capacity potential on each installation and, as with capacity, Edwards AFB and Fort Irwin contribute the largest share of solar potential among the seven military installations studied.

[104] There are minimum ground acreage areas for each solar technology that vary from 5 acres for crystalline-silicon PV systems with a simple fixed axis to 500 acres for Trough Concentrating Solar Power systems. These size minimums are listed for each technology at the beginning of this Economic section of the report and correspond to the project sizes that may be most readily developed.

Table 5.43 – Total Economically-Viable Acreage[105] Available for Solar Development on Cantonment[106] and Range Ground Sites

Military Installation	Cantonment Ground Sites	Range Sites	Total for Ground Sites
MCAGCC Twentynine Palms	553	0	**553**
MCLB Barstow	0	0	**0**
NAWS China Lake	3,930	2,847	**6,777**
Chocolate Mountain AGR	0	0	**0**
NAF El Centro	0	0	**0**
Edwards AFB	933	23,394	**24,327**
Fort Irwin	5,757	12,971	**18,728**
Total	**11,173**	**39,212**	**50,385**

Table 5.44 – Economically-Viable Acreage by Suitability Type for Ground Site Solar Development at all Installations

Private Ownership	Private Ownership Acreage	MILCON Ownership Acreage
100% of Acreage for ―Suitable” Ground Sites	25,344	0
25% of Acreage for ―Likely Suitable” and ―Questionably Suitable” Ground Sites	25,041	0
Total Acreage for Solar Development of Ground Sites	50,385	0

[105] To total acreage available on each installation, 100% of ―suitable” acreage after GIS analysis is added to 25% of ―likely suitable” and ―questionably suitable” acreage. Only acreage that is economically-viable (i.e., with an internal rate of return above the study threshold) for at least one solar technology is listed in this table. However, three installations had acreage that was available for solar development, but not economically-viable under the study assumptions -- MCLB Barstow had 696 total acres (660 ―suitable” and 36 ―likely suitable” or ―questionably suitable” after the 75% reduction), Chocolate Mountain AGR had 3,910 total acres (3,768 ―suitable” and 142 ―likely suitable” or ―questionably suitable” after the 75% reduction), and NAF El Centro had 377 ―suitable” acres that passed the technical screening test but failed the economic screening test.

[106] The separation between ―cantonment” and ―range” areas is very clear on some military installations, and less clear on others. Cantonment areas typically have built infrastructure (buildings, parking facilities, maintenance areas, wastewater treatment, etc.), while range areas typically involve active military mission, operational, and field test activities. For the purposes of classification, we have assigned all ground sites into one category or the other. Maps in the prior GIS Analysis section illustrate the potentially-suitable sites in cantonment and range areas for each military installation, as well as the boundaries applied to cantonment areas at each military installation, and offer explanations for the classifications. Some special issues in classifying ground areas as cantonment vs. range are also covered in commentary associated with installation-level tables on solar potential.

5.10.2 Economic Results by Military Installation

This portion of the Economic Results section details projected solar potential for each of the seven California military installations in a common table format and offers commentary on the solar potential estimated at each military installation. The installations are reviewed in the following order:

1. MCAGCC Twentynine Palms
2. MCLB Barstow
3. NAWS China Lake
4. Chocolate Mountain AGR
5. NAF El Centro
6. Edwards AFB
7. Fort Irwin

The totals in the tables below detailing solar potential for each military installation should not be summed across technologies. This is because the study evaluated multiple technologies on ground sites (all six technologies, subject to their different minimum and maximum sizes per site) and building roof sites (crystalline-silicon and thin-film fixed-mount). Therefore, summing the capacity (MW) would result in an over-estimation of total solar potential since multiple technologies cannot be built simultaneously on the same site.

In all instance, the projected economic results for private ownership in this study exceeded the results for MILCON ownership. All solar capacity results are rounded to the nearest MW.

MCAGCC Twentynine Palms Economic Results

Table 5.45 – Potential for Economically-Viable Solar Development[107] at MCAGCC Twentynine Palms under Private Project Ownership

	Installed Capacity (MW_{AC})						Output (MWh_{AC})
Solar Technology	**Range Ground Sites**	**Cantonment Ground Sites**	**Building Roof Sites**	**Paved Parking Sites**	**Unpaved Parking Sites**	**Total Capacity**	**Year 1 Output**
Crystalline-Silicon PV Fixed-Mount	No Valid Sites	113	3	0	No Valid Sites	**116**	**241,668**
Thin-Film PV Fixed-Mount	No Valid Sites	70	2	N/A	N/A	**72**	**152,641**
Crystalline-Silicon PV Tracking	No Valid Sites	77	N/A	N/A	N/A	**77**	**216,348**
Thin-Film PV Tracking	No Valid Sites	49	N/A	N/A	N/A	**49**	**137,281**
Dish/Stirling CSP	No Valid Sites	88	N/A	N/A	N/A	**88**	**211,637**
Trough CSP	No Valid Sites	N/A	N/A	N/A	N/A	**N/A**	**N/A**

[107] ―N/A" in a table cell indicates that the solar technology is not reviewed for that site type. The matrix in Table 5.45 summarizes the technology-site pairings reviewed in this study. For further detail, please see Section 5.6.

Table 5.46 – Potential for Economically-Viable Solar Development at MCAGCC Twentynine Palms under MILCON Project Ownership (MW_{AC})

Solar Technology	Range Ground Sites	Cantonment Ground Sites	Building Roof Sites	Paved Parking Sites	Unpaved Parking Sites	Total (All Site Types)
Crystalline-Silicon PV Fixed-Mount	No Valid Sites	0	0	0	No Valid Sites	**0**
Thin-Film PV Fixed-Mount	No Valid Sites	0	0	N/A	N/A	**0**
Crystalline-Silicon PV Tracking	No Valid Sites	0	N/A	N/A	N/A	**0**
Thin-Film PV Tracking	No Valid Sites	0	N/A	N/A	N/A	**0**
Dish/Stirling CSP	No Valid Sites	0	N/A	N/A	N/A	**0**
Trough CSP	No Valid Sites	0	N/A	N/A	N/A	**0**

Table 5.47 – Economically-Viable Acreage for Ground Site Solar Development at MCAGCC Twentynine Palms

Private Ownership	Private Ownership Acreage	MILCON Ownership Acreage
100% of Acreage for ―Suitable” Ground Sites[108]	461	0
25% of Acreage for ―Likely Suitable” and ―Questionably Suitable” Ground Sites	92	0
Total Acreage for Solar Development of Ground Sites	**553**	**0**

MCAGCC Twentynine Palms has a dry lake bed site (with 204 suitable acres and 163 questionably suitable acres for potential solar development – 204 ―suitable” and 162 ―questionably suitable” acres) that is included in the cantonment area totals above. The military installation is already exploring large-scale solar development on the lake bed. This military installation also has 462 acres (257 ―suitable” and 205 ―questionably suitable” acres) of ground space elsewhere in the cantonment available for solar development. All of this potentially developable acreage at the military installation may have floodplain conflicts that would need to be investigated and likely mitigated.

As mentioned in the earlier transmission costs section of the report and in the Utilities portion of Appendix A, MCAGCC Twentynine Palms is planning for two new transmission lines. For this reason and due to the relatively modest acreage available for additional solar development here, no additional transmission costs were modeled for this military installation.

MCAGCC Twentynine Palms has no valid unpaved parking sites in this study because it did not provide GIS data on unpaved parking.

---

[108] For MCAGCC Twentynine Palms, it is assumed that the dry lake bed site flood zone issues would be mitigated by the installation under its current solar development plans. No additional cost to such mitigation is assigned in this study.

MCLB Barstow Economic Results

Table 5.48 – Potential for Economically-Viable Solar Development at MCLB Barstow under Private Project Ownership							
	Installed Capacity (MW_{AC})						Output (MWh_{AC})
Solar Technology	**Range Ground Sites**	**Cantonment Ground Sites**	**Building Roof Sites**	**Paved Parking Sites**	**Unpaved Parking Sites**	**Total Capacity**	**Year 1 Output**
Crystalline-Silicon PV Fixed-Mount	No Valid Sites	0	5	0	0	**5**	**9,401**
Thin-Film PV Fixed-Mount	No Valid Sites	0	3	N/A	N/A	**3**	**6,020**
Crystalline-Silicon PV Tracking	No Valid Sites	0	N/A	N/A	N/A	**0**	**0**
Thin-Film PV Tracking	No Valid Sites	0	N/A	N/A	N/A	**0**	**0**
Dish/Stirling CSP	No Valid Sites	0	N/A	N/A	N/A	**0**	**0**
Trough CSP	No Valid Sites	N/A	N/A	N/A	N/A	**N/A**	**N/A**

Table 5.49 – Potential for Economically-Viable Solar Development at MCLB Barstow under MILCON Project Ownership (MW_{AC})						
Solar Technology	**Range Ground Sites**	**Cantonment Ground Sites**	**Building Roof Sites**	**Paved Parking Sites**	**Unpaved Parking Sites**	**Total (All Site Types)**
Crystalline-Silicon PV Fixed-Mount	No Valid Sites	0	0	0	0	**0**
Thin-Film PV Fixed-Mount	No Valid Sites	0	0	N/A	N/A	**0**
Crystalline-Silicon PV Tracking	No Valid Sites	0	N/A	N/A	N/A	**0**
Thin-Film PV Tracking	No Valid Sites	0	N/A	N/A	N/A	**0**
Dish/Stirling CSP	No Valid Sites	0	N/A	N/A	N/A	**0**
Trough CSP	No Valid Sites	0	N/A	N/A	N/A	**0**

Table 5.50 – Economically-Viable Acreage for Ground Site Solar Development at MCLB Barstow		
Private Ownership	**Private Ownership Acreage**	**MILCON Ownership Acreage**
100% of Acreage for ―Suitable” Ground Sites	0	0
25% of Acreage for ―Likely Suitable” and ―Questionably Suitable” Ground Sites	0	0
Total Acreage for Solar Development of Ground Sites	**0**	**0**

At MCLB Barstow, the range areas are not feasible for solar development due to conflicts with desert tortoise habitat.

The two distinct cantonment areas at MCLB Barstow (Nebo and the Yermo Annex) are combined in the data presented below. Of the 696 acres available for solar development, 34% is in the Nebo portion of the military installation, and 66% is in the Yermo Annex. However, that combined acreage of 696 translated into ground site capacity of 170 MW_{DC} and less, which was not enough to compensate for the fixed costs of transmission to the large substation identified for this military installation. Therefore, the MCLB Barstow ground sites were not economically viable under this study's assumptions, though they are technologically viable.

Descriptions and maps of the potentially-suitable solar sites in each of these two areas are presented in the earlier GIS section of this chapter. The relatively small amount of available acreage at MCLB Barstow is due to both the small overall size of the military installation relative to others in the study and the fact that desert tortoise habitat issues rendered the MCLB Barstow range unsuitable for solar development.

NAWS China Lake Economic Results

Table 5.51 – Potential for Economically-Viable Solar Development at NAWS China Lake under Private Project Ownership

	Installed Capacity (MW_{AC})						Output (MWh_{AC})
Solar Technology	**Range Ground Sites**	**Cantonment Ground Sites**	**Building Roof Sites**	**Paved Parking Sites**	**Unpaved Parking Sites**	**Total Capacity**	**Year 1 Output**
Crystalline-Silicon PV Fixed-Mount	610	841	1	0	No Valid Sites	**1,452**	**2,892,329**
Thin-Film PV Fixed-Mount	378	522	1	N/A	N/A	**901**	**1,826,245**
Crystalline-Silicon PV Tracking	403	557	N/A	N/A	N/A	**960**	**2,631,205**
Thin-Film PV Tracking	253	349	N/A	N/A	N/A	**602**	**1,669,275**
Dish/Stirling CSP	N/A	N/A	N/A	N/A	N/A	**N/A**	**N/A**
Trough CSP	0	0	N/A	N/A	N/A	**0**	**0**

Table 5.52 – Potential for Economically-Viable Solar Development at NAWS China Lake under MILCON Project Ownership (MW_{AC})

Solar Technology	Range Ground Sites	Cantonment Ground Sites	Building Roof Sites	Paved Parking Sites	Unpaved Parking Sites	Total (All Site Types)
Crystalline-Silicon PV Fixed-Mount	0	0	0	0	No Valid Sites	**0**
Thin-Film PV Fixed-Mount	0	0	0	N/A	N/A	**0**
Crystalline-Silicon PV Tracking	0	0	N/A	N/A	N/A	**0**
Thin-Film PV Tracking	0	0	N/A	N/A	N/A	**0**
Dish/Stirling CSP	N/A	N/A	N/A	N/A	N/A	**N/A**
Trough CSP	0	0	N/A	N/A	N/A	**0**

Table 5.53 – Economically-Viable Acreage for Ground Site Solar Development at NAWS China Lake

Private Ownership	Private Ownership Acreage	MILCON Ownership Acreage
100% of Acreage for ―Suitable" Ground Sites	5,269	0
25% of Acreage for ―Likely Suitable" and ―Questionably Suitable" Ground Sites	1,508	0
Total Acreage for Solar Development of Ground Sites	**6,777**	**0**

Within NAWS China Lake, 2,847 acres (or 42%) of the suitable acreage is in portions of “range” areas such as G Range and C Approach Corridors that tend to be very close-in to the “Mainsite” cantonment. The remaining 3,930 suitable acres (58% of installation total) are within Mainsite itself. All Mainsite acres that are available for solar development are “suitable”, while the available range acreage is a mix of “suitable,” “likely suitable,” and “questionably suitable” lands.[109]

NAWS China Lake has the third-highest potential for solar development among the military installations studied, behind only Edwards AFB and Fort Irwin, and well ahead of MCAGCC Twentynine Palms. MCLB Barstow, Chocolate Mtn. AGR, and NAF El Centro had no economically-viable solar capacity.

Dish/Stirling technology was found to be technically-unsuitable at NAWS China Lake due to its heat signature and interference with IR research, development, test, and evaluation.

At NAWS China Lake, the majority of the suitable ground sites are located in Kern County (and a minority in San Bernardino County and none in Inyo County), so Kern County is utilized for the study’s lease rate calculations.

[109] The range land with some degree of suitability is comprised of G Range Approach Corridor (852 acres of suitability rating =1); Corridor C (487 acres of suitability rating = 1); Armitage Airfield (1,439 acres with suitability rating =2 and 1,694 acres with suitability rating = 3); and the George area (840 acres with suitability rating = 2 and 2,060 acres with suitability rating = 3). Suitability rating = 2 (likely suitable) and rating = 3 (questionably suitable) acreages are reduced by 75% in this study to obtain the total acreage available for solar development.

Chocolate Mountain AGR Economic Results

Table 5.54 – Potential for Economically-Viable Solar Development at Chocolate Mountain AGR under Private Project Ownership

	Installed Capacity (MW_{AC})						Output (MWh_{AC})
Solar Technology	**Range Ground Sites**	**Cantonment Ground Sites**	**Building Roof Sites**	**Paved Parking Sites**	**Unpaved Parking Sites**	**Total Capacity**	**Year 1 Output**
Crystalline-Silicon PV Fixed-Mount	0	No Valid Sites	No Valid Sites	No Valid Sites	No Valid Sites	**0**	**0**
Thin-Film PV Fixed-Mount	0	No Valid Sites	No Valid Sites	No Valid Sites	No Valid Sites	**0**	**0**
Crystalline-Silicon PV Tracking	0	No Valid Sites	No Valid Sites	No Valid Sites	No Valid Sites	**0**	**0**
Thin-Film PV Tracking	0	No Valid Sites	No Valid Sites	No Valid Sites	No Valid Sites	**0**	**0**
Dish/Stirling CSP	0	No Valid Sites	No Valid Sites	No Valid Sites	No Valid Sites	**0**	**0**
Trough CSP	0	No Valid Sites	No Valid Sites	No Valid Sites	No Valid Sites	**0**	**0**

Table 5.55 – Potential Capacity for Economically-Viable Solar Development at Chocolate Mountain AGR under MILCON Project Ownership (MW_{AC})

Solar Technology	Range Ground Sites	Cantonment Ground Sites	Building Roof Sites	Paved Parking Sites	Unpaved Parking Sites	Total (All Site Types)
Crystalline-Silicon PV Fixed-Mount	0	No Valid Sites	No Valid Sites	No Valid Sites	No Valid Sites	**0**
Thin-Film PV Fixed-Mount	0	No Valid Sites	No Valid Sites	No Valid Sites	No Valid Sites	**0**
Crystalline-Silicon PV Tracking	0	No Valid Sites	No Valid Sites	No Valid Sites	No Valid Sites	**0**
Thin-Film PV Tracking	0	No Valid Sites	No Valid Sites	No Valid Sites	No Valid Sites	**0**
Dish/Stirling CSP	0	No Valid Sites	No Valid Sites	No Valid Sites	No Valid Sites	**0**
Trough CSP	0	No Valid Sites	No Valid Sites	No Valid Sites	No Valid Sites	**0**

Table 5.56 – Economically-Viable Acreage for Ground Site Solar Development at Chocolate Mountain AGR

Private Ownership	Private Ownership Acreage	MILCON Ownership Acreage
100% of Acreage for —Suitable” Ground Sites	0	0
25% of Acreage for —Likely Suitable” and —Questionably Suitable” Ground Sites	0	0
Total Acreage for Solar Development of Ground Sites	**0**	**0**

Chocolate Mountain AGR is almost entirely a range area, with minimal building and parking areas and no significant portion that would be classified as ―cantonment.” The installation’s peak on-site electricity demand is only about 300 kW, less than $1/10^{th}$ the demand of the next-smallest California military installation in electricity demand (NAF El Centro) and about $1/100^{th}$ or less the electricity demand of the largest military installations (MCAGCC Twentynine Palms, Edwards AFB, and Fort Irwin). Therefore, the only site type potentially available for solar development at this installation was ground-mounted.

Though Chocolate Mountain AGR has 3,910 acres that are technically-viable for solar development, the combination of transmission costs and below-average solar irradiance (among the installations studied) caused solar development to be economically unviable for any of the six technologies packages studied.

At Chocolate Mountain AGR, the acreage with suitability ratings of 1-3 was all located in Riverside County, so Riverside County is utilized for the study’s lease rate calculations.

NAF El Centro Economic Results

Table 5.57 – Potential for Economically-Viable Solar Development at NAF El Centro under Private Project Ownership							
	Installed Capacity (MW_{AC})						Output (MWh_{AC})
Solar Technology	**Range Ground Sites**	**Cantonment Ground Sites**	**Building Roof Sites**	**Paved Parking Sites**	**Unpaved Parking Sites**	**Total Capacity**	**Year 1 Output**
Crystalline-Silicon PV Fixed-Mount	No Valid Sites	0	No Valid Sites	0	No Valid Sites	**0**	**0**
Thin-Film PV Fixed-Mount	No Valid Sites	0	No Valid Sites	N/A	N/A	**0**	**0**
Crystalline-Silicon PV Tracking	No Valid Sites	0	N/A	N/A	N/A	**0**	**0**
Thin-Film PV Tracking	No Valid Sites	0	N/A	N/A	N/A	**0**	**0**
Dish/Stirling CSP	No Valid Sites	0	N/A	N/A	N/A	**0**	**0**
Trough CSP	No Valid Sites	N/A	N/A	N/A	N/A	**N/A**	**N/A**

Table 5.58 – Potential for Economically-Viable Solar Development at NAF El Centro under MILCON Project Ownership (MW_{AC})						
Solar Technology	**Range Ground Sites**	**Cantonment Ground Sites**	**Building Roof Sites**	**Paved Parking Sites**	**Unpaved Parking Sites**	**Total (All Site Types)**
Crystalline-Silicon PV Fixed-Mount	No Valid Sites	0	No Valid Sites	0	No Valid Sites	**0**
Thin-Film PV Fixed-Mount	No Valid Sites	0	No Valid Sites	N/A	N/A	**0**
Crystalline-Silicon PV Tracking	No Valid Sites	0	N/A	N/A	N/A	**0**
Thin-Film PV Tracking	No Valid Sites	0	N/A	N/A	N/A	**0**
Dish/Stirling CSP	No Valid Sites	0	N/A	N/A	N/A	**0**
Trough CSP	No Valid Sites	0	N/A	N/A	N/A	**0**

Table 5.59 – Economically-Viable Acreage for Ground Site Solar Development at NAF El Centro		
Private Ownership	**Private Ownership Acreage**	**MILCON Ownership Acreage**
100% of Acreage for ―Suitable" Ground Sites	0	0
25% of Acreage for ―Likely Suitable" and ―Questionably Suitable" Ground Sites	N/A	N/A
Total Acreage for Solar Development of Ground Sites	**0**	**0**

At NAF El Centro, the range area did not have any viable areas for solar development due to a combination of biological, cultural, and mission compatibility conflicts. Therefore, no range areas at this military installation were even considered in the economic modeling.

On the cantonment at this military installation, there were 377 suitable acres. However, that size translated into ground site capacity of 90 MW_{DC} and less, which was not enough to compensate for the fixed costs of transmission to the nearest large substation. Therefore, the NAF El Centro ground sites were not economically viable under this study's assumptions, though they are technologically viable.

There only six buildings at NAF El Centro whose roofs were sufficiently large to be considered in this study, and their combined space would have yielded well under 1 MW of solar potential even under the most favorable of our study assumptions. However, none of the six roofs had pitches (roof angles) that could be confirmed to support solar installation. There were additional concerns about the height of these buildings and their locations along the installation airstrip. For all of these reasons, the building roofs were deemed unsuitable for solar development under this study's parameters.

At NAF El Centro, data for unpaved parking locations were not provided.

Edwards AFB Economic Results

Table 5.60 Potential Capacity for Economically-Viable Solar Development at Edwards AFB under Private Project Ownership							
	Installed Capacity (MW_{AC})						Output (MWh_{AC})
Solar Technology	**Range Ground Sites**	**Cantonment Ground Sites**	**Building Roof Sites**	**Paved Parking Sites**	**Unpaved Parking Sites**	**Total Capacity**	**Year 1 Output**
Crystalline-Silicon PV Fixed-Mount	5,098	203	7	0	0	**5,308**	**10,000,057**
Thin-Film PV Fixed-Mount	3,165	126	4	N/A	N/A	**3,295**	**6,317,963**
Crystalline-Silicon PV Tracking	3,347	134	N/A	N/A	N/A	**3,481**	**9,000,445**
Thin-Film PV Tracking	2,101	84	N/A	N/A	N/A	**2,184**	**5,716,885**
Dish/Stirling CSP	0	0	N/A	N/A	N/A	**0**	**0**
Trough CSP	0	0	N/A	N/A	N/A	**0**	**0**

Table 5.61 Potential for Economically-Viable Solar Development at Edwards AFB under MILCON Project Ownership (MW_{AC})						
Solar Technology	**Range Ground Sites**	**Cantonment Ground Sites**	**Building Roof Sites**	**Paved Parking Sites**	**Unpaved Parking Sites**	**Total (All Site Types)**
Crystalline-Silicon PV Fixed-Mount	0	0	0	0	0	**0**
Thin-Film PV Fixed-Mount	0	0	0	N/A	N/A	**0**
Crystalline-Silicon PV Tracking	0	0	N/A	N/A	N/A	**0**
Thin-Film PV Tracking	0	0	N/A	N/A	N/A	**0**
Dish/Stirling CSP	0	0	N/A	N/A	N/A	**0**
Trough CSP	0	0	N/A	N/A	N/A	**0**

Table 5.62 – Economically-Viable Acreage for Ground Site Solar Development at Edwards AFB		
Private Ownership	**Private Ownership Acreage**	**MILCON Ownership Acreage**
100% of Acreage for ―Suitable" Ground Sites	1,766	0
25% of Acreage for ―Likely Suitable" and ―Questionably Suitable" Ground Sites	22,561	0
Total Acreage for Solar Development of Ground Sites	**24,327**	**0**

The areas reviewed at Edwards AFB included the Main Base, the North Base, and the Air Force Research Laboratory (AFRL).

Edwards AFB had the highest solar potential of the military installations studied . At Edwards AFB, the majority of the suitable ground sites are located in Kern County (and a minority in San Bernardino and Los Angeles Counties), so Kern County is utilized for the study's lease rate calculations. Among Edwards AFB ground site solar capacity, 96% is in the range areas and 4% in the cantonment areas. For the purposes of calculating transmission point of interconnection costs for solar projects at Edwards AFB, cantonment and range sites are combined because the sites tend to be in close proximity to each other and the transmission costs are, then, allocated among the cantonment and range sites in proportion to their acreage available for solar development. The potential roof and parking sites in the North Base portion of Edwards were very limited (two roofs and three parking areas) and were eliminated from the analysis due to their proximity to the North Base airstrip and broader installation infrastructure.

Fort Irwin Economic Results

Table 5.63 – Potential for Economically-Viable Solar Development at Fort Irwin under Private Project Ownership							
	Installed Capacity (MW_{AC})						Output (MWh_{AC})
Solar Technology	**Range Ground Sites**	**Cantonment Ground Sites**	**Building Roof Sites**	**Paved Parking Sites**	**Unpaved Parking Sites**	**Total Capacity**	**Year 1 Output**
Crystalline-Silicon PV Fixed-Mount	2,721	1,208	1	0	0	**3,930**	**8,028,866**
Thin-Film PV Fixed-Mount	0	0	1	N/A	N/A	**1**	**1,696**
Crystalline-Silicon PV Tracking	1,821	808	N/A	N/A	N/A	**2,629**	**7,331,701**
Thin-Film PV Tracking	1,144	0	N/A	N/A	N/A	**1,144**	**3,222,402**
Dish/Stirling CSP	0	0	N/A	N/A	N/A	**0**	**0**
Trough CSP	0	0	N/A	N/A	N/A	**0**	**0**

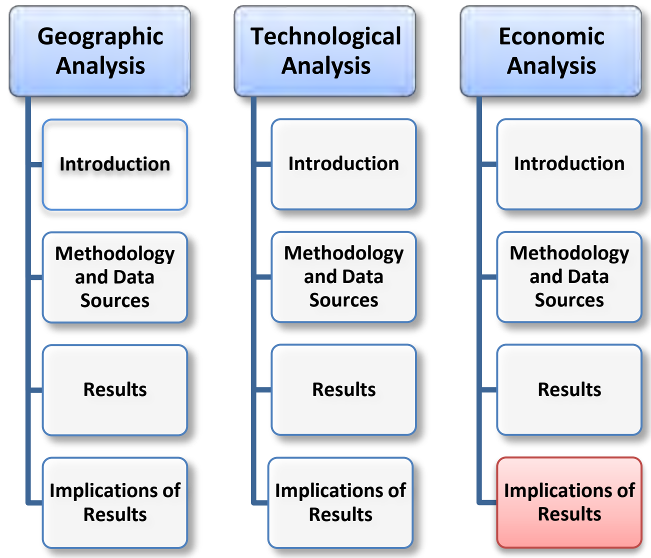
Table 5.64 – Potential for Economically-Viable Solar Development at Fort Irwin under MILCON Project Ownership (MW_{AC})						
Solar Technology	**Range Ground Sites**	**Cantonment Ground Sites**	**Building Roof Sites**	**Paved Parking Sites**	**Unpaved Parking Sites**	**Total (All Site Types)**
Crystalline-Silicon PV Fixed-Mount	0	0	0	0	0	**0**
Thin-Film PV Fixed-Mount	0	0	0	N/A	N/A	**0**
Crystalline-Silicon PV Tracking	0	0	N/A	N/A	N/A	**0**
Thin-Film PV Tracking	0	0	N/A	N/A	N/A	**0**
Dish/Stirling CSP	0	0	N/A	N/A	N/A	**0**
Trough CSP	0	0	N/A	N/A	N/A	**0**

Table 5.65 – Economically-Viable Acreage for Ground Site Solar Development at Fort Irwin		
Private Ownership	**Private Ownership Acreage**	**MILCON Ownership Acreage**
100% of Acreage for ―Suitable” Ground Sites	17,848	0
25% of Acreage for ―Likely Suitable” and ―Questionably Suitable” Ground Sites	880	0
Total Acreage for Solar Development of Ground Sites	**18,728**	**0**

The suitable “cantonment” sites with economic potential at Fort Irwin were in the region between the installation’s main gate and the developed core of the military installation within the Ring Road. The suitable, likely suitable, and questionably suitable “range” sites with economic potential were exclusively within the Goldstone property that Fort Irwin leases to NASA.

Of Fort Irwin’s total available land for solar development, 12,971 acres (69%) is on the NASA Goldstone range, and 5,757 acres (31%) is in Fort Irwin’s cantonment. Taken together, Fort Irwin offers the second-most solar development potential of the seven military installations studied, trailing only Edwards AFB.

5.11 Implications of Economic Analysis Results



The key implications of the economic review can be grouped into eleven categories:

1. Large ground sites on installations, where suitable for utility scale solar development, tend to be economically viable for PV technologies.
2. Small ground sites, at installations where there is limited land availability, tend to be economically unviable due to the potentially high fixed costs of interconnecting to transmission substations.
3. To avoid conflicts with military operational or mission activities, suitable ground sites are most often located within or close to cantonment areas at the military installations.
4. Solar development can be suitable on certain ranges.
5. A large portion of the solar development potential is on ground sites within the installations' cantonment areas
6. Solar development on building roof sites is economically viable, but cannot make a large-scale contribution to the military installations' utility scale solar development compared with ground sites.
7. Solar development opportunities on paved and unpaved parking facilities at military installations are significant, but their economics are currently poor due to the added cost of metal parking canopies.
8. Crystalline-silicon PV single-axis tracker is the solar technology with the highest projected investment returns in the study, due to its combination of low cost of installation and high electricity output. The other PV technology packages analyzed also generate attractive financial returns on many large ground sites.
9. The CSP technologies studied were not economically viable in most cases due to their higher installed costs, though great uncertainty exists about CSP costs due to the scarcity of recent CSP projects in the U.S.
10. Transmission costs, and the distances from military installations to large transmission substations, are important drivers of overall project economics.
11. Private ownership is more economically viable than MILCON in most circumstances.

Each of these implications is described in greater detail below.

Implication #1: Large ground sites are economically viable
Under private ownership (i.e., accessing Federal solar incentives), development was found to be economically viable for solar PV technologies on five of the seven military installations studied.

Solar projects are modeled to achieve greater than 12% IRRs under the study assumptions for these ground sites.

The recent trend of decreasing solar PV installed costs, together with the study's detailed estimates of future electricity prices in Southern California and the continuation of the current Federal incentive regime until 2015, are the main drivers of project viability. The outstanding solar resources (sunlight) on these desert military installations also support project economics.

In total, approximately 4,000 to 11,000 MW_{AC} of solar development potential is projected on ground sites at the seven military installations, depending on which PV technology is deployed. The annual electricity output from these PV systems would be from about 8,000 to 21,000 GWh in 2015, which is equivalent to 11-29% of the California RPS renewable requirement for that year.[110]

If even one-tenth of this potential is practically developed by or near the study's baseline year of 2015, that would represent almost 400 to 1,100 MW, which is equivalent to 1-3% of California RPS.

Implication #2: Small ground sites are not generally economically viable, due primarily to transmission costs

Except at MCAGCC Twentynine Palms, where a transmission upgrade project is already planned, ground sites at military installations with limited land availability for solar were not economically viable. Specifically, both at NAF El Centro (with 377 acres of technically-eligible land available for solar development) and at MCLB Barstow (with 696 acres of technically-eligible land available) the high minimum fixed costs of connecting to large transmission substations brought the solar sites' returns below the study threshold. If either closer transmission substations could be used for interconnections or more suitable land could be identified at these military installations (allowing larger solar projects), the economic returns to projects at NAF El Centro and MCLB Barstow would increase. Though Chocolate Mountain AGR had significantly more technically-eligible acreage (3,910 acres) than NAF El Centro and MCL Barstow, transmission costs were a major factor in rendering its technically available land economically unviable for solar development under the study assumptions.

However, very small ground projects, on the order of 1-4 MW and covering 5-20 acres each, would likely be economically viable on NAF El Centro and MCLB Barstow if they could be interconnected through the existing military installation electrical infrastructure and their maximum output capacity kept below the installations' respective peak demands.

---

[110] The California Renewable Portfolio Standard (RPS) sets a requirement that 33% of retail electricity sales in the State be from identified renewable energy sources by December 31, 2020. That 33% by 2020 requirement translates into 102,000 GWh/year from renewable sources by that year. California has an intermediate RPS goal of 25% renewable electricity (73,000 GWh/year) by December 31, 2016, and that 25% requirement is used in the calculation because this study assumes that solar facilities are built in 2015.

Implication #3: Military and operational conflicts are major factors in eliminating range area availability

By far the largest aggregate land areas on the military installations are on the ranges. However, the ranges on several installations had mission compatibility and other conflicts that rendered the vast majority of their land area unsuitable for solar development. The most common of these conflicts was due to military mission or operational activity. This was a major factor in the complete elimination of the range areas from solar project suitability at MCAGCC Twentynine Palms, NAF El Centro, and Fort Irwin (outside of the NASA Goldstone complex) , and elimination of 99% of the range at Chocolate Mountain AGR. Mission and operational conflicts also eliminated much of the large range at NAWS China Lake, though some range areas immediately adjacent to the NAWS China Lake cantonment passed the study's suitability tests. Many other factors from the dozens of GIS variables studied, such as desert tortoise habitat at MCLB Barstow, eliminated certain range areas.

Additional study of mission and operational conflicts with specific solar technologies along the lines recommended in the earlier Mission Compatibility chapter should clarify the proper scope of exclusions for mission and operational reasons in the future.

Implication #4: Utility scale solar development has potential on certain ranges

While the range areas on several military installations were determined to be entirely unsuitable for mission/operational reasons, conflicts with protected habitat, and other reasons, there were parts of range areas on three military installations (NAWS China Lake, Edwards AFB, and the NASA-leased Goldstone complex at Fort Irwin) found to be suitable and economically-viable. The largest of these available areas was Edwards AFB. The Edwards AFB, NAWS China Lake, and NASA Goldstone ranges each had at least 960 MW_{AC} of solar development potential.

Implication #5: Cantonment areas offer a substantial portion of installation' solar development potential

Although range areas comprise the great majority of the total acreage on the installations studied, the degree of conflicts on range areas from mission, habitat, and other factors tends to be much higher than for cantonment areas. Because of these conflicts, cantonment areas comprise a relatively large percentage (22%) of the economically-viable sites in this study. Over 1,500 MW_{AC} of economically-viable solar development potential exists on cantonment ground sites alone. Economically-viable cantonment ground sites are present at four installations – MCAGCC Twentynine Palms, NAWS China Lake, Edwards AFB, and Ft. Irwin.

Implication #6: Building roof-mounted solar is viable on military installations, but has limited scope

Five of the seven military installations in the study had large building roofs suitable for solar development. The study estimates these projects to be financially-viable under private ownership, with expected investment returns of 15% to 19%. However, the roof square footage available for mid-sized or large solar projects is very limited when compared to the potential for ground-mounted solar at the military installations. The aggregate, viable solar potential on building roofs across all military installations is estimated to be about 20 MW_{DC} or 17 MW_{AC} in 2015. This compares to total peak electricity demand of well over 100 MW across all of the military installations studied and the 7,147 MW_{AC} of ground site potential for solar on the installations.

The primary reasons for the modest roof potential are (a) there are a relatively small number of roofs large enough (~ 20,000 sq. ft.) to host 200 kW or larger solar projects, (b) in aggregate, almost 40% of the space on such roofs would be excluded from solar development due to pitch, orientation, roof obstructions and other factors, and (c) roof replacement cycles restrict how many roofs could host solar beginning in 2015.

Over the next 20-30 years, if all roofs are replaced in solar-ready condition, the rooftop solar potential would triple from the 20 MW figure reported here.

Implication #7: Many parking lots could accommodate solar development, but added costs are now prohibitive

On the paved and unpaved parking facilities reviewed in this study, a total of over 200 MW_{DC} in solar development potential technically exists. That total exceeds the sum of the non-coincident peak electricity demands of the military installations. However, when that technical potential was run through the study's economic models, the parking installations were found to be uniformly unviable from an investment perspective. The reason was that paved parking projects (at a standard clearance of 9 feet) cost about 30% more than roof-mounted projects. Unpaved parking projects (with a higher clearance of 14 ft) cost about 34% more than roof-mounted systems. The reason for the added cost (more than $1,000/kW) is the steel materials and construction required for solar canopies.

Ancillary benefits of solar canopies such as better conditions for servicing vehicles, less wear-and-tear on vehicles, and possibilities for charging or off-loading power from electric vehicle were not considered in this analysis. If these ancillary benefits are deemed important in the future, or steel or general solar project costs decrease, parking projects could play an increasingly important role in solar development on military installations.

Implication #8: Crystalline-silicon PV with trackers is the most economic technology package, but all PV technologies can have attractive financial returns on ground sites

A total of six solar technology packages were modeled technically and economically for ground sites in this study:

- Crystalline-silicon PV fixed-mount
- Crystalline-silicon PV single-axis tracking
- Thin-film PV fixed-mount
- Thin-film PV single-axis tracking
- Dish/Stirling CSP
- Trough CSP

Of these six packages, the one with the highest average investment return was the crystalline-silicon PV tracker. Its IRR was a few percentage points higher than those of other PV technologies due to its combination of high electricity output (capacity factors of 25-26%) and lower peak output per acre (thus lowering transmission interconnection costs) more than offsetting its 17% price premium versus fixed-mount systems. Lower peak output from a solar facility lowers its transmission costs because transmission lines and substations are sized in relation to the maximum AC electricity output they must carry.

The other PV technology package also achieved attractive IRRs for ground sites.

Implication #9: CSP technology packages studied are not economically viable

In this study, two CSP technologies were modeled on suitable and sufficiently-large ground sites. Those technologies, Dish/Stirling and Trough, had appreciably lower investment rates of return than the four solar PV technology packages modeled. The higher estimated installed costs for these CSP technologies compared to PV technologies caused their projected investment rates of return to fall below the study threshold for CSP Trough technology on all installations and for Dish/Stirling on all except one military installation – MCAGCC Twentynine Palms. For MCAGCC Twentynine Palms, a two-line transmission project already planned for the military installation eliminates transmission costs as a constraint and, thereby, improves solar economics there for the Dish/Stirling system. The CSP Trough technology could not be evaluated at MCAGCC Twentynine Palms because it did not have sufficient available acreage.

However, the small number of CSP systems that have been recently built in the U.S., and even worldwide, and the wide variety of CSP technology packages that may be technically feasible makes estimates about what CSP installed costs will be in 2015, how they will differ by project size and other variables, and their performance difficult and subject to wide interpretation.

Implication #10: Transmission costs, and the distances from military installations to large transmission substations, are important drivers of overall project economics.

One of the more significant factors in the study's economic model of ground sites is the cost of building transmission lines from sites available for solar development on the military installations to large, existing transmission substations. The transmission cost alone can lower the project IRR by 10 percentage points for a given military installation under this study's assumptions. The transmission cost is required in order to make the electricity output from the modeled solar plants, which typically greatly exceeds the military installations' on-site hourly electricity demands, available for sale into the wholesale market.

Military installations that are closer to existing transmission facilities should face smaller transmission costs and, therefore, higher estimated investment returns if the existing transmission infrastructure is viewed as a constraint on solar development. Over long periods, planning for the siting of transmission facilities can be integrated with solar development plans to reduce the effect of this constraint.

Implication #11: Private solar project ownership is more economically viable than MILCON

Currently, Federal solar incentives are based in the income tax code, so entities such as the DoD that have no income tax liability cannot directly access them. These tax incentives (principally, the 30% investment tax credit and the MACRS depreciation allowance) can jointly reduce net installed project costs by well over 40% for a private owner. These savings dramatically improve private owner returns and much more than compensate for the financial benefits of MILCON ownership (e.g., no income or sales tax liability and a lower discount rate).

The DoD can indirectly participate in the Federal tax incentives by either signing a PPA for output from a military installation-sited, privately-owned solar plant and/or by developing an energy joint venture, enhanced use lease, or other contracting arrangement wherein the DoD receives a share of private owner returns as excess land lease payments.

To the extent that the Federal solar incentives are reduced or their eligibility tightened, MILCON ownership will become a relatively more attractive option.

5.11.1 Environmental Impacts of Solar Development on Military Installations

On-installation solar energy development has the potential to provide additional environmental benefits to the military along with electricity and potential energy security. On-installation solar energy development will help the DoD meet its renewable energy mandates and goals along with having significant air quality and GHG emissions impacts. At the same time, solar energy development has the potential to negatively affect the environment of the Mojave and Colorado Deserts through the loss of valuable desert habitat and increased strain on already overtaxed water supplies in the region.

5.11.2 Renewable Energy Impacts

EPAct 2005 and EO 13423 mandate that the DoD procure renewable energy to meet 7.5% of its electricity consumption in 2013 and following years while rewarding on-site renewable energy generation with a double credit towards the renewable energy goal. These same policies also mandate that annual energy intensity decline by 30% between 2005 and 2015. Conservatively, assuming the DoD continues to consume as much electricity in 2015 as it did in 2009, 30 million MWh (30 TWh), each 100 MW of additional single-axis tracking solar PV installed on the seven military installations would generate enough electricity annually to equal 0.75% of the DoD's total annual electricity consumption.[111] Because on-installation solar energy development would count double towards the EPAct 2005 renewable energy requirements, the electricity generation of 100 MW of on-installation PV would count as 1.5% of the DoD's total electricity consumption. As a result, only 490 MW of single-axis tracking PV located across the seven military installations in the study would be necessary to generate enough renewable energy to meet all of the DoD's EPAct 2005 and EO13423 renewable energy mandates.

---

[111] Assuming a capacity factor of 26.2%.

In addition to the Federal Government's EPA 2005 and EO 13423 renewable energy goals, the DoD has an additional goal of producing or procuring no less than 25% of the DoD's total facility energy consumption from renewable energy sources by 2025. For more information about compliance with EPAct 2005, EO13423, and other Federal and DoD-specific renewable energy goals, see the Solar Development Context Chapter.

5.11.3 Air Impacts

One of the primary benefits of solar energy is that it has zero direct emissions of air pollutants. This contrasts with conventional fossil fuel-based electricity generation which is a leading domestic emitter of air pollutants harmful to human health like sulfur dioxide (SO_2) and GHGs like carbon dioxide (CO_2). By generating electricity with solar energy, electricity generation from other sources, including fossil fueled plants, will be displaced, resulting in avoided air pollution emissions from the electricity sector.

Identifying exactly how much air pollution has been avoided by the electricity output of a specific solar energy facility is infeasible because of the complex nature of U.S. electricity grid and the fact that air pollutant emissions from the electricity sector vary by fuel, region, time of day, and many other factors. As a result, a number of different methodologies have been developed to approximate the environmental benefits of no-emission renewable energy sources such as solar. This study used the EPA's Emissions and Generation Resource Integrated Database (eGRID) which is a comprehensive source of data on the environmental characteristics of the U.S. electricity sector. Within this database is information about the average air emissions of non-baseload electricity generation for 26 different regions of the U.S. The five military installations of the California Mojave Desert are located in the WECC California subregion while the two installations of the California Colorado Desert are located in the WECC Southwest subregion.

Table 5.66 – EPA eGRID Subregion Output Emission Rates for Non-Baseload Generation

eGRID subregion	CO_2 (lb/MWh)	CH_4 (lb/MWh)	N_2O (lb/MWh)	NO_x (lb/MWh)	Ozone season NO_x (lb/MWh)	SO_2 (lb/MWh)
WECC California	1,045.30	0.03942	0.00474	0.3481	0.3213	0.1699
WECC Southwest	1,211.84	0.02056	0.00931	1.0408	1.0189	0.4500

Source: eGRID, 2010

As shown in Table 5.66, full installation of the economically-viable ground-mounted solar projects (using the crystalline-silicon tracking technology) would avoid millions of metric tons of CO_2 emissions, thousands of metric tons of NO_x and SO_2 emissions, and hundreds of metric tons of CH_4 and N_2O emissions.

Table 5.67 – Avoided First Year Emissions from Full Installation of Ground Mounted Solar Projects						
	CO_2	CH_4	N_2O	NO_x	Ozone season NO_x	SO_2
Military Installation	**metric tons/yr**	**metric tons/yr**	**metric tons/yr**	**metric tons/yr**	**metric tons/yr**	**metric tons/yr**
MCAGCC Twentynine Palms	102,397	4	< 1	34	31	17
MCLB Barstow	-	-	-	-	-	-
NAWS China Lake	1,247,249	47	6	415	383	203
Chocolate Mountain AGR	-	-	-	-	-	-
NAF El Centro	-	-	-	-	-	-
Edwards AFB	4,266,531	161	19	1,421	1,311	693
Fort Irwin	3,475,800	131	16	1,157	1,068	565
Total (All Installations)	**9,091,977**	**343**	**41**	**3,028**	**2,795**	**1,478**

While the eGRID 2010 data is for 2007 rather than a more recent year, the emissions rates serve as a good approximation of likely avoided emissions for solar energy generation in the regions. Likewise, while eGRID shows a clear division between the two subregions used to calculate these avoided emissions, the location of the seven military installations along the border between the two subregions would likely mean that any solar energy installed on any of the seven installations would actually deliver avoided emissions somewhere between the numbers provided for the two WECC subregions as some of the electricity displaced by the solar energy facility would come from WECC California and some would come from WECC Southwest. Nonetheless, Table 5.67 illustrates that MW of solar energy installed delivers significant environmental benefits to regional air quality as well as yielding significant GHG reductions. However, it is worth noting that many of the power plants that supply Southern California are located to the east of major populations centers which, because of prevailing winds going from west to east, means that the air quality benefits from increased solar energy use in the Mojave and Colorado Deserts will be most directly felt by Nevada, Utah, Arizona, and New Mexico.

5.11.4 Water Impacts

Depending upon the technology used, solar energy developments may have a minor or a major impact on a region's water resources. As is discussed in the Solar Technology Characterization Chapter, water consumption for solar energy facilities can vary from as little as 8 gallons of water used per MWh of electricity generated from a solar PV facility (or zero if the facility opts to not wash its PV panels at all) to more than 800 gallons per MWh for a wet-cooled CSP

Trough facility (DOE, 2009). From a capacity perspective, 100 MW of solar PV might consume as much as 4.5 acre-feet of water per year.[112] This level of annual water consumption equates to 18 water efficient suburban homes.[113] This means that 100 MW of solar PV is effectively equivalent to one suburban residential city block in terms of water consumption. By comparison, a wet-cooled 100 MW CSP Trough facility would consume approximately 540 acre-feet of water in a year.[114] Consequently, such a facility would consume more water than 2,000 water efficient suburban homes, making its water consumption equivalent to a small town. One option to reduce the water consumption of CSP trough or tower facilities is to employ dry or hybrid cooling systems. By using a dry cooling system, water consumption can be reduced to as low as ~78-90 gallons per MWh, which translates to approximately 52-60 acre-feet per year per 100 MW.

Table 5.68 – Estimated Annual Water Consumption By Solar and Cooling Technology

	Water Usage (acre-feet/year/100 MW)			
Cooling Technology	**Solar PV[115]**	**CSP Dish/Stirling[116]**	**CSP Trough[116]**	**CSP Tower[116]**
No Cooling	4.5	13.4	NA	NA
Dry Cooled	NA	NA	52	60
Wet Cooled	NA	NA	538	403

Source: DOE, 2009

In the western and central Mojave Desert, groundwater is the primary source of water. The sparse rainfall in the High Desert combined with rapid development and population growth has overtaxed the region's aquifers, resulting in rapid groundwater depletion. In response to the depletion of the region's water resources, the Mojave Water Agency and the State of California have implemented the Regional Recharge and Recovery project, a $48 million project to import and purify 40,000 acre-feet of water annually from California's State Water Project canal system to be placed in recharge basins to replenish the Mojave aquifers (MWH, 2011). Given the region's water resource limitations, the environmental impact of increasing the region's water demand by hundreds of acre-feet per year would be significant unless additional water imports through the State Water Project or regional water demand reductions were negotiated as a mitigation measure.

The significant water consumption of a large CSP facility may present less of an environmental impact in the Imperial Valley region of the Colorado Desert, where both NAF El Centro and Chocolate Mountain AGR are located. Because the Imperial Valley's groundwater resources are highly saline and unusable without desalination and purification, the Imperial Valley imports

[112] An assumed capacity factor of 21% results in 100 MW of PV generating 183,960 MWh of electricity in a year. That means at 8 gallons per MWh, a 100 MW PV facility would consume 1,471,680 gallons of water, or approximately 4.5 acre-feet.
[113] While the typical suburban American household consumes 1 acre-foot of water per year, this is atypical for the desert southwest where water efficient suburban households consume closer to 0.25 acre-feet per year.
[114] An assumed capacity factor of 25% results in a 100 MW CSP facility generating 219,000 MWh of electricity in a year. At 800 gallons per MWh, a 100 MW CSP Trough facility would consume 175,200,000 gallons of water annually, or approximately 538 acre-feet.
[115] Assumed capacity factor of 21%.
[116] Assumed capacity factor of 25%.

more than 3 million acre-feet of water each year from the Colorado River, in large part for use by the valley's agricultural industry. The valley already has a fallowing program to decrease water consumption and additional fallowing to free up additional water for other in-valley uses is permissible. Consequently, the environmental impact of a solar facility's water consumption is potentially less severe in the Colorado Desert because a mechanism already exists by which solar energy developers can obtain imported water and mitigate their use by paying local farmers to use less water by either fallowing fields, improving the water efficiency of their agricultural practices, or planting less irrigation intensive crops.

5.11.5 Habitat Impacts

While rooftop and parking structure solar energy developments have negligible habitat impacts because of their utilization of already developed land, ground-mounted solar projects have the potential to significantly impact undeveloped desert lands due to project's large physical footprint. As is discussed in the Development Limitations section of the Policy Review Chapter, ground-level solar energy development typically requires the clearing, grading, and soil binding or deposition of gravel to lands that are going to be used as part of a solar energy development. Solar energy facilities typically require between 5 and 10 acres of land per MW of capacity, meaning that a large solar energy facility can result in hundreds of acres of lost desert habitat.

Roads and transmissions lines must also be built to connect the solar energy facility with surrounding infrastructure, which can further reduce pristine desert habitat and lead to additional fragmentation of the desert environment. In addition to species that make the desert floor their home, the loss and fragmentation of habitat can affect other species, such as Nelson's Bighorn Sheep, that migrate through the area in particular corridors to get between seasonal habitats. For more information about the habitat and potential species impacts of solar energy development in the Mojave and Colorado Deserts, see the Geographic Setting Characterization Chapter.

Because of solar energy's large potential footprint, thoughtful solar energy development siting and mitigation efforts are critical to minimizing the negative environmental impacts of ground-mounted solar. Solar energy developers often seek to develop disturbed areas that have low environmental value such as landfills and previously used parcels of land. Likewise, consultation with environmental experts to identify and avoid high value habitats is a basic part of the siting process.

But even with well-considered siting of a solar energy facility, negative impacts to environmentally valuable land and protected species are unlikely to be avoided in the Mojave and Colorado Deserts. Typically, protected species inhabiting an area poised for development, such as the Desert Tortoise and Mohave Ground Squirrel, are captured and relocated to other suitable habitat but this relocation process can still take a toll on species population numbers and does not directly address the loss of habitat. In addition, solar energy developers typically mitigate the impact of their development by acquiring and setting aside additional land of high environmental value for conservation. In other cases mitigation can take the form of improvements to neighboring land to address potential problems like the fragmentation of habitat.

This study's GIS analysis includes a screening process to remove high value environmental lands found on the seven military installations from consideration as future sites for solar energy development. The environmental value of remaining lands is also factored into the overall suitability of the lands for solar development. By avoiding development on high value habitats and species corridors and subsequently employing species and habitat conservation best practices during the construction and operations phases, solar energy development on the seven military installations can be achieved with minimal impact to important habitats and protected plant and animal species.

5.12 Planned and Existing On-Installation Solar Energy Facilities

Presently, the largest solar energy facility on a U.S. military installation is found at Nellis Air Force Base. The 14.2 MW solar PV facility was completed in 2007 using approximately 70,000 solar panels from SunPower on single axis tracking systems spanning 140 acres of disturbed land, including 33 acres of capped landfill north of the Air Force Base's main runway. Each year the solar energy facility generates more than 25,000 MWh of electricity, equivalent to a quarter of the installation's total annual electricity consumption.[117] The project was financed using an indefinite PPA whereby the solar facility owner, MMA Renewables, sells the electricity generated by the facility to Nellis AFB (via NV Energy, the local utility) at 2.2 cents per kWh, saving the installation $1 million a year in electricity costs, in return for a 20 year ground lease and ownership of the Renewable Energy Certificates (RECs) which are then sold to NV Energy for compliance with Nevada's RPS program. Key factors in making the Nellis solar energy facility economically attractive to all parties involved were the private developer's access to financial incentives and the high value of the RECs generated by the facility due to the Nevada RPS program's solar set aside and 2.4 solar REC multiplier (USAF, 2009). Each of these incentives is described in greater detail in the Solar Development Context Chapter.

[117] As is noted in the Installation and Unit Characterization Appendix, all of the Nellis system's electricity output is exported from Nellis AFB to the transmission grid even though the Base is the purchaser of the electricity. The solar facility is not directly connected to the Base's electricity distribution network because of grid stability issues.

Table 5.69 – Planned and Existing On-Installation Solar Energy Facilities Larger Than 5 MW in California and Nevada

Developer	Military Installation	State	Nameplate capacity (MW)	Technology Type	Finance Method	Status	Completion Date
Clark Energy Group and Acciona Solar	Fort Irwin	CA	500	Concentrating and Crystalline Silicon PV	Enhanced Use Lease	Assessment	2022
Fotowatio Renewable Ventures	Edwards Air Force Base	CA	500	Crystalline Silicon PV	Enhanced Use Lease	Planned	Unknown
SunPower	Nellis Air Force Base	NV	14.2	Crystalline Silicon PV	PPA	Completed	2005
Not Yet Identified	Nellis Air Force Base	NV	18	Crystalline Silicon PV	X	Proposed	2012/2013
Not Yet Identified	NAWS China Lake	CA	13	Crystalline Silicon PV	PPA	Proposed	Unknown
Not Yet Identified	MCAGCC Twentynine Palms	CA	40-50	Crystalline Silicon PV	PPA	Proposed	Unknown

The Nellis AFB solar facility is currently the only utility-scale (>5 MW) solar energy facility located on any of the nine military installations involved in this study. The next largest solar energy facility is MCAGCC Twentynine Palms' 1.1 MW solar PV facility. Outside the nine military installations being studied, additional large solar energy facilities on military installations include a 6 MW solar PV facility at the Air Force Academy in Colorado Springs, a 2 MW solar PV facility at Fort Carson, and a 1.4 MW solar PV facility at MCB Camp Pendleton

Following the success of the initial 14.2 MW solar project, Nellis AFB is planning to contract for the development of a second, 17.7 MW solar facility at the south end of the main base. In addition to the second Nellis solar energy facility, the DoD has plans to undertake solar energy projects at many of its installations in the western U.S, including projects at Fort Irwin (up to 500 MW), Edwards AFB (up to 500 MW), MCAGCC Twentynine Palms (up to 50 MW), NAWS China Lake (13 MW), Luke AFB (15-17 MW), and Davis-Monthan AFB (14.5 MW). It is expected that solar PV technologies will be used for all of the projects that are eventually developed although concentrating solar technologies are being considered for the Fort Irwin development. A complete listing of existing and planned solar projects larger than 5 MW may be found in Table 5.69 above.

In addition to these large solar energy projects, the DoD has developed or is in the process of developing more than 400 smaller solar energy projects ranging in capacity from 1 kW up to 1 MW. As currently planned, all of these projects will also utilize solar PV technologies (GAO, 2010).

5.13 Economic Analysis Reference Tables

Table 5.70 – Wholesale On-Peak[118] and Off-Peak Firm[119] Physical Electricity Price Projections (not including RECs) in $/MWh		
Year	**Southern California Firm On-Peak Wholesale Electricity Price (Real 2010 Dollars)**	**Southern California Firm Off-Peak Wholesale Electricity Price (Real 2010 Dollars)**
2015	$62.18	$42.64
2016	$62.21	$43.32
2017	$60.57	$42.21
2018	$59.03	$41.10
2019	$60.74	$44.43
2020	$62.66	$47.94
2021	$66.34	$48.76
2022	$72.74	$48.86
2023	$84.70	$47.41
2024	$85.85	$49.11
2025	$87.02	$50.85
2026	$88.22	$52.09
2027	$89.44	$53.35
2028	$90.67	$54.65
2029	$91.93	$55.97
2030	$93.20	$57.31
2031	$94.60	$59.32
2032	$96.04	$61.39
2033	$97.52	$63.52
2034	$99.03	$65.71

[118] For this study's electricity price modeling, ―on-peak" is defined as Monday through Saturday from 7:00am to 11:00pm for this study, consistent with reporting in the energy publication *Platt's Daily*. ―Off-peak" is defined as all other hours. The prices in this table are for firm supply, and contain energy costs and a capacity scarcity premium.

[119] These firm prices include both an energy component and a capacity scarcity premium, but do not include the REC component. REC pricing projections are discussed in their own section (3.2.4) of this chapter.

Table 5.71 – Summary Results of Energy Joint Venture Alternative Ownership/Gains-Sharing Scenario			
Military Installation	**Ground Acreage Economically Viable for Solar Development**	**Excess Annual Rent (rounded to nearest $1MM above 16% Project IRR**	**Excess Annual Rent Per Acre**
MCAGCC Twentynine Palms	553	$2,000,000	$3,616
MCLB Barstow	0	$0	$0
NAWS China Lake	6,777	$12,000,000	$1,771
Chocolate Mountain AGR	0	$0	$0
NAF El Centro	0	$0	$0
Edwards AFB	24,327	$36,000,000	$1,480
Fort Irwin	18,728	$2,000,000	$107
Total	**50,385**	**$52,000,000**	**$1,032**

Table 5.71 describes the excess rent that may be available to the military land owner and may be captured under the energy joint venture statute, enhanced use lease, or other contracting arrangement above a 16% investment hurdle rate. This 16% investment hurdle rate is set much higher than the study's 12% minimum investment threshold (discount rate) for private owners to allow a cushion for negotiation. The potential excess rent for each military installation was calculated by simply dividing the solar projects' net present value (NPV) under private ownership (in 2015 dollars) in excess of a 16% nominal rate of return and dividing by the 20 years assumed for the solar assets. The NPV calculations use the crystalline-silicon tracking technology, which is the technology yielding the highest investment rate of return. The excess rent rates differ by military installation because solar projects' profitability differs by military installation, driven primarily by distance to significant transmission points of interconnection, project size in relation to transmission line capacities, County, and solar resources (sunlight). For example, at Fort Irwin, the distance to the major available transmission substation used in this study was more than 70 miles. This significantly increased the cost of on-installation solar, and thereby reduced the potential for ―excess" rents: the cantonment IRR was below the 16% threshold, while the range IRR was only slightly above 16%. In comparison, at Twentynine Palms, the study assumed that the likely new solar capacity build in 2015 would be served by the new transmission line currently (in 2011) under development and therefore would bear no additional transmission interconnection costs.

Table 5.72 – Summary of Annual Standard Solar Rents and Excess Rents from Energy Joint Venture					
Military Installation	**Ground Acreage Economically Viable for Solar Development**	**Standard Annual Rent per Acre**	**Excess Annual Rent per Acre**	**Combined Standard and Excess Annual Rent per Acre**	**Annual Rent Payments**
MCAGCC Twentynine Palms	553	$1,039	$3,616	$4,655	$2,574,367
MCLB Barstow	0	$0	$0	$0	$0
NAWS China Lake	6,777	$1,001	$1,771	$2,772	$18,783,533
Chocolate Mountain AGR	0	$0	$0	$0	$0
NAF El Centro	0	$0	$0	$0	$0
Edwards AFB	24,327	$1,001	$1,480	$2,481	$60,350,451
Fort Irwin	18,728	$1,039	$107	$1,145	$21,450,164
Total	**50,385**	**$1,015**	**$1,032**	**$2,047**	**$103,158,515**

Table 5.72 describes the combination of the excess rent that would be available to the military land owner and may be captured under the energy joint venture statute, enhanced use lease, or other contracting arrangement above a 16% investment hurdle rate and the standard solar rent available to the land owner under the DOI BLM methodology set forth in Section 5.9.7 above. Per acre rents are shown rounded to the nearest dollar in this Appendix, but have decimal detail in the underlying calculations. The rental rates in this Appendix differ by military installation because (a) the acreage component of the BLM rate differs by County, and (b) solar projects' potential profitability differs by military installation. The figures reported here are for ground-mount installations using the crystalline-silicon tracking technology, and the rents, in 2015 dollars, assume that the technology component of the BLM standard rent is fully implemented. In practice, the technology component of the BLM rent does not become fully implemented until year 5 of a solar project. The ratable, 5-year implementation of the BLM technology rent schedule is, however, embedded in the economic modeling of this study, except for this simplified Appendix table.

6 Energy Security

6.1 Introduction

Energy security for the DoD means having assured access to reliable supplies of energy and the ability to protect and deliver sufficient energy to meet operational needs (DoD, 2010f). In the context of this study, energy security refers to the ability of a military installation to conduct the essential components of its mission with little or no vulnerability to disruption of energy supplies from outside the facility. As articulated in DoD's ―Operational Energy Strategy" the Department of Defense directly supports military operations from missions located at fixed installations in the United States (DoD, 2011d). These missions primarily rely on civilian infrastructure for energy supplies, particularly the electrical grid. Such energy infrastructure remains vulnerable to disruption from hazards, including weather, natural disasters, human error, maintenance shortfalls, equipment failures, and attacks on infrastructure, including cyber attacks. It is the DoD's policy to assure reliable energy supply for critical operational missions at fixed installations.

Solar energy can potentially address an installation's vulnerability to disruptions of the public electricity grid that powers the base. While solar is expected to be able to contribute to an installation's energy security, the optimal approach to addressing a specific installation's energy security is mission- and site-specific. The optimal approach depends, in part, on what emergency scenarios the installation is trying to plan for, what energy infrastructure already exists on the installation, and the rules and incentives arising from the local energy market. The key aspects of scenario planning include:

- How likely is it that the Base will lose power?
- How long will the outage or outages last?
- Will other supplies – such as generator fuel – be deliverable during the outage?
- What electrically-powered services on the Base need to continue to operate?
- What are the costs for different kinds of energy security hardware, software and systems?
- How do those costs vary based on the frequency of power outages and their duration?

This chapter will review the range of issues that need to be considered in evaluating installation-level energy security risks and solutions, and describe a few of the technologies that can provide on-installation energy security. The chapter concludes with a description of various options on the use of diesel generators and large-scale solar located on a microgrid-equipped installation.

6.2 Energy Service Disruption Scenarios

The electric grid is electrically robust but physically fragile. It is vulnerable to a wide range of events that may adversely impact its operations. These include intentional man-made events such as terrorist attacks, sabotage and cyber attacks, as well as natural phenomena such as earthquakes, ice storms, high winds and electrical storms (lighting). Grid system events such as equipment overloads; equipment failure; loss of generating resources; aircraft and automobile accidents; construction and maintenance accidents; and the results of operator error may also stop electric power deliveries. Any of these may result in limited or total shutdown of the electrical grid for a period of time. This period may be short, as typically is the case during an electrical storm, or have a much longer duration, as often is the case after a major natural disaster. However, while the cause of these events may be very different, any one may result in the facility being electrically isolated from the grid (DoD, 2008a). To continue uninterrupted operations, the facility must have the ability to provide its own electricity, at least for its critical loads.

Some events that may cause grid interruption also may have greater impact than just an electrical grid failure. For example, earthquakes occur with little or no notice, can have catastrophic consequences, and may impact all types of infrastructure and thousands or millions of people across a wide area (DHS, 2005). Even if an earthquake is not centered at or in the immediate vicinity of a DoD facility, it can still have significant impact on that facility's operations by disrupting the electric grid, natural gas and oil pipelines, road and rail transportation of fuel supplies, water pipelines and water supplies, water and wastewater treatment systems, communications, and access roads to the facility. In addition, military and non-military support personnel and their families living off-base may be killed, injured or impeded from reaching the facility. Military installations may also be called upon to provide support, relief, and shelter for local communities during emergencies while maintaining normal operations at the facility.

Other natural disasters occur after some degree of warning. For example, weather forecasters can predict the path and likely timing of a hurricane or severe storm with some level of accuracy. These early warnings allow time for evacuations of personnel and assets that may be damaged, pre-positioning of assets to support emergency relief efforts, and other preparations that may help mitigate the impact of the natural disaster. However, while this early warning may allow time for these preparations, the disruptions to services resulting from a hurricane may be just as severe as those resulting from an earthquake.

Man-made events and disasters such as sabotage and terrorist attacks, especially if they involve nuclear or biologic/chemical weapons, may not only cause grid and infrastructure outages and failure, but also may result in denial of access to those areas to repair or replace damaged equipment. Even if all areas remain open and accessible, heightened alerts and increased security subsequent to a terrorist attack or sabotage incident may result in delays in delivering resources such as fuel and spare parts. As a result, the electric grid, natural gas supplies and fuel deliveries may be compromised or unavailable for an extended period.

6.3 Energy Security Requirements During Grid System Failure

6.3.1 Outage Duration

The most frequent grid outages are of short duration and last for minutes or hours. These outages may result from such events as lighting strikes, traffic and other accidents, equipment failure, equipment maintenance, and even rolling grid outages resulting from generation shortages. During such short duration outages critical loads must continue to be served, but it may not be necessary to serve all loads within the installation. Service to non-critical loads such as general area air conditioning, street lighting, and residential loads could be disconnected, to be restored once the utility grid connection is re-established. This means that the total load to be served during a short-term grid outage would be a fraction of the normal load of the facility.

Grid outages that last for days or weeks are less common. They may result from natural or man-made disasters, extreme weather conditions, or a general grid system failure. During a longer-duration grid failure, critical loads must be served but it may also be necessary to serve less critical loads so that normal facility operations can continue. Under these circumstances, the size of the total load to be served may approach the normal operating load of the facility.

6.3.2 Critical Point Load, Critical Microgrid, or Complete Distribution System Backup

Individual critical loads, or point loads, may be served by stand-alone backup energy systems such as diesel engine-generators and/or batteries. For these point loads, the backup energy systems must be configured and sized to handle the full requirements of the critical load and meet the requirements for transition from the grid. Critical loads may also be organized and connected into micro grids within the base distribution system so that they can share a backup energy source. This can provide some economy of scale, take advantage of diversity of load, increase reliability, and provide additional monetary and power quality benefits.

If a significant portion of the base distribution system is to be served during a grid failure, the system must be designed to allow for island mode operation (see below) and include sufficient on-site energy sources to provide for the full demand of the system.

6.3.3 Island Mode Operation

In the event of a utility grid failure, if the installation distribution grid, or a part of that grid, is to continue to operate isolated from the utility grid, it must operate in ―island" mode. To operate in this mode, the base must be able to isolate itself electrically from the utility grid. Then, the base's electrical distribution system and any generation connected to that system must be able to maintain frequency at or about 60 Hz notwithstanding variations in system demand (load). Otherwise, equipment connected to the distribution grid could be damaged.

The island system can operate out-of-phase with the utility grid with no ill effects to equipment. However, before reconnecting and re-synchronizing to the utility grid, the island system's frequency and phase must be adjusted to exactly match that of the grid. Automated synchronizing controls and disconnect/reconnect breakers, subject to the approval of the utility, can be employed to achieve islanding. Coordination, approval, and/or notification to the utility or grid operator may be required before an installation reconnects to the larger electric grid.

Developing an on-installation generation and distribution system that can operate in islanded mode is a complex undertaking and the DoD is currently demonstrating a number of different approaches. Generation equipment connected to the installation distribution system must be capable of operating in island mode and designed so that it does not disconnect automatically when the utility grid connection fails. This is particularly the case for PV systems. Most solar PV inverters disconnect automatically for safety reasons when they sense a grid failure; among other things, this protects utility personnel working to restore the grid from getting shocked. A PV system intended for islanded operation needs to be designed so that it continues to operate even when the larger public grid is down, and all issues related to safety of operation need to be addressed.

6.3.4 Black-Start Capability

Another important issue to be considered in designing an emergency backup energy system is the ability to provide black-start. Black-start capability means that a generator can be started without an outside energy source. For example, a diesel engine-generator that can use its local batteries to start can be considered a black-start generator. If the same diesel engine-generator requires an outside source of power to start it, then it cannot be considered a black-start generator.

Black-start capability is important in the event of a grid failure as some means must be available to initiate the backup power supply systems. In most cases this will be provided by batteries or some other form of energy storage system capable of starting other forms of power generation such as diesel engine-generators. Solar PV, as discussed below, can also provide black-start capability during daylight hours.

6.4 Alternative Solar Energy Solutions

The main characteristics of the principal solar energy technologies are described briefly below, with a focus on their attributes that affect energy security. A more detailed description of each technology is included in the Solar Technology Characterization Chapter.

6.4.1 PV Solar

Because PV systems directly convert sunlight into electricity, their output is very dependent on the instantaneous level of sunlight. Passing clouds, for example, can cause significant variations in electrical output. These changes in output occur almost instantaneously and can cause instability in the electrical system and damage to connected equipment unless there is some other source of energy to –smooth out” energy flow. The effect of these fluctuations is minimized when the PV system is connected in parallel with the utility grid; the size and capacity of the grid can make up for the variations in power output of the PV system. However, in the case of a grid failure, energy storage or an alternative power source would be necessary in order to smooth out the fluctuations in the output level from the PV generation system, reduce potential instability, and prevent loss of service. This means that a PV system that is being designed to operate in an island mode must include some form of regulation and smoothing equipment.

6.4.2 Concentrating Solar Power

Because CSP systems use an intermediate heat transfer medium (e.g. heat transfer fluid, molten salts, or gas) there is a certain amount of thermal inertia in the system. For example, in a 220 MW CSP Trough plant, there are 1,228,000 gallons of thermal heat transfer fluid (NREL, 2006). Circulating this fluid through the solar field piping, pumps, and heat exchangers takes many minutes. As a result, a brief reduction in sunlight (e.g. when a cloud passes across the mirror field) does not reduce energy output as severely as in a PV system.

As with PV systems, CSP plants can only generate power during daylight hours and thus need energy storage or some form of backup power to deliver power 24/7. However, unlike PV systems, CSP plants can use thermal storage or an auxiliary fossil-fired boiler to maintain power output.

6.5 Storing Energy from Solar Plants for 24/7 Operations

Solar energy facilities can only generate electricity from sunlight during daylight hours. Energy storage or some other form of backup power is therefore needed to provide continuous electrical service during non-daylight hours. Both PV and CSP plants can be designed and sized to provide sufficient power during daylight hours to serve installation needs and also to charge energy storage equipment to provide overnight service. However, energy storage technology currently is costly, as will be discussed in further detail below.

6.5.1 Alternative Energy Storage Technologies

The primary means of energy storage currently available include:

1. Battery Energy Storage
2. Thermal Energy Storage
3. Pumped Energy Storage
4. Compressed Air Energy Storage (CAES)
5. Superconducting Magnet Energy Storage (SMES)
6. Ultra Capacitor Energy Storage
7. Flywheel Energy Storage

Each of these, and their applicability to energy storage as part of solar energy based secure energy supply, is discussed briefly below.

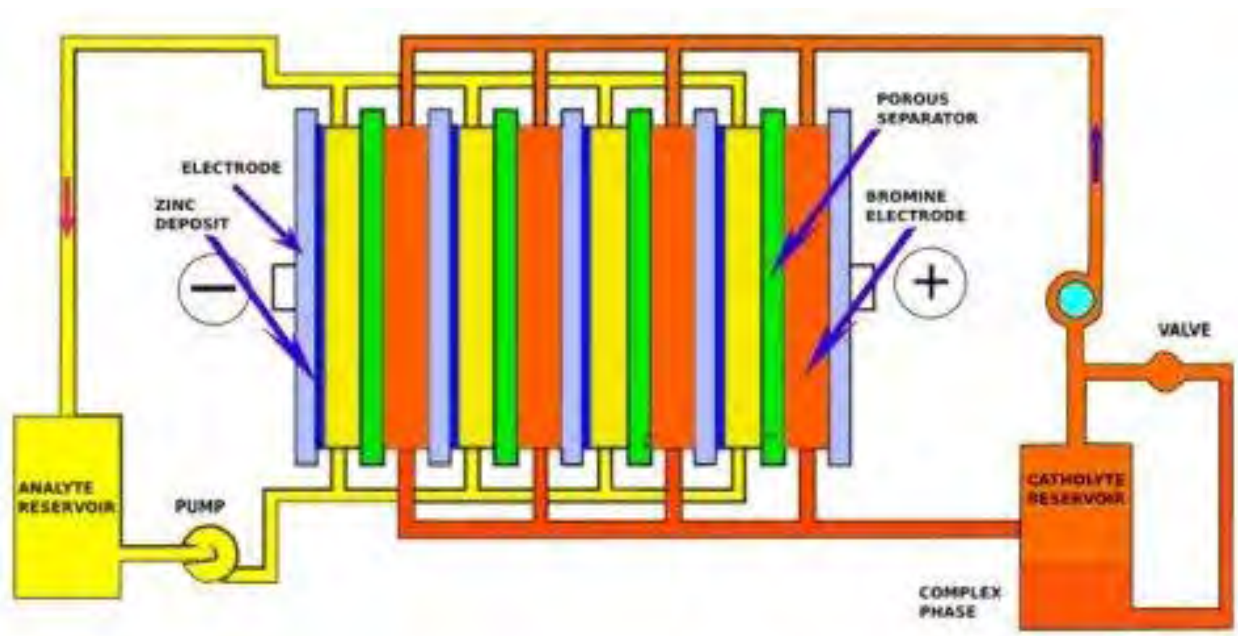


Figure 6.1 – Typical Flow Battery: ZESS Zinc Flow Battery Technology

6.5.1.1 Battery Energy Storage

Two primary types of batteries may be used to store electricity generated from solar energy: flow batteries and conventional batteries.

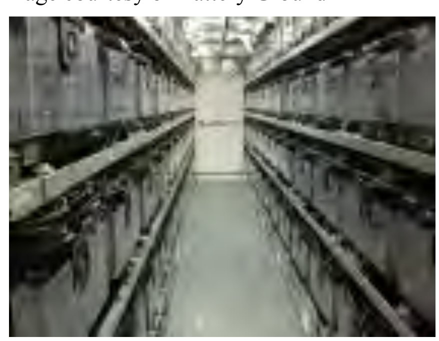
A flow battery is a rechargeable battery in which an electrolyte containing one or more dissolved electroactive chemicals flows through an electrochemical cell that converts chemical energy directly to electricity (Zest Energy, 2011). Additional electrolyte is stored externally and is fed by gravity or using electric pumps through the cells of the reactor. These batteries can be rapidly "recharged" by replacing the electrolyte liquid while simultaneously recovering the spent material for reuse. They can run indefinitely as long as the electrolyte in the system is being replenished. Flow batteries are most often used for load balancing, peak load reduction, storing renewable power, voltage support, and frequency regulation. Their instantaneous capacity (kW or MW) depends upon the number of cells and their size. Their energy storage capacity (kWh or MWh) is dependent upon the volume of external electrolyte. External power supplied to the batteries from solar generation or other sources of generation may be used to re-charge them by recovering the spent electrolyte for re-use.

Sodium-Sulfur (NaS) Battery
Image courtesy of New Energy and Fuel

Conventional batteries such as NaS (Sodium-Sulfur), PbA (Lead Acid), Li-Ion (Lithium Ion) and NiMH (Nickel Metal Hydride) can also be used for storing solar generated energy for nighttime use. These batteries have typically been used on a large scale for emergency backup and Uninterruptible Power Supplies (UPS) in facilities such as data centers, power plants, refineries, airports, hospitals, and water and wastewater pumping plants.

Nickel Metal Hydride Batteries
Image courtesy of Battery Ground

Batteries have good power and energy densities meaning they can provide both power in megawatts and energy in megawatt hours for reasonably long periods. One of the drawbacks however is their “round trip” efficiency, i.e., the output energy as a percentage of the input energy. Typical roundtrip AC-to-AC efficiencies for batteries are 60 – 75%.



Typical Large-Scale Li-ion Battery Storage
Image courtesy of AES

Recently, renewable power plant developers and electric utilities have started to include banks of conventional batteries in renewable power generation plants to reduce output fluctuations, provide voltage support and frequency regulation, and to allow for energy sales during periods when the generating equipment is not generating (e.g. solar generation during nighttime hours). For example, a 125 MW wind turbine generating plant to be located on Laurel Mountain in West Virginia recently announced they will include 16 containers containing over 1.3 million lithium-ion cells organized into batteries each containing 96 cells to produce a total output of 32 MW (PSCWV, 2011). This energy storage device will store some of the wind energy generated during times of high output. The storage system will mitigate spikes in grid deliveries and also allow releases of stored energy during times of low generation.

Batteries have a fast response time to system fluctuations and can provide system smoothing and stability. They offer an ideal but relatively costly form of energy storage. They may also require replacement after a few years or after or few hundred or thousand charge/discharge cycles and care must be exercised in disposal of old batteries.

Typical Large-Scale Li-ion Battery Storage
Image courtesy of AES

6.5.1.2 Thermal Energy Storage

CSP systems use an intermediary thermal transfer medium such as organic thermal fluid, molten salts, or gas to transfer heat generated from concentrated sunlight into a thermal cycle that then converts the thermal energy into electricity, typically using a Rankine cycle steam or organic fluid turbine generator. The intermediary thermal fluid, molten salts, or gas may also be used to heat a thermal storage medium which can then be used at a later time as a source of thermal energy in the same Rankine cycle to generate electricity. This means that thermal energy may be stored during daylight hours and used during non-daylight hours to generate electricity, providing the potential for continuous solar energy electricity production.

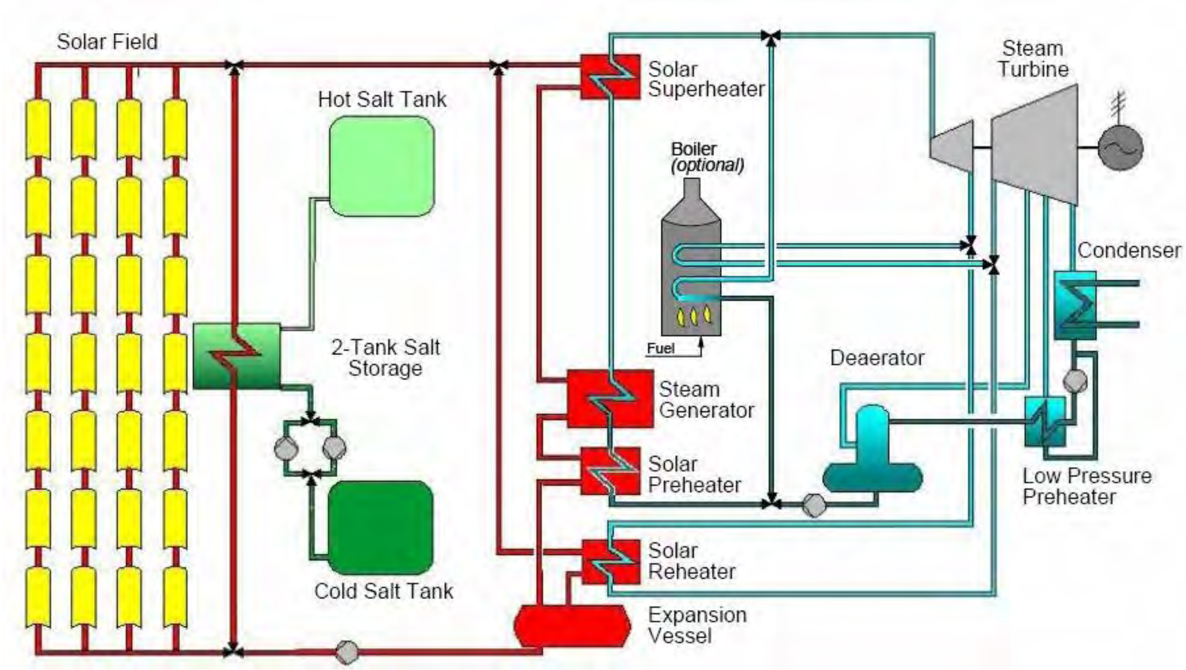


Figure 6.2 – Schematic Flow Diagram of Parabolic Trough CSP Plant with Thermal Storage (NREL, 2005)

There are a variety of thermal storage mediums that can be used including molten salts, concrete, phase-change materials, and the thermal transfer fluid itself (NREL, 2011d). Multi-megawatt CSP plants with thermal energy storage have been built and are operating successfully (NREL, 2007). This thermal energy storage can be sized to provide full or reduced output throughout all non-daylight hours.

6.5.1.3 Pumped Energy Storage

Pumped storage generation uses grid power to pump water up to a height and stores it as a form of potential energy. When there is a need for power, the water is released, driving a turbine, and generating electricity. Pumped storage units are primarily used to support the electrical grid during short-term emergencies (e.g. when a transmission line fails), to provide short-term load balancing when generation doesn't match load, and to provide peak demand capacity. They typically use low cost off-peak energy for pumping while generating power during periods when power prices are high.

Pumped storage plants can have generating capacities of many thousands of megawatts (Dominion, 2011; Consumer Energy, 2011). They represent the cheapest of all the energy storage options and also are highly efficient, long lasting, and fast responding. However, their biggest limitation is their dependence on geography and topography and access to significant water resources. Given the scarcity of water resources in the Mojave and Colorado Deserts, pumped storage units are not viable in these areas.

6.5.1.4 Compressed Air Energy Storage (CAES)

CAES systems use air that has been compressed, usually with low cost off-peak electricity, as the pressurized air input into the combustion section of a combustion turbine (CT) (CNET News, 2008). This compressed air is mixed with fuel which is then used to power the turbine of the CT and generate electricity. CAES may use compressed air tanks, but on a scale sufficient for the energy storage needs of a military facility, they require special geological formations such as underground limestone caves. This makes CAES a location-limited resource. They have a quick response time, long life, and are a cheap source of power provided the equipment (e.g. the CT) is already in place. However, they require fuel in order to operate and therefore do not offer complete energy security without outside resources.

Because of its geographical limitations, CAES is unsuitable for energy storage in the Mojave and Colorado Deserts installations.

6.5.1.5 Superconducting Magnet Energy Storage (SMES)

Superconducting Magnet Energy Storage (SMES) is presently being used for industrial processes such as chip fabrication that require high power quality. The storage mechanism involves storing large amounts of electricity in the magnetic field of a large superconducting coil. Since the coil is superconducting, there are negligible losses in the entire storage system. Efficiency is very high, >90%, as is the response speed.

However, with present technology, large amounts of energy cannot be stored using SMES. Consequently, SMES is not a suitable means of energy storage at the scale required for most military base applications.

6.5.1.6 Ultracapacitor Energy Storage

Capacitors can store energy indefinitely when disconnected from a power source and can provide almost instantaneous energy into a power circuit. Ultracapacitors have a very high energy density, many orders of magnitude greater than standard capacitors but are expensive. Their primary use in energy storage applications is in providing short duration discharge to reduce voltage and power fluctuations, to capture energy in uses such as regenerative braking, and to provide additional power during large motor startup. They are not suited for a large-scale, long-duration energy storage application.

6.5.1.7 Flywheel Energy Storage

Flywheels store energy in the angular momentum of a spinning mass. A flywheel is charged by spinning it with an electric motor. During discharge, the same motor acts as a generator, producing electricity from the rotational energy of the flywheel. Most flywheel systems are capable of several hundred thousand full charge-discharge cycles and enjoy much better cycle life than batteries. They are capable of very high cycle efficiencies of over 90%. Since the energy sizing of a flywheel system is dependent on the size and speed of the rotor, and the power rating is dependent on the motor-generator, power and energy can be sized independently. The disadvantage of flywheels is their relatively poor energy density and large standby losses (DOE, 2008e).

Flywheel energy storage is ideal for instantaneous system backup of short duration. Based on the current levels of technology, flywheels do not offer a suitable means of energy storage in sufficient quantities for long-term grid outages but could be used to integrate a solar system into a micro-grid to extend fuel supplies.

6.5.2 Costs of Energy Storage

Table 6.1 shows the comparative costs of battery storage technologies.

Table 6.1 – Comparative Capital Costs of Battery Storage Technologies

Technology	Current Cost ($/kWh)	10-yr Projected Cost ($/kWh)
Flooded Lead-acid Batteries	$150	$150
VRLA Batteries	$200	$200
NiCd Batteries	$600	$600
Ni-MH Batteries	$800	$350
Li-ion Batteries	$1,333	$780
Na/S Batteries	$450	$350
Zebra Na/NiCl Batteries	$800	$150

Source: SNL, 2008

While there has been a considerable amount of research and development on battery storage technologies, there are few large-scale, long-duration battery energy storage systems in operation and as a result, little recent published data. To gather more current data and verify the data in the table above, battery suppliers and storage project developers were contacted. Based on these telephone interviews, the following current comparative capital costs for battery storage systems were compiled.

Table 6.2 – Indicative Capital Costs for Energy Storage Technologies

Technology	Current Cost ($/kW)	Projected Cost 2013-2015 ($/kW)
Inverter and Power Conditioning Equipment	$400 - 600	$100
Balance of Plant	$300	$300
	Current Cost ($/kWh)	**Projected Cost 2013-2015 ($/kWh)**
Flooded Lead-acid Batteries	$150	$150
Li-ion Batteries	$1,500	$600
Na/S Batteries	$500 - 650	$300

Table 6.2 shows that the costs of battery energy storage are high. For example, consider a lead-acid battery system designed to supply a 1 MW load for 16 hours each day (e.g., when a solar plant is not generating). Such a system would cost $2.4 million. Using lithium-ion batteries or nickel metal hydride, the projected costs would be $9.6 and $4.8 million respectively. The requirement for energy storage (kWh), power level (kW), and charge/discharge characteristics are specific to the design and application of the storage system.

6.5.3 Cut-Over Speed

The speed at which any backup system or energy storage system can take over and supply the necessary load is important so that continuous operation of critical loads may be maintained. This is termed cut-over speed. Batteries, PV, flywheels, ultracapacitors, fuel cells, and SMES systems have an almost instantaneous cut-over speed meaning that they can almost instantaneously carry load if there is a failure or interruption of grid service. Diesel generators and simple cycle combustion turbines, often used for backup service, may take many minutes to reach operational speed and capability to carry load. However, energy security technologies can be used in combination. For example, battery systems are often used in combination with diesel generators with the batteries providing sufficient time for the diesel generator to start, come up to speed and start generating. Table 6.3 shows the cut-over speed of various types of energy storage system and backup power supply.

Table 6.3 – Cut- Over Speed of Energy Storage and Backup Energy Technologies

Technology	Cut-Over Speed – Time from 0 to 100% Power
Pumped Storage	0.5 min
CAES	5 min
SMES	<0.002 sec
Hydrogen Fuel Cells	<0.002 sec
Conventional Batteries	<0.002 sec
Flow Batteries	<0.002 sec
Ultracapacitors	<0.002 sec
Flywheels	<0.002 sec
Simple Cycle Combustion Turbine	5 min
Diesel Generator	0.5 min

Source: Hunwick, 2005

6.5.4 Black-Start Capability

Black-start capability describes a generator's ability to start operation and produce power without the need for an outside source of electricity, whether from the electric grid or another generator. Black-start capability is important in the event of a grid outage. Solar PV systems have 100% black-start capability during daylight hours. Solar CSP systems do not because they need a source of power, such as batteries, to operate pumps and auxiliary systems until the plant reaches operating temperatures. Energy storage systems such as batteries can provide black-start capability as do traditional backup generation systems such as engine-generators and combustion turbines provided they have battery or compressed air operated starting systems.

Table 6.4 summarizes the primary characteristics of 24/7 capability, independence from outside fuel resources, and the ability for black start for each of the primary solar energy choices and energy storage systems.

Table 6.4 – Operational Capabilities of Solar Generation and Energy Storage Systems

	24/7 Capability?	Independent of Offsite Fuel?	Black-start capability?
Reciprocating Engine Generator	Yes	No	Yes [2]
PV – with reciprocating engine backup	Yes	No	Yes [2]
PV – with battery backup	Yes	Yes	Yes
Micro-turbine	Yes	No	Yes [3]
CSP – with gas or oil boiler backup	Yes	No	Yes [3]
CSP – with thermal storage	Yes	Yes	Yes [3]
CSP – with battery backup	Yes	Yes	Yes
PV – alone	No	Yes	Yes [1]
CSP – alone	No	Yes	No

Notes: 1. Daylight only,
2. Requires battery or compressed air start capability
3. Requires battery backup sufficient to start plant auxiliaries

6.6 Traditional Emergency Generation Technology

Liquid fueled reciprocating engines (e.g., diesel gen sets) are the most commonly used sources of emergency backup generation. Along with liquid or gas fired combustion turbines, they can have black-start capability and, once started, can operate indefinitely provided there is an available source of suitable fuel. Diesel gen sets can be in stationary fixed installations or trailer mounted and movable. When used for emergency supply, they are most typically directly connected to the critical loads they serve or to a local distribution panel that serves the critical loads. They may also be connected to a micro grid and serve critical and other loads through the micro grid.

Diesel gens are easy to install, easy to operate, robust, and relatively inexpensive. Because diesel engines are commonly used in military transport equipment, their routine maintenance should not be a major issue. However, it is critical that routine maintenance is performed and that the engines are routinely started and tested in order to confirm they will operate when required in an emergency. Lack of, infrequent, or poor routine maintenance is the leading cause of backup diesel generators failing to operate when required in an emergency.

The smaller, high speed diesel engines can be at full load in less than a minute after starting. However, even with this short start-up time, to avoid interruption to critical loads, power must still be provided from some other backup source (e.g. batteries).

The primary drawback of diesel generators in an emergency backup application is their need for fuel, which could be problematic during an emergency. A typical diesel gen set used for backup power will consume approximately 70 – 75 gallons of fuel per MWh generated at full load (Caterpillar, 2011). Fuel consumption is higher at partial loads and at elevated temperatures during summer months and in hot desert locations. This means that for an installation requiring an average of 10 MW to power critical loads, the fuel consumption over a 24 hour period would be 16,800-18,000 gallons. Dedicated tank storage would be required to provide fuel for the duration of the emergency unless outside fuel could be delivered. The cost of this tank storage as well as the carrying costs for the fuel stored within the tanks must be considered when the total costs of backup generation are evaluated.

Another drawback of diesel generators is their air emissions. Typically diesel generators that are used for backup are strictly limited to the number of hours of operation allowed each year. With this limitation they are not required to have the same level of emissions controls as those diesel gens that are to be run on a continuous basis. This results in a lower capital cost but it does limit the number of hours of operation allowed annually. Actual limits will be based on local and state permit requirements, but typically the maximum allowed will be 200 – 500 hours per year depending on attainment/non-attainment level of the installation location. The operations hours permitted each year include the hours required for routine testing. This limit may be of concern if using these diesel generators as the sole source of supply during long duration outages.

Another alternative traditional technology used for backup power supply is a combustion turbine. Combustion turbines can be designed to burn natural gas, liquid fuels, or both. They may be operated on natural gas when it is available or on liquid fuels such as No. 2 oil, JP-5, and JP-8 if natural gas service is interrupted. But as with gen sets, the weakness of combustion turbines is their reliance on fuels sourced from off-base and the need to have sufficient fuel storage to power the turbines for the duration of an emergency or until fuel deliveries can be re-established. Combustion turbines also suffer the same emissions issues as diesel generators and their inability to provide instantaneous power when the grid fails because of the start-up time.

6.7 Potential Role of Solar Energy for Emergency Backup Supply

Developing an emergency electricity supply scenario for a given installation requires the development of a detailed project design, which is beyond the scope of this study. However, a general perspective on the use of solar power as an emergency generation resource can be obtained by considering a few hypothetical cases.

For the purpose of this discussion, it is assumed that a military installation already has a microgrid installed, which, among other things, is connected to all existing critical loads. A microgrid is required to exploit solar power for emergency backup. It also provides significant security benefits for a backup system that relies solely on diesel generators. Beyond their energy security benefits, microgrids also offer the potential to provide economic and power quality benefits while an installation is tied to the utility grid.

The potential sources of on-site power generation are: 1) diesel generators tied to the existing microgrid in the cantonment area, 2) remote third party owned solar not tied to microgrid, and 3) cantonment third party solar that is tied to the existing microgrid. Most DoD facilities already have some level of emergency backup power that is supplied by diesel generators. Many of the installations also currently host third-party owned solar projects, either adjacent to the cantonment or in other areas, or have the technical and economic capability to do so, as discussed in the Solar Potential Assessment chapter.

Based on these three sources of on-site power, multiple operational scenarios can be envisioned. They range from reliance solely on diesel generators and making no use of solar generation to reliance on solar to provide some or all of the power required for the critical load. The most likely future scenario would be a hybrid system using a mix of diesel generators and on-site solar to slow the draw-down of generator fuel stored on base and to meet a portion of the peak demand.

For a diesel-only configuration, the number and size of the diesel generators must match the expected peak power requirement with sufficient redundancy for reliability. In addition, sufficient fuel must be stored on site to provide for the duration of an expected grid failure, adjusted for expectations that fuel replenishment from outside the installation would either be continued or interrupted. To meet energy security requirements beyond that already provided by the existing diesel generators would require significant capital investments in generators, fuel storage infrastructure, and fuel. Ongoing O&M costs would include maintenance of the generators and fuel for testing to ensure reliability. These costs are sensitive to the total critical load and the duration of outage.

Reliance on solar to provide a 24-hour resource for critical load requires a significant amount of energy storage, which as discussed above is expensive. To meet energy security requirements beyond that already provided by any existing diesel generators would require significant capital investments in large-scale electric power storage and associated O&M costs for maintenance. In addition to these costs, a remote area solar plant (sited at a distance from the cantonment area) would require significant capital costs for transmission and associated O&M costs for the interconnect. It will also require a call option with the third party owner and operator of the remote solar PV plant. These costs are sensitive to the total critical load of the outage.

A hybrid system that uses diesel generators plus solar in the cantonment area is likely to be a more cost effective solution than reliance on solar alone to fully meet the critical load requirement. Under this approach, the levels of energy and fuel storage could both be minimized. Designing an optimal system will be sensitive to both the size of the load and to the expected frequency and duration of a grid outage.

6.8 Conclusion

While a solar plant can provide an important energy security contribution to a military installation, alternatives such as diesel generators are in common use and should be considered in designing an optimum system. Traditional engine-generator sets can provide energy security in most scenarios, even taking into account the need to store large quantities of fuel. A hybrid system allows development of a more robust solution and, depending on the mission requirements a more cost effective solution.

The cost of battery storage is significantly higher than the cost of diesel backup at present, even if a large volume of fuel storage is required to allow for many hours of diesel generator operation. However, this conclusion should be revisited regularly in the coming years. Battery technology is receiving significant investments of public and private R&D funds, and it is expected that battery costs will continue to fall at the same time that battery performance improves.

It is also worth noting that this discussion does not take into account a number of potential collateral benefits of having energy storage equipment connected to the microgrid under normal operating conditions. These include providing ancillary services such as volt-ampere reactive (VAR) correction, reactive power compensation, voltage support and improved grid stability. However, providing these services requires more charging/discharging of the energy storage system, which will shorten its life. This is especially the case with lead acid batteries which have a limited number of charge/discharge cycles before requiring replacement. Other types of batteries can accept significantly more charge/discharge cycles before requiring replacement, but their initial capital costs are also significantly higher.

7 The Solar Development Context

7.1 Introduction

Solar development on the nine DoD installations addressed by this study is governed by a complex web of laws, regulations, and market rules, administered by public and quasi-public entities at the Federal, State and local levels. Few if any of these rules were designed with solar in mind; several were promulgated long before solar energy began its real penetration in the marketplace in the past 10 years. DoD staff and the private developers they increasingly work with need to master this thicket of rules to avoid or mitigate policy barriers and to maximize the benefit of any available incentives.

As demonstrated by the Solar Potential Assessment chapter, this ―development context” can have a material impact on what lands are available for solar development, which solar technology can be used, and whether a project will be financially viable.

This chapter addresses each of the major components of the development context in turn, starting with the Federally-mandated renewable energy goals that are a major driver for solar development on DoD installations. The discussion then reviews some of the principal challenges confronting large-scale solar development, most notably the lack of transmission capacity in these regions and the uncertainty related to developing solar projects on ―withdrawn lands” within the boundaries of the nine installations. A range of biological, cultural and visual resource issues are then reviewed, along with the complex permitting process that major solar projects must comply with. Finally, the contextual review concludes with an overview of the incentives and financing structures that are the other principal driver (along with Federal-level mandates) of solar development on military installations and indeed throughout the country.

7.2 Mandates and Goals

In recent years, Federal agencies have taken an interest in renewable energy development for a variety of reasons such as a desire to reduce and stabilize electricity costs and reduce agency GHG emissions. Congressional and DoD recognition of the value of renewable energy has led to the creation of Federal renewable energy mandates which have provided Federal agencies with concrete renewable energy procurement targets, driving the development of new renewable energy projects at Federal facilities. Likewise, the aggressive RPSs in California and Nevada have created important market demand for renewable energy and driven continued investment in renewable energy projects in both states.

Generally speaking, the mandates and goals discussed below can be divided into two or three categories: those that are applicable to all electricity customers, and those that apply only to Federal facilities or only to DoD facilities. For the first category, a military installation might have the same goal or obligation as a nearby school, hospital or office building. Mandates in the second and third categories are intended to be incremental to those in the first category. These incremental goals were established to ensure that Federal facilities demonstrated leadership in renewable energy development and adoption and that Federal goals and mandates would drive renewable development that was additional to that driven by State-level mandates. Where the DoD was given goals in addition to those established for other Federal agencies, the same logic applies, but here the DoD is positioned as a leader within the Federal family.

Types of Renewable Energy Products

Renewable energy products come in several different forms. The main distinctions between renewable energy products are where the renewable energy is generated and who ultimately owns the RECs generated from the facility. Because many policies are specific about what renewable energy product types can be counted for compliance purposes (and under what circumstances), the details of each product and their use is important.

- Direct REC purchases: Electricity consumers can directly purchase ―unbundled" RECs (RECs sold separately from the electricity) to pair with a portion or all of their electricity consumption. RECs represent the technology and environmental attributes of electricity generated from renewable resources. Ownership provides REC owners with the ability to claim renewable energy consumption along with associated environmental benefits.
- On-Site Generation of Renewable Electricity: Renewable electricity generated by end-use customers for use by their own facilities. The RECs generated by an on-site renewable energy facility must be retained by the customer in order to claim consumption of the renewable energy. However, many site hosts sell some or all of the electricity and some or all of the RECs generated by projects on their land.
- Green Power Purchases: Many utilities and competitive electricity providers across the country offer green power programs that allow customers to purchase renewable energy to meet a portion or all of the electricity purchased from the power provider. The renewable electricity typically costs slightly more than conventional electricity in order to compensate the power provider for the additional cost of procuring renewable energy. The RECs associated with the renewable electricity are retained and retired by the power provider on behalf of the green power customer.

7.2.1 Federal Government

The following is a summary of the mandates that require Federal agencies to meet renewable energy generation and/or consumption targets (DOE, 2011d).

The Energy Policy Act of 2005 (EPAct 2005): EPACT 2005 established the initial Federal renewable energy procurement targets. It requires that Federal agencies utilize renewable energy for electricity consumption (to the extent that is economically and technically feasible) for at least the following percentages of total consumption within the specified fiscal years:

- No less than 3 percent of total electricity consumption in fiscal years 2007-2009.
- No less than 5 percent of total electricity consumption in fiscal years 2010-2012.
- No less than 7.5 percent of total electricity consumption starting in fiscal years 2013 and beyond.

The qualifying renewable energy technologies for electricity consumption include ―solar, wind, biomass, landfill gas, ocean (including tidal, wave, current, and thermal), geothermal, municipal solid waste or new hydroelectric generation capacity achieved from increased efficiency or additions of new capacity at an existing hydroelectric project". Additionally, EPAct 2005 incentivizes Federal agencies to produce renewable energy on-site or on Federal or Native

American lands by allowing Agencies to double count the amount of energy produced on those lands if it is also consumed at a Federal facility (GPO, 2005).

Executive Order 13423 (EO 13423) “Strengthening Federal Environmental, Energy, and Transportation Management”: EO 13423 established more stringent goals by requiring that at least 50 percent of the requirements from EPACT 2005 be met through ―new” sources of renewable energy. The ―new” sources include facilities or infrastructure placed into operation after January 1, 1999. EO 13423 also stipulated that a limited amount of thermal energy (e.g., geothermal heat) can count toward the EO goals but not toward the EPAct 2005 goals. EO 13423 stipulates that each Federal agency, ―to the extent feasible… implements renewable energy generation projects on agency property for agency use.” Finally, the EO directed that agencies can purchase RECs in order to meet EO 13423 requirements (Federal Register, 2007).

The Energy Independence and Security Act of 2007 (EISA 2007): EISA 2007 established a voluntary Congressional goal that 25 percent of the electricity consumed in the United States should come from renewable energy sources by 2025. EISA 2007 required that proposals for new Federal Agency buildings must include "an estimate of the future energy performance of the building or space and a specific description of the use of energy efficient and renewable energy systems, including PV systems, in carrying out the project.” EISA 2007 specifically required that new buildings and major renovations to Federal buildings must reduce fossil fuel consumption relative to 2003 levels by 55 percent by 2010, 65 percent by 2015, 80 percent by 2020 and 100 percent by 2030 (DOE, 2008a).

The National Defense Authorization Acts of 2007 (NDAA 2007) and 2010 (NDAA 2010): NDAA 2007 translated the renewable energy target of EISA 2007 into a mandate specifically for the DoD. NDAA 2007 mandated that 25 percent of all electricity consumed by the DoD must be generated from renewable sources by the year 2025. NDAA 2010 modified the language contained in NDA 2007 to replace ―electricity” with ―facility energy”. This enables the DoD to achieve the NDAA 2007 requirement to utilize renewable energy for 25 percent of DoD facility energy consumption by considering both renewably-generated electricity and thermal energy (e.g., thermal energy generation from solar water heaters) together by 2025. Neither NDAA 2007 nor 2010 stipulated any renewable energy targets for any year other than 2025 (GPO, 2008; GPO 2009).

Executive Order 13514 (EO 13514) “Federal Leadership in Environmental, Energy, and Economic Performance”: EO 13514 establishes that the reduction of GHG emissions is a priority for Federal agencies and builds upon the Federal renewable energy mandates dictated by EPAct 2005, EISA 2007 and EO 13423. EO 13514 requires that agencies develop inventories of their GHG emissions for each fiscal year beginning in January 2011, set GHG reduction targets for fiscal year 2020, and create a strategic sustainability performance plan to document progress (Federal Register, 2009). In response, the DoD announced in January, 2010 that it had set a department-wide goal of reducing GHG emissions from non-combat activities by 34% by 2020, exceeding the broader Federal Government goal of 28% (DoD, 2010e; White House, 2010). EO 13514 also specifies that agencies must increase the use of renewable energy and implement renewable energy generation projects on agency property.

Secretary of Navy's Alternative Energy Goal: As part of the its Energy Goals, the Navy has set the goal of achieving 50% of its shore-based energy requirements from alternative sources[120] and making 50% of the Navy's installations net-zero for GHG emissions by 2020. These goals are voluntary but provide an aggressive standard for the Navy to pursue over the next decade (DON, 2010). Renewable energy generation will be an important instrument in meeting these goals.

Army Net Zero Goal: The Army has created a pilot program to demonstrate whether and how installations could achieve net zero energy, water, and/or waste by 2020. With respect to energy, the intent of the program is to combine on-installation renewable energy generation with energy conservation and efficiency and the recovery of waste heat so that an installation will produce as much energy as it consumes. Nine Army installations and components are participating in the Energy Net Zero pilot program.

7.2.1.1 Mandate and Goal Compliance – Renewable Energy Goals

Currently, there is a lack of consensus within the Federal Government about a single set of rules for achieving compliance with each of the seven sets of renewable energy mandates and goals described above. The DOE's Federal Energy Management Program (FEMP) issued official guidance for Federal agency compliance with EPAct 2005 and EO 13423 in 2008. According to FEMP, in order ―for renewable energy or RECs to count under the EPAct 2005 requirement or the EO 13423 requirement, both the renewable attributes and the non-energy attributes must be retained by the agency, retired, or precluded from transfer to a third party…. Agencies are required to retain ownership of the RECs from projects in order to count them towards the EPAct 2005 or EO 13423 requirements" (DOE, 2008b).

This is more than a bookkeeping consideration. For a renewable energy project sited on a Federal facility, the RECs generated by the project can represent a considerable fraction – roughly a quarter -- of the project's potential value. A project's off-installation sale of RECs can be the margin between financial viability and financial failure. This can create an awkward choice for a DoD installation working with private-sector solar developers, who, under California law, would own the RECs arising from projects that they pay for. Under one scenario, the installation can let the developer sell the RECs so that the project is financeable and to maximize the DoD's revenue (from land rental) or minimize the DoD's expenses (of power purchases). Doing so, however, eliminates the opportunity to contribute to the DoD's compliance with EPAct. Under the alternative scenario, the installation can ask for the RECs to be bundled as part of the land lease or PPA. This scenario will result in the installation receiving a lower ground rental payment and/or paying a higher power purchase price compared with the first scenario; the incremental cost of the RECs could be high enough to render the transaction uneconomic from the installation's perspective.

In order to encourage the development of renewable energy on Federal lands, EPAct 2005 also allows for a bonus for Federal agencies that site renewable energy projects on Federal agency property. For each 1 MWh of renewable energy generated at on-site renewable energy facilities

[120] Alternatives sources is not defined.

in which a REC is retained for use with EPAct 2005 compliance, Federal agencies receive double the credit towards their EPAct 2005 renewable energy requirements, making 1 REC from an on-site renewable energy facility worth 2 MWh instead of just 1. It is important to note that this bonus is not considered double counting because it is a policy internal to the Federal Government and does not allow for the same RECs to be used by two separate entities and doesn't change the environmental attributes of the RECs.

If the RECs from an on-site renewable energy facility are sold or relinquished, the Federal agency cannot use the RECs or the REC bonus for compliance with EPAct 2005 unless eligible RECs are purchased to replace the RECs sold.[121] Such REC swapping can make financial sense where the Federal Government is generating high value RECs, most commonly RECs generated from solar energy, which can be sold at a premium price in certain states (including Nevada) and replaced with less expensive RECs from other eligible renewable energy resources (FEMP, 2008). If a swap is not implemented and RECs are not retained, the on-site project makes no contribution towards the EPAct 2005 goal.

The Federal government has yet to provide clear guidance about the renewable energy goals within EISA 2007 and NDAA 2007 and 2010. Both the DOE and EPA have maintained that the same standards that apply to compliance with EPAct 2005 and EO 13423 should also apply to these more aggressive renewable energy goals and mandates, meaning that the DoD needs to own RECs, either through purchase or retention, to claim compliance with these goals. In contrast, the DoD's current position is that ownership of RECs is not necessary in order to count renewable energy generation that occurs on military installations towards their 2025 renewable energy requirements.

This disagreement has a number of implications. Under the DoD's interpretation, developers of on-installation renewable energy projects can sell the RECs to other parties, improving cost-effectiveness and allowing more projects to be built. However, this approach may contravene Congressional intent: these mandates were implemented so that Federal agencies would be leaders in RE development and so that their efforts would be incremental to the level of renewable energy development that would otherwise occur in response to other policies such as state RPS programs. Selling a project's RECs to other parties negates the incrementality of the project. At present, it is not clear when this disagreement will be resolved, in part because the one and only compliance year for both the Congressional goal and the DoD mandate is still 14 years in the future. As a practical matter, the divergence between how the DoD treats RECs for EPAct 2005 compliance versus how it treats RECs for NDAA compliance means that the DoD essentially has two goals and two parallel but different scoring systems: one that counts on-installation projects that are permitted to sell their RECs (the NDAA scoring system) and a second that does not count such projects (the EPAct scoring system).

7.2.1.2 Mandate and Goal Compliance – GHG Goals

The initial GHG accounting and reporting standards to be used by Federal agencies to meet their EO 13514-driven GHG reductions were finalized in October 2010 but further changes to the

---

[121] Projects that pre-dated the guidance were exempted from this rule, but only through 9/30/2011.

standards are expected later in 2011. For GHG accounting purposes, emissions are categorized into Scopes 1, 2, and 3. Scope 1 emissions are all direct GHG emissions, for example, emissions from a power plant located on a military installation. Scope 2 emissions are all indirect GHG emissions that result from consumption of electricity, heat, or steam produced offsite. Scope 3 emissions include all other indirect emissions of GHGs including transport-related activities, emissions resulting from production of purchased materials, etc.

The use of zero or low-GHG emission renewable energy, whether through on- installation renewable energy facilities or the purchase of renewable energy or RECs, reduces a Federal agency's Scope 2 emissions. The use of renewable energy, and in particular third-party owned renewable energy systems on military lands, is a key part of the DoD's plans for achieving their goal of a 34% reduction in GHG emissions by 2020. According to the Council on Environmental Quality's (CEQ) guidance on GHG accounting and reporting in response to EO 13514, ―RECs are essential to making claims about GHG reductions… whatever acquisition method is used, the REC must be owned by the agency to make the GHG reduction claim, and the RECs should include all their attributes, including GHG benefits, for the claim to be valid" (CEQ, 2010).

Despite concerns expressed by the DoD, the 2010 CEQ guidance specifically states that the avoided emissions that result from third-party owned, on-site renewable energy systems can only be claimed by a Federal agency if the Federal agency ―owns RECs for the energy produced by the system. If the agency does not own the RECs and environmental attributes for the renewable energy produced by the system, the electricity delivered and associated emissions are calculated as conventional grid-supplied electricity" (CEQ, 2010).

The CEQ guidance makes one concession to the DoD, by allowing Federal agencies to count the avoided emissions from third-party owned, on-site renewable energy facilities in which the Federal agency has not purchased or replaced the associated RECs to contribute to reductions in the agency's Scope 3 emissions. This allowance for Scope 3 reductions for renewable energy that is not produced or consumed by the hosting Federal agency is likely to conflict with international Scope 3 accounting standards currently being drafted by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). The problem with the Federal Government claiming Scope 3 reductions for RECs they do not own is that these claims will overlap with the Scope 2 emissions reduction claims the purchaser of the RECs is entitled to make, resulting in the double counting of the GHG reduction impact from the same renewable energy system.

Beginning in December 2010, an interagency workgroup began working to update the EO 13514 guidance including accounting for third-party owned energy systems on Federal property. As of this writing, the DoD, DOE, and EPA have not been able to come to an agreement as to how third-party renewable energy systems on Federal property should be treated for GHG accounting. The DOE and EPA have expressed concern that without revising the rules to require REC ownership in order for the avoided emissions from renewable energy to be included in Scope 2 (or 3), the value of RECs generated on Federal property will be diminished and the larger REC market will be hurt. On the other hand, the DoD has expressed concern that requiring retention or replacement of RECs generated by a third-party renewable energy system on Federal property in order to claim the GHG reductions will present a significant financial barrier that could threaten the capacity of the DoD to develop renewable energy systems on its installations. Final recommendations to CEQ for revisions to the existing guidance were due June 30, 2011 with subsequent revisions to Federal GHG accounting and reporting guidance expected in early 2012.

7.2.2 State Renewable Portfolio Standards

7.2.2.1 California

Overview

California state legislation passed in April 2011 increased the state's RPS from 20% by 2010 to 33% by 2020. The RPS is defined as the –specified percentage of electricity generated by eligible renewable energy resources that a retail seller or a local publicly owned electric utility is required to procure." Achieving this new requirement will involve bringing numerous utility scale and hundreds of smaller distributed renewable energy generation facilities online and constructing seven new transmission lines across the state. The legislation outlines intermediate deadlines to facilitate reaching the 33% by 2020 requirement. Retail sellers and utilities must reach 20% by 2013 and 25% by 2016. According to California's three largest utilities (SCE, PGE, and SDGE), contracts have been signed to fulfill the RPS out to 2020.

The RPS is important for DoD installations for two reasons:

- DoD installations, as buyers of electricity, will see an increasing share of their purchased electricity come from renewable sources, without taking any further action. However, Federal mandates are intended to be incremental to State mandates, so the California RPS will not, by itself, enable the DoD to meet its Federal mandates.
- Renewable project developers who hope to sell into the California RPS could choose to site projects on DoD lands. However, as discussed in the previous section, the off-installation sale of a project's RECs to serve the RPS means that the project cannot be counted for compliance with EPAct 2005 and EO 13423 goals. There are also questions as to whether such a project could help the DoD meet its NDAA 2007 and 2010 goals and its EO 13514 GHG goals.

Through the end of 2013, at least 50% of renewable energy used for compliance must come from renewable energy generation whose first point of interconnection is within California, is scheduled into a California balancing authority without substituting electricity from another source, or has a contract to dynamically transfer electricity to a California balancing authority. This percentage increases to 65% for 2014-2016 and 75% for 2017 and beyond. There are also separate limits on the use of out-of-state unbundled RECs: through 2016, unbundled RECs can account for no more than 25% of a regulated entity's portfolio, after which this limit falls to 10%.

These requirements are meant to keep renewable energy jobs, market growth, and the associated environmental benefits of renewable energy generation within California. However, rules that favor in-state businesses, in appearance or reality, risk being challenged under the U.S. Constitution's Commerce Clause, which grants Congress specific power to regulate interstate commerce and which has been invoked to strike down state laws that, among other things, unduly discriminate against businesses domiciled in other states. California's RPS program, which is similar to many other state RPS programs with policies limiting the use of out-of-state RECs, could draw legal scrutiny for regulating interstate trade. However, it is possible that the RPS will be favorably reviewed by U.S. courts because the program's compliance requirements do not explicitly limit the amount of out-of-state renewable energy that can be used.

Renewable Resource Eligibility

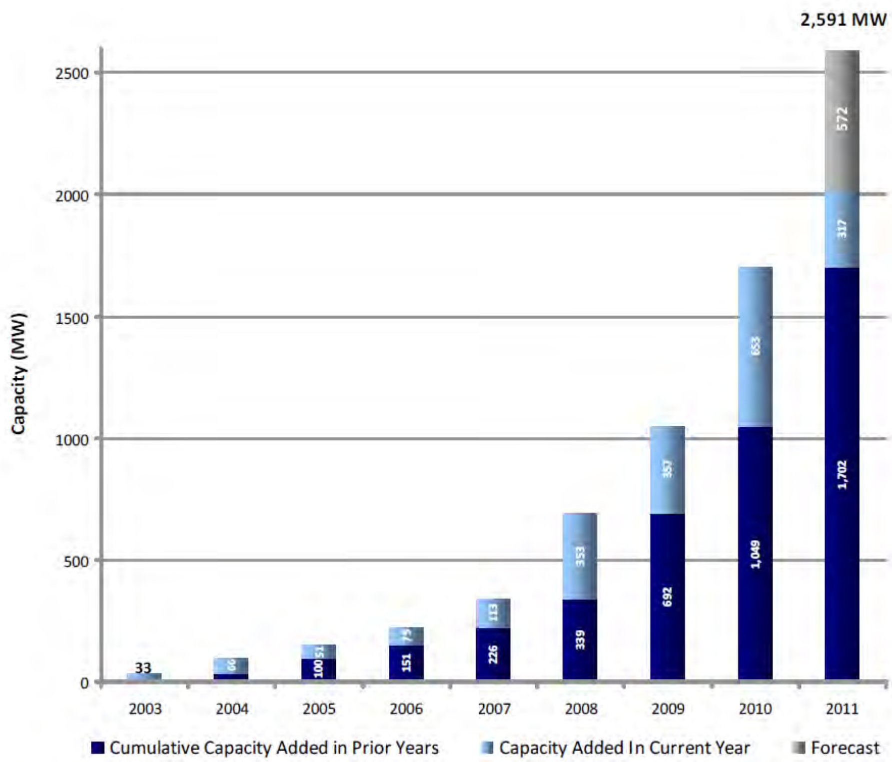
A variety of renewable energy technologies satisfy the revised state RPS requirement. The specific parameters applicable to each technology and REC eligibility is summarized in Table 7.1. CAISO is empowered to determine fair interconnection to the grid. Renewable energy facilities participating in certain provisions are excluded from net metering eligibility.

Table 7.1 – Eligible Renewable Energy Resources – California

Technology	RPS Qualification Parameters	REC Eligibility
Anaerobic Digestion	No restrictions.	Eligible
Biodiesel	No restrictions.	Eligible
Biomass	Facility must report the types and quantities of the biomass fuels used to the California Public Utilities Commission (CPUC).	Eligible
Energy Efficiency	Does Not Qualify	Not Eligible
Energy Recovery Processes	Does Not Qualify	Not Eligible
Fuel Cell (renewable energy powered)	Facility must be economically viable. GHG emissions must be less than or equal to a standard renewable energy facility.	Eligible
Geothermal	No restrictions.	Eligible
Hydropower	Facility must be less than 30 MW in size Facility must use an existing conduit facility Incremental generation from efficiency improvements	Not Eligible
Landfill gas	No restrictions.	Eligible
Municipal Solid Waste (MSW)	Facility must use non-combustion thermal process without oxygen. Facility must not emit air contaminants, GHGs, water waste, or hazardous waste.	Eligible
Ocean thermal, wave, and tidal	No restrictions.	Eligible
Solar Technologies	CPUC will determine the effective load carrying capacity and establish the contribution to RPS. If a solar thermal facility receives financial assistance to remain economically viable, financial disclosure is required.	Eligible
Waste Tires	Does Not Qualify	Not Eligible
Wind	CPUC will determine the effective load carrying capacity and establish the contribution to RPS. If the facility receives financial assistance to remain economically viable, financial disclosure is required.	Eligible

Notes: California Legislature, 2011.

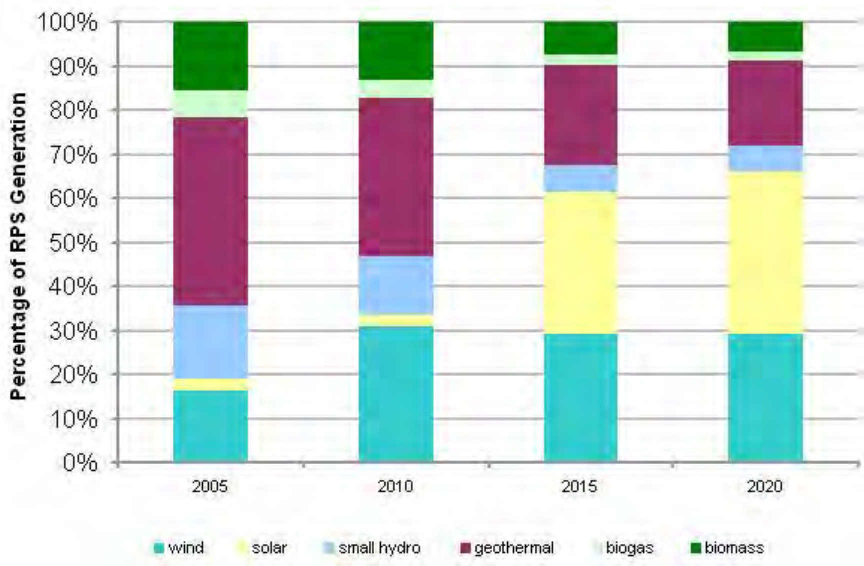
Since the beginning of the RPS program, approximately 2,000 MW of renewable energy has achieved commercial operation. Within the last four years, the annual addition to renewable energy capacity has increased from 113 MW in 2007 to 653 MW in 2010. Moving toward the 33% goal in 2020, the RPS program is expected to drive exponential growth, beginning with approximately 900 MW projected to come online in 2011 (see Figure 7.1). Such a significant and rapid increase in renewable energy capacity will strain the existing transmission infrastructure and require approximately seven new transmission facilities to come online in the next five years.



Source: CPUC, 2011a.

Figure 7.1 – Renewable Energy Capacity Growth in California

The mix of renewable energy sources is projected to change significantly over the next 10 years. Utility-scale solar installations are expected to provide a significantly larger percentage of California's renewable energy by 2020 (see Figure 7.2) (CPUC, 2010b). By 2020, the relative share of biomass, geothermal, and small hydroelectric facilities in the RPS portfolio will shrink significantly.



Source: CPUC, 2010b.

Figure 7.2 – Past and projected breakdown of renewable energy source

Feed in Tariff Program

California also has a FIT program, which creates a standard contract for the purchase of renewable energy generation from facilities smaller than 1.5 MW for the three investor owned utilities (IOUs) in California. While facilities of this size are small relative to the solar potential on each installation, installations should still participate in the FIT to the extent technically and economically feasible. The new RPS program caps participation in the state's FIT program at 750 MW.

7.2.2.2 Nevada

Overview

Nevada's RPS program requires each retail electricity seller and electric utility in the state to supply 25% of retail electricity sales with renewable energy generation by 2025. Table 7.2 shows the eligible renewable energy resources for use in compliance with Nevada's RPS program. Retail sellers and utilities must reach intermediate annual renewable energy requirements of 15% by 2011, 18% by 2013, 20% by 2015, and 22% by 2020.

Table 7.2 – Eligible Renewable Energy Resources – Nevada		
Technology	**RPS Qualification Parameters**	**Portfolio Energy Credit (PEC) Eligibility**
Anaerobic Digestion	No restrictions.	Eligible
Biodiesel	No restrictions.	Eligible
Biomass	No restrictions.	Eligible
Energy Efficiency	Measure must be sited or implemented at a retail customer's location. Measure must be partially or fully subsidized by the electric utility. Measure must reduce the customer's energy demand rather than shifting it to off-peak hours	Not Eligible
Energy Recovery Processes	Facility must be less than 15 MW in size. Facility must convert otherwise lost energy from "the heat from exhaust stacks or pipes used for engines or manufacturing or industrial processes; or the reduction of high pressure in water or gas pipelines before the distribution of the water or gas." Facility cannot use additional fossil fuel or require a combustion process to generate the electricity.	Not Eligible
Geothermal Direct-Use	No restrictions.	Eligible
Geothermal Electric	No restrictions.	Eligible
Hydroelectric	No restrictions.	Eligible
Landfill Gas	No restrictions.	Eligible
Municipal Solid Waste (MSW)	No restrictions.	Eligible
Ocean thermal, wave, and tidal	Does Not Qualify	Not Eligible
Solar Technologies	Facility may employ solar water heat, space heat, thermal electric, thermal process heat, PVs, and/or pool heating.	Eligible
Waste Tires	Facility must use microwave reduction.	Eligible
Wind	No restrictions.	Eligible

Source: NVTREC, 2011.

Solar Carve Out

Through 2015, at least 5% of the renewable energy acquired must be sourced from a solar technology, including solar water heating, space heating, thermal electric, thermal process heat, PVs, and/or pool heating. Beginning in 2016, the solar carve out requirement increases to 6% of all renewable energy. Because renewables will be 25% of all electricity sales after 2025, solar will account for about 1.5% (6% x 25%) of total retail electricity sales after that date.

Portfolio Energy Credit Market

The Public Utilities Commission of Nevada (PUCN) has established a program to allow energy providers to buy and sell portfolio energy credits (PECs) in order to meet the state wide RPS. One PEC is equivalent to 1 kWh of electricity but solar PV, energy efficiency measures, customer-maintained distributed systems, and electricity generated during peak hours all receive additional multipliers. The intent of the PEC multipliers is to stimulate the development of particular renewable energy/energy efficiency resources by generating more than one PEC per kWh, increasing the value of underlying electricity generated or saved. Actual pricing data shows that PECs are valued at approximately $0.04 per PEC (kWh) or $40/MWh. Additional information on the value of PECs is provided in the Incentives section below.

7.3 Withdrawn Lands

The vast majority (90%) of the land within the boundaries of the nine military installations covered by this study is not owned by the DoD, but is instead DOI land that has been withdrawn from most or all public uses and reserved for the use of the military (see Table 7.3). Most of the military installations occupy numerous separate land withdrawals of differing age, prescribed uses, periods of effect (if a period is specified), and with different Federal agencies in charge of managing the land. This division of management authority and responsibility creates one of the most challenging barriers to the development of solar energy facilities on the nine military installations.

Table 7.3 – Withdrawn Lands on Mojave and Colorado Desert Installations[122]

Military Installation	Acres Withdrawn	Total Acres	Withdrawn %
Edwards AFB	83,110	308,123	27%
Fort Irwin	725,062	754,134	96%
China Lake	1,108,956	1,108,956	100%
Chocolate Mtn.	226,711	463,623	49%
El Centro	47,870	56,289	85%
Twentynine Palms	472,649	595,578	79%
MCLB Barstow	3,683	6,176	60%
Nellis AFB	10,290	14,000	74%
Nevada T&TR	2,919,890	2,919,890	100%
Creech AFB	2,940	2,940	100%
Total	5,601,161	6,229,709	90%

Source: (Pease, 2011)

The land withdrawals for the military installations in the Mojave and Colorado Deserts started in 1940 with the initial land withdrawal at what is now Fort Irwin. With the U.S. entry into World War II, many more land withdrawals in the region followed, some just a few acres and others numbering in the hundreds of thousands of acres. Most of the land withdrawals conducted before the enactment of the Engle Act of 1958 continue to be in effect today without any formal expiration dates or requirements for renewing the withdrawals. Prior to the Engle Act, the Secretary of Defense would request specific lands from the Secretary of the Interior for national security reasons and the Secretary of the Interior would oblige by ordering the lands reserved for military use.

---

[122] The withdrawn land acreage figures reported in this table are currently under review by the DoD/DOI Interagency Land Use Coordinating Committee and should be considered preliminary data only. For example, other sources indicate that 8% of China Lake is DoD fee land and 92% is withdrawn land.

Beginning with the Engle Act of 1958, land withdrawals of more than 5,000 acres required an Act of Congress as well as a term for which the land withdrawal would be effective. Beginning with the enactment of Federal Land Policy and Management Act (FLPMA) in 1976, the maximum length of a land withdrawal was set at 20 years before a renewal was required (later extended to 25 years). FLPMA also required the DoD to develop a land management plan for withdrawn lands.

Currently, the DoD and DOI are working together to extend the land withdrawals at NAWS China Lake and Chocolate Mountain AGR, both of which expire in 2014, for an additional 25 years. The DoD and DOI are also currently working to come to an agreement on a westward expansion of MCAGCC Twentynine Palms through a land withdrawal that would add as much as 332,000 acres to the installation. Additional military land withdrawals in the Mojave and Colorado Deserts are set to expire in 2019, 2021, 2024, 2025, and 2026.

While the details of post-FLPMA land withdrawals vary in many respects, each land withdrawal permits the military to use the withdrawn lands for a specific set of purposes agreed upon by both the DoD and DOI and authorized by Congress for so long as the land withdrawal is valid. While no military land withdrawals to date have specifically mentioned renewable energy generation as a permissible use for withdrawn lands, each land withdrawal includes phrasing that reserves the land for other defense-related purposes consistent with specific purposes for which the withdrawn lands were originally secured. This ―other defense-related purposes” phrasing has led to a wide range of interpretations as to how withdrawn lands can be used by the military for solar energy development. The Army has interpreted this clause to mean that the Army can use the land for any purposes they deem valuable, including for use in leasing to private solar energy developers for retail electricity generation to be supplied to the installation or wholesale electricity generation to be supplied to the regional grid (King, 2011). In contrast, the Air Force and Navy/Marines have interpreted this clause more narrowly to mean that the military services have the authority to lease the land to private developers for solar energy development so long as the resulting electricity generation is sold to the military installation for on-installation use (USAF, 2011; Lundstrom, 2011).

A further challenge with withdrawn lands is that the duration of most of the largest land withdrawals extends for only 20-25 years, after which the withdrawal terminates or Congress renews it. This conflicts with the economics of solar energy development which tends to require at least 20 years of operation for the developer, whether the military or a private entity, to obtain a reasonable return on their investment. Consequently, the military lacks the ability to provide 20 year ground leases on withdrawn lands in most cases because it cannot be assured that it will control the land for the full term of the lease.

There are also financial and mandate considerations. DoD installations can collect and partially retain cash or in-kind payments from large-scale solar PPAs and Enhanced Use Leases. Any compensation not retained by the installation can be retained within the installation's military department. BLM, on the other hand, collects right of way payments and returns the funds to the Treasury. (An installation would naturally be more motivated to expend development effort on a project that would yield direct benefits to the installation.) There are also questions about how large-scale solar projects on withdrawn lands might be credited towards EPAct and NDAA goals.

As a result of these factors, the large expanses of withdrawn lands on the nine installations are in a state of renewable energy development limbo. The military controls the lands for most purposes, but their ability to lease these lands to third-party developers is uncertain. Even if the land could be leased, the 25-year withdrawal renewal cycle may make it difficult to lease the land for terms of greater than 20 years, particularly later in the life of a withdrawal. And the uncertainty about where the benefits will accrue reduces motivation to pursue project opportunities.

Recently, the DoD and DOI have created an executive-level committee to resolve the land withdrawal issues between the two Departments. The committee, led by senior representatives from both departments has begun a series of meetings with the goal of generating an inter-department partnership or memorandum of understanding that will resolve key issues, including which department has the authority to lease withdrawn lands for renewable energy development, how leasing revenue should be distributed, and how credit towards meeting Federal renewable energy mandates and goals would be divided between the two Departments.

For the purpose of the Solar Potential Assessment, the study team did not attempt to forecast the outcome of these discussions. Instead, the analysis used the following methods and assumptions to address the withdrawn lands issue:

- The study would not differentiate between the solar potential on withdrawn lands and DoD fee lands.
- The analysis assumed that the two Departments would reach an agreement that permits leasing of withdrawn lands to third-party developers for large-scale solar development.
- Such leases would be at least 20 years in duration.
- The developer would pay rent to the Federal Government, without identifying which department specifically would receive the rental payments.

7.4 Utility Policy and Planning

7.4.1 Transmission

One of the key constraints to large-scale solar development in the Mojave and Colorado Deserts is access to electric transmission capacity. Any large solar energy projects in the deserts would need to contract for long-distance transmission of its electricity output because the Mojave and Colorado Deserts have low electricity demand outside of the military installations themselves.

The Mojave Desert is crossed by many large transmission lines connecting the electricity demand of the Los Angeles Basin and Las Vegas areas with power plants to the north and east. Unfortunately for renewable energy developers, these existing transmission lines are operating close to or at capacity and cannot deliver any additional renewable power to markets. Little available transmission capacity currently exists in the Colorado Desert either, in large part because very little transmission capacity crosses the Colorado Desert.

In recent years, as renewable energy development pressure has increased in both deserts, additional transmission capacity has been proposed and planned. However, transmission planning, construction and cost allocation is extraordinarily complicated, with responsibility divided among a range of public and private organizations at the Federal, Regional, State and local levels. Jurisdiction is fragmented, although the electrical grid is highly interconnected. This fragmentation and complexity causes large-scale transmission expansion to be planned on multi-year or decadal timescales.

In an attempt to speed the development of critical transmission corridors, EPAct 2005 authorized the Federal Energy Regulatory Commission (FERC) to issue the necessary permits for transmission projects in national interest electric transmission corridors (NIETC) if state or regional authorities are unable or unwilling to approve transmission projects within one year of receiving a complete application (GPO, 2005). Southern California, including all of the Colorado Desert and most of the Mojave Desert, falls within one of the two NIETC designated by the DOE in 2007 (DOE, 2011f). The FERC's NIETC permitting authority has yet to be used to permit a transmission project in California, in part because of lengthy court cases which have limited the application of FERC's permitting authority and required policy revisions and in part because of concerted efforts by state and regional transmission authorities to address the region's transmission constraints themselves. Recent policy changes have increased the likelihood that FERC may use its NIETC permitting authority in the future although there are no clear plans for it to be used in Southern California at present.

The challenge of transmission expansion was dealt with indirectly in the Solar Potential Analysis. Essentially, the study team was faced with three choices for addressing the very real constraint that transmission places on large-scale solar:

- Enforce the constraint in the analysis for the year 2015. This is the most realistic option, but the result (no ability to site large-scale solar on most or all of the 9 installations) would not illuminate the solar potential on these installations.
- Attempt to project and model the actual in-service dates for the necessary transmission expansion projects that would allow large-scale solar development on the nine installations. While this would be an interesting approach, the cost and time needed to undertake such an analysis was well in excess of what was available to support this study.
- Assume that the necessary transmission would eventually be built. This is not an unreasonable assumption in general, although it is entirely unreasonable within the 2015 timeframe. However, using this approach permitted the study team to conduct all of the other modeling of the technical and economic potential for large-scale solar development on the nine installations.

Ultimately, the study team implemented the third approach. The costs of connecting large-scale solar projects to the transmission network were included in the economic analyses, but the lack of available transmission capacity in 2015 was ignored. Thus, the results of the Solar Potential Assessment need to be interpreted as solar potentials that will exist once sufficient transmission infrastructure is built to unlock them. Realistically, that will likely be many years after 2015.

7.4.1.1 Regional Transmission Overview

SCE and SDG&E are the major utilities in Southern California. The region also includes utilities that do not participate in the California Independent Service Operator (CAISO) such as the Imperial Irrigation District (IID) and Los Angeles Department of Water and Power (LADWP) (see Table 7.4 below).

Table 7.4 – Major Utilities in California

North/South California	Utility Name
Northern California	Pacific Gas and Electric (PG&E) North
	Sacramento Municipal Utility District (SMUD)
Southern California	Southern California Edison (SCE)
	San Diego Gas and Electric (SDG&E)
	Imperial Irrigation District (IID)
	Los Angeles Department of Water and Power (LADWP)

Figure 7.3 below shows some of the major transmission corridors in Southern Nevada and Southern California. The Intermountain DC line from central Utah into Nevada is a large corridor that enables more than 2,000 MW of power transfer. Similarly, the West of Colorado River transmission path interconnects the entire Southern Nevada and Arizona markets to the Southern California market. The transfer limit on this path is about 10,000 MW with flows averaging at around 6,000 MW across the year in the east-to-west direction.

Southern Nevada is typically a power exporting region with surplus coal and gas generation. Power is transferred out to Arizona and Southern California power markets. In contrast, Southern California is an importing region with power imports making up a significant share of the capacity needed to meet demand in the region.

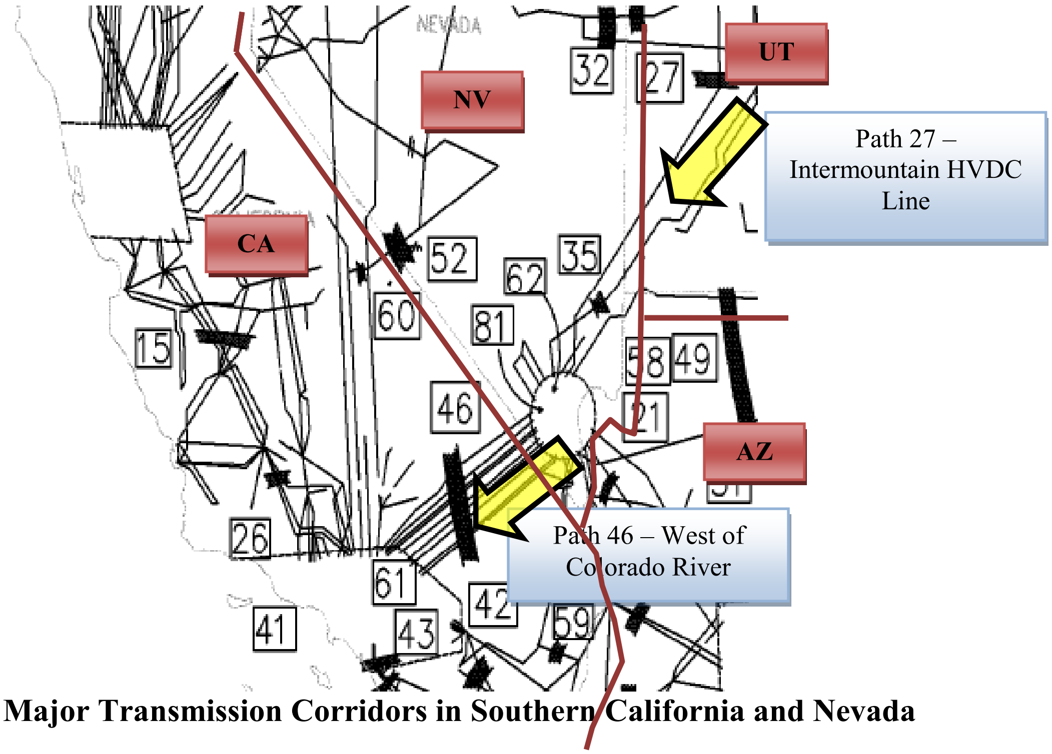


Figure 7.3 – Major Transmission Corridors in Southern California and Nevada

As can be seen in Figure 7.4 below, there are heavy flows (about 7,000 to 8,000 MW) on Path 46 during the winter months (December through March). In both the transmission corridors discussed above, transmission capacity is very restricted in the east-to-west direction. Based on a review of recent WECC path utilization reports, we believe there may not be any firm transmission capacity available on these corridors year-round. However, there is capacity available in the west-to-east direction (i.e., movement of power from California to Nevada, Utah).

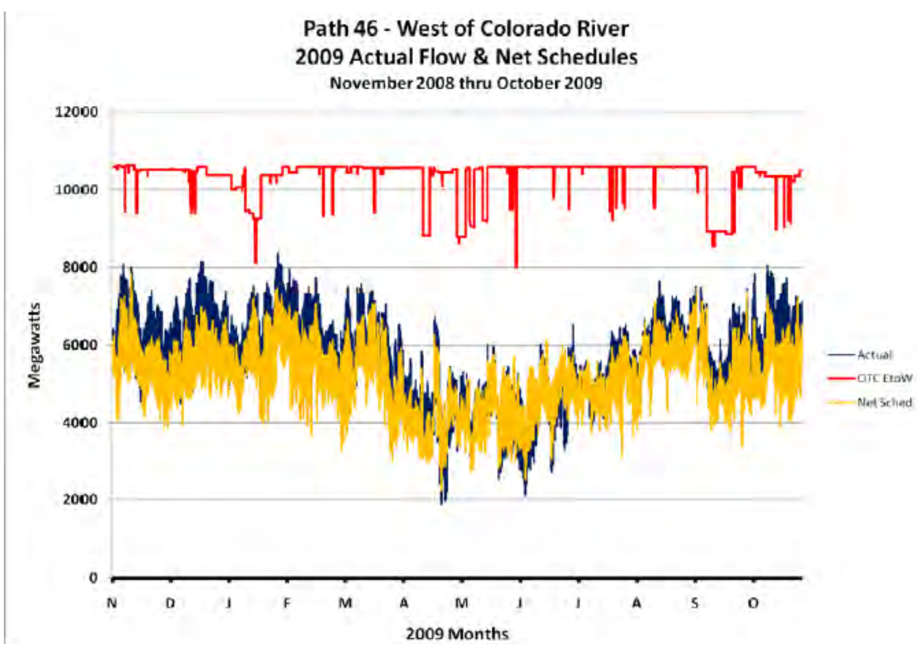


Figure 7.4 – 2008-09 Yearly Transmission Flows from Southern Nevada into California

7.4.1.2 Transmission Planning

The organizations and initiatives involved in identifying and siting new transmission lines in the CA and NV region are:

1. California Independent System Operator (CAISO): CAISO is responsible for developing a transmission plan for the entire CAISO territory (CAISO, 2011). The participating transmission owners and other transmission project sponsors can submit their transmission proposals during an annual project request window. CAISO then performs all necessary transmission planning studies in accordance with established standards and selects the projects for its annual transmission plan.

2. Nevada Power Company (NV Energy): Each year NV Energy completes an informal update to its transmission plan. Every 3 years, NV Energy develops an Integrated Resource Plan (IRP) that is submitted to the Public Utilities Commission of Nevada. The IRP includes a 20 year transmission plan that identifies all new transmission facilities, 200 kV and above, and all facility replacements and/or upgrades required over the next 20 years to reliably and economically meet customers' needs. The IRP includes an action plan which covers the next three years in detail (NV Power Company, 2011).

3. Imperial Irrigation District (IID): IID plans transmission in its territory on an identified need basis.

4. Utilities within CAISO: The three large investor-owned utilities (IOUs) in California – PG&E, SCE, and SDG&E – form most of the service territory of the CAISO. These utilities also identify transmission enhancement needs, and build new transmission lines based on CAISO's approval. An example would be the Tehachapi transmission project built by SCE, to provide more transmission access to renewables in the region.

5. Los Angeles Department of Water and Power (LADWP): LADWP is a balancing authority and the largest municipal utility in the country. It performs transmission planning for its local system while participating in regional and sub-regional transmission planning committees such as the Western Electricity Coordinating Council's (WECC) Transmission Expansion Planning Policy Committee (TEPPC) (LADWP, 2007).

6. The Southwest Transmission Expansion Planning (STEP) group performs transmission planning activities for the region. The primary purpose of the STEP is to coordinate transmission planning activities in Southern Nevada, Arizona and Southern California to build a robust transmission system that can support generation re-dispatch, support bilateral power supply contracts, meet state RPS goals, and ensure a reliable system. Over the last few years, the STEP group has developed three main projects:

    - The first set of upgrades to prominent transmission paths in the three states (AZ, NV and CA) was completed in 2006 and increased transmission capability by 505 MW.

- Most of the second set of upgrades is complete. When all of the upgrades are complete, they will increase transmission capability by a further 1,245 MW.
- The third set of upgrades is the second circuit of the Palo Verde-Devers transmission line. SCE is now pursuing the California portion of the line to enable interconnection of several solar power stations in eastern California and has received DOI approval to proceed with the line.

7. Western Renewable Energy Zones (WREZ) Analysis: Begun in 2008, this analysis is jointly sponsored by Western Governors' Association (WGA) and the DOE. The WREZ Analysis seeks to identify areas in the Western Interconnection that have significant renewable resources so that transmission expansion can be targeted to facilitate the development of renewable energy. The WREZ project will also produce conceptual transmission plans for delivering that energy to where it is needed within the Western Interconnection (WGA, 2011).

8. Renewable Energy Transmission Initiative: The Renewable Energy Transmission Initiative (RETI) is a California wide initiative to identify the transmission projects needed to accommodate the State's renewable energy goals, support future energy policy, and facilitate transmission corridor designation and transmission and generation siting and permitting. RETI will assess all competitive renewable energy zones in California and possibly also in neighboring states that can provide significant electricity to California consumers by the year 2020. RETI will also identify those zones that can be developed in the most cost effective and environmentally benign manner and will prepare detailed transmission plans for those zones identified for development (CEC, 2011c).

9. California Transmission Planning Group (CPTG): The CTPG is a forum for conducting joint transmission planning and coordination in transmission activities to meet the needs of California consistent with FERC Order 890. The CTPG was formed as a result of discussions facilitated by FERC to address California's transmission needs in a coordinated manner that would respect various business models. The CTPG includes transmission owners with an obligation to serve and transmission operators. CTPG is tasked to develop a California state-wide transmission plan to meet the state's RPS goal of 33% renewable energy by 2020. CTPG is seeking to leverage a diverse portfolio of renewable energy generation technologies (wind, geothermal, hydro, biomass and solar) available to supply projected electricity demand in California from now to beyond 2020. In this effort CTPG is utilizing the RETI conceptual plan as a starting point (CTPG, 2011).

10. FERC: Southern California has been designated as a NIETC by FERC and the DOE, which grants FERC the authority to issue permits for transmission projects that will address the transmission constraints of the region if state and regional transmission authorities have not permitted a proposed transmission project within a year of the project's completed application.

11. In addition to the above entities, West Connect (a sub-regional power system coordination entity in the Western Interconnection) and WECC's (the regional entity

responsible for coordinating and promoting bulk electric system reliability in the Western Interconnection) TEPPC are engaged in encouraging the development of regional transmission expansion plans that would reduce duplication and improve the efficiency of transmission plans.

Transmission owners such as SCE, SDG&E, PG&E, LADWP, and IID build transmission along with merchant (non-utility) companies. Entities such as WECC, CAISO, WGA, CTPG and initiatives such as RETI enable the identification of transmission projects needed for increased reliability, transmission access, and to alleviate congestion. These entities do not have the mandate or the authority to actually build transmission, and usually do not take a position for or against a specific transmission project.

The transmission planning process occurs in multiple timelines – short term, medium term, and long term. Usually, long term plans such as the 10, 15 or 20 year transmission planning exercises are carried out by a central power system operating entity – such as the CAISO or WECC to ensure inclusion of a broad range of issues, and analyze the entire interconnected system (in this case, the Western Interconnection) instead of a specific service area. Performing the analysis over the entire system ensures that the impacts to the entire system are considered when optimal transmission expansion plans are being developed for particular sub-regions. Shorter term (5 years or less) transmission plans are performed by both system operators and individual utilities to maintain reliable service while addressing load growth, transmission service requests, public policy directives, and stakeholder concerns. Provisions for local planning are compliant with FERC Order 890 as required, and are covered by Attachment K in each Transmission Provider's Open Access Transmission Tariff (OATT) where applicable. A snapshot of various regional planning groups in the West (as recognized by WECC), is given in Figure 7.5 below.

Figure 7.5 – Sub-regional Planning Groups in the Western United States

It is important to note that transmission planning is a continuous process, with a specific update schedule. Currently, the WECC-TEPPC performs a 10-year and a 20-year transmission planning exercise. These plans will be updated on a specified schedule – usually once every two years. The 10 –year plan is a bottom-up process that incorporates coordinated input assumptions from other planning processes with extensive analysis using power system simulation models. The 20-Year Plan builds on the 10-Year Plan and is based on the analysis of a broad set of energy futures resulting from a scenario development process.

Table 7.5 below shows existing transmission projects in the southern California and Nevada regions. In most cases, the transmission projects listed below are structured to pass through renewable energy rich regions of California and Nevada or to otherwise promote the increased use of renewable energy by resolving transmission bottlenecks that were keeping renewable energy resources from connecting to electric load centers. Data in Table 7.5 is based on NERC Long Term Reliability Assessment, 2010 unless otherwise indicated (NERC,2010).

Table 7.5 – Southern California and Nevada Transmission Projects										
Project name	**From Terminal**	**To Terminal**	**Line Length (Miles)**	**Operating Voltage (kV)**	**Voltage Type (AC/DC)**	**Capacity Rating (MW)**	**Expected In-Service Year †**	**Cost ($ MM) ††**	**Who pays?**	**Developer Name**
Eldorado-Ivanpah Transmission Project [2]	Boulder City, NV	Primm, NV	35	220	AC	N/A	2013	440[1]	Southern California Edison (IOU)[1]	Southern California Edison (SCE) Company[2]
Tehachapi Renewable Transmission Project (TRTP)	Tehachapi, CA	Saugas, CA	82.7	500 and 220	AC	3950	2010	2,000[1]	SCE[2] (Costs allocation among generator (gen-tie), CAISO grid users, and CA ratepayers for cost recovery back-stop)[3]	SCE[1]
	Tehachapi, CA	Mira Loma, CA	250	500	AC	3950	2013			
Devers – Colorado River and Devers – Valley No. 2 Transmission Project	Colorado Rivers, CA	Devers, CA	115	500	AC	1200	2013	650[1]	SCE[2] (Single Utility, Single rate (CAISO) jurisdiction)[3]	Southern California Edison Company
	Valley, CA	Devers, CA	42	500	AC	1200 5	2013			
Green Energy Express	Eagle Mountain, CA	Devers, CA	70	500	AC	2000	2015	400[4]		Green Energy Express LLC[4]
Pony Express[5]	Eldorado, NV	Iron Mountain, CA	170	500	AC	1200	2015	N/A	N/A	Clear Power LLC[5]
	Iron Mountain, CA	Devers, CA	100	500	AC	1200	2015			

Table 7.5 – Southern California and Nevada Transmission Projects

Project name	From Terminal	To Terminal	Line Length (Miles)	Operating Voltage (kV)	Voltage Type (AC/DC)	Capacity Rating (MW)	Expected In-Service Year †	Cost ($ MM) ††	Who pays?	Developer Name
Metro Renewable Express[5]	Devers, CA	M. Loma, CA	60	±300	DC	2000	2015	N/A	N/A	Clear Power LLC[5]
Barren Ridge Renewable Transmission Project[6]	Barren Ridge, CA	Haskell, CA	61	230[6]	AC	950	2013	233[6]	Municipal Utility	Los Angeles Department of Water and Power[6]
	Haskell, CA	Castaic, CA	12	230[6]	AC	950	2013			
	Barren Ridge, CA	Rinaldi, CA	76[7]	230[6]	AC	650	2013			
Sunrise Powerlink Project[8]	Suncrest, CA	Sycamore Canyon, CA	28	230	AC	1000[9]	2012	1883[8]		San Diego Gas and Electric
	Imperial Valley, CA	Suncrest, CA	91	500	AC	1000[9]	2012			
Valley Electric Association Transmission Project[10]	Sterling Mountain, NV	Northwest, NV	41	230	AC	320	2011			Valley Electric Association
ON Line – Southern portion of Southwest Intertie project.	Las Vegas, NV	Ely, NV	235	500	AC		2012	510[11]	Great Basin Transmission (Private Company) will pay 75% of the cost (i.e., $ 380 Million) while NV Energy (IOU) will contribute $ 130 Million[12]	Great Basin Transmission LLC and NV Energy[11]

Table 7.5 – Southern California and Nevada Transmission Projects										
Project name	**From Terminal**	**To Terminal**	**Line Length (Miles)**	**Operating Voltage (kV)**	**Voltage Type (AC/DC)**	**Capacity Rating (MW)**	**Expected In-Service Year †**	**Cost ($ MM) ††**	**Who pays?**	**Developer Name**
Southern Nevada Intertie Project[13]	Las Vegas, NV	Boulder City, NV	60	500	AC		2013			Great Basin Transmission LLC[13]
Renewable Transmission Initiative[14]	Lassen, CA	Clark County, NV[14]	530	345 or 500[14]	AC				IOU	NV Energy

† This is the expected year of service. It may change based on the progress of the project.
†† This is an initial estimate of the cost and may change as the project progresses.
[1] EEI, 2010.
[2] SCE, 2010.
[3] CIEE, 2009.
[4] Troutman Sanders, 2009.
[5] Clean Power, 2011.
[6] Lakes Town Council, 2009a.
[7] Lakes Town Council, 2009b.
[8] SDG&E, 2010.
[9] WECC, 2011a.
[10] ECI, 2011.
[11] DOI, 2010b.
[12] Robison, 2010.
[13] NV Legislature, 2011b.
[14] EzNotice, 2011.

In addition to the transmission projects listed in Table 7.5, the Governor of Nevada formed the Renewable Energy Transmission Access Advisory Committee (RETAAC) to determine areas suitable for renewable energy development (NVSOE, 2010). This committee worked in two phases – Phase I of the committee was established in May 2007 and Phase II in June 2008. In Phase I, RETACC:

- Identified six (6) economically viable geothermal zones, four (4) solar zones, twelve (12) wind zones and four (4) biomass zones within the state.
- Identified the transmission lines necessary to access those zones and their land use constraints.

In Phase II, RETAAC:

- Determined the power potential for the renewable energy zones designated by the first phase.
- Reviewed the environmental, land use and permitting constraints.
- Identified potential construction corridors that could avoid these constraints.
- Reviewed the potential revenue needs for construction, among other duties.

The transmission projects proposed at the conclusion of Phase II are as shown in Figure 7.6.

Figure 7.6 – Existing and Proposed Transmission from RETAAC Phase II (NVSOE, 2010)

Recently, NV Energy announced the Renewable Transmission Initiative (RTI) which is an effort to engage renewable developers, load serving entities, and others to assess their interest in obtaining transmission service from renewable energy zones in Nevada to loads in other markets, particularly California and the Desert Southwest. Through the proposed RTI, NV Energy hopes to identify the necessary transmission facilities to be developed to further the State of Nevada's renewable energy development goals by first issuing a Solicitation of Interest (SOI) to ask market participants to indicate the amount of point-to-point transmission service they are interested in obtaining. If NV Energy receives substantial responses to its SOI, it believes that there may be the potential to develop new overhead transmission facilities in north-central, western, and southern Nevada.

In addition, the Nevada State Assembly in June 2011 passed AB 416 which would have required utilities in the state to expand their transmission planning activities to include construction or expansion of transmission facilities for use by renewable energy facilities regardless of the purchaser of the renewable energy (NV Legislature, 2011). The bill would have effectively eased Nevada's restrictions on building transmission capacity for us to export power for out-of-state use to help promote greater renewable energy development in the state. Ultimately, AB 416 was vetoed by Nevada Governor Sandoval because of concerns the bill did not sufficiently protect Nevada ratepayers from utility cost increases and would allow NV Energy to circumvent normal PUCN approval processes (Schwartz, 2011).

At the Federal level, in July 2011 FERC issued a final rule (Order No. 1000) on transmission planning and cost allocation that may prove to be beneficial to the renewable energy industry in the coming years. Rule 1000 requires public utility transmission providers to participate in regional transmission planning processes which must consider public policy-driven transmission benefits, such as state RPS goals or Federal clean air rules, along with conventional reliability and cost benefits. In addition, transmission providers must also coordinate with adjacent transmission providers in neighboring regions. The rule also establishes six regional cost allocation principles which regional transmission planning processes must incorporate into their cost allocation methods for transmission projects as well as six interregional principles which transmission providers must incorporate into interregional cost allocation methods for any interregional transmission projects (FERC, 2011).

Order No. 1000 is expected to help standardize transmission cost allocation across regions of the country, reducing a market barrier that has slowed or stalled many regional and interregional transmission projects in recent years. By incorporating public policy benefits into the transmission planning and cost allocation processes, Order No. 1000 will also increase the number of beneficiaries from new transmission projects, which will result in transmission costs being more broadly dispersed, increasing the economic potential of remote renewable energy developments and the overall economics of larger transmission projects.

7.4.1.3 Transmission Management

In Southern Nevada and California, transmission is managed by the following utilities and transmission owners:

- Los Angeles Department of Water and Power
- Southern California Edison Company
- Metropolitan Water District of Southern California
- San Diego Gas & Electric
- Western Area Power Administration – Upper Plains
- Western Area Power Administration – Desert Southwest Region
- Arizona Public Service
- Salt River Project
- Nevada Power
- Southwest Transmission Cooperative
- Intermountain Power Agency
- City of Vernon

The nine military installations considered in this study fall under the jurisdiction of SCE, SDG&E, NV Energy, and LADWP.

Capacity on transmission lines is typically allocated through an ―Open-Season" solicitation and events. Typically in an open-season event, transmission owners offer up new capacity that became available in the system due to network upgrades or new project additions to potential market participants. Generation owners have an opportunity to submit transmission service reservation applications to obtain transmission capacity during network open-season events.

Three different types of transmission capacity can be reserved on existing and proposed new transmission lines:

1. Firm Point to Point Transmission Service
2. Non-Firm Point to Point Transmission Service
3. Conditional Firm Service

Firm transmission service guarantees a fixed MW capacity on a transmission path for a specified period of time at a specified $/kW cost. The firm service is the most reliable since these transactions are the last to be curtailed under stressed network conditions. In contrast, the non-firm transmission service faces a curtailment challenge and is the first to be curtailed if there are network overloads. However, the transmission charges are proportionally lower for the non-firm service since it has a higher risk of curtailment.

The conditional firm transmission service is a relatively new concept that was introduced to accommodate intermittent generation like wind and solar in the system. Conditional Firm Service is a form of long-term transmission that a transmission owner may be able to provide when there is not enough long-term Available Transfer Capacity to grant a transmission request.

This is done by adding constraints that give the transmission provider additional curtailment rights when granting conditional firm transmission access.

Intermittent generators of power, including wind and solar energy facilities, would typically request transmission access through an application for a Transmission Service Agreement (TSA) with the incumbent transmission owner. For example, if a solar facility is to be built at NAWS China Lake, then the application for a TSA would be submit to SCE. The transmission service application would request specific details on the Point of Receipt (POR – where power is injected onto the electrical grid), the Point of Delivery (POD – where power is delivered to a potential buyer), the MW capacity requested, and the time-period for the reservation. A sample reservation request data-table from LADWP is provided in Figure 7.7 for reference.

Ref No.	Date Rec.	Status	Customer	POR	POD	Capacity	Start Time	Stop Time
09142000-01	9/14/2000	Received	Williams Energy	NAV-CRY	MD2	500-MW	6/1/2003 0:00	6/1/2008 0:00
09142000-02	9/14/2000	Received	Williams Energy	NAV-CRY	MCC5	500-MW	6/1/2003 0:00	6/1/2008 0:00
09142000-03	9/14/2000	Received	Williams Energy	NAV-CRY	NAV	100-MW	6/1/2003 0:00	6/1/2008 0:00
06122001-01	6/12/2001	Received	Harper Lake EP	ADL-MKT	ELD	2000-MW	9/1/2002 0:00	9/1/2032 0:00
01312001-01	1/31/2001	Received	Southern Sierra Power	Jawbone Cyn	SYL	273-MW	12/31/2001 0:0	12/31/2026 0:0
01312001-02	1/31/2001	Received	Southern Sierra Power	Jawbone Cyn	LUGO	273-MW	12/31/2001 0:0	1/1/2027 0:00
04182001-01	4/18/2001	Received	Silver Hill Energy Assoc	SYL-NOB	SYL	1600-MW	4/1/2005 0:00	4/1/2015 0:00
07112001-01	7/11/2001	Received	Williams Energy	NAV-CRY	CRY	200-MW	1/1/2004 0:00	1/1/2009 0:00
07112001-02	7/11/2001	Received	Williams Energy	NAV-CRY	CRY	200-MW	1/1/2004 0:00	1/1/2009 0:00
07112001-03	7/11/2001	Received	Williams Energy	NAV-CRY	CRY	100-MW	1/1/2004 0:00	1/1/2009 0:00
07112001-04	7/11/2001	Received	Williams Energy	NAV-CRY	CRY	100-MW	1/1/2004 0:00	1/1/2009 0:00
09232002-01	10/10/2002	Received	Pacificorp Power Mktg	Jawbone Cyn	LUGO	200-MW	7/31/2004	7/31/2005

Figure 7.7 – Sample Transmission Reservation Requests to LADWP

Additional information about the transmission application and reservation process can be found in Section 7.4.2.

Transmission costs are administered based on Open Access Transmission Tariff (OATT) of the transmission owner. FERC Order 890 requires every transmission owner to provide an OATT for market participants to understand the costs for transmission reservation and other ancillary services. Table 7.6 below provides a sample transmission fee structure for LADWP. Similar fee structures for SCE, SDG&E and Nevada Power are available in their respective OATT documents. Typically, Schedule 7 and 8 of the OATT list the fees associated with firm and non-firm transmission service.

Table 7.6– Sample LADWP Transmission Service Rates

Tariff	Firm Transmission Service	Non-Firm Transmission Service
Daily Delivery	$0.15/kW	$0.15/kW
Weekly Delivery	$0.9/kW	$0.9/kW
Monthly Delivery	$3.89/kW	$3.89/kW

Since solar facilities in Southern California and Nevada are expected to have capacity factors in the 18-25% range, transmission reservations can be a challenging issue. Some of the utilities in the Southern Nevada and California region are looking at a tiered structure based on dispatch, which would modify the OATT to help low capacity factor resources like wind and solar procure transmission service at competitive rates.

For example, IID is currently working on a modification to the transmission rate structure that would reduce the tariff for resources dispatching at around 25% capacity factor. Figure 7.8 shows a sample of the new structure and the older values. The proposed structure reduces the cost of reserving transmission capacity for a solar facility from $9.09/kW to $5.29/kW, a 40% reduction.

Current Rate			
	Cost/kW-month	$ 1.69	
		Capacity Factor	Cost/MWh
		100%	$ 2.27
		50%	$ 4.54
		25%	$ 9.09
A preliminary estimate of the new rate is:			
Proposed Rate			
	Cost/kW-month	$ 0.75	
	Energy Cost ($/MWh)	$ 1.26	
		Capacity Factor	
		100%	$ 2.27
		50%	$ 3.28
		25%	$ 5.29

Note: The new rate shown is only a sample and is not a final value.

Figure 7.8 – Sample New Transmission Rate Structure (IID, 2011)

7.4.1.4 Transmission Expansion Constraints

Major issues affecting the renewable energy projects that require incremental transmission are:

- ―Chicken and egg" timing problem— new transmission capacity is much easier to plan and obtain financing for when there are specific generation and electricity demand sources that will utilize the new capacity. But it is very difficult to plan and build a remote renewable energy project unless the transmission is there to serve them.
- Transmission lines take years to complete while solar and wind farms can be completed in months. This can discourage large renewable energy development because the chances of power curtailment are high without adequate transmission capacity. Wind curtailments in ERCOT are an example of this situation. Projects such as the Competitive Renewable Energy Zone (CREZ) in Electric Reliability Council of Texas (ERCOT) and the Tehachapi project in California are examples of transmission projects that connect remote high renewable energy potential areas to load centers thereby providing an incentive for renewable energy development.
- Developers need to be sure there is a clear, predictable process for transmission project cost allocation and cost recovery, particularly if a transmission project crosses more than one utility's footprint and would serve a wider area. Moreover, unlike conventional generation, renewable energy sources cannot operate at their rated capacity all the time. In such a situation, developers must choose between a low capacity, low cost

transmission line that may lead to curtailment of renewable generation, or a high capacity, high cost alternative that may be under-utilized most of the time.
- Due to the remote location of most large renewable energy projects, long-distance transmission is required. Large transmission projects are costly and difficult to finance and build for individual, independent renewable energy project developers. Consequently, a trade off may have to be made between utilizing lower quality renewable energy sources that are closer to major areas of electric load and higher quality renewable energy sources that are more distant.
- Because many significant renewable resource areas are far from loads, the transmission lines needed to serve them may cross multiple states and Federal lands, requiring lengthy, costly, and potentially contentious environmental and regulatory permitting processes.

7.4.2 Interconnection

In recent years, states with significant renewable energy development have seen the transmission interconnection study and permitting process develop into a significant bottleneck in the renewable energy development process. For instance, in certain regions of southern California the local transmission authority had an interconnection study backlog of six years. The Interconnection Agreement is crucial for renewable energy generators because it permits the renewable energy facility's operator to connect the facility to the utility's electrical distribution and transmission infrastructure. Without an Interconnection Agreement granted by the operator of the transmission system in the region, renewable energy facilities cannot connect to the utility grid, even if the renewable energy facility is sited on a retail customer's property and all the electricity generated from the facility is going to be consumed by the customer.

Typically, the power grid operator in the region of the proposed power plant performs a set of studies (system feasibility, system impact, facilities study, etc.) to assess the severity of various types of impacts from the proposed power plant to the larger grid. Transmission upgrade costs are a function of the severity of these impacts and actions needed to mitigate them, with the underlying principle of maintaining system reliability after interconnection of the proposed power plant to the grid comparable to levels before interconnection. These system studies must be performed for each proposed interconnecting facility. The specific methodology used by system operators to perform these studies may be different, but the underlying reliability criteria that must be maintained are fairly standard across regions and operators, and is set by the North American Electric Reliability Council (NERC).

In most cases, paying for the cost of both the interconnection study and a certain portion of any infrastructure improvements needed for interconnection are the responsibility of the proposed new electricity generating facility. These interconnection costs can range from a few hundred thousand dollars to hundreds of millions of dollars, depending on the interconnection point and size of the generation project, and the power plant owner may be required to pay the entire cost depending on the nature of the upgrades needed. For example, in the part of the California electric grid controlled by CAISO, most of these interconnection costs tend to be Network Upgrades, which are transmission upgrades needed in the backbone transmission system used by the entire regional power grid. The interconnecting facility's developer/owner is responsible for paying the costs of the Network Upgrade but is repaid the upgrade costs over a five year period following the beginning of the upgrade's commercial operation date under the terms of most Interconnection Agreements.

The FERC has regulatory authority over interstate transmission lines but does not directly manage the nation's electricity transmission grid. Instead, FERC provides regulatory oversight and guidance for the local transmission authorities who are empowered to manage transmission and planning within their territory. FERC's guidance for local transmission authorities on standard interconnection agreements and procedures was issued in 2003 as Order No. 2003-C which requires local transmission authorities to adopt FERC's pro forma interconnection procedures and agreement language.

In a key policy decision, FERC granted Regional Transmission Organizations (RTOs) and Independent System Operators (ISOs) the authority to create their own interconnection procedures and agreements so long as modified standards met with FERC's approval. California, through its CAISO, opted to create its own interconnection process.

7.4.2.1 Nevada

Because Nevada does not have an ISO and does not belong to an RTO, the transmission interconnection process follows the FERC Order No. 2003-C guidance and makes a good introduction to interconnection procedures. For southern Nevada, NV Energy is the regional transmission interconnection authority. Nevada uses a serial interconnection study process whereby a potential electricity generation developer's submission of an interconnection application reserves a specific place in the interconnection study queue. Potential facilities for a given area are then studied serially to evaluate what additional interconnection impacts each potential facility will have on the larger transmission grid.

For larger generators (nameplate capacity greater than 20 MW), there are seven phases to the interconnection process:

1. Submission of Interconnection Application
2. Hold Scoping Meeting to discuss potential issues
3. Conduct Feasibility Study
4. Conduct System Impact Study
5. Conduct Facilities Study
6. Signing of Standard Large Generator Interconnection Agreement
7. Construction of necessary interconnection facility and network upgrades

The entire interconnection process from application to signing of an agreement can take less than half a year or almost two years depending upon how quickly the various studies are conducted and whether the project developer disputes any of the findings in the studies.

For Small Generators (rated capacity of 20MW or less), a faster, less expensive interconnection process is available although the steps in the process are similar to those of a Large Generator. Small Generators can typically expect the entire process to take less than half a year from start to finish.

A Fast Track interconnection process is available for proposed electricity generating facilities with a rated capacity of 2 MW or less. Instead of using the step-wise study process used for larger facilities, potential Fast Track facilities must simply pass a set of screens. For qualifying facilities, the Fast Track process can result in an approved interconnection agreement in less than a month. Facilities that fail to pass one of the Fast Track screens will require a supplementary review study in order to be approved for an interconnection agreement.

Facilities small enough to be net metered do not have to pay any interconnection application fees.

As of June 2011, more than 3,000 MW of renewables (mostly solar) have applied for transmission access in NV Energy's service territory with proposed online dates in the next three years.

7.4.2.2 California

Because California has an ISO, it was permitted to design its own transmission interconnection process that expands upon the interconnection process outlined by FERC in Order No. 2003-C. The state and region's strong support of renewable energy has resulted in recent years in the state's three IOUs being overloaded with interconnection applications for many areas of the state. Beginning in 2011, CAISO along with IOUs PG&E and SCE have revised their interconnection procedures, switching from a serial interconnection analysis process to a cluster analysis in which projects are grouped within a region. The interconnection authority performs the interconnection study for the entire group, and distributes the resulting transmission upgrade costs to all the proposed interconnection facilities in the group based on their usage of the upgrades. The cluster analysis design ensures a small impact to the group if one of the proposed power plants in that group is cancelled and reduces the number of interconnection studies needed, speeding up the entire process. The 2011 interconnection procedure revisions increased fees and the rigor of the interconnection study process for smaller facilities in order to discourage speculative electricity generating projects and the breaking up of larger projects into separate, small projects to avoid the lengthy review process. SDG&E is expected to make similar revisions to its interconnection procedures in the near future.

Building on FERC's interconnection process, California has removed the distinction between Small and Large Generators and has instead shifted to four different interconnection processes depending upon the size, impact, and location of the proposed generating facility.

The default interconnection process that generating facilities must go through is the Cluster Study. The Cluster Study is scheduled to occur once each year and takes all interconnection applications received in the last year and divides them up based on their location so that all generating facilities that are going to impact the same area of the transmission grid are studied together. There are two phases to the Cluster Study that consider the potential system impacts and necessary facilities upgrades if all the proposed generating facilities in the cluster are to interconnect to the transmission grid.

It is nearly impossible to determine when transmission access can be granted once the interconnection request is made since there are many circumstances outside of the system operator's control that a proposed power plant must comply with, such as environmental requirements, land acquisition, equipment availability and permits. However, the entire timeline for the overall interconnection process of the CAISO, is given in the table below (Figure 7.9):

120 days	Step 1	Queue Window Open
1-30 (30 days)	Step 2	IR Validation
31-60 (30 days)	Step 3	Scoping meetings
61-240 (180 days)	Step 4	Project grouping / Base Case Development
	Step 5	Phase I Studies
241-270 (30 days)	Step 6	Results Meetings
271-330 (60 days)	Step 7	LOC Posting
In coordination with the annual CAISO TPP (Approx 330 days)	Step 8	Project Refinement and Facilities Study Process (Phase II Study)
Within 90 Days following the Phase II Studies	Step 9	LGIA Execution

Figure 7.9 – Estimated Timelines for CAISO Interconnection Process

A second, similar interconnection process, the Independent Study Process (ISP), is available for potential generating facilities that can pass CAISO's and the local IOU's electrical independence tests for the transmission and distribution systems. These tests evaluate the potential impact of the proposed generating facility on any other generating facilities ahead of it in the interconnection queue. Generating facilities that can demonstrate that their interconnection will not affect any other interconnecting facilities are eligible for ISP. The advantage of ISP is that the study process is considerably quicker, taking only half a year, because no other facility interconnections are considered.

Smaller generating facilities, with a maximum capacity of 2-5 MW depending upon which transmission authority the facility is interconnecting with, can apply for interconnection using the Fast Track process. Fast Track facilities must pass 6 to 10 screens in order to be approved for an interconnection agreement and cannot require more than a limited amount of interconnection facility construction. Because no in-depth studies are required, the Fast Track process is quicker and less expensive than the Cluster Study and ISP options.

Finally, Rule 21 allows for a simplified interconnection process for generating facilities that pass the initial review process screens. Failure to pass the screens necessitates a supplemental review process which may require an interconnection study. Unlike the other interconnection processes which are administered by CAISO and the IOUs, Rule 21 is administered by the California Public Utility Commission (CPUC). While Rule 21 does not have a maximum capacity to its eligible facilities, in practice it has largely been utilized by facilities that are utilizing net metering and consequently are 1 MW in capacity or smaller. The main reason for the limited use of Rule 21 is because generating facilities larger than 1 MW aren't commonly able to qualify for the simplified interconnection process because of Rule 21's Screen #2 which prohibits the export of power across the Point of Common Coupling, where the local electrical power system (EPS), meaning the facility's electrical system, connects to the Area EPS (i.e., the utility grid).

Beginning in April of 2011, the CEC and CPUC have begun the process of revising Rule 21 by convening Working Groups. Because the Rule 21 revision process has just begun, it is too early to project what changes to Rule 21 will be made in the coming years. Similarly, because CAISO's and the IOUs' recent interconnection process changes marked a significant change in interconnection analysis policy, additional revisions to the rules should be expected in the coming years as additional issues are identified with the new interconnection process.

There is a significant amount of renewables generation, especially solar energy facilities, proposed for development in the Southern California and Nevada region. For example, the CAISO which manages the transmission system for most of California has over 70,000 MW of proposed power plants in some stage of the interconnection application process. More than half of the total capacity in the queue is solar energy capacity.

Other areas in Southern California outside the purview of CAISO, such as the Los Angeles basin, are also experiencing a high volume of transmission access requests. The latest interconnection queue (as of March 2011) from LADWP shows roughly 4,800 MW of renewables (wind and solar) requesting transmission access, with online dates of July 2011 and beyond. The interconnection processes used by LADWP are similar to those of CAISO (such as clustering), and the timeline for completion of the interconnection study varies between 90 and 180 days depending on the accuracy of cost estimates developed for the required transmission upgrades to facilitate transmission access.

As of January 2011, about 1,000 MW of proposed generation plants, mostly renewables (wind, geothermal and solar) are requesting transmission access in the service territory of the IID in California. These power plants are proposed to come online in 2011 and 2012. Similar to CAISO and LADWP, IID also employs a clustering scheme to study these interconnection requests in two six-month windows each year.

7.4.3 Net Metering

Net metering, or net energy metering (NEM), is the policy of allowing electricity customers to self-generate electricity from renewable energy systems to offset some or all of their electricity use. Because renewable energy generation does not match a customer's electricity demand profile, net metering allows customers to make use of the larger electricity grid as a type of electricity storage system. When the customer is consuming utility-provided electricity the meter spins forward (although utility meters increasingly don't ―spin" as the industry transitions to digital smart meters) and spins backwards when the customer is generating electricity in excess of their own demand, injecting electricity back on the utility's distribution lines for consumption by other customers.

State net metering rules establish 3 important parameters of net metering programs:

- What customers are paid for their avoided purchases of utility-supplied electricity and for their exports of surplus power to the grid.
- The largest size customer-sited generation facility allowed to participate in the program (e.g., 1 MW)
- The aggregate amount of net metered capacity permitted on the utility system (e.g., 200 MW)

Customers accrue credits for electricity they supply to the grid which can then be used to purchase electricity on other days, months, or in some cases, years when their electricity demand exceeds their electricity generation.Net metering is advantageous for distributed renewable energy generation because it allows customers to be ―paid" retail rates for energy they don't purchase from the grid, which tend to be significantly higher than wholesale rates, so long as they continue to be a net consumer of electricity.

Typically, customers have an incentive to size their renewable energy systems to not exceed their own electricity demands because utilities are not required to pay net metering customers the retail rate for the net export of electricity to the grid. The price paid for these net exports is set by state public utility commissions and varies widely, typically between zero and some proxy for the wholesale price of electricity, or, more rarely, the retail rate.

An additional benefit for net metering solar energy systems is that solar energy generation tends to follow peak electricity demand, generating the most electricity on hot summer days when the electricity grid is most stressed by high electricity demand. In recent years, utilities have developed Time of Use (TOU) electricity rates. Under these rate structures, the utility charges high electricity rates during high demand periods to discourage electricity consumption when additional electricity is expensive to generate and transmission capacity is scarce. TOU rates can also encourage electricity demand during low demand, off-peak periods when electricity is inexpensive to generate and transmission capacity is more accessible. By utilizing TOU net metering rates, available in both California and Nevada, net metering customers can not only reduce their power bill by generating some of their own electricity, they can also take advantage of the higher value of the electricity generated during the middle of the day while still being able to take advantage of low-cost, off-peak electricity.

While TOU rates encourage larger solar energy systems to take advantage of the higher value of on-peak electricity generation, there is an upper limit to the benefit a larger solar energy system will provide. In Nevada, any unused on-peak electricity credits that a net metering customer has accrued in a particular year will be applied to off-peak periods on a kWh-for-kWh basis rather than a dollar value basis. This means that a customer that has accumulated $100 worth of on-peak credits from the net generation of 400 kWh of on-peak electricity (thus worth $0.25/kWh) will, at the end of the year, see the utility apply those credits to the customer's off-peak electricity consumption, even though 400 kWh of off-peak electricity might only be worth $15. In contrast, California is one of the few states where the IOUs compensate net metering customers with the dollar value of the credits earned by excess generation, meaning that $100 in net on-peak generation credits can be used to offset $100 in off-peak electricity consumption.

7.4.3.1 California

California's original net metering law was enacted in 1996 and today requires utilities, with the exception of the LAWDP, to allow customers to net meter renewable energy systems located on their premises up to 1 MW in nameplate capacity per utility customer. In 2010, California doubled the aggregate net metering limit to 5% of the utility's aggregate customer peak demand. Net metering customers in California retain ownership of the RECs generated by their renewable energy systems except for net surplus electricity sold to the utility, in which case the RECs are sold along with the electricity (DSIRE, 2011a).

California does not allow any additional demand, standby, customer, minimum monthly, interconnection, or other charges that would increase an eligible customer's costs beyond those of other customers in the rate class the customer would otherwise be in (DSIRE, 2011a). Customers who wish to self-generate more than 1 MW of renewable energy systems are not eligible for net metering and must work directly with their local utility to come to an agreement that is suitable to both parties. Such agreements will likely include additional fees prohibited for NEM customers such as standby charges.

In October 2009, California enacted AB 920, also known as California Solar Surplus Act, which requires California's electric utilities to pay net metering customers wholesale electricity rates for any net excess generation the customer's solar or wind energy system generated during a given year. While the program went into effect at the start of 2010, the CPUC has yet to finalize an approved net surplus compensation (NSC) rate for the state's utilities to pay its net surplus generation customers. The CPUC is currently considering whether to use the Market Price Referent (MPR) rate as the basis for the NSC. While it has already been decided that the RECs associated with net surplus generation are the property of the local utility, the CPUC is also considering whether an additional premium should be included in the NSC as compensation for the sale of the REC to the local utility.

The application process for net metering programs varies slightly between utilities in California but typically consists of submitting an interconnection application, signing the resulting Interconnection Agreement, and passing an inspection by both the local Building and Safety department and the local utility. Submission of additional information about the solar or wind energy system being installed may be necessary depending upon the utility and the nameplate capacity of the net metered system. Once the necessary paperwork has been received, the local utility will provide an approval letter along with any other necessary account tracking materials like an NEM tag to be placed on the utility meter. The utility may need to install a new utility meter depending upon whether the customer's current meter allows for bi-directional tracking and whether the customer is shifting to a TOU rate.

The CPUC is currently considering SDG&E's filed 2012 General Rate Case which would set the utility's rates and tariffs for 2012-2015. As part of its proposed decoupling of electricity consumption and grid maintenance fees, SDG&E has proposed a new ―network use charge" to be phased in starting in 2014 that would charge net metering customers for both electricity demanded from and electricity supplied to the larger electricity grid. If the network use charge were approved by the CPUC, small and medium-sized, net metered solar energy systems would be significantly more expensive to operate, diminishing any utility bill savings for customers utilizing solar energy systems. It is also expected that if the CPUC approves the network use charge for SDG&E that the state's other two major IOUs, PG&E and SCE, would file to create similar network use charges for their net metering customers. The CPUC is not expected to make a final decision on SDG&E's proposed rate changes until late 2012 (Wolff, 2011).

7.4.3.2 Nevada

Nevada quickly followed California by enacting a net metering law in 1997. Subsequent revisions have required the state's IOUs to offer net metering to customers for on-site renewable energy systems up to 1 MW in nameplate capacity per utility customer. Unlike California, Nevada has additional stipulations limiting the size of net metering customers renewable energy systems to the greater of 150% of the customer's peak demand or the limit of the demand the customer's rate class may place on the utility system. Nevada IOUs are required to offer net metering until the total capacity of the net metered systems in its service territory equals 1% of the utility's peak capacity. Net metering customers in Nevada retain ownership of the RECs generated by their renewable energy systems unless the local utility subsidizes the system (DSIRE, 2011b).

Nevada utilities must also freely provide NEM customers with system capacities of 100 kW or less with bi-directional meters and are not allowed to charge any additional fees to customers that would increase their monthly charges above what they would otherwise be if they were not a NEM customer. For NEM customers with systems larger than 100 kW, Nevada utilities are permitted to charge for the installation of meters capable of measuring the NEM system's output and customer load. Nevada utilities are also permitted to charge NEM customers with systems larger than 100 kW for any upgrade costs to the utility's system that are required in order to make the customer's system compatible with the utility's system (DSIRE, 2011b).

Utility customers with renewable energy systems that are too large to qualify for net metering must work directly with their local utility to come to an agreement that is suitable to both parties. Such agreements will likely include additional fees prohibited for NEM customers such as standby charges.

Unlike California, Nevada does not have any plans at this time to require utilities to compensate NEM customers for any net excess generation and actually prohibits utilities from paying customers for excess generation. Currently, excess electricity generation credits are permitted to roll over from one period to the next indefinitely until used. For NEM customers that utilize TOU rates, excess credits from one TOU period, such as the summer peak period, can be carried forward for use in the same period in subsequent months, but must be applied across all available TOU periods when the corresponding TOU period ends (i.e., the transition between summer and winter TOU rates) (DSIRE, 2011b).

The application process for NV Energy's net metering program includes the submission of a net metering application and a one-line diagram of the renewable energy system before the installation of the system and the submission of a Voltage Verification Form, the building permit, contractor invoices, and a signed Net Metering Agreement. Customer must work with their contractor to resolve any issues identified by NV Energy as the utility has final approval of the renewable energy system and may prohibit the interconnection of the system to the electricity grid until any system issues are resolved.

7.4.4 Renewable Energy Sales

7.4.4.1 California

In its role as regulator of privately-owned electric utilities in California, the CPUC requires that the state's three investor owned utilities (IOUs) obtain approval for rate recovery from the CPUC for all PPAs the IOUs enter into for RPS-eligible energy. The CPUC reviews these contracts and makes its approval determination based on the metrics of least-cost and best fit. The CPUC is also the chief administrator of the state's RPS program and is in charge of setting procurement targets, and verifying and enforcing compliance for each utility in California to ensure that each is making the necessary progress towards meeting its renewable energy procurement obligations (CPUC, 2011c). In order to meet the rising RPS renewable energy requirements, the CPUC requires that each of the three IOUs annually solicit offers from renewable energy developers for new supply to meet the RPS.

At the CPUC's direction, utilities are expected to use a least-cost, best-fit methodology for identifying and contracting with renewable energy projects. In making their selections, utilities are expected to take into consideration both the quantitative attributes of proposed projects, such as curtailability, dispatchability, local reliability, and repowering, as well as their qualitative attributes, such as impact to low-income or minority communities, environmental stewardship, and resource diversity (CPUC, 2004).

Beginning in 2007, California's RPS required each of the state's three investor owned utilities (IOUs) to have a FIT to purchase electricity at the market price referent (MPR) from renewable facilities up to 1.5 MW in capacity owned by public water and wastewater agency customers. This program was subsequently expanded by the CPUC to encompass other retail customers in the SCE and PG&E territories. The amount of power permitted to use the FIT was initially capped at 250 MW but the cap was later raised to 478 MW (CPUC, 2010a). The FIT has yet to deliver the intended solar energy development boost to mid-sized solar projects, with less than 20 MW of solar capacity having come online through the FIT program by the end of 2010 (ACORE, 2010a).

In 2010, the FIT program was augmented by the creation of a new Renewable Auction Mechanism (RAM), a simplified and market-based procurement program for renewable energy projects less than 20 MW in capacity. Under RAM, prospective renewable energy projects submit bids to obtain power purchase contracts with California's three large IOUs and are evaluated on a least-cost basis. The two-year program is intended to generate contracts for 1,000 MW of new renewable energy generation from four semi-annual auctions of 250 MW each. Each utility's share of the cumulative capacity goal is proportional to their retail sales. The nonnegotiable bids from developers are screened for viability and winners are selected based on the lowest price bids within each type of electricity product (CPUC, 2010a).

The selected developers must provide development and performance deposits and must have a commercial operation date within 18 months of contract execution, although one 6 month extension is available to compensate for unexpected regulatory delays. RAM bidders must also show that the development team includes members that have experience developing at least one project of similar technology and capacity and that the proposed development is based on commercially available technology. In turn, the IOUs must submit annual reports to the CPUC for evaluation (CPUC, 2010a). The IOUs must hold their first auctions by November 15, 2011 and their second by May 31, 2012.

As a new program, it is unclear how successful RAM will be but significant concern has been expressed about the 18 month completion requirement. California's slow interconnection approval process takes at least 18 months to navigate from start to finish, which means that as the RAM rules currently stand, renewable energy developers must begin the interconnection application process well before the developer's project is selected through the RAM program in order for the project to receive its interconnection approval, complete construction, and be commercially operable in time to meet the RAM contract's deadline.

7.4.4.2 Nevada

The Public Utility Commission of Nevada (PUCN) is responsible for designating renewable energy zones where commercially developable renewable resources exist but are constrained by insufficient transmission capacity. Each of Nevada's electric utilities is required to submit to the PUCN a long-term plan for generation and transmission. These integrated resource plans (IRPs) must include compliance plans for procuring sufficient renewable energy to meet the state's RPS program requirements and proposals for how to expand transmission capacity to serve PUCN-identified renewable energy zones.

Compared with California, solar developers seeking to contract for delivery of power in Nevada have a limited and straightforward process. Nevada utilities are expected to hold annual requests for proposals (RFPs) if they require additional renewable energy to meet their RPS program requirements for the coming years. Once a Nevada electric utility has settled on a PPA contract with a renewable energy developer, the utility must submit the PPA to the PUCN for review to determine that the PPA does not pay the renewable energy provider more than a ―just and reasonable rate" for the renewable energy or RECs provided (NRS, 2011).

7.5 **Federal Planning**

For decades, access to the energy resources that reside over, on, and under Federal lands and waters has been a key factor in supplying the United States with domestically produced energy resources, including oil production from leased Federal lands and electricity generated from federally-owned hydroelectric dams. Between the DOI, the USDA, and the U.S. Forest Service, the Federal Government manages 700 million acres of land and 1.7 billion acres of the outer continental shelf. Building upon the efforts of previous administrations, the Obama Administration has made it a top priority to increase the production, development, and delivery of renewable energy from federally managed lands in a manner that still protects the public's interest and quality of life (DOI, 2011a).

As the largest land owner in the solar resource-rich Mojave and Colorado Deserts with 26 million acres of public lands, the Federal Government owns a key asset that solar developers need (CBI, 2010). In 2010, the DOI's BLM authorized Right-of-Way (ROW) leases for 9 solar projects with a total capacity of 3,682 MW (see Table 7.7). Eight of them are located within the Mojave and Colorado Deserts of southern California and Nevada.

Table 7.7 – DOI 2010 Fast Track Solar Energy Developments

Project Name	Location	Solar Technology	Authorized Nameplate Capacity (MW)	Authorized Acreage
Blythe Solar Power Project	Blythe, CA	CSP Trough	968	7,025
Calico Solar Project	Barstow, CA	CSP Engine and PV	663.5	4,613
Chevron Energy Solutions Lucerne Valley Solar Project	Lucerne Valley, CA	PV	45	422
Genesis Solar Energy Project	Blythe, CA	CSP Trough	250	1,800
Imperial Valley Solar Project	El Centro, CA	PV	709	6,500
Ivanpah Solar Electric Generating System	CA across from Primm, NV	CSP Tower	370	3,471
Silver State Solar Energy Project (North)	Primm, NV	PV	60	618
Crescent Dunes Solar Project	Tonopah, NV	CSP Tower	110	1,620
Amargosa Farm Road Solar Project	Amargosa Valley, NV	CSP Trough	464	4,350

Source: BLM, 2011e

In March of 2011, BLM announced a list of ten more ―priority" solar energy projects for which it is looking to fast track approval by the end of 2011 (see Table 7.8). The ten fast tracked solar projects have an aggregate nameplate capacity of almost 3,000 MW. Two projects, Abengoa's 250 MW Mojave Solar Project and CSolar's 200 MW Imperial Solar Energy Center, had been approved by the BLM by September 2011. As with the projects discussed above, nine of the ten fast tracked solar projects for 2011 are located in the Mojave and Colorado Deserts of southern California and Nevada (BLM, 2011f). In total, the BLM has more than 100 applications pending from solar developers for ROWs on BLM land. These projects encompass more than 1 million acres and could have a nameplate capacity of as much as 61,000 MW (DOI, 2011a).

Table 7.8 – DOI's 2011 Fast Track Solar Energy Developments

Project Name	Location	Proposed Solar Technology	Proposed Nameplate Capacity (MW)	Proposed Acreage
Desert Sunlight Solar Farm Project	Desert Center, CA	Thin Film PV	550	4,245
Palen Solar Power Project	Desert Center, CA	CSP Trough	484	3,119
Ocotillo Sol	El Centro, CA	PV	14	115
Sonoran Solar Project	Buckeye, AZ	CSP Trough	375	3,700
Rice Solar Energy	Blythe, CA	CSP Tower	150	1,410*
Abengoa Mojave Solar	Barstow, CA	CSP Trough	250	1,778*

CSolar West	El Centro, CA	Thin Film PV	250	1,130*
CSolar Imperial Solar Energy Center	El Centro, CA	Thin Film PV	200	947*
Centinela	El Centro, CA	Thin Film PV	275	2,054*
Moapa Solar Project	Glendale, NV	PV	350	2,000

Source: BLM, 2011f
* Project proposed for non-Federal lands but EIS is necessary because Federal ROW is required for transmission or access to the proposed project.

7.5.1 DOI/DOE Solar PEIS

Currently, the DOI’s BLM, the largest land owner in both the Mojave and Colorado Deserts, and the DOE’s Energy Efficiency and Renewable Energy Program (EERE) are jointly developing a Solar Programmatic Environmental Impact Statement (PEIS) to evaluate the environmental impact of both agencies modifying select programs and processes in order to promote utility-scale solar energy development in six western states. The Solar PEIS is being developed in response to EPAct 2005 and Executive Order 13212 which urge Federal land management agencies to identify and make available lands suitable for private renewable energy development. BLM is also interested in a programmatic approach because of the large number of ROW applications it has received in recent years from potential solar energy developers (SEDPEIS, 2010a). The Solar PEIS is considered ~~“a~~ prelude to permitting or sponsoring large-scale solar electricity-generating installations in the Western United States, including the Southern California desert” (CEC, 2008) and could affect solar development on DoD installations by making BLM lands either more or less attractive to solar developers compared with DoD lands.

The PEIS will help facilitate environmentally responsible utility-scale solar energy development on public lands in six western states (Arizona, California, Colorado, New Mexico, Nevada, and Utah). The PEIS specifically focuses on public lands administered by BLM within these six states (SEDPEIS, 2010b). By pre-screening Federal lands for suitability for solar energy development and conducting detailed EISs, the PEIS can expedite the solar energy development process for designated Federal lands and identify any key environmental issues that may present a barrier to solar energy development as well as potential mitigation methods. The PEIS can also expedite the development process for solar energy developments adjacent to the Federal lands being assessed by providing an already approved preliminary EIS from which the solar energy developer and government agencies can start.

The goal of the Solar PEIS is to establish specific siting criteria and best management practices with the intention of minimizing environmental and cultural impacts of solar energy development. The Solar PEIS will also provide information regarding the possible expansion of the transmission network on public lands in order to interconnect solar energy electric facilities. Although the Solar PEIS will not supplant the need for site-specific environmental review of individual solar energy proposals, the Solar PEIS will provide guidance for how solar energy proposals should be planned by following prescribed best management practices and mitigation strategies. However, until the Solar PEIS is completed the BLM will continue to process solar energy applications on a case-by-case basis.

The solar PEIS is assessing the environmental impacts of the following solar energy technologies (SEDPEIS, 2010b):

- Concentrating Solar Power (CSP)
  - Parabolic trough (including linear Fresnel reflector)
  - Power tower
  - Dish systems
- Concentrating PV (CPV)
- PV Systems – crystalline and thin-film modules

The Draft PEIS evaluates direct, indirect, and cumulative impacts to:

- Lands and Realty
- Specially Designated Areas
- Rangeland Resources
- Recreation
- Military and Civilian Aviation
- Geologic Setting and Soil Resources
- Minerals
- Water Resources
- Ecological Resources (including plants, wildlife, aquatic biota, and special status species)
- Air Quality and Climate
- Visual Resources
- Acoustic Environment
- Paleontological Resources
- Cultural Resources
- Native American Concerns
- Socioeconomic Resources
- Environmental Justice
- Transportation
- Hazardous Materials and Waste
- Health and Safety (SEDPEIS, 2010b)

As part of the PEIS, two BLM policy alternatives are being considered along with a No Action alternative. The PEIS considers the impact of BLM implementing new policies and design features for analyzing solar energy development on BLM-administered lands available for ROW applications (SEDPEIS, 2010b). Both action alternatives involve the creation of 24 Solar Energy Zones (SEZs), areas of priority development located throughout the six states involved in the PEIS. Under the solar energy development program alternative, these 24 areas are prioritized for solar energy development and associated transmission infrastructure development and would involve land use plan amendments but other BLM land would continue to available for solar energy development (SEDPEIS, 2010c). Under the SEZ program alternative, the same policies as in the solar energy development program would be implemented but solar energy development would be restricted to the 24 SEZs. The No Action alternative would result in the BLM continuing to issue ROW authorizations for utility-scale solar energy developments on a case-by-case basis.

In addition, the PEIS considers one alternative for the DOE along with the No Action alternative of the DOE continuing to address environmental concerns for solar projects the agency supports on a case-by-case basis. In the alternative being considered, the DOE would develop guidance with recommended environmental best practices and mitigation measures that could apply to any DOE-supported solar energy projects (SEDPEIS, 2010d).

The draft PEIS was published in December 2010 and the public comment period for the draft EIS closed on May 2, 2011. In order to address key issues identified during the initial public comment period, Secretary of Interior Salazar made public a supplement to the draft PEIS prepared by the BLM and DOE on October 27, 2011 which provided a more complete methodology for identifying SEZs, more details about the incentives for developers to site new projects in SEZs such as greater approval certainty and shorter permitting times, and identified on-going regional planning processes for identifying additional SEZs. The draft PEIS supplement reduced the number of SEZs being considered to 17, totaling 285,000 acres of potentially developable land, by refining and removing SEZs with development constraints or serious resource conflicts. As part of the modified preferred alternative, the supplement also established a variance process that will allow the development of well-sited projects outside of SEZs on an additional 20 million acres of public land for any new projects not yet being processed by the BLM. The public comment period for the draft supplement will end on January 27, 2012 (BLM, 2011d).

As of October 2011, there was no set date for the Final PEIS to be published and with the addition of the draft PEIS supplement, it is not expected that a final PEIS document will be ready before mid or late-2012.

7.6 Development Limitations

7.6.1 Water Scarcity

Water scarcity has been a challenge in the Mojave and Colorado Deserts ever since people came to settle in the region. The arrival of solar energy projects in the deserts has added another source of water demand to a region that is already overtaxed in many areas.

Water resources have come under increasing pressures in the Mojave area in the past three decades. As the populations of nearby towns and cities grow, demand for both ground and surface water resources increase. In Nevada, Las Vegas is the nation's fastest growing city, with a population that is expected to double by 2050. In southern California, fast-growing desert communities in Victor and Antelope Valleys will double the number of residents within the next 25 years.

The result of this growth is that local water demand is fast approaching capacity as groundwater is withdrawn faster than it can be recharged. Cities have begun to investigate options for importing nearby surface water and large-scale engineering projects are now underway to draw more water from Lake Meade, a natural reservoir for the Mojave area, and distant aquifers. These projects are highly controversial and have garnered a number of lawsuits as proponents and critics debate their impact on fragile desert habitats, existing water rights, and local economies.

Both PV and concentrating solar energy technologies require water in order to operate. For all solar technologies, water is used to clean the panels and mirrors in order to keep the systems operating at optimal efficiency, although some PV facilities opt to forgo cleaning the panels and accept the small loss in energy generation that results. Concentrating solar trough require significantly more water to drive the steam turbines and cool the system.

As discussed in the Solar Potential Analysis chapter, this study assumes that any CSP Trough systems use a ―dry” (air) cooling system, rather than the much more water-intensive ―wet” (evaporative) cooling system because of the relative scarcity of water in the Mojave and Colorado Deserts. Dry-cooled CSP Trough facilities can use as little as 80 gallons of water per MWh. In comparison, Stirling Engine systems typically use 20 gallons per MWh and PV systems use approximately 8 gallons per MWh in a high insolation region like the Mojave and Colorado Deserts.

Although this study evaluates only the most water-conservative technology options, the reality at some of the desert military installations is that water is exceedingly scarce, and that concentrating solar technologies may be eliminated from consideration for that reason alone.

7.6.2 Environmental Resources

7.6.2.1 Habitat Disturbance

The construction of ground-level solar energy facilities typically begins with the clearing and grading of land, removing all or most of the natural habitat that resides within the footprint of the solar facility. Any protected plant and wildlife species located within a facility's footprint are removed and relocated before construction begins and security fences are installed around the facility, in part to keep wildlife out of the construction zone. Once the land is cleared, any roads necessary for the facility are built and a soil binder or pea gravel is laid down to reduce erosion.

For PV systems, underground conduit, overhead transmission lines, and inverter and transformer pads are installed once site preparation is finished. Next, PV panel supports and frames are installed, either by using steel beams driven into the soil to a depth of six feet or by using a ballasted system that does not penetrate the soil. PV panels are then affixed to the frames and connected to the electrical distribution system. Finally, inverters and transformers are installed and connected to the PV arrays through the network of underground conduit and to the larger transmission grid through the overhead transmission line. Because of the extensive coverage of a PV facility's solar arrays and significant land disturbance (particularly if ground penetrations are used to secure the racking) within a PV facility's footprint, the environmental impact of a ground-level PV facility is significant for the area within and immediately surrounding the facility but less significant to the broader region. Outside the immediate footprint of the facility, the land is left undisturbed with the exception of the overhead transmission line that connects the PV facility to the larger transmission grid.

In the case of CSP trough facilities, once site preparation is complete, concrete foundations are built on which the facilities' power plant and cooling system will reside and overhead transmission lines are constructed to connect the facility to the designated substation. Construction of these buildings and installation of power generation and cooling system equipment follows. Because CSP trough systems require water for cooling and as a secondary working fluid, either wells must be dug to tap local aquifers or water lines must be constructed to import the facility's required water. The last step before commissioning is to install the reflecting mirrors and distribution pipes for the primary working fluid. As with PV facilities, the local environmental impact of a CSP facility is significant but largely contained to the footprint of the facility with the exception of the transmission line which connects the facility to the larger transmission grid.

7.6.2.2 Regulatory Framework and DoD Policies

Federal Framework

Each DoD installation is responsible for ensuring compliance with Federal biological resources regulations related to NEPA, Clean Water Act (CWA), FESA, Bald Eagle and Golden Eagle Protection Act (Eagle Act), and Migratory Bird Treaty Act (MBTA). Additionally, although most state laws do not generally apply to Federal actions on DoD installations, these installations often cooperate with state resource agencies to ensure compliance with relevant state laws and regulations.

NEPA regulations require Federal agencies to consider the consequences of human activities on the natural environment. As a result, all Federal agencies are required to develop documents (Environmental Assessments and/or Environmental Impact Statements) assessing the environmental impact of and alternatives to major Federal actions significantly affecting the environment (EPA, 2011). Specific to vegetation communities, NEPA guidance directs Federal agencies to consider habitats critical to ecological processes as part of the preparation and review of environmental impact assessments (EPA, 1999a).

The Sikes Act requires each DoD installation to develop and implement an Integrated Natural Resource Management Plan (INRMP). An INRMP is developed through coordination among the DoD installation, the USFWS, and respective state fish and wildlife agencies. These planning documents serve as management tools that ensure military operations and natural resources conservation are integrated and consistent with stewardship and legal requirements, including those listed above (USFWS, 2004).

California Framework

Relevant state biological resources laws and regulations in California affecting solar energy development include the California Environmental Quality Act (CEQA), CESA, Porter-Cologne Water Quality Control Act, and relevant sections of the CDFG Code.

CEQA, the California state-level counterpart to NEPA, is similar in that it requires a comprehensive review of the environmental impacts that may result from a proposed project. However, CEQA is more extensive than NEPA, mandating the adoption of mitigation and avoidance and minimization measures. CEQA does not apply to Federal actions on Federal lands. However, DoD installations often coordinate with state resource agencies to ensure compliance with CEQA. The CEQA and NEPA processes are typically done simultaneously when both apply.

Nevada Framework

In Nevada, revision of a Nevada Revised Statute (NRS) expanded the state's requirement to classify wildlife; reptile classification became either protected or unprotected. Currently, protected species may be further classified as sensitive, threatened, or endangered. Policies and regulations necessary to the preservation, protection, management, and restoration of wildlife and habitat are established by the Nevada Board of Wildlife Commissioners through adoption of rules and regulations as set forth in the Nevada Administrative Code. The Nevada Division of Forestry also regulates the collection of cactus and yucca through permit requirements under NRS 527.070.

The primary environmental regulation for energy facilities in Nevada is the Utility Environmental Protection Act (UEPA). UEPA also requires a review of the environmental impacts from any energy generating facilities greater than 70 MW as well as a consideration of alternatives. When both apply, the NEPA processes is conducted first and any documents created are reviewed by the Public Utility Commission of Nevada (PUCN) to determine if any additional documentation is necessary for PUCN consideration of the proposed project's environmental impacts. More information about NEPA, CEQA, and UEPA can be found in Section 7.7.

7.6.2.3 Vegetation Communities

To begin the analysis of the environmental effects of an action, the distribution and extent of vegetation communities is determined. Mapping of vegetation communities relies on GIS databases (e.g., Vegetation Classification and Mapping Program and Biogeographic Information and Observation System) and field mapping and verification surveys. State-wide and regional GIS vegetation mapping data are available and should be consulted to determine the preliminary distribution and extent of all vegetation communities for a specific project location. However, unless recent installation-wide vegetation mapping has occurred for the INRMP or similar resource management programs, field surveys are typically required to ensure GIS data are up-to-date, accurate, and complete. Systematic field techniques are required to ensure adequate coverage and mapping of the potential biological constraints in the project area. To determine the extent of constraints from sensitive vegetation communities, analysts overlay the project footprint with the updated vegetation community map. This analysis determines acreages of each vegetation community occurring within the project footprint.

The Colorado and Mojave deserts support a number of sensitive vegetation communities. The California Natural Diversity Database (CNDDB) maintains a list of special-status vegetation communities throughout the state. Special-status vegetation communities include those communities that are ~~"o~~f limited distribution statewide or within a county or region and are often vulnerable to environmental effects of projects" (CNDDB, 2009). This list[123] may serve as a useful tool for the DoD installations to determine which vegetation communities may require more intensive avoidance, minimization, and mitigation measures.

---

[123] See http://www.dfg.ca.gov/biogeodata/vegcamp/pdfs/natcomlist.pdf for the list of special-status vegetation communities, as defined by CNDDB.

Potential Effects of Solar Development Projects on Vegetation Communities

NEPA, CEQA, and UEPA regulations mandate the consideration of direct, indirect, and cumulative effects of Federal actions on the natural environment. Direct effects are ―caused by the action and occur at the same time and place" while indirect effects are ―caused by the action and are later in time or farther removed in distance" (43 FR 56003). Cumulative effects result ―when the effects of an action are added to or interact with other effects in a particular place and within a particular time" (EPA, 1999b). The analysis of indirect and cumulative effects is limited to reasonably foreseeable future impacts and actions. The anticipated effects of solar energy development on DoD installations for each impact category include the following:

- *Direct Effects*: Direct effects to vegetation communities may include removal of vegetation and/or damage to biological soil crusts within project footprints during land-clearing and land-grading operations.
- *Indirect Effects*: Indirect effects to vegetation communities may include altered topography and drainage patterns, runoff, sedimentation, accidental contaminant spills, fugitive dust deposition, and introduction and spread of noxious weeds and invasive plant species. These impacts have the potential to degrade vegetation communities, reduce biodiversity, or result in the replacement of one vegetation community by another.
- *Cumulative Effects*: Cumulative effects may include impacts to vegetation communities resulting from future construction of additional infrastructure (i.e., access roads, transmission lines, and natural gas or water pipelines) required for operation of solar energy facilities. These effects would include similar effects to those listed above for direct and indirect impacts.

Potential Avoidance, Minimization, and Mitigation Measures for Vegetation Communities

CEQA requires adoption of feasible avoidance, minimization, or mitigation measures are required to reduce impacts of a project to a less-than-significant level while NEPA contains no such mandate. Nevertheless, the following mitigation and avoidance and minimization measures are generally implemented to minimize solar energy development impacts on sensitive vegetation communities.

- Implementation of siting and design measures. These may include such measures as minimizing project footprints, utilizing previously disturbed lands for project and staging areas, avoidance of sensitive vegetation communities, utilizing existing infrastructure (i.e., access roads and utility corridors), and prevention of soil deposition and erosion.
- Development and implementation of an Integrated Vegetation Management Plan to control introduction and spread of noxious weeds and invasive plant species.
- Revegetation and restoration of project area with locally and regionally appropriate native plant materials.
- Development and implementation of an Animal, Pest, and Vegetation Control Plan that limits and specifies appropriate use of herbicides.
- Development and implementation of an Ecological Resources Mitigation and Monitoring Plan. The plan should include such elements as revegetation, soil stabilization, and erosion reduction measures, mitigation and monitoring of unavoidable impacts, and compensatory mitigation and monitoring to address effects to vegetation communities.

- Development and implementation of a Spill Prevention and Emergency Response Plan to address spills of any toxic substances before they enter aquatic or other sensitive habitats.

7.6.2.4 Jurisdictional Waters/Wetlands

The Clean Water Act (CWA) is the primary Federal law that protects the physical, chemical, and biological integrity of the nation's waters, including lakes, rivers, wetlands, and coastal waters. Jurisdictional waters and wetlands refer to state and federally regulated waters or wetlands that cannot be filled or altered without permits from regulatory water resource agencies.

Under Section 404 of the CWA, the USACE governs under what circumstances dredge or fill material may be discharged into waters or wetlands under Federal jurisdiction. Importantly, under Section 401 of the CWA, states have the authority to review and certify Federal permits for compliance with state water quality standards. For California, the Porter-Cologne Water Quality Control Act authorizes the State Water Resources Control Board (SWRCB) and Regional Water Quality Control Boards (RWQCBs) to certify Section 404 permits. In addition, this act authorizes the RWQCBs to issue Waste Discharge Requirements (WDRs) defining limitations on allowable discharge to waters under state jurisdiction. RWQCBs may issue these WDRs for Section 404 applications.

The CDFG and the Nevada Department of Wildlife (NDOW) have jurisdictional authority over streams and lakes and wetland resources associated with these aquatic systems. Although these regulations do not apply to Federal actions on Federal lands, DoD installations may decide to coordinate with CDFG and NDOW to ensure compliance. Similar to the constraint analysis conducted for vegetation communities, project footprints are overlaid with mapped jurisdictional water features to determine acreages of each mapped feature.

Potential Effects of Solar Energy Development Projects on Jurisdictional Waters/Wetlands

Developers of solar facilities must consider the following direct, indirect, and cumulative impacts to jurisdictional waters and wetlands:

- Land disturbance impacts, including impacts such as modification of natural surface water flow and drainage systems and diverting and/or channelizing streams. These can result in increased sedimentation and dissolved solid loads in water downstream and flooding.
- Water consumption impacts from use of water resources for construction, O&M activities related to solar energy development. Facility water usage may result in harmful overconsumption of the limited water resources available in the Mojave and Colorado Deserts.
- Cumulative impacts to water resources resulting from future construction of additional infrastructure (i.e., access roads, transmission lines, and natural gas or water pipelines) required for operation of solar energy facilities. These effects would include similar effects to those listed above.

Potential Avoidance, Minimization, and Mitigation Measures for Jurisdictional Waters/Wetlands

To address the impacts discussed above, water resource regulatory agencies may require the following avoidance, minimization, and mitigation measures:

- Implementation of siting and design measures. These may include use of appropriate buffers around jurisdictional waters and wetlands, siting facilities and construction activities outside the 100-year floodplain, minimizing the project's footprint, utilizing previously disturbed lands for project and staging areas, utilizing existing infrastructure (access roads and utility corridors), and prevention of soil deposition and erosion.
- Development and implementation of Stormwater Management Plans and BMPs that comply with state standards.
- Development and implementation of a Master Streambed Alteration Agreement in accordance with CDFG standards.
- Development and implementation of a Spill Prevention and Emergency Response Plan to address spills of any toxic substances before they affect water resources.
- Use of solar technologies that require less intensive use of water resources.

7.6.2.5 Special-Status Species (Threatened, Endangered, Sensitive, and Rare Species)

Federal and State statutes require the consideration of special-status species for activities that may affect these species. For the purposes of solar energy development on DoD lands, special-status species may include plants and animals that are legally protected under the ESA, MBTA, Eagle Act, and/or relevant state laws and regulations. Although state laws and regulations do not necessarily apply to Federal actions occurring on Federal lands, DoD installations often cooperate with state resource agencies to ensure compliance with these laws and regulations. Therefore, special-status species will generally fall into one or more of the following categories:

- Plant and animal species listed or proposed for listing as threatened or endangered under the ESA and/or CESA;
- Plant and animal species that are candidates for listing under the ESA;
- Avian species protected under the MBTA;
- Avian species protected under the Eagle Act (bald eagle and golden eagle);
- Species that have been ranked by the State of California or Nevada as S1 or S2, or species of concern; and/or
- Species that are identified as fully-protected under state statutes.

Take[124] of species protected under these various statutes is generally prohibited. However, these statutes, with the exception of state fully-protected species, include permitting mechanisms that provide for exceptions to take prohibitions. For instance, Section 7 of the ESA allows for *incidental take*[125] for Federal projects or actions that will not jeopardize the continued existence

[124] The definition of ―take" will vary between statutes. For instance, take is defined more narrowly under the MBTA than the ESA.
[125] ―Incidental take" is defined as take that is ―incidental to, and not intended as part of, an otherwise lawful activity" (64 CFR 60728).

of listed species. In order to receive take authorization for special-status species, project proponents must analyze the level of impact to special-status species and/or its habitat for a given project. If the level of impact meets a threshold, as specified by the relevant statute or regulations, project proponents must indicate how avoidance, minimization, or mitigation measures will reduce the level of impact to an acceptable level.

The Federal ESA also affords protection to designated *critical habitat.*[126] The USFWS is required to designate critical habitat for species listed as threatened or endangered under the act. Federal agencies are required to ensure that their activities do not adversely modify designated critical habitat, even if this habitat is currently unoccupied. Modifying habitat on DoD lands that is pending a future designation of critical habitat subject to INRMPs is generally precluded as well (Public Law 108-136). Nevertheless, modification of previously designated critical habitat (i.e., critical habitat for the threatened desert tortoise) may occur within DoD installations. Moreover, previously designated or pending and future critical habitat designations may border these installations. Therefore, potential onsite and offsite constraints of critical habitat should be considered during solar energy development on these installations.

Coordination with resource agencies (i.e., USFWS, CDFG, NDOW) and GIS database searches are often required to determine which special-status species have the potential to occur within or near the project area and which critical habitat designations may occur within or near the project area. Once potential is determined, field surveys are often required to verify the presence of a special-status species or its habitat. Importantly some special-status species require focused, protocol-level surveys to determine presence/absence of the species or its habitat. Special-status species and critical habitat occurrences are overlaid with project footprints to determine the extent of constraints from these species and habitats.

Many of the analyses required by the various statutes and regulations protecting special-status species may be conducted simultaneously. For instance, incidental take permits for avian species listed under ESA are generally adequate to cover permit requirements of the MBTA or Eagle Act.

Potential Effects of Solar Development Projects on Special-Status Species
Impacts to special-status species may occur during all phases of solar energy development. These impacts may come in the form of direct, indirect, and/or cumulative impacts to species and/or their habitat. Special-status species impacts associated with solar energy development on DoD installations may include the following:

- *Direct Impacts*. Direct impacts to special-status species resulting from solar energy development include destruction or modification of suitable or critical habitat or direct

[126] ―Critical habitat" is defined by the ESA as ―the specific areas within the geographical area occupied by the species, at the time it is listed, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and specific areas outside the geographical area occupied by the species at the time it is listed that are determined by the Secretary to be essential for the conservation of the species" (16 U.S.C.A § 1533).

killings of individuals from ground-disturbing activities and the addition of hazardous structures such as transmission towers and lines.

- *Indirect Impacts*. Indirect impacts to special-status species include introduction of non-native predators/competitors, habitat quality impacts (i.e., water quality impacts, dust deposition), habitat fragmentation, interruption of wildlife movement corridors, and disturbance and harassment of animal species.
- *Cumulative Impacts*. Cumulative impacts may include impacts to special-status species resulting from future construction of additional infrastructure (i.e., access roads, transmission lines, and natural gas or water pipelines) required for operation of solar energy facilities. These impacts would include similar impacts to those listed above for direct and indirect impacts.

Potential Avoidance, Minimization and Mitigation Measures for Special-Status Species
When the presence of a special-status species and/or its habitat is confirmed, avoidance, minimization, and mitigation measures may be required to reduce the level of impact to an acceptable level. These measures will vary widely depending on level of species protection, as determined by relevant statutes and regulations, and project-specific details. *Formal consultation*[127] with resource agencies should be initiated as early as possible to determine appropriate site- and species-specific avoidance, minimization, and mitigation measures. However, the following list provides some common types of avoidance, minimization, and mitigation measures that have been required by Federal and State agencies to avoid and/or minimize impacts to special-status species and their habitats.

- Pre-construction surveys to determine presence and abundance of species. Biological monitors may also be required during project construction phases to ensure compliance with special-status species regulations and implementation of agreed-upon avoidance and minimization measures.
- Translocation of species from areas of direct effect to other suitable areas. Consultation with resource agencies will be required to determine appropriate translocation methods.
- Implementation of siting and design measures to avoid important breeding, foraging, roosting, and migration habitat. These may include siting projects on pre-disturbed habitat, minimizing project footprints, avoidance of groundwater withdrawals, and implementation of exclusionary fencing (temporary and/or permanent fencing).
- Temporal/seasonal restrictions are often required to avoid certain construction activities during breeding or active seasons. These are especially common for special-status birds, including raptors.
- Compensatory mitigation of direct effects to special-status species habitat.
- Habitat restoration of special-status species' habitat following project completion.

---

[127] ―Formal consultation" generally occurs when a Federal agency determines their action is likely to adversely affect a federally listed species. The process includes submission of a formal request to initiate consultation, information sharing between agencies, and a Biological Opinion (BO) which determines whether the proposed activity will jeopardize the continued existence of a listed species. Formal consultation has specific deadlines (i.e., the USFWS has 45 days after completion of formal consultation to issue the BO) that limit the timeframe of consultations.

- Development and implementation of a Spill Prevention and Emergency Response Plan to address spills of any toxic substances before they affect species or their habitats.
- Development and implementation of an Animal, Pest, and Vegetation Control Plan that includes measures to prevent attraction of predators or enhancement of predator populations.
- Development and implementation of a USFWS, CDFG, or NDOW approved conservation program. These may include such programs as Recovery Crediting Systems (RCS) or Conservation Banking.

7.6.3 Cultural Resources

7.6.3.1 Regulatory Framework and DoD Policies

Each DoD installation is responsible for ensuring compliance with Federal and State cultural resources regulations. Federal compliance for solar projects is carried out in accordance with regulations implementing Section 106 (36 CFR §800) of the National Historic Preservation Act (NHPA) (16 U.S.C. 470f). Section 106 requires that an installation must consider the effects of an undertaking on significant cultural resources, termed *historic properties*. If a project will result in an adverse effect on a historic property, those effects must be evaluated against the benefits of the project, project alternatives, and mitigation and minimization options. Other Federal cultural resources regulations may be applicable. Additionally, under Section 106, each installation is also required to consult with American Indian Tribes regarding traditional cultural properties (AFFTC, 2009).

DoD Instruction 4715.16, *Cultural Resources Management*, requires each installation to develop and implement an Integrated Cultural Resources Management Plan (ICRMP). An ICRMP identifies an installation's responsibilities and methods for the management and protection of cultural resources. Ensuring compliance is the responsibility of the Base Historic Preservation Officer (BHPO), by authority of the Installation Commander (AFFTC, 2009).

7.6.3.2 Types of Cultural Resources

The most desirable areas for solar development in the Colorado and Mojave Deserts are flat valley floors. Ancillary facilities like roads and transmission lines are also typically found on valley floors but may also extend across nearby valley slopes and mountain ranges. Aside from some traditional cultural properties (TCPs), trails, and other linear features that might cross these valleys, the areas that are likely to possess historic properties, whether prehistoric or historic, will most likely be near dry lake beds, in dune areas, or near water sources.

Archaeological and Built Environment Resources
Historic properties are significant cultural resources that are listed in, or eligible for listing in, The National Register of Historic Places (NRHP), the official list of the Nation's historic places authorized under the NHPA. These resources include districts, sites, buildings, structures, and objects that are significant in American history, architecture, archeology, engineering, and culture. These National Register properties are distinguished by having been documented and evaluated according to uniform criteria and standards, which are designed to help Federal agencies identify important historic and archeological properties worthy of preservation and of consideration in planning and development decisions.

The types of cultural resources typically found in the Colorado and Mojave Deserts include prehistoric and historic sites, features, and artifacts. These resources provide a range of information about past human activity. Prehistoric sites consist of residential bases, temporary camps, areas of resource collection or processing, caches, trails, rock art, and geoglyphs (large-scale ground art made by removing soil or piling rocks). Historic period sites are locations showing evidence of past activities associated with mining, homesteading, ranching, communications or transportation activities, and those sites and locations associated with historic military activity.

Two National Historic Trails (NHTs), created by an act of Congress, cross the study area. The Old Spanish NHT crosses the Mojave and Colorado Deserts in California and Nevada (see Figure 7.10), and the Juan Bautista de Anza NHT crosses the Colorado Desert in California. These trails are given the same status as National Historic Landmarks and are managed as historic properties. NHTs are significant not only for their routes but for the associated sites and features that exist along the trails.

Figure 7.10 – Western Section of Old Spanish Trail (NPS, 2009)

Traditional Cultural Properties and Sacred Sites

Federal legislation, including the American Indian Religious Freedom Act (AIRFA), Sections 106 and 110 of the NHPA, EO 12898, and EO 13007, requires Federal officials to ensure that Native American traditional cultural properties (TCPs) receive consideration in the management of Federal lands.

A TCP is a significant cultural resource associated with the cultural practices or beliefs, rooted in a living community's history and important to maintaining the cultural identity of the community. TCPs include burial remains, trails, sacred sites or landscapes, and habitat areas used for hunting and plant collecting. Federal officials are required to ensure that Native American TCPs receive consideration in the management of Federal lands.

In the Colorado and Mojave Deserts, two types of TCPs, geoglyphs and cultural landscapes, are of particular concern when siting a solar project. These TCPs pose challenges to solar project siting because of their large physical and visual scale.

Geoglyphs were constructed on flat or gently sloping desert pavements by clearing or arranging pebbles and rocks to form alignments, clearings, and figures. Geoglyphs may be relatively small or may extend hundreds of meters across desert pavement. These features occur throughout the deserts of southeast California and adjacent portions of southern Nevada (BLM 2010a).

In the Colorado and Mojave Deserts, trail networks may tie together cleared circles, geoglyphs, rock rings and other desert pavement features, rock art sites, artifact scatters, water and food resource locations, and elements of the physical landscape that comprise prehistoric-ethnohistoric period cultural landscapes. These cultural landscapes, tied together by trail networks, are thought to have represented the cosmology of American Indian groups during this period and they are still valued by living American Indian tribes. Segments of many trails are still visible, connecting various important natural and cultural landscape elements. These trails are often marked by votive stone piles (cairns) and ceramic sherd scatters (pot drops). Examples of trails in the Colorado and Mojave Deserts include the Salt Song Trail (associated with the Paiute and Chemehuevi tribes), Xam Kwatcan Trail (associated with the Quechan tribes), and the Halchidoma Trail (associated with Lower Colorado River Yuman Tribes). In the Colorado Desert, a Prehistoric Trails Network Cultural Landscape has been formally recorded along the Lower Colorado River (BLM, 2010a).

7.6.3.3 Cultural Resources Issues in Solar Development Projects

The potential for impacts on cultural resources from solar energy development, including ancillary facilities such as access roads and transmission lines, is directly related to the location of the project and the amount of land disturbance proposed. However, before development of Federal lands may occur, it is necessary for the managing Federal agency to identify significant cultural resources (historic properties) and consult with American Indian tribes regarding TCPs early enough that impacts to historic properties and TCPs may be avoided as much as possible in order to comply with Section 106 guidelines. Consideration of historic properties and TCPs early in project planning reduces the chances that a project will have direct or indirect impacts to these resources. If impacts to a historic property or TCP cannot be avoided through siting and design changes, effects of the project must be mitigated.

Potential Effects of Solar Development Projects on Cultural Resources

The direct effects of solar energy development on historic properties and TCPs may include partial or complete destruction of historic properties within the project footprint resulting from the clearing, grading, and excavation of the project area and from construction of facilities and associated infrastructure. In practice, a ―direct effect” under Section 106 is limited to the direct physical disturbance of a historic property. Ground-disturbing construction activities can directly impact cultural resources by damaging and displacing artifacts, diminishing site integrity and altering the characteristics that make the resources significant.

―Indirect effects” are those that are immediate but not physical in character, such as visual or noise intrusions, as well as reasonably foreseeable direct effects that may occur later in time as a result of project implementation. In the case of historic architectural resources and places of traditional cultural importance, immediate impacts can occur to the setting of a resource even if the resource is not physically damaged. Construction of a solar development project may result in vehicular and pedestrian access to historic properties and TCPs in the vicinity of the facility, which in turn may cause physical damage to historic properties from increased vandalism, illegal collection of artifacts, and destruction of resources by vehicles traveling on the site. Indirect effects include impacts on the cultural landscape resulting from viewshed alteration (glare, intrusions on the horizon or key observation points), noise intrusions that may affect the peacefulness of a TCP, and the erosion of disturbed land surfaces.

Cumulative effects must also be considered an issue in developing solar projects. Through ongoing consultation with the State Historic Preservation Office (SHPO) and appropriate American Indian tribes, it is likely that many adverse effects on significant resources in a particular project area could be mitigated to some extent although some visual and landscape scale impacts may not be mitigatable to the satisfaction of all interested parties. Issues to consider for cumulative impacts include impacts to trails and analyzing cumulative impacts on entire landscapes within a tribe's traditional use area rather than isolated resources (BLM, 2010a).

Avoidance through Consultation, Project Siting and Design

Under Section 106, avoidance of historic properties is preferred over mitigating adverse effects of an undertaking on historic properties. Methods that reduce the potential to affect historic properties are described below.

- Early, in-depth consultation is essential to project planning. Although cultural landscapes may be regional in scale, objections to development within a cultural landscape are typically focused on more localized aspects of the landscape (e.g., a point at which two trails cross, a pass, a geoglyph, a ceremonial site). Consultation efforts may include interviews and field visits with tribal representatives in order to determine what aspects of the landscape are of critical concern. American Indian Tribes are often encouraged to participate in the environmental analysis of a project so that mutually agreeable management decisions can be developed. This form of in-depth consultation has been successfully conducted at DOE's Nevada National Security Site (DOE, 1996).
- Siting a project on previously disturbed land. This reduces the potential to cause direct physical impacts to known historic properties.
- Design modifications. Once cultural resources identification efforts have been made through consultation, background research, field surveys, and evaluations, facility design (including ancillary facilities) can be modified where possible to avoid historic properties and traditional cultural properties.
- In the case of national historic trails, avoiding the siting of facilities in locations that would alter the visual setting in a way that would reduce the historic significance of the trail may be necessary because the historic context contributes significantly to the historic significance of the trail.
- Avoiding the siting of facilities in locations that would degrade the visual setting of TCPs where the landscape setting and viewshed observed from the TCPs may contribute to its importance to a tribal group.
- Avoiding tribal burial sites. A discovery plan should be developed in the event a burial site is encountered during project implementation.

7.6.3.4 Potential Mitigation Measures

If effects to historic properties (including TCPs) cannot be avoided, DoD installations must resolve those adverse effects. Section 106 also requires Federal agencies to consult with Indian Tribes regarding historic properties of significance to the Tribes that may be affected by an undertaking (36 CFR 800.2 (c)(2)). Resolution of adverse effects is typically formalized in a Memorandum of Understanding between the lead agency, the state SHPO, American Indian tribes, and other consulting parties, which details the responsibilities and steps to take in avoiding, reducing, or mitigating effects to historic properties. A Historic Properties Treatment Plan is developed that specifies in detail how the property or properties will be mitigated. Typical mitigation measures are described below.

- For archaeological sites that are significant because they may provide important scientific data, data recovery is the mitigation method most likely employed. Data recovery entails the development of a research design, excavation, laboratory analysis, preparation of a report, and curation of artifacts.
- For built environment resources, documentation to record a resource before project implementation degrades or destroys the resource is typically carried out. The National Park Service has developed a suite of mitigation documentation specifically for built environment resources that includes Historic American Building Surveys, Historic American Engineering Records, and Historic American Landscape Surveys. These forms of documentation include research, extensive recordation and photography, and preparation of a report. Once completed, the document is held in the Library of Congress.
- If the project lies within an area that has the potential to contain undiscovered buried cultural resources, a monitoring plan should be prepared describing the procedures to be carried out in the event a buried archaeological site is encountered during project implementation and preventive measures to address unauthorized access, looting, vandalism, and erosion.
- Adverse effects to a TCP must be resolved through consultation with the affected tribal groups. Tribal concerns and input must be taken into consideration when developing possible mitigation measures. Although concerns about project effect on a TCP are usually localized, consideration of the entire landscape should be taken into consideration when developing mitigation.
- Conduct cultural resources sensitivity training and education for facility workers and the public. Educating people about the fragile nature of cultural resources and their importance to American Indian tribes could reduce occurrences of human related disturbances to nearby historic properties.

7.6.3.5 Visual Resources

Planning the appropriate location of a facility to minimize its visual dominance is the preferred method of visual resource management. Large solar electric generation facilities may occupy many square miles of what was a naturally appearing landscape. Attempting to visually mitigate a solar facility that is poorly sited can be a futile effort. However, a well conceived project location will require little or no visual mitigation.

Because of their large horizontal, and in some cases vertical, footprint, utility-scale solar electric generating facilities can have enormous viewsheds. Negatively perceived visual impacts in certain situations can have a radius of over 10 miles and consequently have an impact on sensitive visual receptors, the people who will note the change in landscape, on adjacent Federal or private lands. The sensitivity of visual receptors is primarily based on the activity in which the receptors are engaged as well as their perceptions, expectations, and experiences. A backpacker on the Pacific Crest Trail will be more sensitive to visual intrusion than a truck driver delivering goods on a freeway. However, given the wide variety of uses for the Mojave and Colorado

Deserts, the perceived impact of a solar energy facility in the region would be likely to generate a wide spectrum of reactions from people living, working, or visiting the area.

Much of the land surrounding desert military bases is under the stewardship of the BLM. All BLM-managed lands are mandated to include Visual Resource Management (VRM) classes in their Resource Management Plans (RMPs). These classes dictate the amount of visual change that is allowable for prescribed management activities. BLM lands that are part of the National Lands Conservation System (NLCS) and the numerous BLM Wilderness areas located in the Mojave and Colorado Deserts are particularly visually sensitive, and their visual integrity is protected by the Federal Lands Policy and Management Act (FLMPA). These visually sensitive areas should be considered carefully as part of the solar planning process. The California desert also includes ancestral properties of Native American Tribes and viewsheds can be sensitive and have Federal protection. For a more in depth discussion of these and other traditional cultural properties please refer to the previous section of this chapter.

A proposed project's sphere of visual influence can be evaluated through a traditional GIS modeling exercise. The final product of this exercise is a map that shows from where on the landscape the solar project components will be visible and to what degree. Additional data layers (e.g., NLCS lands) can subsequently be added to this baseline data, making this product an invaluable site planning tool. As an example, the BLM's solar PEIS comprehensively documents the potential visual impacts of solar electrical generation projects on Federal lands. This document evaluates an array of solar technologies and suggests potential mitigation measure and best management practices to potentially accommodate the large number of right-of-way applications BLM has received for renewable energy proposals on land under their stewardship.

An example of a likely negative visual impact that would result from solar energy development is the change in land color and texture from disturbing land during the construction process. The ground plane of the California desert typically has little or patchy vegetative cover. Therefore, the ground plane is very visible. Years of exposure to wind have resulted in the removal of fine sediments, revealing a coarse interlocking pebble and cobble-sized rock layer called desert pavement. In certain areas, the pavement may also acquire a patina (coloration) indicative of time. Manganese oxide in the rocks eventually weathers causing a darkening known as desert varnish or rock rust. Ground-disturbing activities, like those typically used to install solar electric generating facilities, can destroy the desert pavement. When the pavement is graded or otherwise disturbed, the graded area will contrast strongly, in color and texture, with the undisturbed desert pavement. This creates an incongruent visual condition that attracts the viewer's attention and will take millennia to re-establish. Installation of any type of solar electric generation facility should be sensitive to this potential reduction in the visual value of the desert ground plane and vegetative cover, and should minimize the disturbance to reduce visual impacts.

The use of visually appropriate colors and textures on human-made structures and facilities is an effective technique to lessen visual contrast and reduce visual impacts. Colors should match the color of the landscape's ground plane. This strategy can be very effective for moderately sized structures like O&M buildings and electrical enclosures.

Access and maintenance roads can create linear scars on the landscape that may conflict with the integrity of an area's existing baseline visual conditions. For instance, the access road for an electrical generation tie-line could be designed in a sinuous manner so as to not compromise the aesthetics of the ground plane. Having roads conform to and follow existing topographic contours and be the minimum width required for safety purposes can further reduce visual impact.

7.6.3.6 Technology-Specific Design Considerations

Utility-scale solar electric generation facilities vary considerably in their potential visual intrusion and negatively perceived visual impacts in a landscape. As technology has developed, there have been increasing economies of scale, resulting in larger, more visually intrusive project designs. Each kind of technology offers its own visual resource management challenges. The following discussion is a synopsis of the major infrastructure components that may negatively affect the visual environment of the landscape of the Mojave and Colorado Deserts.

PV – Crystalline

Crystalline PV solar panel installations are land intensive (typically several acres per MW) facilities. These panels are positioned relatively close to the ground so the extent of their viewshed can be somewhat limited when thoughtfully sited in the landscape. Often, the solar panels are mounted on trackers that follow the sun's apparent movement across the sky effectively capturing the maximum solar incidence. The PV solar panel's visual impact is typically associated with the size of its horizontal footprint and the incongruent color of the PV panels, which contrast strongly with the color and texture of the ground plane and vegetative cover.

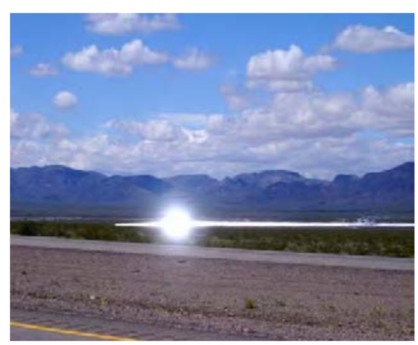
Nellis AFB Solar PV on Single-Axis Trackers
Image courtesy of Gizmag.

PV – Thin Film

Thin film solar panel installations are very similar to crystalline PV installations in form, color, and character. This technology typically is mounted on stationary rack systems, as opposed to trackers, which allow them to have a lower vertical presence than crystalline PV. Thin film PV is less efficient than crystalline PV, requiring a larger horizontal footprint to achieve the same nameplate generation capacity.

CSP – Parabolic Trough

Parabolic trough is the most proven of the CSP technologies and is used extensively in the desert. The installation involves parallel rows of curved mirrors that focus sunlight onto central receiver tubes. This technology can have significant visual impacts. Because of their height, the parabolic mirrors are more visible than PV. There is a potential for fugitive glare, and there is a stark contrast in color and texture between the infrastructure and the ground plane. Furthermore, trough technology requires cooling towers which create a greater



Reflected sunlight manifests itself as fugitive glare
Image courtesy of Argonne National Laboratory.

vertical intrusion and generate steam or air shimmer whose motion attracts attention.

Airborne dust particles are illuminated, creating a light veil
Image courtesy of buyacar.co.uk.

***CSP – Power Tower*[128]**

Solar power tower technology is a new presence in the desert. The central tower of a plant can be 500 or more feet tall and visually prominent in the low profile desert landscape. Additionally, under optimal conditions, the receiver becomes illuminated by the focused sunlight from the heliostat field. Airborne particulate matter may also be illuminated and create a veil or tent from the central receiver to the perimeter of the heliostat array. The vertical and horizontal presence of this technology varies by manufacturer but its visual impact is the most profound of existing solar generating technologies. Plumes of steam or air shimmer from exhaust heat are also a byproduct of the cooling process associated with this technology. Additionally, power towers typically require a Federal Aviation Commission obstruction to air travel light, which will affect the visual impact of the facility.

Diffuse glare from the central receiver of a solar power tower
Image courtesy of Recharge News.

CSP – Stirling Dish

Stirling dish technology's effect on the visual environment may not be as well understood as the other four technologies because its application to date has been limited to demonstration platforms. The parabolic dishes focus sunlight onto a Stirling engine which creates electricity. The dishes are 30 feet in diameter so the vertical visual presence is significant. Each dish is it own power generation unit and precisely tracks the sun's apparent movement across the sky. The technology is very efficient in focusing the sun's solar incidence on the dish engine so the effect of fugitive glare is minimal under normal operating conditions.

7.7 Key Permitting & Approval Processes

Other sections of this chapter discuss the substantive issues that solar developers must address in the planning and construction process, such as the protection of biological, cultural and visual resources. This section summarizes the regulatory and permitting processes through which many of the substantive issues are investigated and resolved. These processes are distributed across the Federal, State and local levels of government.

The Solar Potential Assessment (see Chapter 6) accounted for the cost of the completing permitting investigations, documentation and applications within the Project Development and Integration line item, which also encompasses arranging for financing, contracting, legal work, and many other ―soft" costs. In total, Project Development and Integration costs were estimated at 7.5% of the total cost of hardware and installation labor. To illustrate, for a ground-mounted crystalline silicon project using single-axis tracking, the total hardware and installation labor cost

[128] Power towers were excluded from the solar potential analysis due to mission incompatibility.

would be about $3,000/kW. Project development and integration would thus add a further cost of about $225/kW (7.5% x $3,000/kW), or about $22 million for a 100 MW project.

7.7.1 Federal Processes

7.7.1.1 NEPA

The National Environmental Protection Act of 1970 applies to all Federal agencies and to most of the activities they approve or carry out. In complying with NEPA, Federal agencies are required to consider, disclose, and reduce the environmental impacts of their proposed actions. For the most part, complying with NEPA involves completing an Environmental Assessment (EA) and preparing an Environmental Impact Statements (EIS) when developing facilities, altering land use, or performing any activities where significant environmental damage may occur. Generally, the EA should state the need for the proposal, environmental impacts of the proposed action, alternatives, and a listing of agencies and persons consulted. If the EA concludes a finding of no significant impact (FONSI), an EIS is not necessary. However, if the EA determines that the proposed actions may lead to significant environmental impacts, an EIS is required. The EIS should detail the purpose of the proposed actions, the affected environment, the environmental consequences, the alternatives, the list of preparers, and an index and appendix. Additionally, it is important to note that each Federal agency may have a list of activities that are categorically excluded from environmental evaluation (EPA, 2010a).

Preparing an EIS ensures that the environmental impacts are taken into consideration early in project development. Each branch of the DoD has a slightly different procedure for complying with NEPA regulations and developing an EIS for review. Generally, the Air Force, Army, and Navy follow the procedure outline below. For the Air Force, the Environmental Planning Function (EPF) is one of the key participants responsible for implementing the NEPA process (USAF, 2009a). For the Navy, the Assistant Secretary of the Navy for Installations and Environment is the principal point-of-contact and director of NEPA compliance. Within the Army, the US Army Installation Management Command is responsible for NEPA compliance. The overall NEPA process typically takes 12-24 months and the general DoD procedures are outlined below:

1. **Identify Need**
   If the proposed activities fall into any of the following categories, an Environmental Impact Statement must be prepared in accordance with NEPA.
   a. Significantly affects environmental quality, or public health or safety.
   b. Significantly affects historic (listed or eligible for listing in the National Register of Historic Places, which is maintained by the National Park Service, DOI), or cultural, archaeological, or scientific resources, public parks and recreation areas, wildlife refuge or wilderness areas, wild and scenic rivers, or aquifers.
   c. Significantly impacts prime and unique farmlands located off- post, wetlands, floodplains, coastal zones, or ecologically important areas, or other areas of unique or critical environmental sensitivity.
   d. Results in significant or uncertain environmental effects, or unique or unknown environmental risks.

e. Significantly affects a federally listed threatened or endangered plant or animal species, a Federal candidate species, a species proposed for Federal listing, or critical habitat.
f. Either establishes a precedent for future action or represents a decision in principle about a future consideration with significant environmental effects.
g. Adversely interacts with other actions with individually insignificant effects so that cumulatively significant environmental effects result.
h. Involves the production, storage, transportation, use, treatment, and disposal of hazardous or toxic materials that may have significant environmental impact.
i. Is highly controversial from an environmental standpoint.
j. Causes loss or destruction of significant scientific, cultural, or historical resources (DoD, 2005).

2. **Notice of Intent (NOI)**
A Notice of Intent must be prepared in order to initiate the formal scoping process. The NOI package must include the NOI, a press release, information for Members of Congress, memo for correspondents, and a ―question and answers" memo. Depending on the branch of the DoD, the NOI may then be published in the Federal Register and public newspapers in the areas affected by the proposed actions.

3. **Draft EIS (DEIS)**
A DEIS must be prepared for public comment and review. This document may be distributed to congressional delegations and committees, governors, national environmental organizations, the DoD, and Federal agency headquarters. Once the document has been approved by select entities, it must be filed with the EPA.

4. **Notice of Availability (NOA)**
The EPA will publish a NOA of the DEIS in the Federal Register. The DEIS must then be distributed to the full list of relevant Federal, State, regional, and local agencies, private citizens, and local organizations.

5. **Public Review**
Publication of the NOA marks the beginning of the public comment period. The public comment period must last at least 45 days. Public meetings or hearings may be deemed necessary. Once the comment period is complete, responses to comments must be issued.

6. **Final EIS (FEIS)**
Comments and changes must be incorporated into the DEIS and a Final EIS must be prepared.

7. **Record-of-Decision (ROD)**
Once the EPA publishes the FEIS in the Federal Register, a ROD will be announced after 30 days in the Federal Register.

7.7.1.2 Federal Land Policy and Management Act

The Federal Land Policy and Management Act (FLPMA) of 1976 governs the uses of Federal public lands and provides for public land sales, withdrawals, acquisitions, and exchanges (NMCWL, 2011). Under this authority, the BLM grants Right-of-Way (ROW) permissions for additional uses of Federal lands. The additional uses commonly include reservoirs, pipelines, communication infrastructure, roads, transportation, and electrical energy generation and transmission facilities. FLPMA also regulates the leasing and permitting process for grazing and for withdrawing Federal lands from mineral entry or development.

Compliance with FLPMA depends on whether a commercial solar developer or a branch of military is developing the solar project. A solar developer must undergo the full ROW approval process to obtain a ROW to generate and transmit electrical energy on Federal lands. However, there is a clause in FLPMA that allows the Secretary of the Interior to grant other Federal departments and agencies ROWs by request rather than through a formal ROW approval process.

Additionally, electricity generating facilities must meet FERC's regulations. FLPMA states that ROW lands, commercial or federal, hosting ―systems for generation, transmission, and distribution of electric energy" must comply with the Federal Power Act (FPA) of 1935.

7.7.2 State Processes

The environmental review process and the utility commission renewable energy approval process are the two primary processes through which proposed solar energy generation facilities are regulated by the state government in both California and Nevada. Additional state permits are likely to be necessary for any utility-scale solar energy developments but vary significantly from one project to the next based on the characteristics of the land being considered for development.

7.7.2.1 Environmental Review

California

The California Environmental Quality Act (CEQA) was passed in 1970 in response to the 1969 passage of NEPA. As with NEPA, CEQA requires that any projects likely to have a substantive effect on the California environment be reviewed by the appropriate regulatory authority, whether that is a state or local agency, and as with NEPA, the more substantial environmental review, called an Environmental Impact Review (EIR), must consider feasible alternatives and mitigation methods that might substantially reduce the environmental impact of a project when reviewing a project. The CEQA review process can be as brief as a few months or as long as several years depending upon the findings of an initial environmental assessment and the determination of whether a full EIR is necessary.

In California, no one agency is responsible for the CEQA review of all potential utility-scale solar energy projects. Like large conventional power plants, solar thermal facilities with nameplate capacities larger than 50 MW must submit an Application for Certification (AFC) with the CEC, which has statutory authority to review the environmental impact of large solar thermal projects. The CEQA review for smaller solar thermal facilities and utility-scale PV facilities are typically conducted by the local jurisdiction during the site permitting process, although the CDFG has the authority to intercede where reasonable (Flynn et al., 2010).

Because many of the recent solar energy projects proposed for the state of California have involved Federal lands, the regulatory requirements for NEPA and CEQA must both be met for a solar energy project to be approved. This overlap of Federal and State processes has resulted in a complicated permitting roadmap for solar project developers. In addition to the BLM and CEC, other Federal and State agencies such as the CDFG, Regional Water Quality Control Board, the USFWS, the National Park Service (NPS), and the EPA also play a role in the environmental review, permitting, and siting of solar facilities on Federal lands in California (Flynn et al., 2010).

In response to the regulatory complexity and redundancy of having two similar environmental reviews conducted for the same solar energy project, BLM and CEC entered into a Memorandum of Understanding (MOU) in 2007 that provides a more efficient joint review process on solar thermal projects above 50 MW. The MOU establishes a framework that allows the CEC and the BLM to share the preparation of the EIS and EIR pursuant to both NEPA and CEQA; this minimizes duplication of efforts. The joint process requires similar information from solar project developers, the public, and other relevant agencies; the typical application processing timeline is about 18 months (BLM/CEC, 2007).

The joint environmental review process includes:

1. Pre-application process – This step ensures that an Applicant is fully informed of the data and information needs of both the CEC and the BLM at the time an AFC is filed with the CEC.
2. Data Adequacy – CEC reviews an AFCs (conferring with BLM staff) to ensure information is sufficient to complete an EIS.
3. Discovery – After AFC approval, CEC and BLM develop public scoping meetings/workshops to discuss project alternatives, biological resources, and cultural resources.
4. Analysis – CEC and BLM split topic areas in the joint environmental analysis. BLM addresses project alternatives, purpose and need, and consultation with Native Americans as required by NEPA. CEC addresses engineering, mitigation measures and all other environmental impacts including air quality, water resources, etc. This joint assessment must be sufficient to meet all Federal and State requirements for NEPA and CEQA and is included as part of the joint Preliminary Staff Assessment/Draft EIS and the joint Final Staff Assessment/Final EIS.
5. Hearings – Both BLM and CEC provide witnesses as subject matter experts and write up hearing briefs. All hearings are open and conducted with the goal of providing transparency and public engagement.
6. Proposed Decision –BLM and CEC confer and comment on the Proposed Decision and record their decision after completion of the Final EIS.

The MOU applies only to solar thermal power plant projects greater than 50 MW. Solar PV projects are not currently under the jurisdiction of the CEC, although CEQA environmental review rules still apply to the local government where a solar energy facility is planned for development.

In August and September, 2011, the California Legislature passed several bills intended to streamline the permitting process for solar energy facilities, including expediting the CDFG review and permitting process and exempting large solar PV facilities from conducting a water use assessment if they use less than 75 acre-feet of water per year, while also increasing permitting fees.

Nevada

Nevada's Utility Environmental Protection Act (UEPA), enacted in 1971, requires that developers seeking to build a solar energy facility with a nameplate capacity greater than 70 MW obtain Public Utilities Commission of Nevada (PUCN) approval before commencing construction. For such facilities, a valid application must include a description of the location and facility to be constructed, a summary of any studies conducted to evaluate the environmental impact of the facility, a description of reasonable alternate locations for the facility, a description of the project's merits, and a statement of why the primary location is best suited for the facility (NRS, 2011). The PUCN reviews the application to determine:

- the probable environmental impact of the facility,
- the necessity of the facility to ensure reliable utility services,
- whether the need for the facility balances any adverse environmental impacts,
- whether the facility represents the minimum adverse environmental impact with current technology compared with the available economically feasible alternatives,
- that the location of the proposed facility conforms to applicable state and local laws and regulations and that the applicant is in the process of obtaining all necessary permits, licenses, and approvals required by Federal, State, and local regulations,
- that the facility will serve the public interest.

The PUCN has 150 days from the date an application is submitted to review and determine whether to grant approval of the application (NRS, 2011).

For projects that require Federal permitting and environmental review, the PUCN has created a two step UEPA application process. Solar project developers must submit a permit application to the PUCN before or at the same time they submit a permit application with the appropriate Federal agency. A subsequent, more detailed application with all the information the PUCN will need to consider the application must be submitted once the Federal environmental analysis is complete. The PUCN will incorporate the findings and conclusions of the Federal analysis into the UEPA environmental review process in order to avoid a duplicative review (NRS, 2011).

Solar energy projects with a nameplate capacity less than 70 MW do not require an environmental review from the PUCN unless they are interconnecting with the grid at a voltage above 200 kV, in which case the PUCN must review the environmental impact of the interconnection facilities under UEPA. While solar energy facilities smaller than 70 MW in gross capacity and interconnecting to the grid below 200 kV do not require PUCN approval, other state permits may be required, such as permits for construction and facility runoff.

7.7.3 Local Processes

Solar energy developments on military land are exempt from local land use restrictions and permit requirements but this exemption does not extend to non-military Federal land (Foster, 2011b).

Solar energy developments located on private or non-military Federal land may need an environmental review from state agencies in California and Nevada. In addition, these developments will likely need to be reviewed by local jurisdictions which have land-use ordinance requirements or restrictions related to commercial solar installations along with associated permitting processes. The number, type, and expense of permits vary by county and state, but most county-level permitting processes require solar energy developers to obtain a Conditional Use Permit (CUP) in order to allow construction of a solar energy facility on lands zoned for other purposes. The issuance of conditional land use permits at the county level usually requires discretionary approval by the County Board and in turn triggers an environmental review process. For example, Kern County in California requires an environmental review process that follows CEQA guidelines before approving the siting of solar energy projects in the county.

As an example of county-level requirements, Table 7.9 below summarizes a subset of the permits needed for a solar energy project sited on private lands within Kern County, California. This list does not include the additional permit requirements needed from other Federal agencies involving endangered species, habitat conservation, water quality, cultural resources, historic preservation issues, aviation planning, seismic evaluation planning, air quality issues, RPS certification, and other hazardous materials permitting requirements.

Table 7.9 – Sample list of permit requirements in Kern County.

Permit/ Authorization	Description of activity requiring approval	Office Granting Permit	Notes
CEQA	CEQA applies to all public projects and all private projects that require a discretionary decision by a public agency.	Kern County Planning Department	Kern County issues a discretionary Conditional Use Permit (CUP).
Zoning, Ordinance or Plan Amendment	A development project must be consistent with land use designations in the applicable local zoning code and land use plan, unless preemption exists.	Kern County Planning Department	Depends on whether the project is located within the Kern County General Plan. Parcels currently have two zoning classifications, (A) Exclusive Agriculture and (FP) Floodplain Combining. Under the Kern County Zoning Ordinance, (A) is designated for agricultural purposes, but other land uses including energy development are permitted. The zoning ordinance also specifies that (FP) district is applicable in FEMA Zone A area, and allows uses similar to the base district. Solar is an allowable use in (A-FP) zoning with a conditional use permit (CUP).

Table 7.9 – Sample list of permit requirements in Kern County.			
Permit/ Authorization	**Description of activity requiring approval**	**Office Granting Permit**	**Notes**
Special Use or Conditional Use Permit	The local government zoning code may provide that the development is allowable in all cases (subject to specified design requirement and other local permits such as building permits) or is allowed only after satisfying certain project specific conditions, unless preemption exists.	Kern County Planning Department	Construction of a solar project would require a CUP for the construction and operation of a solar PV generation project within (A-FP) zoned land. Obtaining the CUP would make the project consistent with the applicable land use plan, policy, or regulation of jurisdictional agencies.
Road crossing or Encroachment Permit	Crossing a road or placing a pipeline in a road	Kern County Roads Department	Needed only if solar project creates tunnels under or digs up a County Road.
Grading Permit	Most local Governments have adopted permitting requirements for certain grading activities.	Kern County Building Department; Engineering and Survey Services Department.	Solar energy projects that result in alterations to land such as excavation, filling, land leveling or agricultural grading will require a grading permit from the county.
Building/New Construction Permit	Most local governments require developers to obtain a building permit before commencing certain construction activities.	Kern County Building Department; Engineering and Survey Services Department.	Many local Governments define ―building" very broadly for purposes of their building permit requirements.
Certificate of Occupancy	Many local Governments require developers to obtain a certificate of occupancy for new construction or occupancy of new construction prior to occupying certain new structures.	Kern County Building Department; Engineering and Survey Services Department.	New solar energy projects will likely require a certificate of occupancy

The various requirements for permits and their associated regulatory agencies are listed in the following tables for solar energy projects sited in California. Table 7.10 addresses projects on private lands while Table 7.11 addresses projects on public lands. Additional permitting requirements exist for other Federal agencies such as the USFWS and the CDFG that are not listed in these tables (California Biodiversity Council, 2009).

Table 7.10 – Private Lands Solar Development Permitting Matrix								
Size of project	**Larger than 50 MW**				**Smaller than 50 MW**			
	CEC	CPUC	Local	BLM	CEC	CPUC	Local	BLM
Solar PV Projects	None	PPA Approval	CEQA and CUP	N/A	None	PPA Approval	CEQA and CUP	N/A
Solar Thermal Projects	CEQA and License	PPA Approval	No CUP needed. Other permits likely.	N/A	None	PPA Approval	CEQA and CUP	N/A

Table 7.11 – Public Lands Solar Development Permitting Matrix								
Size of project	**Larger than 50 MW**				**Smaller than 50 MW**			
	CEC	CPUC	Local	BLM	CEC	CPUC	Local	BLM
Solar PV Projects	None	PPA Approval	N/A	NEPA and Right-of-Way	None	PPA Approval	N/A	NEPA and Right-of-Way
Solar Thermal Projects	CEQA and License	PPA Approval	N/A	NEPA and Right-of-Way	None	PPA Approval	N/A	NEPA and Right-of-Way

7.8 Incentives

Although the cost of electricity generation using solar technology is falling fast, solar-generated electricity is still more expensive than power delivered from the public grid. To overcome this gap and encourage solar deployment, the Federal and State governments offer a range of incentives for the installation of solar projects. With these incentives, solar projects can be economically successful, particularly in areas with good solar resources and high market prices for electricity and Renewable Energy Certificates (RECs), a description which fits the Mojave and Colorado Desert region. However, as will be more fully described below, most solar incentives are tailored for private-sector owners. As a result, for the nine installations covered by this study, almost all of the privately-developed solar projects modeled in the Solar Potential Assessment chapter were found to be economically successful. By contrast, military-owned projects were found to be uneconomic without exception, even with a relatively undemanding hurdle rate of 7% (real) per year.

The remainder of this section reviews the available incentives starting with Federal incentives and concluding with State and utility incentives.

7.8.1 Federal

U.S. Department of Treasury's Business Energy Investment Tax Credit and Temporary Renewable Energy Cash Grants Program

Private developers, including developers using a third-party financing model such as a PPA or operating lease with a Federal agency, are eligible to receive the U.S. Department of Treasury's Renewable Energy Grant or the Business ITC. For solar PV and thermal projects, both of these incentives are equal to 30% of the solar system's full capital cost. The key difference between the two incentives lies in how they are paid: the Renewable Energy Grant is paid directly by the Treasury to the developer, while the ITC is claimed via the tax filing process. The ITC therefore requires that the developer have a substantial tax liability to monetize its benefits, or, more commonly, that the developer partner with a tax equity investor. The tax credit can be carried forward for up to 20 years if the credit exceeds a business's tax liability.

Applications for Renewable Energy Grants are being accepted as of this writing for projects with 2009, 2010, and 2011 construction start dates. Currently, there are no plans to extend the Renewable Energy Grants program beyond 2011 although renewable energy developers and program supporters are lobbying Congress for an extension, as was granted in 2010. After 2011, developers can still apply for the ITC which will continue to accept applications for renewable energy projects placed into service before December 31, 2016. After 2016, the ITC reverts to a 10% credit.

Modified Accelerated Cost-Recovery System (MACRS)

Under the MACRS, solar PV and concentrating solar technologies are eligible for accelerated depreciation schedules of 5 years. This program allows for the full adjusted basis value of the solar project to be used as a tax deduction over the first five years of the facility's operation. For solar projects that utilize the Federal 30% ITC or cash grant, an adjusted basis value of 85% of the full capital cost is used, effectively deducting half the ITC or cash grant from the MACRS basis. A bonus depreciation equal to 100% of the adjusted basis of the property is available for 2011 before reverting to 50% of the adjusted basis for 2012. The bonus depreciation rules do not override the depreciation limit that applies to projects that utilize the Federal business ITC or renewable energy grant. For projects that use this tax credit/grant, the adjusted basis of the project must be reduced by half of the amount of the energy credit/grant (DSIRE, 2011b). It remains unclear whether the bonus depreciation incentive will be available after 2012 as Congress has consistently extended the incentive, retroactively, for only a year or two at a time before letting it expire once more.

DOE's Loan Guarantee Program

Commercially developed solar PV and thermal projects on all military installations are eligible for a DOE Loan Guarantee through the DOE's Section 1705 Program. This temporary program created by the American Recovery and Reinvestment Act of 2009 authorizes loan guarantees for renewable energy systems, electric power transmission systems, and advanced biofuels that commence construction before September 30, 2011. The amount of the loan must be repaid before 90% of the useful lifetime of the system has been reached or before 30 years, whichever is sooner.

As of September 23, 2011, the DOE has provided complete or partial loan guarantees for more than $16 billion through the Section 1705 Program, including almost $12 billion in loan guarantees for solar generation projects such as Abengoa Solar's $1.2 billion CSP Mojave Solar Project now under construction. The Section 1705 program's solicitation period is closed as of this writing and a new solicitation period has not been announced. At present, the future of the broader DOE loan guarantee program beyond the 2011 Fiscal Year is uncertain as Congress considers whether to make significant cuts to the program or defund the program altogether.

A subset of the Section 1705 Program is the Financial Institution Partnership Program (FIPP) which partners the Energy Department and qualified finance organizations for loan guarantees for qualifying renewable energy generation projects. FIPP is designed to expedite the loan guarantee process and expand senior credit capacity for renewable energy generation projects that use commercial technologies (DOE, 2011b).

USDA's High Energy Cost Grant Program
Commercially developed solar PV and thermal projects on all military installations are potentially eligible for a USDA's High Energy Cost Grant. The maximum grant is $5,000,000 and may cover the cost of energy generation, transmission, and distribution facilities. In order to be eligible, the community surrounding the military installation must have energy costs at least 275% above the national average, which sets the trigger price at approximately $0.264 per kWh for the 2010 application period (USDA, 2010).

Because these grants are drawn from a limited budget each year (and thus cannot be counted upon, unlike the tax preferences discussed above), they were not incorporated into the project financial analysis in the Solar Potential Assessment.

7.8.2 State

7.8.2.1 California

California Solar Initiative PV Incentives Program
The California Solar Initiative (CSI) program was launched in 2006 to distribute $3 billion in incentives to speed the construction of 3,000 MW of solar energy to California by 2016. PG&E, SCE, and SDG&E participate in the program. The incentives are distributed through two mechanisms, Expected Performance-Based Buydowns (EPBB) and Performance-Based Incentives (PBI). The mechanisms consist of 10 Steps: each step is defined by a new MW capacity goal and is associated with a decreasing incentive amount.

The following military installations are technically eligible to receive CSI incentives for solar energy projects through SCE:

- National Training Center and Fort Irwin (SCE)
- NAWS China Lake (SCE)
- Edwards AFB (SCE)
- MCAGCC Twentynine Palms (SCE)
- MCLB Barstow (SCE)

For privately-owned solar systems under 30 kW, the EPBB incentives started at a Step 2 value of $2.50 per watt AC and will decline until Step 10 is reached at a rebate value of $0.20 per watt AC. For government-owned systems under 30 kW, the EPBB incentives started at a Step 2 value of $3.75 per watt AC and will decline until Step 10 is reached at a rebate value of $0.70 per watt AC. For privately-owned systems larger than 30 kW, the PBI incentives started at a Step 2 value of $0.39 per kWh and will decline until Step 10 is reached at a rebate value of $0.03 per kWh. For government-owned systems larger than 30 kW, the PBI incentives started at a Step 2 value of $0.50 per kWh and will decline until Step 10 is reached at a rebate value of $0.10 per kWh (Go Solar California, 2011b).

As of September 2011, the non-residential class is at Step 8 in the SCE service territory, indicating that the program is nearing its overall capacity goal and also indicating that the remaining incentives are much less generous than those available earlier in the program's history.

Although these installations are technically eligible to receive CSI funds, it is unlikely that any of them actually will. SCE is expected to have fully allocated its CSI program budget by the end of the 2011. Program Administrators are still accepting reservation request applications and any approved applications will be incentivized as funds become available (Go Solar California, 2011a). In the short term, it is possible that the CSI program may receive additional funds; however, this will not guarantee long term funding of the program.

Because of this funding uncertainty, the Solar Potential Assessment assumed that no CSI funds would be available.

Tax Incentives

In 2010, California created an exclusion from the state's sales and use tax for the design, manufacture, production, or assembly of alternative energy source products, including solar energy products. The sales and use tax exclusion must be applied for with the California Alternative Energy and Advanced Transportation Financing Authority and includes application and administrative fees of at least $15,250. The tax exclusion requires at least 25% of the total excluded purchase in the first year and extends for three years once the application has been approved. The tax exclusion is scheduled to run through 2020 (CAEATFA, 2010).

While not applicable for direct military construction and ownership of solar energy facilities, private solar energy facility developers and owners benefit from California's property tax exemption for solar energy property. The current property tax exemption is set to expire at the end of 2016 (California Legislature, 2011b).

REC Sales

The voluntary REC market is evolving and there are opportunities to sell the RECs through an aggregator or directly to another organization. CPUC rulings have set the valuation range at $0.005 to $0.05/kWh and recent (summer 2011) transactions have seen voluntary RECs (i.e., RECs purchased for reasons other than satisfying the State RPS) transactions being valued in the range of $0.01 to $0.015/kWh (Foster, 2011a). The Solar Potential Assessment chapter describes the method used to forecast REC prices during the study's analysis period (2015-34).

7.8.2.2 Nevada

NV Energy Renewable Generations Rebate Program

Commercially developed solar PV projects in Nevada are eligible to receive solar energy rebates through the NV Energy Renewable Generations Rebate Program. However, the program has often exhausted its incentive budget in the past, and its availability for funding future projects at any point in time cannot be confidently assumed.

In September 2011, the Renewable Generation Rebate Program accepted 920 applications and issued 134 reservations for solar energy rebates through a lottery because of over-subscription to the program (NV Energy, 2011a). Successful applicants will receive an incentive of $4.70/kW for up to 100 kW for ―public property” projects. (NV Energy, 2011b)

In addition, it is not clear whether Creech and Nellis AFBs would be eligible to participate in the program. Program rules do permit the participation of ―public entities,” but defines that group as ―A department, agency or instrumentality of the State or any of its political subdivisions,” (NV Energy, 2011). This would appear to exclude the AFBs.

The PECs generated from systems that receive rebates are transferred to NV Energy.

Portfolio Energy Credits

Both government- and commercially-developed solar PV and thermal projects on military installations are eligible for Portfolio Energy Credits (PEC). The PEC trading program allows renewable energy producers to earn PECs (which are conceptually the same as RECs in California) and sell them to utilities obligated under Nevada's RPS program. Generally, 1 PEC is equivalent to 1 kWh, but adders are applied to certain sectors. For example, a 2.4 multiplier is applied to PV and a 1.05 multiplier is applied to customer-maintained systems. Consequently, a customer-maintained PV development is eligible to receive 2.45 PECs for each kWh generated. The solar 2.4 multiplier only applies to customer-sited projects for which more than 50% of the electricity produced is used on the premises. NV Energy defines the customer's premises as ―all of the real property and apparatus employed in a single enterprise on an integral parcel of land undivided by public highways, streets, alleys or railways.”[129]

Participants in NV Energy's Renewable Generations Rebate Program are required to transfer the PECs associated with their generation to NV Energy as a condition of participation.

Tax Incentives

In 2009, Nevada enacted a sales and use tax abatement for renewable energy equipment purchases associated with generation facilities greater than 10 MW. The incentive reduces the sales and use tax rate from ~7.5% (depending on the county) to 2.25% for renewable energy projects that comply with various restrictions including creating a certain number of well-paying jobs for Nevada residents, providing health insurance for workers, and making a specified capital investment in the state of Nevada. The sales tax abatement runs through 2049. This exemption is not available to governmental entities (NREEEA, 2009).

Private solar energy developers can also benefit from Nevada's property tax exemption for solar energy property. The exemption applies to all years following the installation of the solar energy facility (Nevada Legislature, 2011).

[129] http://nvenergy.com/company/rates/snv/rules/images/Rule_1__South.pdf

7.9 Federal Financing Options

The simplest method of financing solar energy facilities on military property is for the DoD to pay for the development of the project directly with the DoD or other Federal funds and to own the facility directly. However, a solar project is capital intensive, and the DoD is ineligible for many of the significant tax-based incentives which can be used to reduce the cost of solar energy facilities. This creates a need for financing options that can stretch the capital cost of the project over time, and also permit the project to take advantage of tax-based incentives.

Funding for Smaller Solar Projects

A large number of DoD solar energy projects that have recently been completed, are under-development, or are planned have been funded through the Energy Conservation Investment Program (ECIP), which received a $120 million boost to its annual appropriations through the American Recovery and Reinvestment Act of 2009. While the limited funds available through the program rule out its use for large, utility-scale solar energy projects, the ECIP is ideally suited as a funding source for smaller commercial-scale distributed solar energy applications. The program is intended to fund projects at military installations that will reduce on-installation energy consumption and emphasize sustainability, energy efficiency, and safety.

These goals are most easily accomplished through a partnership with a private-sector developer. There are several different authorities available to the DoD to support such financing structures. Each authority has distinct rules regarding how ground is leased, whether the project's electricity can or must be purchased as part of the transaction, and how benefits are accounted for within the Department.

Under a PPA, the developer agrees to install, own, operate, and maintain a solar energy system on military property for the life of the contract, typically between 15 and 25 years, and in return the military installation purchases some or all of the electricity generated (DOE, 2011d). The private developer can take advantage of applicable tax-based financial incentives, including ITCs and MACRS, to reduce the overall cost of the project by up to 40%. In addition, a private developer can boost the project's revenue and potential for financial success through the sale of the RECs generated by the project, either to the military or in the open REC market. (However, as noted elsewhere in this chapter, off-installation sales of RECs remain controversial because such sales limit the installation's ability to contribute to meeting the DoD's EPAct and, potentially, NDAA goals.)

The PPA financing option is further strengthened for the DoD because, unlike the rest of the Federal Government, which cannot sign contracts lasting longer than 10 years, the DoD has the authority to sign PPA contracts, referred to as Utility Service Contracts by the Office of the Secretary of Defense (OSD), up to 30 years with the Secretary of Defense's approval through the authority granted to the DoD by 10 USC 2922a (DOE, 2010b). The Secretary's approval authority has since been delegated to the Deputy Under Secretary of Defense for Installations and Environment. The availability of contracts up to 30 years removes a significant barrier faced by other Federal agencies as solar energy facilities typically require a PPA of at least 20 years in order to be attractive to both the developer and the electricity purchaser. The OSD is currently working to streamline the process for obtaining 2922a approval (OSD, 2011).

Military installations can also use Energy Savings Performance Contracts (ESPC) and Utility Energy Services Contracts (UESC) for renewable energy projects. Both have most commonly been used by the Federal Government in the past to finance energy efficiency projects that typically include the installation of a number of different energy efficiency measures. But as the capital costs of solar energy facilities continue to decline, ESPCs and UESCs are increasingly being considered as a financing option for solar energy developments, especially when combined with energy efficiency projects.

Under an ESPC, an Energy Service Company (ESCO) pays the cost of installing a solar energy facility on the property of the customer in return for the host customer signing a long-term contract to pay the ESCO from the energy savings generated by the on-site solar energy facility. Under a UESC, the local utility performs the same role. Both types of contracts minimize the risk to the electricity customer of an underperforming solar energy facility or other energy saving measures by setting the maximum annual payment to the service company at the savings generated by the portfolio of energy saving measures installed. The Army already has established an Indefinite Delivery, Indefinite Quality (IDIQ) contract which can be used to expedite the process of implementing an ESPC (EERE, 2010). In addition, the DOE has a Super ESPC with 16 ESCOs to assist Federal agencies, including the DoD, in achieving energy efficiency, renewable energy, and water conservation projects.

One constraint that PPAs, ESPCs, and UESCs suffer from is that they are predicated on the electricity being consumed directly by the host customer. This limits the size of a solar energy facility to the load of the customer. But for several military installations in the Mojave and Colorado deserts, there is the potential to site solar energy facilities on large tracts of open land that would generate electricity well in excess of the electricity consumed by the local installation.

Two financing options exist for these military installations to take advantage of their large on-installation solar energy potential. The first option is to enter into an Energy Joint Venture (EJV) with a private developer. The military services are authorized to enter into EJVs under 10 USC 2916, which grants the Secretary of a military department the authority to "sell, contract to sell, or authorize the sale by a contractor to a public or private utility company of electrical energy generated from alternate energy or cogeneration type production facilities which are under the jurisdiction (or produced on land which is under the jurisdiction) of the Secretary concerned." For EJVs, the military service involved contracts to lease the land to a solar developer and can receive payment for the land and/or for the electricity sold to third parties. Any cash payments generated from the leasing of land for solar development or the sale of electricity is deposited in the appropriation account related to electricity supply at the Service Department level (DOE, 2009c). These funds may then be used for "military construction projects under the energy performance plan developed by the Secretary of Defense under 10 U.S.C. 2911(b), including minor military construction projects authorized under 10 U.S.C. 2805 which are designed to increase energy conservation". Use of these funds for minor military construction projects requires notification of the relevant Congressional committee(s) (DoD, 2009).

The second option is to pursue a EUL with a private solar energy developer. Unlike with a PPA, EPSC, or UESC, a EUL is essentially a real estate transaction whereby the solar developer is leasing land from the Federal agency to construct and operate a solar energy facility. But unlike an ordinary lease, the solar developer in an EUL pays the military installation through in-kind considerations equal to the value of the lease rather than directly with cash. In-kind consideration can take many forms but may include renewable electricity and can be combined with PPAs, ESPCs, and UESCs (EERE, 2010).

The military's experience with EULs for renewable energy projects is still in its early stages although solar EULs have been proposed at both Fort Irwin and Edwards AFB. Each military service is currently working to better understand and clarify the mechanisms by which an EUL can be used for potential solar energy projects.

8 Conclusions and Recommendations

8.1 Key Findings

Over 7,000 MW_{AC} of technically-viable and financially-feasible solar electricity development potential exists across seven California military installations in the Mojave and Colorado Deserts. This potential is achievable using industry-standard crystalline-silicon PV single-axis tracking technology; 99% of this potential is on ground sites, with less than 1% on large roofs.

If all of this 7,000 MW_{AC} in solar potential were actually developed starting in 2015, it could produce over 19,000 GWh per year, which is more than 30 times the combined on-site electricity consumption at these installations, and equal to about 25% of California's 2015 RPS goals. These solar facilities could potentially produce up to $100 million per year of economic benefit for the Federal Government in the form of rental payments, discounted power, in-kind consideration, or some combination among them.

Although these numbers are large in the context of the U.S. solar market, they arise from developing only a tiny fraction – less than two percent – of the surface area of the seven installations. The vast majority of the installations' acreage is unavailable for solar development because of conflicts between solar technology and mission performance, biological resources, cultural resources, and other screening factors.

Even if the DoD were to focus exclusively on installation cantonment areas, almost 1,600 MW_{AC} of economically-viable solar potential exists. This level of solar development could produce almost eight times more electricity than the seven military installations consume annually.

The DoD has options that allow it to avoid investing its own funds in building solar projects. The Department has existing authorities that permit it to work with private-sector developers to build solar projects. This approach shifts the capital investment burden to the private developer, and also allows the solar project developer to gain access to the substantial tax-based incentives for solar development. Because of these incentives, most of the solar technical potential on the seven California installations offers a good financial investment for a private sector developer. Because it pays no taxes, and therefore cannot use tax-based incentives, the DoD cannot develop any of the solar potential at an economically sensible rate of return using its own funds.

The DoD has the potential to harvest significant benefits from solar development, at little or no cost in terms of investment capital or degraded mission performance. However, to realize this opportunity, the Department would need to develop a thoughtful program, with the necessary funding, leadership support, and capacity building to see it to fruition. The DoD could increase and coordinate internal efforts in two main areas: policy development, and, programmatic development and implementation.

8.2 Recommended Policy Actions

Several policy-driven barriers can raise the costs of solar development, slow the development process, or stop solar development entirely. The discussion below identifies several of the key barriers and recommends DoD action.

8.2.1 Clarify withdrawn lands policy with Dept. of the Interior (DOI)

Installation staff repeatedly mentioned that uncertainty about the military's legal authority to use withdrawn lands for renewable energy development, discussed in greater detail in Section 7.3, inhibited consideration of large-scale solar projects. Because withdrawn lands make up the majority of the lands within the boundaries of the seven installations considered in this study, resolving their status with the DOI is critical if the DoD intends to develop utility-scale solar energy projects.

Developing a cooperative approach would benefit both parties. The DoD's renewable energy development efforts are inhibited by uncertainty about withdrawn lands. And the DOI cannot develop these withdrawn lands without the DoD's assistance in view of the fact that most of the technically- and economically-suitable land is located within or immediately adjacent to installation cantonments.

The key area of negotiation centers on whether military installations currently possess or could possess the authority to lease withdrawn lands to private developers for renewable energy projects that will sell their electricity output to the grid rather than for on-installation use. The DoD may have a compelling case for retaining control of any withdrawn lands used for solar energy developments if it can be demonstrated that the land housing the solar energy facilities might still have considerable value for military use, for example as buffer. In addition, the two Departments (DOI and DoD) could work together to reach consensus on how to partition leasing authority between them, as well as any potential revenues and ancillary benefits that might arise from a solar energy project on withdrawn land.

Reaching an agreement to create a land leasing process for renewable energy projects and to share the benefits could open up large tracts of land within the Mojave and Colorado Deserts as well as many other areas of the country.

8.2.2 Work with stakeholders to accelerate transmission development

The lack of transmission capacity is the single largest barrier to large-scale solar development on the seven California installations. The DoD and the many other stakeholders affected by this constraint could increase their efforts to encourage transmission owners and planners to expand capacity on existing transmission lines and expedite the necessary transmission build-out.

8.2.3 Clarify DoD policy on Renewable Energy Credit (REC) ownership and accounting

Presently, the DoD is exploring how it is going to procure sufficient renewable energy to meet its future renewable energy mandates and goals. Many energy managers with the DoD prefer to develop as much renewable energy on its installations rather than purchasing bundled or unbundled RECs. However, under the third-party finance model that will likely dominate renewable energy development on military installations, it is the developer, not the installation, that is the initial owner of any RECs arising from a project.

If the installation purchases electricity from an on-installation project, unless the installation also purchases the RECs or purchases RECs from elsewhere, the parent Service cannot claim to be consuming renewable electricity. While an added expense, the DoD will likely have to join the larger renewable energy market in retaining or purchasing RECs in order to make progress towards complying with its renewable energy mandates and goals.

There are two possible strategies where the DoD can own RECs and comply with its renewable energy mandates and goals. The most direct but expensive method is for the DoD to purchase the RECs generated by third-party renewable energy facilities on its installations. Alternatively, the DoD can stretch the impact of its limited utility and energy investment budgets by instituting a policy of purchasing low-cost RECs in the voluntary REC market to replace the typically higher cost RECs generated by the privately developed renewable energy projects on its installations in California and other States with RPS mandates. This allows the military to demonstrate its commitment to developing renewable energy and creating more sustainable military operations, but at a lower cost and without double counting RECs and falling out of step with the larger renewable energy market policies.

8.2.4 Clarify and develop programs to achieve energy security goals

As mentioned in the Energy Security chapter, the DoD has a significant interest in promoting energy security. But the DoD lacks clear goals and benchmarks to achieve energy security. The military Services require guidance about what types of energy security challenges the installations need to be prepared to overcome, the types of actions that should and should not be taken to improve energy security, and the –price” or value of energy security benefits in the investment process. When energy security goals and benchmarks are in place, the DoD can launch targeted energy security programs using advanced technologies such as microgrids, renewable energy coupled with energy storage, and hybrid systems comprised of renewable energy systems paired with traditional diesel gensets.

8.2.5 Increase coordination and integration of renewable energy projects and initiatives between military installations and Services

The DoD could make a greater effort to keep energy managers and other key personnel involved in renewable energy project planning at each military installation informed about the efforts, initiatives, and lessons learned by other military installations and Services. Each military installation addressed by this study seemed to have a slightly different interpretation about what types of solar energy projects were feasible, how land leases could be structured and on what kinds of land, and whether the electricity generated could be sold to the grid or not. Likewise, each installation seemed very interested to hear about the renewable energy plans at other installations. The fact that different installations have different understandings about the basic ground rules for renewable energy development fosters a sense of uncertainty that may deter private-sector solar developers from proceeding with project development.

By better informing energy management personnel at each military installation about the renewable energy activities of the DoD as a whole, including the deal structures and financing methods used, the DoD will be better able to present a united front when talking with private developers about potential investment opportunities on military installations. Better informed military installations will also speed the learning of best practices, which will streamline the solar energy planning process to ensure that the right project aligns with the right deal structure.

8.2.6 Develop a consistent and incentive-focused formula to allocate project benefits and costs between the host installation and parent organizations

The utility savings or revenues generated by a privately developed solar energy facility located on military land will often flow to an account at the major command, support organization or Service level rather than to the host installation. Installation representatives often mentioned that this lack of ―local benefit” provided little incentive for military installations to commit their land holdings and to assign staff resources for the lengthy efforts necessary to bring a renewable energy project to fruition. This lack of incentive for solar energy development seems to have its greatest affect on utility-scale solar energy projects. One of these projects can require great effort from otherwise overstretched installation staff, and with the power flowing out to the public grid, the installation may see no direct benefit in return for its effort supporting the project's development. As one installation staff person replied when asked about utility-scale solar development, ―We don't see it as our mission to become DoD Power and Light.”

Providing clear incentives for military installations to invest in and host renewable energy projects will likely generate increased interest and support from military installation staffs. The DoD could commit a significant percentage of any utility savings or revenues generated by renewable energy projects to the installation that generated the savings/revenues. Installations could receive these funds in the form of increased funding for additional energy projects and improvements or other desirable infrastructure initiatives.

8.2.7 Work with the DOI's Bureau of Land Management (BLM) to ensure that the Federal Government is maximizing its compensation from land rentals while allowing solar developers to make an attractive rate of return.

As discussed in the Solar Potential Assessment chapter, BLM's solar land lease rates in southern California could roughly double and still provide an attractive rate of return for private developers under the study's assumptions. The DoD should consider working with BLM to evaluate the merits of re-calibrating Federal compensation for land leases so that it can continue to achieve BLM's fair market value goal against a backdrop of rapidly changing and regionally-variable solar economics. The two Federal organizations could develop a cooperative approach so that private solar developers will not have an incentive to work with one agency over the other because of more attractive land rental rates.

8.2.8 Develop and apply a consistent methodology for mission compatibility analysis within DoD installations, and analyze DoD lands in advance of programmatic scale-up.

―Conflicts with mission performance” was the single most important factor limiting the potential for solar development across the 9 installations evaluated. More than 90% of the land surface of these installations was rated unsuitable for solar development for this reason. This study relied on discussions with range operators and training managers for most of the mission compatibility analysis; a few installations had GIS data layers that delineated likely mission hazards such as Surface Danger Zones. Because the results relied, to a great degree, on the best professional judgment of range management staff, they were non-reproducible and difficult to generalize to other installations or to communicate to the solar development community.

In the future, DoD should consider developing a mission compatibility assessment methodology that can be applied within its own installations; this would complement the mission compatibility analysis strategy already called for under Section 358(d)(1)(b) of the Ike Skelton National Defense Authorization Act for Fiscal Year 2011 for infrastructure projects notified to the Department of Transportation pursuant to Section 44718 of Title 49, United States Code for air navigation hazard assessment (and thus predominantly “outside the fence”). DoD’s “inside the fence” methodology should address the full range of renewable energy technologies and would need to address the full range of mission activities, including those that give rise to “physical” and “spectrum” conflicts, and it should also address project effects both within and across installations. Developing this methodology will require coordination of representative installation-level staff; managers in the Service-level range management offices; OSD’s Training, Readiness, Test and Evaluation offices; OSD's Facilities Energy office; as well as the existing DoD Siting Clearinghouse.

The methodology could be applied in several ways. One option would be to survey many or all CONUS installations using the methodology to identify those areas that are mission-compatible for different kinds of renewable energy development. This option has the advantage of clarifying where (and how much) suitable land is located for further development study, and would be more likely to provide consistent results across installations. A second option would be to wait until a renewable energy developer had initiated conversations with installation staff, and then apply the methodology to that installation for that renewable energy technology. This approach would be less costly than the first option, but would suffer from lack of a consistent approach. Additionally, the first option could be implemented well in advance of any specific renewable energy development proposal being offered, and thus would not add any time to the project analysis process, and, the existence of a national mission compatibility analysis would ensure that neither developers nor installation staff would expend effort on evaluating project ideas located in clearly unsuitable areas.

8.3 Recommended Programmatic Actions

In addition to the policy actions discussed above, the DoD should consider establishing a consistent and comprehensive program to accelerate the development of solar projects on the California installations. The program could involve the following streams of work:

8.3.1 <u>Goal Setting</u>

While it’s tempting to use the MW potential estimates derived in this study to set goals, there are a number of reasons not to follow that path. First, this study’s solar potential estimate relied on Geographic Information Systems (GIS) data from the installations and other regional sources that while extensive and well-integrated, were of varying quality, resolution, age and completeness. Second, even GIS analysis conducted foot-by-foot over hundreds of thousands of acres as conducted here is not a substitute for on-the-ground investigations of a site’s solar development potential; the truth on the ground will often differ from what is shown in the GIS. Third, even if all of the identified potential is in fact “real”, the gross potential may not be a desirable target. The Department may choose instead to pursue a development goal sufficient to meet its statutory and Executive Order mandates. Installations may also choose lower goals to preserve developable acreage for other uses.

Rather than setting a numeric goal for solar development, the DoD should instead consider establishing progress goals for the development process. These could take the form of milestone dates for completion of major steps in the development process, such as completing ―high grading” (see Section 8.3.3 below) within 8 months and completing the initial round of project procurement by the end of 2013.

If incentives are aligned and analytical and contracting resources are available in sufficient quantity to support a scaled-up process, the DoD can expect to receive numerous development proposals. The installations and supporting organizations will be highly motivated to move the projects through the milestones without undue delay. A numerical MW goal may be irrelevant or a needless distraction.

8.3.2 Scale Up Analytical and Contracting Resources

The seven California installations have limited staff to tackle a major expansion of solar development. The Service-level support organizations (e.g., NAVFAC Southwest; AFCESA, MCI-West; Corps of Engineers) can and have offered important assistance in the past, but they too have limited staff to handle a development program of anything approaching this magnitude. Those organizations could use additional expertise across several functions:

- land appraisal;
- mission compatibility analysis;
- biological and cultural resource analysis;
- solar site engineering;
- electrical infrastructure engineering;
- utility account management;
- financial analysis;
- procurement, especially in the context of third-party financing vehicles;
- contracting;
- monitoring and evaluation; and,
- program communications, management and control.

This expertise could provide distributed assistance among the installations and the support organizations. Placing some of the expertise at the support organization level helps to create centers of excellence that can service multiple installations. Some of the expertise could also reside at the installation level; except for the smallest installations, there could be multiple projects under consideration at any time, each of which would need focused input from experts located onsite.

8.3.3 Priority Setting

As discussed in the Solar Potential Assessment chapter, the results of this study are indicative of the technical and economic potential for solar at each installation, but are neither engineering studies nor investment-grade project appraisals. Instead, the Solar Potential Assessment is the first of several steps in the process of procuring solar development.

The next step would be to set priorities. During this stage, installation staff, working with supporting organizations, could ―high-grade" the highest priority sites to pursue in a first, pilot phase of large-scale (>50 MW) solar RFPs. The priority sites would be large parcels that are:

- free of mission conflicts;
- free of known environmental, biological and cultural resource conflicts;
- suitable for solar development from an engineering perspective;
- able to access existing electrical infrastructure if possible; and,
- not slated for any other critical use.

8.3.4 Industry Outreach and Mobilization

In parallel with the priority-setting process, the installations and their support organizations could broaden their outreach to the solar development community. While solar developers are generally aware of the opportunity to bid on solar projects on DoD installations, the creation and roll-out of a large-scale program could be communicated to the development community early, often, and as thoroughly as possible. Developers will be interested to know of a multi-installation program and milestone completion dates. They will want to know how the DoD and BLM intend to manage withdrawn lands, and how DoD will overcome transmission constraints. Perhaps most important of all, developers will see an expansion of DoD staffing and a commitment to use third-party financing authority as signals of the DoD's seriousness and as indicators of the potential scale of this business opportunity.

8.3.5 Project Procurement

Current procurement practice appears to be serviceable for a scaled-up solar development program, but could improve with only modest additional investment of procurement resources. The DoD could continue the current practice of hosting Industry Days and onsite tours of potential solar development project sites. The Services' recent practice of awarding multiple IDIQ development contracts is sensible and should be considered for expansion.

However, the development community will be motivated to fully engage in the process in direct relationship to the quality of the site screening recommended in Section 8.3.3 of this chapter. Developer interest will increase as the clarity of installation site data improves - especially certification that sites are free of conflicts; the DoD has adequate indemnification provisions; and the sites are otherwise suitable for solar development. This is in contrast to a few recent projects offered for bid by the DoD before resolving resource conflicts and policy issues. Unfortunately, developers invested substantial effort in responding to these projects, but found that a long and seemingly endless series of delays still awaited them after project award.

Additionally, the DoD could issue an RFQ or other discovery process before any RFP whereby potential bidders could suggest ways to structure the solar project (and its bid specifications) to maximize its total economic potential. Without this step, the Federal Government may inadvertently include provisions in its RFP specifications that unnecessarily raise project costs and, thereby, lower bidder interest, project returns, and potential rental payments.

8.3.6 Maximizing Value to the Government

As discussed in the Solar Potential Assessment chapter, it appears that the government may be able to extract a larger rental payment (either directly, or in the form of discounted power, or as in-kind consideration) than the BLM is currently set to earn under its standard solar leasing program and under a standard competitive Federal procurement process. This may be the case, in particular, for sizable solar projects in locations with excellent solar economics at the time the procurement is being considered.

While a competitive bidding process could, in theory, provide the government with the best value possible, in reality developers have their own bidding practices that may result in less-than-optimal results for the government in a number of situations. Some developers may not bid on a specific project due to time pressure or for other reasons, resulting in fewer bids. Those developers that do bid will have different expectations of future development costs and revenues, including the cost of solar hardware, installation labor, balance of system costs, and their earnings from power and REC sales.

As an alternative supplement to standard procurement processes, military installations and their supporting organizations could build economic models that replicate the pro forma models used by developers, and use these models in negotiations to drive the best possible bargain consistent with fair market value at the time of the procurement. RFPs could establish the implicit or explicit rental payment as a key evaluation criterion for comparing proposals. Bidder technical capability, creditworthiness, and acceptance of contractual terms could also be among the criteria. Armed with its own modeling framework and data from projects at other DoD installations, the DoD negotiating team can compare offers with its own independent government estimates and press for the arrangement that delivers current fair market value to the government while providing for an acceptable rate of return for the developer and project investors.

8.4 Conclusion

The DoD has the potential to dramatically increase its level of solar development using third-party capital and without compromising mission performance. It is clear that solar developers are highly motivated to pursue projects under present conditions, and those conditions are only expected to improve through 2016 as solar prices continue their expected decline. However, at the end of 2016 the most important solar tax incentive will decrease by two thirds (if not reduced sooner). The DoD is in the position to take advantage of the value offered during this five year window. It will take time to address the preparatory policy steps suggested in Section 8.2 of this report's recommendations and to build and launch the focused development program described in Section 8.3. By pursuing these challenging opportunities, the DoD may be able to take advantage of solar resources on military installations in a manner consistent with the military mission.

Appendix A – Installation and Unit Characterization

A.1 Fort Irwin

Introduction

Fort Irwin and the National Training Center (NTC) serve as the U.S. Army's premier training center. Fort Irwin is located approximately 37 miles northeast of Barstow, California, in the high Mojave Desert, midway between Las Vegas, Nevada, and San Bernardino, California, in central San Bernardino County. The installation is composed of 754,134 total acres and is surrounded by desert hills and mountains. Natural vegetation is sparse and consists of mesquite, creosote, yucca plants, and other low-growing plants.

Fort Irwin maintains a small-town atmosphere with town hall meetings and other community forums even though soldiers from other installations rotate through the NTC several times per year. It is home to 4,709 assigned military; 4,910 rotational soldiers; 7,461 family members; and a civilian workforce of 5,646.

History and Historic Mission

Although the NTC is only 29 years old, Fort Irwin traces its history back to the late 1930s when the War Department identified a need for an anti-aircraft training range. On August 8, 1940, a Presidential Order withdrew an estimated 1,000 square miles of public land from the operation of the public land laws in the high desert area of southern California and called it the Mojave Anti-Aircraft Range. Two years later, the reservation received its official title of Camp Irwin.

In 1944, the camp closed and remained in a caretaker status until 1951, when it was reactivated to become the home of the Army Armor and Desert Training Center. In August 1961, Camp Irwin received its fort status and the designation as a permanent Class I installation. Also during this period, NASA was granted approval to position its Goldstone Deep Space Communications Complex on the installation. In 1973, with the end of the Vietnam War, the government deactivated Fort Irwin, placed it in caretaker status, and turned it over to the state of California for use as a training area by the National Guard and Army Reserve.

In 1978, the outlook for Fort Irwin changed. The Training and Doctrine Command of the U.S. Army was looking for a site to house its NTC. The site had to be large enough and far enough away from civilian populations to be able to provide realistic training. The NTC required at least 400,000 acres for maneuver area and ranges. It also had to have uncluttered airspace and favorable weather conditions. The Army considered 11 sites before it selected Fort Irwin in 1980. It officially opened as Fort Irwin and the NTC in July 1981.

The first training rotation occurred in March 1982. From the beginning, NTC has been hosting 10 brigade combat teams a year for one-month training rotations, which results in the NTC training 50,000 to 60,000 soldiers a year.

Currently, the NTC trains soldiers how to search for insurgents and spot snipers and recognize car bombs and improvised explosive devices in the kinetic battlefield. It also teaches soldiers how to build relationships with the local inhabitants in the non-kinetic battlefield. Officials from many countries visit the NTC and use it as a model to build their own training centers.

Present-Day Mission

Fort Irwin's current mission is to:

- Provide tough, realistic joint and combined arms training
- Focus at the battalion task force and brigade levels
- Assist commanders in developing trained, competent leaders and soldiers
- Identify unit training deficiencies and provide feedback to improve the force
- Prepare for success on the future joint battlefield
- Provide a venue for transformation
- Take care of soldiers, civilians, and family members

National Training Center

The NTC trains by conducting force-on-force and live-fire training for ground and aviation brigades in a joint scenario across the spectrum of conflict. It uses a live virtual-constructive training model, portrayed by a highly lethal and capable opposing force and controlled by an expert and experienced Operations Group. Army and joint service units, along with other governmental agencies, deploy to Fort Irwin for training rotations, which typically involve field training such as situational training exercises and full-spectrum operations.

Each rotation brings 4,000 to 5,000 soldiers who represent major combat, combat support, and combat service support elements of an Army Heavy Brigade Combat Team or Armored Cavalry Regiment. The brigade and its joint partners use the full complement of its combat, combat support, and combat service support systems in an expanded NTC maneuver area that has multiple urban operations sites and portrays the complexity and human dimension of the modern battlefield.

Reserve Component units train in rotations with combat support/combat support service training in support of rotations and Annual Training/Inactive Duty Trainings (AT/IDT) occurring with the use equipment from the Mobilization and Training Equipment Site (MATES). Modernized and fully capable joint organizations, facilities, and equipment support rotational training. NTC has a post-mobilization mission as a center capable of accepting, training, and deploying divisions or separate brigades.

11th Armored Cavalry Regiment

The 11th Armored Cavalry ―Blackhorse" Regiment is the NCR's opposing force (OPFOR). To accomplish its crucial Army training mission, the regiment is organized with one armor squadron, one mechanized infantry squadron, and a regimental support squadron. Supplementing the regiment's warfighting capability are two affiliated National Guard units that round out the regiment's warfighting capabilities under full mobilization: 1) the 1st Squadron, 221st Cavalry, Nevada Army National Guard (ARNG); the regiment's Armored Reconnaissance Squadron, and 2) the 1st Battalion, 144th Field Artillery, California ARNG; the Fires Battalion. Ten times a year, the regiment's troopers provide units from all over the continental United States with the most accurate replication of conditions in theater possible, to prepare them for upcoming deployments to Iraq or Afghanistan. Blackhorse troopers simulate everything from Iraqi town storekeepers to insurgent leaders, giving training units a true test of their lethal and non-lethal skills. Between these rotations, the regiment's troopers focus on individual and crew-level combat proficiency skills to keep current on Army soldier and qualification tasks.

916th Support Brigade

The 916th Support Brigade is responsible for providing world-class integrated Joint, Interagency, Intergovernmental, Multinational (JIIM) contracted support and rotary-wing aviation sustainment to rotational units, NTC customers, and other government and civil agencies. It also supplies trained and ready warriors to support combat operations in the war on terrorism, while simultaneously providing exceptional quality of life to soldiers, civilians, and family members. In addition, it provides integrated sustainment operations at the NTC Forward Operating Bases and ensures seamless sustainment operations of the NTC Prepositioned (PREPO) and Civilian on the Battlefield Vehicles (COB-V) fleets.

Operations Group

The Operations Group's mission to train Army combat units to a demanding standard using realistic scenarios; to provide training feedback to soldiers, leaders, and staff at every level, platoon to brigade; as well as to provide information to units, agencies, and training institutions to improve the force. The Operations Group provides more than 600 After Action Reviews (AAR) every rotation. These AARs contain valuable information that provides battle planning, preparation, and execution feedback to the training units. The group numbers approximately 700 soldiers and is broken down into several field observer and controller teams qualified in the doctrinal conduct of battalions and brigades in combat, combat support, and combat service support operations.

The Operations Group uses modified rotational scenarios to keep pace with the changing world environment. Training units are now challenged with a significantly more complex battlefield that includes civilians, media, United Nations officials, host country representatives, guerrilla forces, provincial reconstruction teams, weapons of mass effect, and war crimes. The goal of these complexities is to replicate for training units the actual conditions they would experience if deployed.

The Operations Group also uses modified scenarios to challenge the new digital systems employed by the Army's modernized forces. These modifications include an increased presence of the opposing force on the battlefield, larger space for battles, and a simulation of the activities of notional adjacent friendly and enemy units. This simulation helps train leaders and staff by ensuring that units with increased battlefield awareness capabilities "see" a large, complex battlefield on their computerized systems.

Reserve Component (RC)

The Reserve Component Operations, Plans & Training (RC-OPT) office serves as the training liaison for all RC units from company to brigade level. The RC-OPT provides operations, training, logistics, and funding guidance to RC units training at the NTC as well as facilitates staff integration, coordination, and information sharing between AC units and RC enablers supporting rotational units up to brigade-size elements. RC-OPT also serves as principal advisor to commanders on matters relating to RC utilization and policies.

Goldstone Deep Space Communications Complex (GDSCC) - Goldstone Deep Space Tracking Facility

The GDSCC, commonly called the Goldstone Observatory, is located about 35 miles north of Barstow inside of the Fort Irwin military reservation, on the western boundary of Restricted Area-2502N. Today, through NASA leasing arrangements with the Army, the GDSCC occupies 132 square kilometers (33,000 acres). It is the largest tracking station in the Deep Space Network (DSN), an international network of large antennas and communication facilities that supports interplanetary spacecraft missions and radio and radar astronomy observations for the exploration of the solar system and the universe.

Part of NASA's Jet Propulsion Lab, the GDSCC's main purpose is to track and communicate with space missions, communicate with deep space probes and satellites, and study asteroids. GDSCC antennas have also been used as sensitive radio telescopes for such scientific investigations as: mapping quasars and other celestial radio sources; radar mapping planets and the moon; spotting comets and asteroids with the potential to impact Earth; and the search for ultra-high energy neutrino interactions in the moon by using large-aperture radio antennas.

Facilities at the GDSCC are clustered at nine separate complexes. Antennas used include eight 34-meter radio dishes and a 70-meter steerable dish. Operated by ITT Corporation for the Jet Propulsion Laboratory, the GDSCC includes the Pioneer Deep Space Station, deactivated in 1981, which is a U.S. National Historic Landmark. Four deep space stations are operational: Echo (DSS 12), Mars (DSS 14), Uranus (DSS 15), and Apollo (DSS 16). A fifth station, Venus (DSS 13), is reserved for research and development; the GDSCC is also a research and development center for advanced systems and prototype equipment that will extend communication ranges, increase data transmission rates, and improve station operations.

Utility Services

Accounts, meters, tariff rates and/or negotiated contracts, and third-party energy supply

Table A.1 – Fort Irwin Utility Overview

Measure	Quantity
Annual Consumption (MWh)	123,000
Monthly High Consumption (MWh)	14,800
Monthly Low Consumption (MWh)	8,200
Monthly High Demand (MW)	29
Monthly Low Demand (MW)	15

Fort Irwin has one main electricity meter connected with SCE that is served under the SCE TOU-8-B utility rate schedule for bundled generation and distribution service. The majority of SCE's distribution charges are determined by the installation's monthly peak demand, so the installation's electricity usage each month determines a minority of its SCE distribution charges. SCE's generation usage charges are time-differentiated into two periods in the winter and three periods in the summer, with higher rates for on-peak periods. This SCE rate schedule also has a large, time-differentiated generation peak demand charge in the summer.

Fort Irwin, unlike some other installations in this study, does not yet participate in SCE's Direct Access program, whereby Fort Irwin could potentially contract for the generation portion of its electricity supply with a competitive market electricity supplier or power authority.

On its main meter, Fort Irwin annually consumes approximately 123,000 MWh, has a peak demand of 29 MW, and spends about $11.5 million on electricity. Its average combined generation and distribution rate is about $94/MWh (or $0.094/ kWh). Fort Irwin provided summary utility data for the period of October 2009 to September 2010, which indicated that the installation's monthly electricity consumption recorded on its utility bills varied from a low of about 8,200 MWh to a high of about 14,800 MWh. The installation's peak demand varied monthly from approximately 15 to 29 MW.

The period of time measured is seven to eight months earlier than the detailed utility bills provided by the other installations in SCE's territory in this study. The difference in periods could account partially for the lower electricity rate of Fort Irwin compared to the other installations. Fort Irwin's high load factor (ratio of average electricity consumption to peak demand) also likely accounts for some of the difference in average electricity costs among installations.

Renewable Energy

In addition to two small distributed solar projects funded in the 2009 fiscal year, Fort Irwin is currently pursuing a 500-MW solar energy development slated to span five sites across the installation. In 2009, the Department of the Army reached agreement with the Clark Energy Group and Acciona Solar Power to construct the five solar developments at Fort Irwin using an enhanced use lease. Three of the five sites are to be located on the GDSCC with the other two located in the southern and eastern portions of Fort Irwin. The initial agreement between the Army and the developers called for the use of both concentrating solar thermal and PV technologies, although military concerns over potential military conflicts with CSP may limit the solar energy developments to PV technologies. Originally slated to be completed in phases beginning in 2013, with a full completion planned for 2022, recent delays have made it unlikely that the solar energy projects will be completed along the original timeline.

Status of Withdrawn Lands

Within Fort Irwin, an area of approximately 118,674 acres is land that the Army withdrew for its use, pursuant to the Fort Irwin Military Lands Withdrawal Act of 2001 (P.L. 107-107, Title XXIX Section 2901 et seq. December 28, 2001). Interspersed within the congressionally withdrawn lands is approximately 15,013 acres of private and state of California-owned inholdings. Approximately 19,643 acres of land on Fort Irwin is proposed to be returned to full training use and 16,901 acres are proposed conservation areas. In total, an estimated 725,062 acres of Fort Irwin are withdrawn lands (Pease, 2011).

Over the past 20 years, several areas of Fort Irwin have been designated off-limits due to environmental and cultural resource requirements and concerns. The most significant reduction in maneuver space came in 1991 when Fort Irwin voluntarily placed approximately 24,000 acres of land and a section to the southwest of the cantonment area off-limits to ground-disturbing training activity as an interim management action for the desert tortoise. This entire area was subsequently designated as desert tortoise critical habitat by the USFWS (50 CFR 17, 59 FR 5820, February 8, 1994).

In 1993, the Army completed a Land Use Requirements Study (LURS) (US Army, 1993) to determine the amount of training land required to meet current and expected future training needs of the NTC. Due to passing years and constantly evolving Army training doctrine, the Army redrafted the LURS in 2002 to reconfirm the need for additional training land as a result of real and anticipated changes in equipment and technology. The 2002 LURS takes into account the types of units, the kinds of maneuvers, and the organizational characteristics of realistic battlefield training missions that exist today and are planned in the near future. Results of the 2002 LURS indicate a need for approximately 624,471 acres of net maneuverable land. Fort Irwin currently has 350,304 acres of maneuverable land available for training, leaving a shortfall of 274,167 acres. The shortfall is based on the acreage required for brigade-size battle scenarios.

Withdrawal and Reservation of Lands for National Training Center

The lands withdrawn within Fort Irwin are solely for use by the Secretary of the Army for the following purposes:

- The conduct of combined arms military training at the NTC
- The development and testing of military equipment at the NTC
- Other defense-related purposes consistent with the purposes specified in paragraphs (1) and (2)
- Conservation and related research purposes

Any changes in these uses must be discussed between the Secretary of the Army and the Secretary of the Interior. In addition, the Secretary of the Army must consult with federally recognized Indian tribes in the vicinity of the lands withdrawn before taking action affecting rights or cultural resources protected by treaty or Federal law.

Management of Withdrawn and Reserved Lands

Throughout the period of the withdrawal and land reservation, the Secretary of the Army is responsible for managing the lands. Military use of the lands that result in ground disturbance, as determined by the Secretary of the Army and the Secretary of the Interior, are prohibited until the Secretary of the Army and the Secretary of the Interior certify to Congress that there has been full environmental compliance in accordance with the FESA of 1973 (16 U.S.C. 1531 et seq.), the National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.), and other applicable laws.

If the Secretary of the Army determines that military operations, public safety, or national security require the closure to the public of any road, trail, or other portion of the lands withdrawn and reserved, the Secretary may take such action as necessary or desirable to effect and maintain such closure. Any closure has to be limited to the minimum areas and periods that the Secretary determines are required for the purposes specified, however.

Immediately preceding and during any closure, the Secretary of the Army must post appropriate warning notices and take other steps, as necessary, to notify the public of the closure. Additionally, the Secretary is required to prepare and implement, in accordance with Title I of the Sikes Act (16 U.S.C. 670 et seq.), an integrated natural resources management plan for the lands withdrawn. Also, in addition to the elements required under the Sikes Act, the integrated natural resources management plan must include the following:

(1) A requirement that any hunting, fishing, and trapping on the lands withdrawn and reserved by this title be conducted in accordance with Section 2671 of Title 10, United States Code
(2) A requirement that the Secretary of the Army take necessary actions to prevent, suppress, and manage brush and range fires occurring within the boundaries of Fort Irwin and brush and range fires occurring outside the boundaries of Fort Irwin that result from military activities at Fort Irwin

Duration of Withdrawal and Reservation

Unless relinquishment is postponed by the Secretary of the Interior, the withdrawal and reservation of the lands completed in 2001 will terminate in the year 2026. At the time of termination of the withdrawal and reservation, the previously withdrawn lands must not be open to any forms of appropriation under the general land laws, including mining laws and mineral and geothermal leasing laws, until the Secretary of the Interior publishes in the *Federal Register* an appropriate order specifying the date upon which such lands shall be restored to the public domain and opened. Lands withdrawn previous to 2001 do not currently have any specific duration or termination date.

<u>Mission Activities</u>

NTC activities center on force-on-force and live-fire training for ground and aviation brigades across the full range of military warfare operations. Army and joint service units along with other governmental agencies deploy to Fort Irwin for training rotations. A typical rotation lasts several weeks and involves field training, including situational training exercises and full spectrum operations.

Fort Irwin Utilization

The southern half of Fort Irwin contains more than 30 non-live fire training areas and numerous ranges for non-dud-producing weapon systems (e.g., service rifles, machineguns). The northern half contains the live-fire training areas, which allow for the employment of dud-producing weapon systems (e.g., mortars, artillery, aviation delivered ordinance). Fort Irwin personnel train 10 Army Brigades (a brigade consists of approximately 4,000 to 5,000 personnel) on a 28- to 35-day rotational basis each year. A typical annual utilization rate is 60,000 personnel trained on the range; during the12-month period beginning June 1, 2010, a total of 60,751 service men and women used Fort Irwin ranges to train for duty in Iraq and Afghanistan (U.S. Army 2011). Goldstone mission activities are described in Section 3.6.

Mission Compatibility

The live-fire and maneuver activities that regularly occur in the north ranges are incompatible with the development of solar energy projects due to the inherent hazards and risks associated with maneuvering large mechanized brigades and employing live ordnance. Additionally, solar energy projects are incompatible with the direct fire ranges and most of the maneuver ranges in the southern region of Fort Irwin. A detailed examination of training range usage patterns before and after the solar build-out, along with surveys of the range users' experiences, will help validate or negate compatibility issues that may apply to future projects. In the future, reexamining range usage and modification to training may be worthwhile after these projects take shape and more solar spectrum compatibility research has been completed.

Biological Issues

Fort Irwin encompasses approximately 754,134 acres, and approximately half of the Fort Irwin land area is used for desert battlefield training. Fort Irwin is situated in the Mojave Desert physiographic province and is characterized by high mountain peaks and ridges that are separated by broad alluvial fans and wide flat valleys. The average elevation of the Mojave Desert in this area is approximately 2,500 feet above mean sea level. The basin and range physiographic province is located to the east, and the Sierra Nevada Range is located to the north of Fort Irwin.

Fort Irwin has a variety of natural vegetation communities and landscape features that offer a diversity of wildlife habitat types. The primary vegetation communities at Fort Irwin include desert sink scrub, saltbush scrub, creosote bush scrub, cheesebush scrub, Mojave wash scrub, Mojave mixed woody scrub, Joshua tree woodland, and alkaline meadow. The most widely distributed plant is the creosote bush (*Larrea tridentata*), which covers extensive areas in nearly pure stands, often in close association with burrobush (*Ambrosia dumosa*).

Creosote bush scrub is the dominant upland community on alluvial fans and has a wide ecological tolerance and can occur in rocky or sandy soils and be an important part of the vegetation in either granitic or carbonate substrate. Creosote bush is relatively tall and broad when compared with other Mojave Desert shrubs and visually dominates the bajadas where it occurs. Creosote bush may be found in pure stands or with various other common and widespread shrubs. Burrobush is the most common shrub found with creosote bush. Other shrub commonly occurring with creosote bush include spiny hopsage, winterfat (*Krashennenikovia lanata*), wolfberry (*Lycium andersonii*), golden cholla, beavertail (*Opuntia basilaris*), Mormon tea (*Ephedra nevadensis and E. californica*) and Acton daisy (*Encelia actonii*).

Saltbush scrub communities are also found at Fort Irwin and are dominated by the following saltbush scrub species: parry saltbush (*Atriplex parryi*), spinescale (*Atriplex spinifera*), shadscale (*Atriplex confertiflora*), allscale (*Atriplex polycarpa*), desert holly, or four-wing saltbush (*Atriplex canescens*). The saltbush scrub community is divided into series, based on the particular dominance of each of the saltbush species listed previously, and these communities occur at various locations throughout Fort Irwin.

The Joshua tree woodland is restricted to the wetter, higher elevations of the Mojave Desert and occurs in the upper reaches of the creosote bush scrub zone on deep valley soils or shallower hillsides. Joshua trees can also occur as scattered individuals at lower elevations along drainages into saltbush communities near lake beds. Within the community, the concentration of Joshua trees often increases with an increase in elevation, and the understory shrub diversity also tends to become more diverse in increasingly rocky and sandy soils. The most common understory species are creosote bush and burrobush.

These habitat types are further defined by a number of distinct landscape features, such as washes and gullies, rock outcrops, cliffs and talus slopes, cave entrances, springs, and seeps. All contribute to the diversity and abundance of wildlife in the area, as they generally provide a microhabitat for wildlife uniquely adapted to or dependent on these features. Seeps and springs provide perennial sources of water and a high concentration of vegetation and cover that contribute to increased wildlife diversity in these areas. A variety of invertebrates, reptiles, birds, and mammals occur across Fort Irwin.

Sensitive plant species at Fort Irwin include the alkali mariposa lily (*Calochortus striatus*), Barstow woolly sunflower (*Eriophyllum mohavense*), Clokey's cryptantha (*Cryptantha clokeyi*), crucifixion thorn (*Castela emoryi*), desert cymopterus (*Cymopterus deserticola*), Lane Mountain milk-vetch (*Astragalus jaegerianus*), Mojave monkeyflower (*Mimulus mohavensis*), Parish's phacelia (*Phacelia parishii*), and the small-flowered androstephium (*Androstephium breviflorm*). The Lane Mountain milk-vetch is federally listed as endangered, whereas the other floral species are listed as sensitive on several Federal, State, and local listings.

Fort Irwin is inhabited by an abundance of wildlife species, including an abundance of invertebrate species (and a large number of insects) and reptiles such as the Zebra-tailed lizards (*Callisaurus draconoides*), side-blotched lizards (*Uta stansburiana*), and western whiptails (*Cnemidophorus tigris*). Bird species have different occurrence patterns at Fort Irwin and may occur as permanent residents, overwinter residents, nesting residents, or they may occasionally pass through during migration. The most commonly observed birds include black-throated sparrows (*Amphispiza bilineata*), house finches (*Carpodactus mexicana*), western kingbirds (*Tyrannus verticalis*), and cactus wrens (*Camplylorhynchus brunneicapillus*), which use the cholla and Joshua trees for nesting. Red-tailed hawks (*Falco jamaicensis*) are the most common raptor, barn owls (*Tyto alba*) are the most common nocturnal avian predator, and turkey vultures (*Cathartes aura*) occur during fall during migration. Several species of shore birds may be seen using lake beds, which often contain standing water after heavy rains, including black-necked stilts (*Himantopus mexicanus*), long-billed curlews (*Numenius americanus*), and American avocets (*Recurvirostra americana*).

Numerous mammal species are occur at Fort Irwin; small mammals include hares and cottontails, antelope ground squirrel (*Ammospermophilus leucurus*), Mohave ground squirrel (*Spermophilus mohavensis*), Merriam's rat (*Dipodomys merriami*), Panamint rat (*Dipodomys panamintinus*), desert kangaroo rat (*Dipodomys deserti*), and deer mice (*Peromyscus maniculatus*). The most common large mammal at Fort Irwin is the coyote (*Canis latrans*), while kit fox (*Vulpes macrotis*), bobcats (*Lynx rufus*), badgers (*Taxidea taxus*), Nelson's bighorn sheep (*Ovis canadensis nelsoni*), and mountain lions (*Felis concolor*) may also occur. Mineshafts, natural caves, and rocky outcrops at Fort Irwin provide potential roosting and nesting habitat for bats, which include the western pipistrelle (*Pepistrellus hesperus*), California myotis (*Myotis* *californicus*), Townsend's big-eared bat (*Corynorhinus townsendii*), and the western mastiff bat (*Eumops perotis*).

More than 30 sensitive animal species occur at Fort Irwin, the most prominent of which are the desert tortoise (*Gopherus agassizii*), golden eagle (*Aquila chrysaetos*), least Bell's vireo (*Vireo bellii pusillus*), mountain plover (*Charadrius montanus*), southwestern willow flycatcher (*Empidonax traillii extimus*), yellow-billed cuckoo (Coccyzus americanus), Mohave ground squirrel, and Nelson's bighorn sheep. By far, the desert tortoise is the most prominent sensitive species and at present, the Biological Opinion for the ongoing mission requires halting military training activities whenever a tortoise is encountered, with subsequent relocation of the animal before military maneuvers resume. The most common and widespread invasive, non-native annual species found at Fort Irwin include red brome (*Bromus madritensis rubens*), split grass (*Schismus barbatus*), cheat grass (*Bromus tectorum*), red-stemmed filaree (*Erodium cicutarium*), biennial mustard (*Hirschfeldia incana*) and Sahara mustard (*Brassica tournefortii*). In addition, a large number of invasive weeds (as many as 50 species) can become locally common as a result of supplemental irrigation in disturbed areas, within drainage ditches, near landscaping, and near farm fields.

Cultural Issues

At Fort Irwin, prehistoric resource types include lithic scatters, lithic reduction sites, lithic quarries, campsites, habitation sites, food processing sites, rock shelters, rock art, rock alignments, stone circles, cleared circles, hearths, and trails. The Fort Irwin area has a history dating back almost 15,000 years, when Native Americans of the Lake Mojave Period were believed to live in the area. Native American settlements and pioneer explorations in the area were first recorded when Father Francisco Garces, a Spaniard, traveled the Mojave Indian Trail in 1796. During his travels, he noted several small bands of Indians and is believed to have been the first European to make contact with the Native Americans of this area.

Historic resources at Fort Irwin include mining sites, military sites, ranching sites, homestead sites, refuse disposal sites, campsites, rock alignments, roads, and trails. Jedediah Smith is thought to have been the first American to explore the area in 1826 and was soon followed by other pioneers traveling the Old Spanish Trail between Santa Fe and Los Angeles where Bitter Springs, on the eastern edge of Fort Irwin, was a favorite stopover site.

Only one documented paleontological site occurs within the Fort Irwin boundary, adjacent to a dry Pleistocene Period lake bed. Excavations conducted at this site recovered 8,332 specimens from 24 different taxa of plant and animals, including the remains of tortoise, large camel, small and large horse, mammoth, dire wolf, shortfaced bears, coyotes, rabbits, rats, and mice. While the age of some of the fossilized specimens may be as much as 1.8 million years old, the majority of the specimens date between 450,000 and 10,000 years before present.

Cultural resources located at Fort Irwin are considered fragile, nonrenewable resources representing thousands of years of human history. The importance of these sites lies in their ability to contribute information to help develop a better understanding of human adaptation to an arid, marginal environment over a long period of time. Fort Irwin and the NTC manage the resources under their purview according to all applicable cultural resources laws and regulations.

A.2 Naval Air Weapons Station (NAWS) China Lake

Introduction

NAWS China Lake is where the Navy and Marine Corps have developed or tested nearly every significant airborne weapon system in the past five decades. China Lake carries out the complete weapon-development process, from basic and applied research through prototype hardware fabrication, test, and evaluation; documentation; and fleet and production support. The installation provides and maintains land, facilities, and other assets that support the Navy's RDTE of cutting-edge weapons systems for the warfighter.

The installation is the Navy's largest single landholding, representing 85 percent of the Navy's land for RDTE use and 34 percent of the Navy's land holdings worldwide, encompassing 1.1 million acres of land in California's northern Mojave Desert. Located 150 miles northeast of Los Angeles, the land ranges in altitude from 2,100 to 8,900 feet and varies from flat, dry lake beds to rugged pine-covered mountains. The majority of the land is undeveloped and provides habitat for more than 340 species of wildlife and 650 plant types. NAWS China Lake is home to approximately 4,400 civilian employees, 1,000 military personnel, and more than 1,500 contractor employees.

History and Historic Mission

During World War II, the Navy found it needed facilities for testing and evaluating rockets that the California Institute of Technology (Cal Tech) was developing for the organization. At the same time, it needed a new proving ground for all aviation ordnance. Cal Tech's Dr. Charles C. Lauritsen and Commander Sherman E. Burroughs met and formed a pact to find a site meeting both their needs.

In the summer of 1943, while searching for an adequate site, Dr. Lauritsen found a two-way landing strip near Inyokern. It was surrounded by nothing but miles of empty desert, yet it was within a reasonable distance from Cal Tech's Pasadena base. The Naval Ordnance Test Station (NOTS) was thus formally established on November 8, 1943, and its mission was defined in a letter by the Secretary of the Navy as "...a station having for its primary function the research, development and testing of weapons, and having additional function of furnishing primary training in the use of such weapons."

Testing began at China Lake within a month of the station's establishment. The vast, sparsely populated desert around China Lake and Inyokern, with near-perfect flying weather and practically unlimited visibility, proved an ideal location not only for testing and evaluation (T&E) activities but also for a complete research and development (R&D) establishment. The early Navy-Cal Tech partnership established a pattern of cooperation and interaction among civilian scientists and engineers and experienced military personnel that transformed China Lake into one of the preeminent RDTE institutions in the world.

In July 1967, the NOTS China Lake and Naval Ordnance Laboratory in Corona, California, merged to become the Naval Weapons Center. Subsequently, the National Parachute Test Range in El Centro was transferred to China Lake in July 1979. In January 1992, the Naval Weapons Center and the Pacific Missile Test Center Point Mugu were disestablished. They joined the naval units at Albuquerque and White Sands, New Mexico, to be established as a single command called the Naval Air Warfare Center Weapons Division. The physical plant at China Lake was the host of the Weapons Division of the Naval Air Weapons Station, performing the main base-keeping functions.

Present-Day Mission

Today's mission of the NAWS China Lake is not much different than it was when the station was first established in 1943: to support the Navy's RDTE missions to provide cutting-edge weapons systems to the warfighter. China Lake carries out the complete weapon-development process from basic and applied research through prototype hardware fabrication, test, and evaluation, documentation, and fleet and production support.

Major China Lake programs include RDTE and support for air-to-air missiles; surface-to-air, and air-to-surface missiles and free-fall weapons; anti-surface weapon systems; cruise missiles; anti-radiation-missile programs; parachute systems and subsystems for aircrews and equipment; avionics hardware and software and total-combat-system operational flight programs (OFPs) for most Navy fighter and attack aircraft; and tactical electronic-warfare and countermeasures systems.

NAWS China Lake’s analysis and T&E capabilities and projects remain unmatched, with simulation of threat weapon systems; major electronic-warfare threat-simulation facilities; and complete test and evaluation—static, live fire, captive-carry, supersonic-track, environmental, radar cross-section—of a wide range of anti-air and anti-surface systems. Contributing to and complementing these projects are broad technology-based efforts, which range from basic research in physics and chemistry to applied projects in energetic materials, embedded computers, specialized semiconductor and superconductor materials, and lasers and optics.

More than 18,000 manned and unmanned military sorties are conducted out of China Lake’s Armitage Field by all U.S. services each year. The restricted airspace used by China Lake aviators is composed of 19,600 square miles of controlled airspace, totaling 12 percent of California’s total airspace, and provides an unprecedented venue for integrated testing and training of today’s warfighter. In addition, foreign military personnel use the airfield and ranges to conduct more than 500 test and evaluation operations each year. As of 2010, about 95 percent of its 1.1-million acres has remained undisturbed during the course of executing the NAWS mission.

Naval Air Warfare Center Weapons Division (NAWCWD)

The NAWCWD is an organization within the Naval Air Systems Command (NAVAIR) dedicated to maintaining a center of excellence in weapons development for the Navy. The NAWCWD is the Navy's field activity for weapon system non-nuclear survivability, weapons lethality, and live-fire testing; its land test range is located at China Lake and its sea test range at Point Mugu. The NAWCWD works in many high-tech areas, including battlespace integration, airborne electronic attack, aircraft survivability, counter-improvised explosive devices, directed energy, robotics, and energetics.

The NAWCWD Weapons Survivability Laboratory (WSL) at China Lake conducts survivability testing for all three major services and industry to provide empirical data on the vulnerability of aircraft to actual threats. In addition, a complete machine shop is on site for fast repair and modification of aircraft and test articles. Testing on full-scale aircraft includes propulsion systems, ballistic impact, hydraulic ram effects on fuel systems, fire detection and extinguishing, fuel ingestion, engines under simulated full-operating conditions, warhead detonations, thermal and structural tests, infrared (IR) signature tests, static and simulated in-flight crew ejections, pool fire, communication link payout, and aerodynamic studies. Testing is performed under rigidly controlled and highly realistic conditions.

Air Test and Evaluation Squadron Nine (VX-9)

In June 1993, the Chief of Naval Operations directed that the naval fighter aircraft community's Air Test and Evaluation Squadron Four VX-4 at NAS Point Mugu, California, and VX-5, be merged into a single operational test and evaluation squadron to be designated as Air Test and Evaluation Squadron Nine (VX-9), with a permanent F-14 Tomcat Detachment to be located at Point Mugu.

VX-9 conducts operational test and evaluation of all air-to-ground weapons, air-to-air weapons, sensors, electronic warfare systems, and mission software upgrades to aircraft and weapon systems. More than 350 VX-9 personnel maintain and fly a diverse fleet of 28 aircraft used in the demanding and dynamic role of operational flight test, supporting both Navy and Marine Corps tactical aviation. VX-9 currently operates and tests the FA-18E/F Super Hornet, FA-18C/D Hornet, AV-8B Harrier, EA-6B Prowler, EA-18G Growler, as well as the AH-1W/Z Cobra and UH-1Y helicopters.

Air Test and Evaluation Squadron 31 (VX-31)

VX-31 provides aircraft, test pilots, project officers, and flight test planning oversight for RDTE of current and future manned and unmanned aircraft, weapons, and weapons systems. VX-31 is tasked with a more scientific approach to RDTE than normally takes place at China Lake. The squadron routinely flies approximately 4,000 flight-hours each year, employing unique manned test assets and unmanned aerial vehicles (UAV) and also operates the Airborne Test Bed program to provide cost-wise support to the Navy’s research community.

A highly diverse workforce consisting of active duty military officers and enlisted personnel, DoD civil service professionals, and contractor team members, VX-31 actively supports daily flight tests, ground tests, and other data-gathering activities. Along with RDTE responsibilities, VX-31 is also responsible for search and rescue (SAR) and passenger/cargo shuttle operations between China Lake and Point Mugu.

Marine Aviation Detachment (MAD)

Marines stationed at China Lake and Point Mugu are on the cutting edge of technology for weapons, weapon systems, and electronic warfare development, test, and evaluation. The mission of the MAD China Lake/Point Mugu is to:

- Provide project management, aviation support, and technical expertise and fleet support for assigned Marine Corps weapons systems and related devices throughout the weapons systems life cycle
- Provide administrative and logistical support for Marines assigned to Naval Air Warfare Center, Weapons Division, Air Test & Evaluation Squadron Nine, and all Marines at China Lake and Point Mugu
- Provide support to Marine officers assigned to the Air Force Test Pilot School at Edwards Air Force Base

Explosive Ordnance Disposal (EOD) Detachments

Navy EOD forces are composed of highly trained, skilled technicians who are experts in explosives, diving, and parachuting. Aboard NAWS China Lake, EOD detachments provide support for weapons tests, explosive hazardous waste treatments, emergency response incidents, and training. The following detachments are located on China Lake:

EODMU3 Detachment
In addition to general mobile unit duties, the EODMU3 detachment provides test support for Naval Air Warfare Center Weapons Division and explosive hazardous waste treatments at NAWS China Lake, as well as emergency response for incidents on and off station.

EODTEUONE Detachment
The EODTEUONE Detachment maintains the EOD Advanced Training Facility at China Lake for pre-deployment training of EOD teams.

Utility services

Accounts, meters, tariff rates and/or negotiated contracts, and third-party energy supply

Table A.2 – NAWS China Lake Utility Overview

Measure	Quantity
Annual Consumption (MWh)	97,000
Monthly High Consumption (MWh)	10,400
Monthly Low Consumption (MWh)	6,900
Monthly High Demand (MW)	21
Monthly Low Demand (MW)	14

NAWS China Lake has one main electricity meter connected with SCE that is served under the SCE TOU-8-B utility rate schedule for bundled generation and distribution service. SCE's generation usage charges are time-differentiated into two periods in the winter and three periods in the summer, with higher rates for on-peak periods. This SCE rate schedule also has a large, time-differentiated generation peak demand charge in the summer.

This installation, unlike Marine Corps Logistics Base (MCLB) Barstow and Marine Corps Air Ground Combat Center (MCAGCC) Twentynine Palms, does not yet participate in SCE's Direct Access program, whereby the installation could potentially contract for the generation portion of its electricity supply with the WAPA in the competitive market like the other two large military installations. NAWS China Lake has plans to pursue WAPA competitive supply.

On its main meter, NAWS China Lake annually consumes approximately 97,000 MWh, has a peak demand of 21 MW, and spends about $11.6 million on electricity. Its average, combined generation and distribution rate is about $120/MWh (or $0.12/kWh). This total cost can be divided into about $43/MWh in distribution charges and $77/MWh in generation charges from SCE. Over the reference period of May 2010 to April 2011, the installation's monthly electricity consumption recorded on its utility bills varied from a low of about 6,900 MWh to a high of about 10,400 MWh; the installation's peak demand varied monthly from approximately 14 to 21 MW.

Renewable Energy

The Navy's goal is to obtain half its energy from renewable sources by 2020, but China Lake has set an even more ambitious goal: to be a net-zero energy consumer by then. The installation is home to the Coso Geothermal Field. Developed in the 1980s using the area's natural geothermic activity to generate electricity, the Coso Geothermal Plant has a capacity of 270 MW and generated more 1.6 million MWh of electricity in 2010 for sale to the local utility. Through 2009, the Coso Geothermal Plant had generated $380 million in revenue for the Navy over its lifetime (GPO, 2010). The field's electricity generation is equal to 16 percent of the entire Navy's electricity consumption at shore facilities.

In addition to the Coso Geothermal Plant, the Navy has developed 12 distributed solar energy projects at the military installation in recent years, totaling well over 1 MW in installed capacity. Among China Lake's 2010 solar energy projects was the installation of 688 kW of PV solar energy capacity on the top of carports at three parking lots. These carports provide shade and lower the temperature in the vehicles parked underneath them by at least 20 degrees. In addition, China Lake has utilized solar PV arrays to provide power to two remote outposts of the installation to save money and reduce the frequency of diesel fuel shipments.

In February 2010, the U.S. Navy awarded a $200-million indefinite delivery/indefinite quantity (IDIQ) contract to five solar energy developers to construct, own, operate, and maintain up to 40 MW of solar energy capacity located on military installations in the southwest United States and sell the resulting power to the Navy. China Lake is expected to be one of the first installations to receive a solar energy facility through this contract. The proposed facility will utilize PV technology and could be as large as 13 MW in capacity.

<u>Status of Withdrawn Lands</u>

NAWS China Lake's most recent land withdrawal was enacted in 1994 with the passage of the California Military Lands Withdrawal and Overflights Act, which reauthorized the Navy's continued use of public withdrawn lands to support China Lake's RDTE and training missions. This land withdrawal extends for 20 years and will expire in 2014 without a legislative extension. As part of the land withdrawal, the Navy was required to develop a comprehensive land use management plan (CLUMP), in accordance with the requirements of the Federal Land Policy and Management Act by October 1997. Proposed land uses include ongoing and future military operations, public health and safety practices, and ongoing and future environmental resources management and conservation at NAWS China Lake.

With the impending expiration of the 1.1-million-acre land withdrawal for NAWS China Lake, the Navy has begun working with the BLM to complete a legislative environmental impact statement (EIS) for a 25-year extension of the China Lake land withdrawal. As part of the land withdrawal, the Navy is proposing to update the installation's CLUMP and expand the installation's testing and training tempo to address the increased demands place on the installation's unique RDTE capabilities. A draft EIS is not expected to be complete before the spring of 2012 with a final EIS expected the following year, which still provides two years for Congress to take action to extend the land withdrawal before it expires at the end of October 2014.

Mission Activities

The mission of China Lake is to support the Navy's research and T&E missions to provide cutting-edge weapons systems to the warfighter. China Lake is where the Navy carries out the complete weapon-development process from basic and applied research, through prototype hardware fabrication, test and evaluation, documentation, and fleet and production support. China Lake's analysis and T&E capabilities and projects remain unmatched for simulation of threat weapon systems; major electronic-warfare threat-simulation facilities; and complete test and evaluation—static, live-fire, captive-carry, supersonic-track, environmental, radar cross-section—of a wide range of anti-air and anti-surface systems. Contributing to and complementing these projects are broad technology-based efforts, which range from basic research in physics and chemistry to applied projects in energetic materials, embedded computers, specialized semiconductor and superconductor materials, and lasers and optics

Range Utilization

More than 18,000 manned and unmanned military sorties are conducted out of China Lake's Armitage Field by all U.S. services each year. The restricted airspace used by China Lake aviators includes 19,600 square miles of controlled airspace—12 percent of California's total airspace—and provides an unprecedented venue for integrated testing and training. Foreign military personnel also use the airfield and ranges to conduct more than 500 test and evaluation operations each year. China Lake is unique in that as a testing and evaluation facility, its land and range use change depending on current test requirements. Because of the testing that occurs, the airspace required to support China Lake operations is quite large and includes airspace also used by Edwards Air Force Base and Fort Irwin. Additionally, target and land ranges of China Lake are found in two separate tracts of land: North Range Complex and the NAWS South Range Complex.

Range usage at China Lake falls into three major categories: R&D, T&E, or training (T) activities. R&D and T&E activities are the primary mission activities at China Lake. Training activities are scheduled on a not-to-interfere basis. The range utilization can be summarized across the following activity categories:

- Air-to-air operations (R&D, T&E, T)
- Surface-to-air operations (R&D, T&E, T)
- Air-to-ground operations (R&D, T&E, T)
- Surface-to-surface operations (R&D, T&E, T)
- Energetics, such as explosives, propellants, and pyrotechnics (R&D, T&E, T)
- Electromagnetics (R&D, T&E, T)
- Test track (R&D, T&E)

- Air combat, aircrew, and combat skills training (T)
- Ground troop training Type I and II (T)

Historic annual range utilization (from 2007 and 2008) can be summarized as 9,829 sorties; 575 energetic tests; 18 test track operations; 100 test days of directed energy operations; and more than 75 combined ground troop training events. Ordnance expenditures included 11,528 bombs; 97,887 gun munitions; 708 rockets; 109 missiles; 56,632 pounds of energetic materials (e.g., C-4, TNT); and 631,249 pounds of propellants.

Mission Compatibility

China Lake's mission of weapons- and systems-related T&E is largely incompatible with large-scale solar development. The overlying hazard zones cover nearly all the land, and they are within the potential impact area for weapons test activity. The spectral conflicts have a profoundly adverse effect on the pristine test environment currently enjoyed and required by the resident test community. Complicating the issue for China Lake is the complete envelopment of the installation by the R- 2508 restricted airspace and its heavy use by the test community to fulfill its requirements to access the ground ranges from all directions. Ranges at China Lake are therefore considered unsuitable for large-scale solar development due to mission incompatibility.

<u>Biological Issues</u>

NAWS China Lake is home to an exceptionally diverse flora and fauna due to a number of factors—in particular, its large size being well over 1 million acres. Approximately 675 known unique vascular plant taxa are found on the property, including monocots, dicots, conifers, ephedras, ferns, and fern allies, and fungi. The installation's water resources include natural springs, seeps, and the water treatment facilities. The wide-ranging elevation gradients spread across the broad Mojave Desert expanse supports and equally high diversity of flora that includes approximately 35 species of reptiles and amphibians, 322 species of birds, and 58 species of mammals.

As diverse as the fauna of NAWS China Lake is, only five species are federally listed as endangered, and only four are federally listed as threatened; only seven are state-listed as endangered, and only three are state-listed as threatened. Of the endangered or threatened species, only three present management issues for NAWS China Lake; the Mohave tui chub, the desert tortoise, and Inyo California towhee. The remainder includes seven transient species, one vagrant species, and one species with unknown status on NAWS China Lake.

The Mohave tui chub (from the fish family that includes carps and true minnows) was federally listed as endangered in 1970 and state-listed as endangered in 1971. The largest known population of Mohave tui chub is in the Lark Seep/G-1 Seep system on NAWS China Lake. The Lark Seep/G-1 Seep drainage system consists of two seeps and about 5 miles of inter-connecting channels. Initially 400 chub were introduced into the Lark Seep lagoon. As the population grew, the fish migrated into the channels. Studies indicate that typically 90 percent of the chub are found in the channels. Slow flowing water within channels is thought to emulate the chub's natural river habitat. The installations' Mohave Tui Chub Recovery Plan contains inventory and monitoring techniques, minimum water levels, and recommended water-quality standards for survival of the chub.

The Mojave population of desert tortoise was federally emergency listed as endangered in August 1989. NAWS China lake tortoise populations are within the West Mojave Recovery Unit, which has sustained severe and rapid population declines of up to 10 percent or more annually since about 1980. Evidence of upper respiratory tract disease or die-offs has not been documented in the NAWS China Lake population. Desert tortoise are a long-lived species (more than 60 years) found in creosote bush scrub, saltbrush scrub, and Joshua tree woodland plant communities from about 1,000 to 3,800 feet elevation. At NAWS China Lake, tortoises are found in all of these habitat types. The highest density tortoise habitat tends to be on gently sloping bajadas in creosote bush scrub with sandy-loam to pebbly soils.

The Inyo California towhee (from the avian family that includes sparrows, buntings, and juncos) was federally listed as threatened in 1987, as the entire population is confined to a very limited habitat, which has been altered and could be further adversely impacted by future land use changes. Inyo California towhees are essentially non-migratory; however, during extreme winter weather they may move attitudinally. Territories are centered around desert riparian vegetation but range into adjacent upland plant communities. The upland plant community surrounding the riparian habitat may be Mojave creosote bush scrub, Mojave mixed woody scrub, blackbrush scrub, or big sagebrush scrub with or without a Joshua tree overstory. It appears that one of the primary reasons that towhees have expanded their range is due to the extensive and ongoing efforts to remove feral burros from the riparian habitats throughout the Argus Range. It further appears that towhees can utilize marginal habitats. These marginal sites may benefit the overall stability and long-term viability of the population.

Four introduced bird species, the chukar, rock dove, European starling, and house sparrow, are present on NAWS China Lake. The chukar is a gamebird in mountainous areas on the North and South ranges. Rock doves, European starlings, and house sparrows are common within the housing area. Two other species, the seesee partridge and crested tinamou, were introduced on the North Range by the CDFG in the late 1960s. The introduction was not successful, and neither species has been observed since its release. Feral horses and burros are two introduced mammals that have successfully established large populations on the ranges.

Of the approximately 675 unique vascular plant taxa are known to occur on NAWS China Lake, as many as 900 unique taxa may occur on site. In comparison, approximately 3,000 vascular plant taxa are known from the California desert region. Thus, NAWS China Lake plant diversity probably represents 20 to 30 percent of the taxa known for the region, within which NAWS occupies only 2 to 3 percent of the California Desert Region.

NAWS China Lake has no federally listed endangered or threatened plant species but is home to 33 rare species. More recently, vegetation surveys have become a frequent component of the environmental assessment process at NAWS China Lake. Areas that have had significant plant surveys include Cactus Flats; K2 Track; Mountain Springs Canyon; Randsburg Wash; Moscow, Wilson, Haiwee, and Margaret Ann Springs; and the Coso Geothermal Area. Plant species that have received special survey attention include creosote bush clonal rings (*Larrea tridentate*), the

Mojave fishhook cactus (*Sclerocactus polyancistrus*), Panamint bird's beak (*Cordylanthus eremicus* ssp. *Eremicus*), Coso Mountains lupine (*Lupinus magnificus* var. *glarecola*), and gypsum linanthus (*Linanthus arenicola*). General floristic and plant community surveys are routinely conducted in association with GIS development, the NAWS China Lake Range EIS, and the ongoing Integrated Natural Resource Management Plan (INRMP) development and improvement.

Managing channel vegetation has been a top priority for NAWS China Lake. Channel vegetation—mainly cattails and rushes—must be removed annually to keep water flowing. Vegetation is removed with a gradeall earth-mover using in-house personnel and equipment. Because the channels were originally constructed to divert water flow from adjacent facilities, funding for vegetation removal has historically been furnished by the Pacific Ranges and Facilities Department. Other funding sources are currently being investigated.

Several pest species are present at NAWS China Lake. Common ravens were native to mountain ranges in and around the Mojave Desert; however, dumps and road kills have enabled ravens to survive summers and winters in the desert. During spring, common ravens can disperse and breed throughout much of the desert. The common raven is a potential pest species because it is known to eat juvenile desert tortoises, a federally and state-listed endangered species. Another potential problem with ravens is their proclivity to nest on power poles. They tend to construct nests on double-arm poles or on transformers, which has the potential for power shorts and disruption.

<u>Cultural Issues</u>

NAWS China Lake contains a wealth of prehistoric archaeological resources. The area is particularly famous for its large obsidian quarries, world-class rock art, and concentrations of terminal Pleistocene and early Holocene artifacts along the ancient shores of China Lake. The archaeological record at NAWS China Lake is truly outstanding, both with respect to its chronological depth and the variety of materials represented. The Late Pleistocene/early Holocene resources around the China Lake Basin remain intriguing to archaeologists to this day, as this area is among the few known locations in North America with both late Pleistocene megafauna and early cultural deposits. Future work at this location may prove to be pivotal in establishing if the association is real and synchronous.

NAWS China Lake also contains thousands of archaeological sites dating throughout the Holocene, or past 10,500 years. The Coso Obsidian Quarries and the Coso Rock Art Area routinely are prominently featured and incorporated in archaeological overviews of the western United States because of the kin, quantity, quality, and condition of these sites. At various periods in the past, obsidian from the Coso quarries was a toolstone traded and used through southern California and the southwestern Great Basin. The Coso Rock Art Landmark contains one of the largest, most impressive, and most pristine concentrations of prehistoric art in the United States.

NAWS China Lake also contains numerous undisturbed late period open-air sites and rock shelters. The latter occur throughout portions of the South Range Complex as well as the Darwin Wash and uplands portions of the North Range Complex. They are noteworthy because they often contain preserved organic materials such as plant and animals remains, hides, basketry, and other textiles. A few prehistoric burials have been discovered, and they tend to been recovered from the dry rock shelters.

NAWS China Lake contains a broad variety of historic-era resources and documents major shifts in land use during the past 150 years. Trappers, missionaries, and settlers traversed the area beginning in about 1830, but they found little reason to stay. The earliest historic resources tend to be affiliated with prospecting and mining, followed shortly thereafter with homesteading and ranching. The Coso Range contains remnants of the earliest mining community at NAWS China Lake, Coso Village, first occupied in the 1860s. The earliest military facility established at NAWS China Lake was built nearby, sometime between 1861 and 1866, apparently to address conflicts between early settlers, miners, and Native Americans. Freight routes and way stations followed shortly thereafter, to transport supplies to miners and ranchers and to haul away the ores, minerals, and precious metals to processing facilities and urban and industrial communities. Homesteading was sporadic and occurred mostly in the early 1900s, and by the beginning of World War II there were fewer than 100 people residing in the region. In the early 1940s, the area shifted to its current military use. For the past 50 years, NAWS China Lake has figured prominently in modern weaponry, particularly aircraft-fired rockets and guided missiles.

A.3 Naval Air Facility (NAF) El Centro

Introduction

NAF El Centro's mission is to provide installation support to Naval Aviation Squadrons and maintain target ranges for their weapons and combat air training. The installation also supports Marine Aviation units, air elements from the Army and Air Force, and international units.

Because of its unique location, NAF El Centro is known to every naval aviator and plays a key role in their initial and refresher training. What makes El Centro stand out is its combination of unique climate, vast unobstructed desert terrain, limited non-military air traffic, and its own dedicated gunnery and bomb ranges. These factors make NAF El Centro an ideal environment for aerial combat maneuvering, air-to-air gunnery, bombing practice and electronic warfare training.

History and Historic Mission

NAF El Centro was commissioned on May 1, 1946, as a Naval Air Station. Prior to that, the installation was a Marine Corps Air Station. Through the years, NAF El Centro has had several names: Naval Air Facility, Naval Auxiliary Landing Field, Naval Air Station, and the National Parachute Test Range.

For the first 35 years, the mission of NAF El Centro was devoted to aeronautical escape system testing, evaluation, and design. In November 1947, the Parachute Experimental Division from Lakehurst, New Jersey, moved to El Centro.

In 1951, the Joint Parachute Facility was established and consisted of the Naval Parachute Unit and the Air Force 6511th Test Group (Parachute). The Air Force remained part of El Centro's test organization for the next 27 years. In 1959, an ejection seat designed for pilot escape from a high-speed jet at altitudes less than 1,000 feet was successfully tested here. The Mercury Space Program parachute system, used for the first U.S. manned satellites and the Apollo re-entry system, was also tested here.

In 1964, the U.S. Naval Aerospace Recovery Facility was designated and on July 1, 1973, it was combined with NAF El Centro to form the National Parachute Test Range. Exactly six years later, the parachute test mission was transferred to NAWS China Lake, and El Centro again became a Naval Air Facility.

Present-Day Mission

Today, NAF El Centro provides realistic training to active and reserve aviation units and activities of the Navy's operating and training forces. Squadrons visit NAF El Centro to practice gunnery, bombing, carrier landings, and air combat. Many believe the training at NAF El Centro is as close as pilots can get to actual air combat.

The facility has two operating runways. The 9,500-foot east-west runway handles 96 percent of the traffic. It is equipped with a Fresnel Lens Optical Landing System at each approach end as well as lighted carrier deck landing areas at both ends so pilots can simulate carrier landings.

Apart from "touch and go" landings and take-offs, aircrews use the many ranges at NAF El Centro to develop their skills. A remote-controlled target area allows naval aviators to practice ordinance delivery. The desert range is used for air-to-ground bombing, rocket firing, strafing, dummy drops, and mobile land target training. The target complex uses the Weapons Impact Scoring System that microwaves target images to a range master control building for immediate verification of weapons delivery accuracy.

The addition of the Display and Debriefing Subsystem (DDS) expanded the role of NAF El Centro to include air combat training by utilizing remote television, acoustical, and laser scoring systems. The DDS is linked with Tactical Aircrew Combat Training System (TACTS) to provide a computerized record of the tactics employed by individual aircrews and to evaluate the effectiveness of each maneuver.

Variable climatic conditions and population are limiting factors at the Navy's only other facilities with similar missions—Fallon, Nevada, and Key West, Florida. As a result, NAF El Centro is very busy and in high demand. On a typical day, more than 450 flight operations occur between 7 a.m. and 11 p.m.

NAF is the "winter home" of the world-famous Blue Angels, the Navy's Flight Demonstration Squadron. Starting every January, the ―Blues" conduct more than two months of intense flight operations prior to the start of their air show season. Until mid-March, the officers and enlisted personnel—who are specialists in all the aviation roles required to support the squadron's maintenance, administration, and public affairs requirements—hone their skills as a cohesive unit.

NAF El Centro and its personnel provide essential support to the squadrons and units training here, including handling flight operations, logistics, billeting, messing, hangars, ramps, aircraft parking space, administration, and supply transport. Every month, seven to 12 squadrons and up to 1,600 personnel train here. Additionally, Air Force parachutists; Navy SEALs; Army Green Berets; and British, French, German, and Italian aviators visit for various phases of their training.

Commander, Navy Installations Command (CNIC) Airfield Operations and Aviation Support

CNIC Airfield Operations and Aviation Support provides Shore Installation Management support to the Navy Air Forces at Navy Air Installations, operating the airfields and providing T-line services, aviation fuel services, passenger terminal services, and cargo handling services.

Air Operations include:

- Administration and station aircraft operations
- Air traffic control
- Aviation fuel support
- Ground electronics
- Airfield facilities
- Passenger terminal and cargo handling

Utility services

Accounts, meters, tariff rates and/or negotiated contracts, and third-party energy supply

Table A.3 – NAF El Centro Utility Overview	
Measure	**Quantity**
Annual Consumption (MWh)	16,500
Monthly High Consumption (MWh)	2,000
Monthly Low Consumption (MWh)	1,000
Monthly High Demand (MW)	4
Monthly Low Demand (MW)	2

NAF El Centro has one main electricity meter connected with the utility IID that is served under the large general service utility rate schedule for bundled generation and distribution service. The installation does not take any competitive or third-party generation supply. The utility's charges consist of a relatively modest peak demand charge, usage-based ―consumption" and ―energy cost adjustment" charges that comprise the vast majority of the bills, and small state charges.

On its main meter, NAF El Centro annually consumes approximately 16,500 MWh, has a peak demand of 4 MW, and spends about $2 million on electricity. Its average combined generation and distribution rate is about $125/MWh (or $0.125/kWh). Over the reference period of June 2010 to May 2011, the installation's monthly electricity consumption recorded on its utility bills varied from a low of about 1,000 MWh to a high of about 2,000 MWh. The installation's peak demand varied monthly from approximately 2 to 4 MW. The installation recently began participating in the utility's net metering program, whereby its onsite renewable energy production is netted against its utility charges.

Renewable Energy

NAF El Centro is home to seven existing distributed solar energy projects, each located on a building rooftop or carport, totaling more than 250 kW in nameplate capacity. The five most recent rooftop projects were funded with American Recovery and Reinvestment Act (ARRA) funds and were completed in 2010. These projects will generate more than 4,000 MWh of electricity a year for the installation.

Status of Withdrawn Lands

NAF El Centro's most recent land withdrawal was enacted in 1996 with the passage of the El Centro Naval Air Facility Ranges Withdrawal Act of 1997, which authorized the Navy's use of public withdrawn lands in accordance with the 1987 cooperative agreement between the BLM and the Navy with regard to the defense-related uses of Federal lands to further the mission of NAF El Centro. This land withdrawal extends for 25 years and will expire in 2021 without a legislative extension. The 46,600 acres of land in Imperial County withdrawn from the operation of the public land laws by the Act constitute almost all of the 47,780 acres of withdrawn lands managed by NAF El Centro. As part of the terms of the land withdrawal, the Navy must continue the process of decontaminating the withdrawn lands.

The remaining 1,180 acres of withdrawn lands was withdrawn in small parcels in 1970 and earlier, do not require Congressional approval, and are indefinite in their duration.

Mission Activities

NAF El Centro's mission is to provide base support to aviation units from the Navy, Marine Corps, Army, and Air Force, as well as international units, and maintain target ranges for their weapons and combat air training. Squadrons visit NAF El Centro to conduct aerial combat maneuvering, air-to-air gunnery, bombing practice, and electronic warfare training. In addition to the extensive range areas, the facility has a 9,500-foot east-west runway that handles 96 percent of the traffic. Equipped with a Fresnel Lens Optical Landing System at each approach end as well as lighted carrier deck landing areas at both ends, pilots can simulate carrier landings.

Range Utilization

Aircrews use NAF El Centro's two Air Operation Range complexes (Range 2510 and 2512) as well as adjacent and nearby ranges for training. The ranges have two live-fire target areas each (Shade Tree 101 and Loom Lobby Target 103 for 2510 and Inky Barley 68 and Kitty Baggage 93 for Range 2512). Additionally, 2510 has drop zones and helicopter landing zones to support parachute operations and training. These ranges are equipped with remote controlled target areas that use Weapons Impact Scoring Systems to provide immediate verification of weapons delivery accuracy. Additionally the DDS support air combat training by utilizing remote television and acoustical and laser scoring systems. The DDS is linked with TACTS to provide a computerized record of the tactics employed by the individual aircrews and to evaluate the effectiveness of each maneuver.

NAF El Centro is very busy and in high demand. Every month, seven to 12 squadrons and up to 1,600 personnel train at NAF El Centro. Additionally, Air Force parachutists; Navy SEALs; Army Green Berets; and British, French, German, and Italian aviators visit for various phases of their training. On a typical day, more than 450 flight operations occur between 7 a.m. and 11 p.m. These units conduct 7,500 to 8,500 sorties and deliver 25,000 to 30,000 bombs/rockets and 200,000 strafing rounds per year on the NAF El Centro Ranges.

Mission Compatibility

Most of the compatibility issues revolve around the land ranges where potential solar energy projects might be established. The 2510 and 2512 ranges at NAF El Centro comprise a total of 56,289 acres of land inside the range borders; NAF El Centro presently owns 7,330 acres with the remainder being withdrawn land. The land controlled by the Navy at NAF El Centro contains the targets and assessment equipment necessary to evaluate training effectiveness. It is mission-critical, and the fact that live ordnance is used on these ranges makes this land incompatible with solar energy development because of the inherent danger associated with the training activities conducted there.

Biological Issues

NAF El Centro is located in the Imperial Valley and the Colorado Desert Region, in the northwest Sonoran Desert. The Colorado Desert includes low-lying areas east of the Peninsular Ranges, which drain into the Colorado River, the lower Gila River in Arizona, Baja California in the southeast, and Sonora Mexico to the southwest. NAF El Centro's northern boundary consists of a gradual ecotone into the Mojave Desert, where winter rains predominate. The area is subject to low, sporadic precipitation and high evaporation levels as one of the hottest, most arid desert environments in North America. NAF El Centro and East Mesa and West Mesa target areas are situated in Imperial Valley, a low-lying basin of the Salton Sea Trough. The elevation of NAF El Centro is 43 feet below sea level.

Ten plant communities are evident on NAF El Centro and its target areas, including three densities of creosote bush scrub (moderate, dense, and sparse). Creosote scrub is the most prevalent community of the Mojave and Colorado deserts and constitutes the majority of both ranges; 80% of the area of West Mesa (e.g., R2510 which includes NAF El Centro, Target 101, Target 103, and the Parachute Drop Zone (PDZ)) and 99% of East Mesa (e.g., R2512 which includes Target 68 and Target 95). The other communities include: stabilized dune, Mesquite mound, tamarisk, riparian, landscaped/agriculture, developed, and barren land.

Creosote scrub communities on East Mesa Target 95 and 68 are primarily creosote and mixed desert forbs. Mature creosote are common to low, sandy mounds. Target 95 supports very robust creosote plants which commonly reach heights of 8 to 12 feet and have diameters of 15 feet. Cover data acquired in the 1996 survey show creosote covering 16% to 25% of Target 95 and Mediterranean grass providing 22% to 30% of the absolute cover. Other associated species typically include Mormon tea (*Ephedra* sp.), popcorn flower (*Cryptantha* sp.), fiddleneck (*Amsinckia* sp.), sun cup (*Camissonia ovata*), plantain (*Plantago* spp), and mustard (*Brassica* spp). Four-wing saltbush (*Atriplex canescens*) is a prominent component of creosote bush scrub in Target 95, providing 12% of the cover. Creosote communities on the West Mesa Targets 101 and 103A are dominated by creosote and white bursage (*Ambrosia dumosa*) with some rhatany (*Krameria* sp.), indigo bush (*Psorothamnus emoryi*), spineflower (*Chorizanthe rigida*), plantain (*Plantago ovata*), galleta grass (*Pleuraphis rigida*), and Mediterranean grass (*Schismus* sp.). Creosote and white bursage covers less than 10% of the absolute cover for Target 103A. Large washes and gullies run through portions of Target 101. The sandy substrate provided by these washes supports sparse plant cover and is composed of similar species to the creosote scrub community. Productivity of the creosote community varies geographically and West Mesa Targets 101, 103, and the PDZ have relatively low and sparse cover.

Mesquite mounds are distinguished by the presence of mesquite (*Prosopis glandulosa*) on small dunes and at least five mesquite mounds are located on East Mesa Target 95, the majority of which are located southwest of the target area. One mesquite mound is found on the boundary of Target 68. The mounds are small and interspersed by flat areas of creosote scrub. Mesquite mounds are currently avoided during military use of the target areas.

Relict dunes are found on East Mesa Targets 68 and 95. At least three longitudinal dunes encroach onto Target 68 from the west. These dunes are small, widely spaced, and impassively stabilized by vegetation. Similar northwest-southeast lying dunes are located in the northwestern corner and along the western boundary of Target 95. This community is characterized by creosote, indigo bush, desert buckwheat, dicoria, coldenia (*Tiquilia plicata*), and sun cup (*Camissonia ovata*). The western border of Target 101 consists of larger dunes which continue westward and northwest into the Superstition Hills. Active dunes develop when sand accumulates and becomes partially stabilized by evergreen and or deciduous shrubs, scattered low annuals, and perennial herbs or grasses. The Algodones Dunes run along the southeast margins of Range 2512. Stabilized and active dunes are avoided during military use of the range.

Tamarisk (*Tamarix ramosissima*) is an invasive exotic known to become established in areas of disturbance. Most of the tamarisk occurring at NAF El Centro is found in the small riparian stream bed located at the northwestern corner of the facility, where numerous, extremely dense stands of tamarisk are found. A small area of tamarisk thicket also occurs on Target 95, and a few scattered tamarisk thickets are located immediately outside of Target 95's southern boundary.

Some desert riparian habitat follows margins of the New River, which approaches the northwest end of NAF El Centro. Some of these areas are jurisdictional wetlands. The vegetative cover in these areas is predominantly bare ground but includes screw bean (*Prosopis pubescens*), tamarisk (*Tamarix aphylla*), sea-blite (*Suaeda torreyana*), big saltbush (*Atriplex lentiformis*), and arrow weed (*Pluchea sericea*).

No sensitive plants that carry Federal legal restrictions are known to occur on Navy lands. However, sensitive plant species are known to occur in the vicinity of NAF El Centro. These include Peirson's milkvetch (Astragalus magdalenae var. peirsonii), which has been reported on the Algodones Dunes south of Highway 78 and may occur on Target 68. Sand food (*Pholisma sonorae*) is also known to occur in the vicinity. This mushroom-like, perennial herb was located on a dune near Target 68 but its occurrence in the area is known to be rare. Finally Thurber's pilostyles (*Pilostyles thurberi*) have been found parasitizing its host shrub, indigo bush, near Target 101 and has been reported in the Superstition Hills. It may be more widely scattered, as its appearance is unpredictable from year to year.

Fifty-five species of birds have been previously observed at the target areas. Twenty-six species were observed on West Mesa and 42 were observed at East Mesa. The higher diversity on East Mesa may be due to the presence of the New Highline Canal and the mesquite mounds of the east targets. Nineteen species of mammals occur on NAF El Centro and its target areas with a higher diversity of mammals found on East Mesa than West Mesa, but the greatest diversity was at NAF El Centro itself where water is plentiful. Eighteen species of reptiles occur (or have been observed) at NAF El Centro. Ninety percent of the natural desert wildlife populations of Imperial Valley can be found in the concentrated aquatic areas where very little disturbance has occurred. The rivers, canals, and drainage channels provide the primary source of refuge necessary for supporting wildlife.

Sensitive wildlife species include the Yuma clapper rail (*Rallus longrostris yumanensis*) which may occur in the wetland in the northwestern corner of NAF El Centro. However, the wetland is adjacent to the water treatment ponds and receives tertiary water and untreated agricultural drainage water. Furthermore, water flow is ephemeral, and the wetland does not contain cattails. The mountain plover (*Charadrius montanus*) has not been observed at NAF El Centro but is a winter resident of the Imperial Valley and could use agricultural fields of alfalfa and bermuda grass at NAF El Centro. Flat-tailed horned lizard (*Phrynosoma mcallii*) is a species that may inhabit many parts of the greater NAF El Centro area. Target 101, Target 103, and Target 68 are considered prime habitat for the flat-tailed horned lizard and are included in the flat-tailed horned lizard Rangewide Management Strategy. Much of this species' habitat has been destroyed by agricultural and urban development. However, the flat-tailed horned lizard is a wildlife species that represents a significant management concern for NAF El Centro. The Colorado Desert fringe-toed lizard (*Uma notata*) is another sensitive species that occurs in the sand dunes in the Superstition Mountains, and occurs along the western edge of Target 103 where dunes encroach onto the edge of Navy controlled property. The Colorado Desert fringe-toed lizard also occurs in the Algodones Dunes and occurs within the R-2512. The desert tortoise (*Gopherus agassizii*) has been surveyed on the target ranges but it is not expected to occur on Navy controlled lands as the natural range of the federally threatened desert tortoise begins outside of the target ranges north and east of the Algodones Dunes, and at the installation of the Chocolate Mountains. Finally, the western burrowing owl (*Athene cunicularia hypygaea*) has some of the largest concentrations in the Imperial Valley due to habitat created from agricultural practices and they are likely to occur throughout the agricultural areas of NAF El Centro.

Invasive/non-native species within the NAF El Centro include tamarisk which has established in thickets on Target 95. The other target areas contain isolated plants, as do the banks of the New River. Common reed (*Phragmites australis*) also occurs at the New River.

NAF El Centro does not use any wells or ground water, receiving all of its water from the IID. The Elder Canal runs along the west border of the Facility, and the Elm Canal along the east. Both are part of the All-American Canal system which connects to the Colorado River. Water is withdrawn from the Elder Canal, then treated with a series of settling ponds and other facilities, and pumped into two large, concrete reservoirs with a combined capacity of 2.5 million gallons. There is an additional 155,000-gallon, elevated distribution reservoir.

<u>Cultural Issues</u>

Archaeological and historical evidence suggests that, with one exception, prehistoric and historic populations did not intensively settle or use the areas where NAF El Centro and its ranges are located. The exception is the time during which ancient Lake Cahuilla existed--approximately A.D. 1050 - A.D. 1450. About 950 years ago, the course of the Colorado River shifted and the Salton Trough filled with fresh water. The result was Lake Cahuilla. It was about 100 miles long and 35 miles across and reached an elevation of approximately 40 feet above mean sea level. (The present-day Salton Sea has an elevation of about 227 feet below mean sea level.) Archaeological evidence suggests groups moved from surrounding areas to take advantage of Lake Cahuilla's rich lakeshore environment. (Ancient Lake Cahuilla's western shoreline is within Range 2510; its eastern shoreline crosses Range 2512). About 500 years ago, the Colorado River again shifted its course east and Lake Cahuilla began evaporating. The evaporation process is estimated to have taken about 50 years. In response, many of the desert's occupants moved west into the Peninsular Range mountain valleys or eastward to the Colorado River.

When the Spanish arrived in 1774, they found the Desert Kumeyaay (also known as the Kamia) occupying what is now southern Imperial County. The Desert Kumeyaay were hunters and gatherers, and they practiced floodplain agriculture. Their habitation sites were centered primarily along the New River and Alamo River sloughs. The western extent of their territory was in the vicinity of Jacumba, and the eastern boundary was probably east of the Sand Hills. The boundary between the Desert Kumeyaay and their northern neighbors, the Cahuilla, crossed what is now the northern extent of Range 2510.

From the 1770s to the 1940s, West Mesa and East Mesa were generally uninhabited. Some travel corridors, however, did cross West Mesa and present-day Range 2510. The most important is commemorated as the Juan Bautista de Anza National Historic Trail. On October 23, 1775, 245 people and about 800 head of livestock left Tubac, Mexico under the leadership of Col. Juan Bautista de Anza. (Tubac is near present-day Tucson, Arizona.) They were headed north to colonize the San Francisco Bay area. On December 11 the expedition departed what is now Yuha Well, and began traveling north through much of present-day Range 2510. They arrived at San Sebastian Marsh (south of Highway 78 and north of RSZ B) on the 13th. Others used this route to travel from Mexico to California until the early 1780s. It then fell into disuse. Mexicans traveling to northern California's gold fields in the late 1840s helped reestablish de Anza's expedition trail as a well traveled route. About 10 years later, John Butterfield, under contract to the U.S. Congress, set up the Butterfield Overland Mail Stage Route. One branch of his stage route, which operated only a few years, ran west of de Anza's route and crossed Range 2510 just to the southwest of Target 103. In 1869, the first transcontinental railroad was finished and the need for transcontinental passenger and mail travel by stagecoach ceased.

The Navy has been conducting systematic cultural resources inventories of NAF El Centro and its ranges since the mid-1990s. More than a thousand cultural resources (archaeological sites, structures, and buildings) are recorded at NAF El Centro and within the greatest extent of its range safety zones. About 200 are located at the Main Facility and within range safety zones A. The prehistoric archaeological sites include temporary habitation areas; hearths; roasting pits; scatters of stone tool-making debris, broken pottery, and fragments of stone used for grinding; cremation areas; rock shelters; trails; and rock features. Most prehistoric archaeological sites on West Mesa and East Mesa are associated with the ancient Lake Cahuilla 40-foot shoreline. The historic- period archaeological sites are primarily trails, roads, and campsites. The pre-1946 buildings and structures on the Main Facility are numerous and include buildings and structures such as explosives magazines, an outside swimming pool, storehouses, hangers, and officer's quarters.

None of NAF El Centro cultural resources is listed on the National Register of Historic Places. Portions of the de Anza trail that cross Anza-Borrego Desert State Park to the northwest of Range 2510, however, are listed in the National Register. In addition, in 1990, the U.S. Congress designated the entire de Anza trail as a national historic trail and in 1999 the White House selected it to be one of sixteen national millennium trails. The Navy evaluated the prehistoric sites and the pre-1946 buildings and structures on the Main Facility and determined that none meets the National Register criteria for evaluation. In a 1995 letter, the State Historic Preservation Officer supported that determination. No Indian reservations are located close to NAF El Centro. The Native American Consultation Database does not identify any Indian tribes as having an interest in cultural resources issues in south-central Imperial County.

A.4 Marine Corps Air Ground Combat Center (MCAGCC) Twentynine Palms

Introduction

MCAGCC Twentynine Palms, California, is the world's largest Marine Corps and live-fire training operations military installation. It is the premier training facility in the world for Marine operations and draws military personnel from all over the world for Combined Arms Exercises.

The two-fold mission of the Marine Air Ground Task Force Training Command (MAGTFTC) is to operate the MCAGCC for live-fire combined arms training that promotes readiness of operating forces and provide facilities, services, and support, responsive to the needs of tenant commands, Marines, sailors, and their families. The population assigned to the combat center totals 9,723 active-duty members; 8,588 dependents; and approximately 1,398 civilians.

Each year, roughly one-third of the Fleet Marine Force and Marine Reserve units—approximately 50,000 Marines—participate in the installation's training exercise program. These training exercises involve every weapons system in the Marine Corps' arsenal, from small arms to attack aircraft. They are essential to maintaining high levels of readiness of the Marine Corps to fight and defend U.S. national interests.

The combat center at Twentynine Palms occupies 932 square miles, or 595,578 acres, of the southern Mojave Desert. Such a sizable land area is essential to the conduct of realistic air/ground combat training exercises.

History and Historic Mission

The oasis of Twentynine Palms was discovered in 1885 by Colonel Henry Washington, who commanded a government survey party. Before the turn of the century, this area was well known by prospectors and miners. The major mountain range, the Bullion Mountains, reflects the influence of those miners and prospectors in the naming of local terrain features and areas. Many abandoned mines are located in the fire and maneuver areas of the combat center. The Dale mines, located 15 miles southeast of the combat center, yielded more than $3 million in gold prior to the turn of the century. Mining continued to be a major activity in the high desert until shortly after World War I.

Veterans of World War I who had suffered lung damage from gas attacks came to Twentynine Palms to recuperate with the help of sunshine, low humidity, and clean air. They were followed by others seeking good health, especially asthma and tuberculosis sufferers. Many of these people took 160-acre homesteads. A common saying at that time was, ―The government bets you 160 acres of desert that you can't survive on it for three years." Many did survive, and their descendants are now among the established families in the recently incorporated (1987) city of Twentynine Palms.

The land has a history of military use dating back to 1940 when the Army used the area for training glider crews. When glider training ended in 1943, the Army switched to training fighter pilots. At the end of World War II, the Navy used the area as a bombing range until 1945 when it was transferred to San Bernardino County. In 1952 the Marine Corps took charge and was designated Headquarters, Marine Corps Training Center, and in 1957 it was commissioned as a Marine Corps Base. In 1979, the installation finally became the MCAGCC.

Present-Day Mission

Each year, the Fleet Marine Force and Marine Reserve units participate in a training and exercise program that involves live-fire weapons systems ranging from personal combat arms to attack aircraft. The program and the ranges that support these exercises are essential to maintaining high levels of readiness of the Marine Corps to fight and defend U.S. national interests.

Although a large installation, the MCAGCC has significant lands that cannot support training due to sensitive cultural or natural resources, the underlying aquifer, or safety/terrain constraints. As a result, approximately 60 percent of the current installation is unavailable for the type of Marine Expeditionary Brigade (MEB) training for which the installation is intended.

The current MAGTFTC mission at Twentynine Palms is aimed at fulfilling training requirements for a large-scale Marine Air Ground Task Force (MAGTF), which requires more training land and airspace than is now available anywhere in the United States. The Marine Corps requires that the training area must, at a minimum, provide three maneuver corridors for a ground combat element composed of three battalions that are simultaneously maneuvering for 48 to 72 hours with combined-arms live fire and the accompanying special-use airspace.

A 2004 Center for Naval Analyses study shows that Twentynine Palms is the only location with sufficient land and airspace potential to meet the training requirements. If any new lands for MEB-level training are sought following NEPA process and the issuance of a Record of Decision, the Marines would steward these new lands and their resources.

Marine Corps Communication-Electronics School (MCCES)

The MCCES trains the majority of Marines in the communications and ground electronic maintenance Military Occupational Specialties (MOS). The mission of the MCCES is to train Marines in ground electronics maintenance, tactical communications, and air control/anti-air warfare operations and maintenance in order to ensure that commanders at all levels within the Marine Corps have the ability to exercise command and control throughout the operational environment. Additionally, the school participates in technical and logistical evaluations for new communication, electronic maintenance, air control and anti-air warfare systems in support of fielding and training development.

7th Marines Regiment

The 7th Marine Regiment is made up of one headquarters company and four infantry battalions, one of which is deployed outside the continental United States at all times. The infantry battalions are the basic tactical units by which the regiment accomplishes its mission of locating, closing with, and destroying the enemy by fire and close combat.

The mission of the 7th Marines is to conduct mechanized, combined-arms operations and other expeditionary operations to support theater engagement plans and contingency operations. The regiment maintains a readiness level that keeps Marines prepared to deploy within 48 hours of the receipt of a deployment (execute) order as either the ground combat element for the 1st MEB or as a major subordinate element of the 1st Marine Division. As directed, the regiment will prepare infantry battalions for deployment to the Pacific Command (PACOM) Area of Responsibility (AOR) in order to support III Marine Expeditionary Force (MEF) operations and training.

This mission to prepare combat ready battalions for the Unit Deployment Program (UDP) and to be prepared to deploy as the division's first or primary Maritime Prepositioned Force (MPF) requires routine and continuous use of the Twentynine Palms training areas and ranges. It is also prepared to provide a first echelon battalion for the I MEF Alert Contingency MAGTF. The regiment serves as the principal source of expertise for armor/mechanized/infantry combined arms operations.

3rd Battalion, 4th Marines

The 3rd Battalion, 4th Marines is an infantry battalion that consists of approximately 1,000 Marines. It falls under the command of the 7th Marine Regiment and the 1st Marine Division. Its mission, training and deployment description, issues, and requirements closely match the organic battalions of the 7th Marines.

1st Tank Battalion (1st Tanks)

The 1st Tank Battalion's mission is to provide combat power to the 1st Marine Division in the form of amphibious and/or Maritime Preposition Forces and conduct operations ashore utilizing maneuverable, armor-protected firepower and shock action to close with and destroy the enemy. As a separate battalion, 1st Tank Battalion is responsible to the Commanding General, 1st Marine Division for providing armored assets as well as anti-armor systems and staff expertise in their employment.

The battalion's live-fire and maneuver training routinely requires extensive use of the Twentynine Palms ranges and training areas, including ground access throughout the installation and ranges.

4th Tank Battalion (4th Tanks)

The 4th Tank Battalion is one of two reserve tank battalions in the Marine Corps and has companies spread across the western United States. In past years, the battalion has supported Marine Reserve units from across the continental United States in many major operations. It routinely deploys to and supports training and exercises at Twentynine Palms.

The unit mission is to provide armored combat power for the Marine Division in an amphibious assault and subsequent operations ashore, utilizing maneuverable, armor-protected firepower and shock effect to close with and destroy the enemy. The battalion is also tasked to organize, train, and equip individual Marines and combat-ready tank companies to augment and reinforce the active-duty component when required to serve as part of the Total Force of the United States. 4th Tank Battalion is a self-sustaining, autonomous unit capable of performing all the tasks of the regular force.

The battalion's live-fire and maneuver training routinely require extensive use of the Twentynine Palms ranges and training areas, including ground access throughout the installation and ranges.

3rd Battalion, 11th Marines

The 3rd Battalion, 11th Marines is an artillery battalion comprising four firing batteries and a headquarters battery. Its primary weapon system is the M777 lightweight howitzer with a maximum effective range of 30 km which requires large training areas and ranges. It falls under the 11th Marine Regiment and the 1st Marine Division and is required to be ready to deploy anywhere in the world as part of the 1st Marine Division's Maritime Prepositioned Force. Its mission is to provide direct support of the 7th Marine Regiment in time of conflict. That support may come in the traditional fashion of artillery support to maneuver forces or by providing batteries to serve as provisional infantry companies. It also has the secondary mission of being the primary providers of civil-military operations (CMO), defined as the activities of the commander that establish, maintain, influence, or exploit relations among military organizations, government, and civilian organizations and individuals.

Meeting the battalion's live-fire and maneuver training requirements makes extensive use of the Twentynine Palms ranges and training areas, including road access for heavy vehicles and towed equipment throughout the Twentynine Palms installation and range areas.

3rd Combat Engineer Battalion (3rd CEB)

The 3rd CEB provides mobility, counter mobility, survivability, and limited general engineering support. The engineer battalion consists of Headquarters and Service Company, Engineer Support Company, four Engineer Line companies, and a Mobility Assault Company. Meeting the battalion's explosives, construction, and other training requirements includes extensive use of the Twentynine Palms ranges and training areas, including road access for heavy vehicles and towed equipment throughout the Twentynine Palms installation and range areas. The battalion is expected to be based in Guam once construction of facilities is complete.

3rd Light Armored Reconnaissance Battalion (3rd LAR)

The 3rd LAR is a light armored battalion of the Marine Corps. The battalion is part of the 1st Marine Division and I Marine Expeditionary Force. Marine Corps Light LAR Battalions are fast and mobilized armored terrestrial reconnaissance units that conduct reconnaissance-in-force (RIF) ahead of the battalion landing teams or division infantry forces. They mainly provide the MAGTF and the Marine Expeditionary Unit (MEU) commanders with vital intelligence of the enemy. Their live-fire and maneuver training requires extensive use of the Twentynine Palms ranges and training areas, including ground access throughout the installation and ranges.

Combat Logistics Battalion 7 (CLB-7)

CLB-7 provides direct support combat logistics support to 7th Marine Regiment and general combat logistics support to other 1st Marine Expeditionary Force units based at MCAGCC. CLB-7 also provides general support to tenant commands at MCAGCC, to units participating in Mojave Viper Exercises, surge-level maintenance to the Exercise Support Division and general support to other units as directed by the Commanding General, 1st Marine Logistics Group.

CLB-7's tasks include distribution, intermediate-level maintenance, supply, engineering, and general services.

With more than 500 Marines and sailors, CLB-7 is a task-organized command composed of three companies: Headquarters and Service Company, Transportation Support Company, and Support Company. This Fleet Marine Force unit is a detachment of 1st Marine Logistics Group based in Camp Pendleton.

CLB-7's direct support combat logistics in any environment and throughout the spectrum of conflict allows 7th Marines to prepare for and sustain combat operations. It provides intermediate maintenance support for ground element equipment; repair parts from a reparable issue point; provides Maintenance Support Teams that inspect, diagnose, classify, and repair equipment at forward sites; ground vehicle recovery and evacuation; point and unit re-supply via mobile combat service support elements; and transportation support including material-handling equipment. It also coordinates and conducts Force Protection defensive operations to include rear area security and internal security; conducts convoy operations and associated convoy security preparations; and trains and organizes to deploy as a command element for operations and exercises. CLB-7's live-fire and maneuver training requires extensive use of the Twentynine Palms ranges and training areas, including ground access throughout the installation and ranges.

D Company, 3rd AA Battalion

The 3rd AA Battalion is one of two Marine Corps active-duty assault amphibian battalions. D Company is a part of the battalion supporting the 1st Marine Division and the I MEF. Its mission is to land the surface assault element of the landing force and its equipment in a single lift from assault shipping during amphibious operations to inland objectives and to conduct mechanized operations and related combat support in subsequent operations ashore. The battalion's live-fire and maneuver training requires extensive use of the Twentynine Palms ranges and training areas, including ground access throughout the installation and ranges.

Marine Aviation Weapons and Tactics Squadron 1 (MAWTS-1)

MAWTS-1, headquartered at Marine Corps Air Station (MCAS) Yuma, Arizona, provides standardized advanced tactical training and certification of Marine Corps aviation unit instructor qualifications that support Marine Aviation training and readiness. It also provides assistance in developing and employing aviation weapons and tactics. Its training, test, and evaluation requirements involve extensive use of the Twentynine Palms ranges and training areas.

Marine Wing Support Squadron 374 (MWSS-374)

MWSS-374 is an aviation ground support unit. The squadron is part of Marine Wing Support Group 37 and 3rd Marine Aircraft Wing. It is stationed at MCAGCC Twentynine Palms with responsibilities for the day-to-day operations of the Twentynine Palms Expeditionary Airfield (EAF).

EAF Twentynine Palms

The Twentynine Palms EAF is under operational control of the Commanding General, 3rd Marine Aircraft Wing. The austere EAF is an example of what naval aviation uses in tactical and deployed situations where no prior airfield exists. It is a cornerstone of the Marine Corps' Combined Arms Exercise (CAX) Program. More than 3 million square feet of aluminum AM-2 matting make up the primary runway, taxiways, and parking areas. The EAF operates as a "host nation" airfield to which deployed units bring their own organic support. Support functions provided at the EAF include: airfield operations, air traffic control, airfield construction, maintenance and repair, aircraft rescue and fire fighting, common aviation support equipment, explosive ordnance disposal, weather services, communications, aircraft refueling, fuel storage, engineer support, and motor transport.

Air and ground operations from the EAF, including live-fire and maneuver training, requires extensive use of the Twentynine Palms airspace, ranges, and training areas, including ground access throughout the installation and ranges.

Marine Unmanned Aerial Vehicle Squadron 1 (VMU-1)

VMU-1 is an unmanned aerial vehicle squadron. It provides aerial surveillance for the I MEF, and it falls under the command of Marine Air Control Group 38 and the 3rd Marine Aircraft Wing. Its mission is to support the MAGTF commander by conducting reconnaissance, surveillance, target acquisition, indirect fires adjustment, and battlefield damage assessment (BDA) and supporting the rear area security plan during expeditionary, joint, or combined operations. The squadron’s air and ground operations, including live-fire and maneuver training, require extensive use of the Twentynine Palms airspace, ranges, and training areas, including ground access throughout the installation and ranges.

Unmanned aircraft systems increase the lethality and effectiveness of Marine Corps air-ground team by extending influence over time and space on the battlefield. The persistence and reach of current UAVs are key characteristics that provide improved aerial reconnaissance and command and control capability exceeding that of manned aviation assets. The near future will see these characteristics expand to also include strike, electronic warfare, and combat logistics. The rapid expansion of these technologies demands significant adaptation in organizational, policy, and doctrine within the Marine Corps and Naval Service as well as training and exercise spaces, including Twentynine Palms. These future developments will impact Twentynine Palms installation facilities and restrictions in airspace, ranges, and training areas.

Marine Unmanned Aerial Vehicle Squadron 3 (VMU-3)

VMU-3 is a UAV squadron that consists of approximately 200 Marines. VMU-3 was the third UAV unit in the Marine Corps established to provide reconnaissance and assist with deployments and training of ground units, and it continues to fly missions in support of 3rd Marine Aircraft Wing, I Marine Expeditionary Force, and the Tactical Training Exercise Control Group (TTECG) on a regular basis. VMU mission, requirements, and issues are similar to those discussed previously for VMU-1. Like VMU-1, the squadron routinely deploys for worldwide operations, and its air and ground operations require extensive use of the Twentynine Palms airspace, ranges, and training areas, including ground access throughout the installation and ranges.

Utility services

Accounts, meters, tariff rates and/or negotiated contracts, and third-party energy supply

Table A.4 – MCAGCC Twentynine Palms Utility Overview		
Measure	**Quantity**	**Total *(including onsite generation)***
Annual Consumption (MWh)	52,000	110,000
Monthly High Consumption (MWh)	7,700	Not available
Monthly Low Consumption (MWh)	2,200	Not available
Monthly High Demand (MW)	23	28
Monthly Low Demand (MW)	6	15

MCAGCC Twentynine Palms has one large electricity meter (Mainside), one meter with modest consumption (Rainbow Canyon), and about 16 much smaller meters for wells and other purposes, connected via a single 34.5-kilovolt (kV) line with SCE. Both of the larger meters are served under SCE TOU-8-B-DBP utility rate schedules, and the meters participate in SCE's Direct Access program, whereby the installation contracts for the generation portion of its electricity supply with WAPA in the competitive market. MCAGCC Twentynine Palms joins with many other Navy and Marine Bases, including MCLB Barstow, in receiving competitive electricity supply service from WAPA, which can provide the installation with greater choice in establishing its rates and greater certainty in budgeting for the generation portion of its electricity costs than if the installation remained on full, bundled tariff service with SCE. Competitive supply, like that from WAPA, may additionally offer savings opportunities compared to bundled utility service, but such savings are not certain. From SCE, MCAGCC Twentynine Palms only receives distribution service (the utility moves the power procured by WAPA from the edge of the SCE system to the installation's meters and maintains its distribution system reliability). The majority of SCE's distribution charges are determined by the installation's monthly peak demand, so the installation's electricity usage each month determines a minority of its SCE charges.

Combined across its two largest meters, MCAGCC Twentynine Palms annually consumes about 52,000 MWh of utility power and about 110,000 MWh of total electricity (the latter figure includes onsite generation), has a peak utility demand of 23 MW and a peak demand (including onsite generation) of 28 MW[130], and spends just over $6.7 million on utility electricity (before departing load charges). Its average, combined generation and distribution rate is about $130/MWh (or $0.13/kWh) before departing load charges. This total cost can be divided into about $51/MWh in distribution charges from SCE and about $79/MWh in generation charges from WAPA.[131] Over the reference period of June 2010 to May 2011[132], the installation's monthly electricity consumption recorded on its utility bills for its two largest meters varied from a low of about 2,200 MWh to a high of about 7,700 MWh. The installation's peak demand with

---

[130] **MCAGCC Growth Start**, MCAGCC Power Background, page 1. This four-page memo is the source for installation-wide data on total (including onsite generation) electricity consumption and winter and summer peak demands. Data on the installation's SCE utility consumption, peak demand, and costs were taken directly from SCE utility bills.

[131] In addition to the WAPA generation charges described here, there are competitive transition charges (CTCs) assessed by SCE in some months that can add roughly 2% on an annual basis to competitive electricity supply costs.

[132] While the SCE utility bills reviewed were for the period June 2010 to May 2011, WAPA volumes and charges reviewed were from the slightly different period of May 2010 to April 2011.

the utility for its two largest meters varied monthly from approximately 6 to 23 MW, and installation-wide total demand (including onsite generation) extends from 15 to 28 MW. Among its two main meters, the Mainside meter represented about 91 percent of total consumption, and the Rainbow Canyon meter represented 9 percent of consumption.

In addition to having more electricity meters than other military installations in this study, MCAGCC Twentynine Palms has a number of other current and planned elements to its electricity supply that are more complex than other installations. Its renewable energy, cogeneration, and other back-up generation activities are discussed in sections that follow, but they likely affect the installation's –standby" rate category for its largest meter and its extra charge from SCE for departing load. That departing load charge ranges from summer lows of less than $10,000/month to more than $70,000 in many winter months and totals greater than $550,000 annually during the reference period (which add about $11/MWh (or $0.011/kWh) to the installation's annual utility costs). The installation is planning to construct two 115-kV electrical lines to serve it in the future in place of the current, single 34.5-kV line, with each 115-kV line having an associated utility meter (PWD Update, 2011).

Renewable Energy Projects

While MCAGCC Twentynine Palms does not have as much installed solar energy capacity as Nellis Air Force Base (AFB) or planned capacity as Fort Irwin and Edwards AFB, Twentynine Palms is the leader in terms of the sheer number of solar energy projects undertaken and planned. Twentynine Palms' 25 solar energy projects include an existing 1.2-MW single-axis tracking PV system funded through an Energy Savings Performance Contract (ESPC) and 1.7 MW of existing rooftop and sunshade solar, and it plans for a 1.5-MW PV solar energy development on a dry lake that is to be privately developed through a PPA. In total, Twentynine Palms is budgeted to have 10.5 MW of solar energy capacity installed on-installation by 2013.

In February 2010, the U.S. Navy awarded a $200-million IDIQ contract to five solar energy developers to construct, own, operate, and maintain up to 40 MW of solar energy capacity located on military installations in the southwest United States and sell the resulting power to the Navy/Marines. The 1.5-MW dry lake solar development at MCAGCC Twentynine Palms is expected to be one of the first three solar energy projects developed as part of the larger IDIQ contract. In the long term, Twentynine Palms plans for the 1.5-MW dry lake PV solar energy facility to be the first phase of a larger development that will comprise 40 to 50 MW of total capacity when completed, making the installation a mid-day exporter of power to the surrounding SCE-managed electricity grid.

MCAGCC also has a continuing program of energy reduction and increasing energy savings measures. MCAGCC Twentynine Palms' completed its new 7.2-MW dual-fueled combined heat and power (CHP, or cogeneration) system in February 2003. The DOE called the project –an outstanding demonstration of the value of CHP for addressing both energy cost and energy security issues at Federal sites." The $16-million CHP project, including more than 3 miles of high-pressure gas lines, design, construction, and financing, was expected to pay for itself in less than four years. The revenue stream from this project provided the financing for the Phase Three upgrades of the installation's ESPC, including its 1.2-MW PV system, three chiller plants, and several other critical infrastructure improvements.

The CHP system was expected to reduce the military installation's need to purchase electricity from the local utility by almost two-thirds, resulting in an annual cost savings of approximately $5.8 million. The savings represent the net effect of reduced electricity purchases; increased natural gas purchases; and maintenance, operation, repair, and replacement costs for the cogeneration system. In the event of a power outage, the CHP system provides reliable power to four critical load circuits on the installation using natural gas (or diesel, in the event of gas failure). The project was accomplished under an ESPC administered by the USACE and the Naval Facilities Engineering Service Center (DOE, 2003).

Status of Withdrawn Lands

The Marine Corps has considered many alternatives to meet its MEB training requirements at MCAGCC. It presented five land acquisition and associated airspace establishment alternatives to interested stakeholders at EIS public scoping meetings in December 2008. Nearly 20,000 public comments on these alternatives and issues have helped to develop a range of reasonable alternatives to meet MEB training requirements, including an ―Alternative 6" that would preserve continued public access to 40,000 acres of important off-road recreation areas in the West Study Area for 10 months of the year when Marines would not be using the area for MEB training. The Marine Corps believes that Alternative 6 is optimal, considering operational and environmental impact factors together.

The draft EIS public comment period ran from February 25 through May 26, 2011, and these public comments are currently being evaluated and responses to substantive comments will be provided in the final EIS. The final EIS and review of public comments is expected to be published in December 2011, followed by the publishing of the Record of Decision (ROD) in April 2012. If the ROD determines that the Marine Corps can pursue land acquisition and air space establishment, the organization will request Congressional action for public land withdrawal for military training and submit the FAA formal processes and actions on Special Use Airspace proposal request (USMC, 2011).

Mission Activities

The mission activities of MCAGCC Twentynine Palms include live-fire combined arms training, urban operations, and joint/coalition level integration training. The installation operating areas are divided into 23 integrated training areas, including the cantonment area (Mainside Area), which contains several non-live fire training facilities. Forty-three individual numbered ground ranges and three aviation ranges with numerous ground targets are designated for air delivered ordnance located throughout the training areas. These ranges are primarily live-fire ranges, that support the majority of the weapon systems in the Marine Corps inventory, but a few ranges are designated for non-live-fire maneuver training and mission rehearsals. The non-live-fire ranges are designed for the use of pyrotechnics, simulated munitions, and blanks. During training events, umpires, controllers, and range safety officers move and shift designated range safety areas to accommodate the scheme of maneuvers and employment of combined arms (direct, indirect, and air delivered ordnance) as the training units maneuver.

Range Utilization

MCAGCC Twentynine Palms hosts military training for personnel from all over the world. Each year, roughly one-third of the Fleet Marine Force and Marine Reserve units—50,000 Marines—participate in the installation's training exercise program. Range usage data collected by the Base Range Control Office indicates that approximately 324,951 people are trained and 3,614,697 pieces of ordinance and ammunition are expended in these training areas (TAs) and ranges each year (Chatelin, 2011).

Mission Compatibility Issues

The compatibility issues associated with the ranges at MCAGCC Twentynine Palms all relate to the activities conducted at the ranges. None of the activities are classified at a sensitivity that prevents access for solar projects; however, the inherent danger associated with the live-fire and maneuver training conducted on the ranges restricts consideration for co-use as sites of large solar energy projects. The exceptions might be the non-live-fire maneuver training areas (Acorn, East, West, Gypsum Ridge, and Mainside); however, with the exception of Mainside, these areas allow for the maneuver of mounted and dismounted ground units, low-level flight operations, the use of pyrotechnics, blanks, and simulated munitions for direct fire weapons. Additionally, Training Area West contains an Explosive Ordnance Disposal live-fire range and a combat vehicle operator's course, making them incompatible for solar energy project usage. Access issues also cause a compatibility issue for most of the training areas. The use of paved or improved ground access routes into the training areas is minimal, restricted by both range regulations and existence of only a few improved surface roads. Increased use of these access routes could interfere with scheduled training requirements and the movement of troops, equipment and supplies and ammunition.

Biological Issues

MCAGCC lies in the south-central Mojave Desert region where temperature and rainfall patterns approach conditions more typical of the hotter, drier Sonoran Desert to the south. Wildlife species at Twentynine Palms are typical of Mojave Desert fauna, with the exception of a wide variety of non desert-adapted species inhabiting Mainside (e.g., the cantonment area in the southern most part of the installation), particularly man-made water areas. Approximately 34 mammal species, 209 bird species, 27 reptile species, and two amphibian species are confirmed at Twentynine Palms. Most wildlife species on the installation (except Mainside) are adapted to desert scrub habitats that provide little cover and xeric conditions. Small-mammal species richness is greater at high elevation sites, and an additional 16 mammal species could potentially reside on installation.

Seeps, springs, and man-made bodies of water provide perennial sources of water and a high concentration of vegetation and cover that contribute to increased wildlife diversity in these areas. Large mammals, such as bighorn sheep, coyote, and bobcat, use these water sources and return to them regularly. Bats typically feed over these areas because of increased abundance of invertebrate prey. Bird species that migrate in the spring and fall (and are not usually associated with desert environment) forage and rest in these areas, particularly at man-made bodies of water. Playas provide little wildlife habitat because they are basically devoid of vegetation; however, they do contain endemic microbiological communities of algae that support brine shrimp. Migratory waterfowl and large mammals may visit these areas after periods of heavy rainfall. Finally, the rocky terrain provides habitat for many reptile, rodent, and bird species.

Sixteen resident and 19 nonresident species are considered to have special status at MCAGCC Twentynine Palms. The desert tortoise, both federally and state listed as threatened, is the only federally listed resident faunal species known on installation. MCAGCC lies within the southern Mojave subdivision of the Western Recovery Unit for the desert tortoise. Critical habitat is not found on the installation; however, the installation shares a 6.2-mile boundary with the Ord-Rodman critical habitat to the northwest, and the Pinto Mountain critical habitat area is 6 miles southeast of the installation boundary. More than 13 studies at MCAGCC have been conducted to characterize the desert tortoise biology, behavior, and life cycle.

Although the vegetation at MCAGCC is predominantly creosote bush scrub and saltbrush scrub, elements more typical of the Sonoran Desert are also present. As of September 1998, there were 387 native and naturalized vascular plants recorded for Twentynine Palms, which included 66 families, 219 genera, 381 species, and 387 total taxa (including subspecies and varieties). A installation-wide survey in 1993 did not find any federally or state threatened or endangered plant species. A more recent study in 2000 reports 11 sensitive plant taxa (of which 10 are documented with California Natural Diversity Database forms) at MCAGCC Twentynine Palms. The sensitive plants include Coulter's goldfields, Robison's monardella, Mojave woolly sunflower, spearleaf, Chinese lantern, silkcotton purslane, and salt spring checkerbloom.

At MCAGCC all species of wildlife are considered within the Integrated Natural Resource Management Plan (INRMP). Some species, however, may be specifically targeted for control, with the exception of the European starling, English sparrow, rock dove (pigeon); household invertebrates, household rodents, and Africanized or European honeybees. Africanized honeybees are prevalent in San Bernardino County. The spread of non-native fire ants is also a major concern. Fire ants are slowly spreading northward from southern California. Their nests can be identified by mounds of excavated sand. Additionally, the Common Raven population has increased greatly due to the increased human presence in the Mojave Desert. The greatest concern with ravens is the predation on young desert tortoises, and raven reduction is a frequently listed strategy for protection of the federally listed desert tortoise.

Coyotes are not considered pest species except when individual animals become a nuisance. Coyotes in the training areas are not controlled unless they show signs of aggression, illness, or injury. Feral and free-roaming dogs are considered a pest species on the combat center and are a concern throughout the desert. They prey on desert tortoise, and the installation is currently cooperating with the Desert Managers Group Interagency Feral-Free Roaming Dog Management Team.

Invasive species at MCAGCC Twentynine Palms affect wildlife habitat, visual quality, land value, and the military training mission. A study of invasive nonnative plants, which was concentrated along the western boundary, observed nine invasive species.. The removal of salt cedar from MCAGCC Twentynine Palms is an ongoing land restoration action. Trees have been removed from Mainside and in the training areas, most notably Lead Mountain. These trees have limited wildlife value, displace native species, and are water-inefficient. More than 40,000 plants have been removed since 1996.

Russian thistle and Saharan mustard are invasive plants that are being targeted for removal in major areas of infestation. Complete eradication is not a reasonable goal for either species, but management efforts will be focused on containment of these species. A nonnative Mediterranean grass is pervasive across the military installation and increases wildfire risks greatly.

Cultural Issues

Native Americans entered the Mojave Desert at least 12,000 years ago. First attracted to the perennial springs and lakeshores as prime hunting and gathering locations, Native Americans continued to hunt game and gather a wide variety of flora resources even as the climate became hotter and drier through time. The MCAGCC installation is rich with prehistoric and historic archeological sites that range in size from a few square feet to many hundreds of acres. Prehistoric archeological sites include high-quality toolstone quarry sites, campsites, rock art and ceremonial locations, caves, and small lithic and ceramic scatters that date from 100 to 10,000 years ago.

Historic archeological sites in the area are related to the first mining efforts in the southern Mojave Desert. These mines were established in the 1880s and were linked to the establishment of railroad sidings and stations in the desert. Mining and ranching dominated the early historic period and were eventually replaced by homesteading. There are 59 known mines/mining sites on the installation, of which 32 were found to be significant and eligible for listing in the National Register of Historic Places. Mining site studies have identified two mining districts: 1) The Lava Bed Mining District is located in the Sunshine Peak Training Area, and 2) the Delta Mining District encompasses the mountain range between Prospect and Delta Training Areas.

World War I veterans who had been exposed to German gas attacks claimed the first homesteads. They moved to the Twentynine Palms region because the dry, clean air was beneficial to their health. In the 1930s, the depression era brought additional residents to the high desert. Some newcomers wanted to get away from the high cost of living in the cities; others wanted to try their hand at mining. This resurgence of mining activity continued well into the 1940s when the military arrived in the desert. The military history of the installation began in 1941 when the Army Air Forces established Camp Condor to train glider pilots. In 1952, the Marine Corps acquired more than 900 square miles in the vicinity of Twentynine Palms, including Condor Field, for use in training Marines with long-range weaponry.

MCAGCC consults with six Native American Tribes that have interests in lands currently occupied by the Marine Corps: the Fort Mojave Indian Tribe, the Colorado River Indian Tribes, the Chemehuevi, the Twentynine Palms Band of Mission Indians, the San Manuel Band of Mission Indians, and the Morongo Band of Mission Indians. Although the military installation does not as yet have any items that relate to human remains or items of cultural patrimony, nor do any of the Tribes identify traditional cultural properties within the installation boundaries, the numerous archeological sites including rock art sites and various rock alignments are interpreted as having cultural significance to Native American groups.

A.5 Marine Corps Logistics Base (MCLB) Barstow

Introduction

MCLB Barstow is located 134 miles east of Los Angeles and 152 miles southwest of Las Vegas in the San Bernardino County High Desert region of the Mojave Desert, near the city of Barstow, CA (population: 22,000). MCLB Barstow conducts procurement, maintenance, repair and rebuild, storage, training, and distribution activities. Active-duty military personnel include approximately 500 sailors and Marines; civilian employees number around 2,500; and Army personnel living on-base total approximately 230, along with their families.

Local Commands and offices include: Command Headquarters, Special Staff Offices (including the Office of General Counsel, Base Inspector, Quality Management, Staff Judge Advocate, Public Affairs, Chaplain, Information Systems, Communications), Headquarters Battalion, Comptroller, Marine Corps Family Team Building/Semper Fit, Public Safety, Installation & Logistics, Maintenance Center, Facilities Services Center, Defense Logistics Agency (DLA), Defense Reutilization and Marketing Office (DRMO).

History and Historic Mission

MCLB was established as the Marine Corps Depot of Supplies (MCDS) at its present location on December 28, 1942. It had originally been planned as a naval supply depot, but the Chief of Naval Operations directed that the facility be transferred to the Marine Corps as a storage site for supplies and equipment needed for the Fleet Marine Forces (FMF) in the Pacific theater during World War II. It was then known as the Marine Corps Depot of Supplies and was under the military command of the Commanding General, Marine Corps Depot of Supplies in San Francisco.

By the end of World War II, the base had outgrown its facilities and, as a result, the Army annexed 2,000 acres of land, approximately 7 miles east of the Nebo Main Base, in October 1946. Located 3 miles west of the town of Yermo, this became the Yermo Annex. In 1954, the Commanding General, Marine Corps Depot of Supplies, moved his flag from San Francisco to Barstow, and since then the base has grown in stature, strength, and size. In March 1961, the importance of MCDS Barstow increased dramatically with the establishment of the Depot Maintenance Activity. In November 1978, the base was redesignated to its present title of MCLB to emphasize its broad logistics support mission.

In the early 1980s, MCLB Albany (Georgia) and Headquarters Marine Corps worked aggressively to integrate logistics support for the FMF and eliminate duplications. As a result, all operational logistics functions moved to Albany and in January 1990, the Commanding General, Marine Corps Logistics Base Albany, was redesignated Commander Marine Corps Logistics Bases.

Present-Day Mission

The base is composed of three principal sites:

- Nebo, which encompasses 1,879 acres and functions as base headquarters and is the main facility for administration, storage, recreational activities, shopping, and housing functions
- Yermo Annex, which encompasses 1,859 acres and is primarily a storage and industrial complex that includes Barstow's Maintenance Center, base stables, and Obregon Park
- The third site, which totals 2,438 acres and comprises rifle and pistol ranges

The mission of the logistics base is to procure, maintain, repair, rebuild, store, and distribute supplies and equipment as assigned; to conduct such schools and training as may be directed; and to perform such tasks and functions as may be directed by the Commandant of the Marine Corps or the Commander, MCLB Albany. These services are primarily focused on Marine Corps forces west of the Mississippi River and to the Far East. MCB provides maintenance and maintenance-related products and services. MCB repairs, rebuilds, and modifies all types of Marine Corps ground combat equipment and combat service support equipment.

The desert site was chosen for two reasons. First, it has excellent outdoor storage conditions, made possible by the area's absence of rainfall and low humidity, which limits mold, rust, and mildew to the equipment. The outdoor cost of storage is minimal compared to the cost of erecting warehouses to store large items like tanks, cranes, and other heavy equipment. The second reason is the availability of transportation. Barstow is served by three major highways—Interstates 15 and 40, both of which pass by the base, and State Highway 58. Barstow also intersects two of America's busiest cross-country railroads, the Burlington Northern-Santa Fe and the Union Pacific, all of which make possible the receiving and rapid shipment of vital supplies and equipment to any part of the United States. In addition, emergency shipments can be airlifted from the Daggett Airport, located 14 miles east of MCLB-Nebo and 7 miles east of MCLB-Yermo Annex. Daggett has 6,000 feet of runway, allowing large aircraft to land there.

The base employs a combined military-civilian work force. The highly technical nature of the work performed there requires a stable work force that is best achieved by career civilians. At the same time, Marines posted to the fleet from Barstow carry with them an intimate acquaintance with the most advanced technical knowledge in their respective fields, increasing the capabilities of the field commander. The departments are directed by a Marine Officer, except for the Comptroller Department, and many tenants and division heads are headed by civilian employees.

Barstow Maintenance Center (Depot)

The Multi-Commodity Maintenance Center (MC) is located within the Yermo Annex of MCLB Barstow. Yermo is located 11 miles east of Barstow adjacent to Interstate 15 (8 miles east of Nebo). The MC repairs, rebuilds, and modifies all types of Marine Corps ground combat equipment and combat service support equipment and provides maintenance and maintenance-related products and services. It consists of three large steel, concrete, and brick buildings totaling 742,510 square feet of covered workspace. Hardstand surrounding the central repair facility provides an additional 1.7 million square feet of outside storage, staging, and limited work area. The central repair shop is structured around a 1,050-foot long by 80-foot wide crane way with two 87.5-ton bridge cranes servicing the crane way. Two 40-ton cranes, a 30-ton crane, a 20-ton crane, two 10-ton cranes, and numerous other smaller cranes are located throughout the building. Shop equipment ranges from heavy industrial equipment to state-of-the-art laser optical test equipment.

The Marine Corps MCs do not specialize in the support of a specific commodity. They are capable of supporting all Marine Corps ground combat and combat support equipment. Personnel are cross-trained to apply common skills to work on a variety of equipment in different commodities. This affords the Marine Corps MCs the flexibility to rapidly realign their work force to meet the changing requirements of the FMF. While the MCs' capacity for each major commodity is highly flexible, their total capacity is relatively constant.

Fleet Support Division

The MCLB Barstow Fleet Support Division is one of the preeminent storage activities within the DoD. Its mission is the receipt, inspection, accounting, issuing, and storage as a part of the management of the Marine Corps Care-in-Storage Program for Stores Accounts Principle End Items (PEI) and small arms components. The Division also executes the MCLB Barstow Supply Support Program, the Assemble and Disassemble Collateral Material (CM), and manages Supply System Responsibility Items (SSRI), Sets, Kits, and Chests in support of Marine Corps requirements. Additionally it provides retail, intermediate, and consumer supply support to base and tenant organizations.

<u>Utility services</u>

Accounts, meters, tariff rates and/or negotiated contracts, and third-party energy supply

Table A.5 – MCLB Barstow Utility Overview

Measure	Quantity
Annual Consumption (MWh)	31,000
Monthly High Consumption (MWh)	3,200
Monthly Low Consumption (MWh)	2,100
Monthly High Demand (MW)	8
Monthly Low Demand (MW)	6

MCLB Barstow has two main electricity meters connected with SCE; one for the Nebo portion of the base and one for the Yermo Annex portion. Both meters are served under SCE TOU-8-B-DBP utility rate schedules, and both meters participate in SCE's Direct Access program, whereby the base contracts for the generation portion of its electricity supply with WAPA in the competitive market. MCLB Barstow joins with many other Navy and Marine installations, including MCAGCC Twentynine Palms, in receiving competitive supply service from WAPA, which provides the base with greater choice in establishing its rates and greater certainty in budgeting for the generation portion of its electricity costs than if the base remained on full, bundled tariff service with SCE. Competitive supply, like that from WAPA, may additionally offer savings opportunities compared to bundled utility service, but such savings are not certain. From SCE, MCLB Barstow only receives distribution service (the utility moves the power procured by WAPA from the edge of the SCE system to the base's meters and maintains its distribution system reliability). The majority of SCE's distribution charges are determined by the base's monthly peak demand, so the base's electricity usage each month determines a minority of its SCE charges.

Combined across its two main meters, MCLB Barstow annually consumes approximately 31,000 MWh, has a peak demand of 8 MW, and spends just over $4 million on electricity. Its average, combined generation and distribution, rate is about $133/MWh (or $0.133/kWh). This total cost can be divided into about $53/MWh in distribution charges from SCE and $80/MWh in generation charges from WAPA.[133] Over the reference period of May 2010 to April 2011[134], the base's monthly electricity consumption recorded on its utility bills varied from a low of about 2,100 MWh to a high of about 3,200 MWh. The base's peak demand varied monthly from approximately 6 to 8 MW. Among its two main meters, the Nebo account represented 27 percent of total annual consumption, and the Yermo Annex represented 73 percent of consumption.

Renewable Energy

While MCLB Barstow currently operates a 1.5-MW wind turbine, the base does not yet possess any solar energy facilities. In February 2010, the U.S. Navy awarded a $200-million IDIQ contract to five solar energy developers to construct, own, operate, and maintain up to 40 MW of solar energy capacity located on military installations in the southwestern Unites States and sell the resulting power to the Navy/Marines. Prior to the IDIQ contracts, the Navy issued a Request for Proposal for a two-site solar energy facility at MCLB Barstow comprising 30 acres—20 acres at the Yermo Annex and 10 acres at the Nebo base. The 30-acre solar development at MCLB Barstow is expected to be one of the first three solar energy projects developed as part of the larger IDIQ contract.

Status of Withdrawn Lands

Approximately 60 percent of MCLB Barstow's lands are composed of land withdrawals from the DOI. The most recent land withdrawal dates back more than 40 years to 1968, while some extend back as far as World War II. Because of their age and size, none of the land withdrawals are subject to periodic Congressional renewal and will remain in effect indefinitely.

Mission Activities

The mission activities at MCLB Barstow involve equipment and vehicle procurement, maintenance, repair and rebuilding, storage, and supplies and equipment distribution.

Barstow Utilization

The ranges on MCLB Barstow are all small arms ranges used for annual qualification and sustainment training for rifle, pistol, and shotgun and for recreational use. They are designed to be static fire ranges, but limited live-fire and maneuver can be conducted with prior coordination and permission. These ranges are not heavily used, but they are critical for conducting required qualification, and proficiency and sustainment training of the active duty personnel assigned to the facility.

---

[133] In addition to the WAPA generation charges described here, there are competitive transition charges (CTCs) assessed by SCE in some months that can add roughly 2% on an annual basis to competitive electricity supply costs.

[134] No November 2010 SCE bill was reviewed for this Base for its Yermo Annex account. That month's consumption was obtained from other bills listing 13-month consumption history. The peak demand and utility cost for November at Yermo Annex were estimated by applying ratios from the December 2010 bill to the November consumption volume.

Mission Compatibility

The activity-related compatibility issues associated with the ranges at MCLB Barstow all relate to operations at the ranges described previously. None of the activities are classified at a sensitivity level that would restrict their usage for solar projects; however, the ranges are used for live-fire training which makes them incompatible with solar energy projects. Other operating areas that comprise the MCLB Barstow Base have been used to support solar energy development and can continue to support these types of projects on a limited basis if properly coordinated with the base and regional commanders.

Biological Issues

The dry, sparse appearance of MCLB Barstow can be deceiving when considering the diversity of plant and animal species which inhabit the base. Five plant communities have been identified on MCLB Barstow: Creosote bush scrub, desert wash scrub, cottonwood-willow, desert wash thicket, and desert pavement. A total of 145 plant species have been identified on MCLB Barstow, representing 39 families and 105 genera. Sixty species were found at the Nebo site, 59 at the Yermo Annex, and 88 at the Rifle Range. A total of 45 animal species have been recorded on base in limited surveys that have not targeted all species groups. The wildlife inventory cataloged one invertebrate, 49 bird, 18 mammal, three amphibian, and nine reptile species.

MCLB Barstow must protect and manage any plant or animal species listed as endangered or threatened under FESA. The desert tortoise (*Gopherus agassizii),* a federally threatened species, is the only federally listed wildlife species documented on MCLB Barstow. The greatest threats to the desert tortoise populations in the West Mojave Desert are probably: disease; the cumulative effects of habitat loss, degradation, and fragmentation from construction, urbanization, and development; and a high level of human access to tortoise habitat. Disease, specifically Upper Respiratory Tract Disease (URTD), may have caused dramatic declines in some populations. The presence of the desert tortoise on MCLB was formally realized in 1992 and approximately 260 acres of MCLB were surveyed for desert tortoises; 170 acres of the Rifle Range's 2,400 acres and about 90 acres within the Nebo area were surveyed. Of the 30 desert tortoises identified during this survey, 26 were found at the Rifle Range. The desert tortoises found inside the Nebo area were relocated to the Rifle Range, and desert tortoise proof fencing was constructed in 1994 along the Nebo Annex perimeter fence in compliance with a 1993 Biological Opinion. This action was taken to prevent tortoises from migrating back onto the Nebo area as environmental clean-up projects (e.g., Superfund projects) were in the planning stage and the area is routinely used for testing military vehicles.

Most native birds that occur at MCLB Barstow are neotropical migratory species, moving between California and countries to the south as part of their life cycle, and using base habitats for stopover resting and replenishment. As a result of obvious population declines, neotropical migratory birds are the subject of an international conservation effort. Reducing or eliminating pesticide use benefits migratory birds. The base's Integrated Pest Management (IPM) program is designed to reduce the use of pesticides to the minimum necessary. DoD policy requires all operations, activities, and installations worldwide to establish and maintain safe, effective, and environmentally sound IPM programs.

The dominant perennial plants on MCLB Barstow are creosote bush and white bursage. Areas dominated by creosote bush and white bursage comprise approximately 70 percent of the Mojave Desert. There are 154 known plant species in 36 families found on MCLB Barstow. No state or federally threatened or endangered plants are known on the base. A search of the California Natural Diversity Database revealed six additional sensitive West Mojave species with the potential to occur on MCLB Barstow (CNDDB 2004). More than half of the floral diversity of California deserts are annual species, and these may only appear when rainfall amounts and patterns are favorable—possibly once every few years. One federally endangered plant species has potential to occur on MCLB Barstow, the lane mountain milkvetch *(Astragalus jaegerianus)*.

Mammals on MCLB Barstow are generally smaller species such as mice, squirrels, and rabbits and on occasion by larger animals such as the bobcat and coyote. Informal inventories have taken place on each of the three parcels, but little is known about mammal species abundance and interactions. Amphibians are inconspicuous at MCLB Barstow; in fact, only three amphibians have been identified to date. Lizards are frequently spotted moving from one shelter to another or resting in the shade. Snakes also occur though they are less likely to be encountered. By far, the desert tortoise has been studied in the greatest detail at MCLB Barstow.

Invasive species have the potential to affect the value of land on several different levels: biological, hydrological, agricultural, recreational, and economic. Introduced weed species can change ecosystem dynamics by changing soil nitrogen cycling, out-competing natives for water, and predisposing an area to wildfire by providing fuel where there otherwise might not be enough to carry a fire. A few invasive weeds species pose a serious long-term threat to desert habitats and need to be targeted for removal. Salt cedar or tamarisk (*Tamarix ramosissima*) and giant reed (*Arundo donax*) are highly invasive plants that occur in desert riparian areas and have the ability to profoundly modify the structure and function of the ecosystem. Salt cedar in particular is growing abundantly in the Mojave River areas of both Nebo and the Yermo Annex. Examination of historical aerial photos of this area show that the Nebo River area has a much greater cover now than it apparently has had throughout this century due to the invasion of salt cedar. Water use by this plant may be lowering the river's groundwater level as well. Native riparian vegetation uses about 6 acre-feet of water per year while tamarisk uses 8 or more acre-feet per year. Due to the nature of salt cedar dispersal along the river and its extensiveness on MCLB Barstow, it will be difficult to control only those thickets which occur on the base; however, MCLB Barstow may be able to control salt cedar through coordinated regional strategies with upstream and downstream land managers.

MCLB Barstow has taken precautions to reduce the abundance of pest species on base. Feral animals, including cats and dogs, can be a threat to human health and native wildlife populations, including threatened and endangered species. Consequently, Marine Corps policy prohibits free-roaming pets, including cats, and the feeding of feral animals at MCLB Barstow. Marine Corps policy also requires all dogs to be licensed, registered with security, and confined to a leash on military installations. Additionally, studies indicate that raven predation has caused at least localized serious reductions in the number of young tortoises surviving to adulthood on base. USFWS bird surveys found a 1,500-percent increase in ravens in the Mojave Desert between 1968 and 1988. A Raven Management Plan is currently under development.

MCLB Barstow has an IPM plan incorporating continuous monitoring, education, record-keeping, and communication to prevent pests and disease vectors from causing unacceptable damage to operations, people, property, material, or the environment. The IPM uses targeted, sustainable (i.e., effective, economical, and environmentally sound) methods, including education, habitat modification, biological control, genetic control, cultural control, mechanical control, physical control, regulatory control, and the judicious use of the least hazardous pesticides.

Cultural Issues

The cultural resources on and surrounding MCLB Barstow provide an account of the unique history of the desert, its changing natural states and usage. Archaeologists have uncovered evidence of ancient man’s presence at the eastern foot of the Calico Mountains, northeast of the Yermo Annex. The Calico Early Man Site contains ancient artifacts reported to date back more than 50,000 years.

Rainbow Basin, 8 miles north of Barstow, contains relics of prehistoric flora and fauna. Fossils such as bones, teeth, and tracks have been revealed for some species of bears, pigs, camels, dogs, antelopes, rhinos, horses, mastodons, rodents, and oreodonts (similar to pigs). The remains of plants such as poison oak, palm, juniper, and oak trees have also been uncovered.

Archaeological resources on MCLB Barstow include two widely dispersed lithic scatters, one sleeping circle site, a petroglyph site, and three prehistoric isolates. Analysis of artifacts recovered from the surface demonstrates no evidence of habitation activities; rather, the recovered materials support the interpretation that the area was used primarily for resource exploitation. The petroglyph and sleeping circle sites may reflect activity associated with a travel corridor through the region. The petroglyph site on the Yermo Annex is located within the abandoned tracked vehicle test tracks. It is enclosed by a chain-link fence in an effort to preserve the rock art as much as possible. The petroglyph is seriously disturbed by the relatively recent carving of initials and dates and particularly by the blasting away of portions of the rock. The petroglyph site in Yermo contains rare remnants of the ―written record” of prehistoric peoples in the Barstow region. Although the rock art site itself, as well as the surrounding archaeological deposits once reported to exist, have suffered from historic exploitation and disruptive land uses, it remains an important site.

The sleeping circle site covers a small area, and it appears that, if it were once larger, the southern portion has been covered by construction of the mounded firing lines. Combined with the absence of both surface and subsurface artifacts, the disturbance of the site’s context severely limits research potential. Historical research and architectural evaluations were conducted for approximately 100 properties in Nebo and the Yermo Annex. No historic properties were found to meet the National Register of Historic Places criteria of eligibility based on the historical research and onsite evaluations. A portion of MCLB Barstow land had been purchased from the Ross family. Though not eligible for the National Register, the gravesite of Walter Ross is an important cultural resource on MCLB. The grave, located in Nebo near Building 33 and north of Joseph Boll Avenue, is fenced and maintained by the Marine Corps in perpetuity.

A.6 Chocolate Mountain Aerial Bombing and Gunnery Range

Introduction

The Chocolate Mtn. AGR is a live-fire training area and ordnance delivery range consisting of approximately 459,000 acres located within desert mountain terrain in Riverside and Imperial counties in southern California. It is approximately 60 miles northwest of Marine Corps Air Station (MCAS) Yuma (Arizona) and is a part of the Bob Stump Training Range Complex (BSTRC), formerly known as the Yuma Range Training Complex (YRTC). The Chocolate Mtn. AGR is closely linked to MCAS Yuma.

History and Historic Mission

The Chocolate Mtn. AGR was created during World War II to provide much needed training in aerial gunnery and bombing to American aircrews. Although military aircraft, weapons systems, and tactics have advanced and changed markedly since the 1940s, the Chocolate Mtn. AGR continues to be a critical military training asset. The Chocolate Mtn. AGR currently provides more than 700 square miles of land and overlying and adjacent special use airspace that extends laterally for thousands of square miles that, among other activities, supports training in air combat maneuvering and tactics; close air support (where air-to-ground ordnance is fired to directly support friendly forces engaged in ground combat); airborne laser system operations; air-to-air gunnery; and air-to-ground bombing, rocketry, and strafing. Artillery, demolitions, small arms and Navy Special Warfare training are also conducted within the range. The greater value of the Chocolate Mtn. AGR, however, is that it is a centerpiece in a much larger training complex that incorporates adjacent and nearby special use airspaces and ranges to support full spectrum combat operations so that Marines can realistically train as they will fight.

The land area of the BSTRC encompasses approximately 1.2 million acres in southwest Arizona and southeast California and is the Marine Corps' largest installation. In addition to the Chocolate Mtn. AGR, the BSTRC includes approximately 5,000 square miles of airspace designated for military use in California and approximately 5,000 square miles of airspace in the western segment of the Barry M. Goldwater Air Force Range (BMGR) designated for military use in Arizona. The complex is the only location available to and operated by the Marine Corps where the primary mission is to provide full-spectrum support for Marine Corps tactical aviation training.

Present-Day Mission

The Chocolate Mtn. AGR supports military aircrew training in air combat maneuvering and tactics; airborne laser system operations; air-to-air gunnery; and air-to-ground bombing, rocketry, and strafing. Artillery, demolitions, small arms, and Navy Special Warfare training are also conducted within the range.

Access to the Chocolate Mountains is by air or surface roads. The Chocolate Mountain Impact Area provides a large land and airspace area for air tactics, Close Air Support (CAS) missions, laser system operations, and air-to-ground bombing, rocket, and strafing exercises. All types of live and inert conventional ordnance up to 2,000-pound general-purpose (GP) bombs, including MK 20 (Rockeye) and cluster bomb units (CBUs), are authorized in specific areas with prior coordination. Due to past noise complaints, High Explosive Ordnance deliveries are restricted to the hours of 0600-2200 local time.

Ranges, Airspace and Usage

The BSTRC is located in the southeastern California and southwestern Arizona deserts approximately 100 miles east of San Diego. An electronic warfare (EW) range is established at MCAS Yuma.

The complex is composed of the following instrumented areas:

- Urban Target Complex Yodaville (R-2301W)
- Cactus West (R-2301W)
- Yuma Tactical Aircrew Combat Training System (TACTS) Range

The following restricted, Military Operating Areas (MOA) and Air Traffic Control Assigned Airspace (ATCAA) are associated with this complex:

- Barry M. Goldwater Gunnery Range (R-2301W)
- Chocolate Mountain Impact Area (R-2507)
- Chocolate Mountain Aerial Gunnery Range (R-2507)
- Abel MOA/ATCAA
- Quail MOA/ATCAA
- Turtle MOA/ATCAA
- Dome MOA/ATCAA
- Imperial ATCAA
- R-2306
- R-2307
- R-2308
- R-2309

Management responsibilities for the BSTRC are shared among several agencies. Presently, MCAS Yuma is the designated using agency and schedules activity for the majority of the YTRC airspace areas. MCAS Yuma is also responsible for land management, environmental compliance, security, training procedures, and safety on the Chocolate Mountain Range as well as for the development, maintenance, and operation of targets and other facilities.

The primary objective of BSTRC management is to maintain and advance the training conditions of the complex so that it continues to offer Marine and other service commanders the diversity and flexibility necessary to employ and exercise their units in all phases of tactical aviation to the fullest extent and under conditions that realistically simulate combat.

Ongoing military use of the land is authorized under various Federal public laws and public land orders. Examples of some of the existing facilities used for training include an auxiliary airfield complex, realistic targets for air-to-ground attack, air-to-air firing ranges, and electronic warfare training ranges.

The Chocolate Mountain Impact Area is an unattended/non-instrumented ordnance range located approximately 60 miles northwest of the MCAS Yuma. It has five target areas, each with numerous individual targets. These targets include vehicle hulks, convoys, anti-air sites, simulated airfield, and headquarters complexes.

The mission of the BSTRC Range Management Department is to safely and responsibly manage the ranges that comprise the BSTRC by controlling all ground activities; conducting range sweep operations; performing target maintenance; ensuring environmental compliance and documentation; providing natural resource management; monitoring legislative actions affecting the BSTRC; coordinating joint range activities with Federal, State, and local authorities; and supporting the training of military units utilizing the BSTRC.

MCAS Yuma Mission

Today, training missions from MCAS Yuma account for 80 percent of USMC air-to-ground weapons delivery aviation training, placing the area ranges and airspace at the top of Marine Corps and DoD priorities. Each year, the air station hosts numerous units and aircraft from U.S. and NATO forces; average annual training levels are approximately 70 aviation units, bringing 600 aircraft and 14,000 personnel.

The air station major tenant units are Marine Aviation Weapons and Tactics Squadron (MAWTS)-1, Marine Aircraft Group-13, Marine Wing Support Squadron-371, Marine Fighter Training Squadron-401, Marine Air Control Squadron-1, and Combat Service Support Detachment-16, with approximately 4,000 active-duty Marines and sailors. MCAS Yuma's personnel and infrastructure cover all garrison mission responsibilities and support a Station Headquarters and Headquarters Squadron (H&HS). H&HS flight operations are performed by three UH-1N Search & Rescue Helicopters and two UC-12 fixed-wing turbo-prop personnel transport aircraft, operating throughout the Yuma ranges.

MAWTS-1

MAWTS-1 provides standardized advanced tactical training and certification of Marine Corps aviation unit instructor qualifications that support Marine aviation training and readiness and provides assistance in developing and employing aviation weapons and tactics. The centerpiece of MAWTS-1 operations is the conduct of two Weapons and Tactics Instructor (WTI) courses per year, producing more than 300 WTI graduates annually. A separate Aviation Development, Tactics and Evaluation Department (ADT&E) at MAWTS-1 develops and evaluates tactics and hardware in all functional areas of Marine Corps aviation, and a Ground Combat Department integrates tactics and training with Marine infantry, artillery, and armor.

MAWTS-1 maintains close, mutually beneficial liaisons with the aviation and tactics schools of the Navy, Army, Air Force, and several allied nations. Each WTI course requires extensive use of all ranges and airspace in the Yuma area including day and night live ordnance delivery, low-altitude flight operations, and supporting ground operations throughout the ranges. The last week of each course is the Final Exercise (FINEX), during which students plan and carry out a fully integrated, combined arms operation. That exercise incorporates all six major functions of Marine Aviation: offensive air support, anti-air warfare, assault support, aerial reconnaissance, electronic warfare, and control of missiles and aircraft as well as extensive ground operations throughout each training area. The MAWTS-1 mission, WTI training courses, and the military training areas and ranges that support those efforts are considered critical to Marine Corps combat readiness.

Marine Aircraft Group (MAG)-13

MAG-13, a key permanent tenant unit at MCAS Yuma, is part of the 3rd Marine Aircraft Wing (based at MCAS Miramar, California). It is composed of Marine Aviation Logistics Squadron-13 and Marine Attack Squadrons (VMA) 211, 214, 311, and 513. VMAs 211, 214, 311, and 513 total 56 AV-8B Vertical Short Take-off and Landing (VSTOL) fighter-bomber jet aircraft that provide close-air support, conduct armed reconnaissance, and assume limited air-defense roles. Squadron training operations in the Yuma area utilize all ranges and airspace as part of daily flight operations and require additional expeditionary airfield facilities (EAF) within the training areas for austere landing, takeoff, and aviation support training. These squadrons maintain a readiness and training cycle to prepare them for combat unit and detachment deployments. The Yuma military training areas and ranges that support training in those mission areas are considered critical to MAG-13 combat readiness.

Marine Wing Support Squadron (MWSS)-371

MWSS-371 provides all aviation ground support (AGS) to all components of the aviation combat element (except ground support functions: aircraft supply, maintenance, and ordnance). They are responsible for sustained air operations at air bases and forward operating bases and are the critical component that gives Marine aviation its expeditionary capability. Training in the training areas and ranges fall within 13 functions:

- Internal airfield communications
- Expeditionary airfield services (EAF)
- Airfield Rescue and Fire Fighting (ARFF)
- Aircraft and ground refueling
- Explosive ordnance disposal (EOD)
- Essential engineer services
- Motor transport (MT)
- Field messing facilities
- Routine and emergency sick call and medical functions
- Individual and unit training
- Chemical, biological, radiological, and nuclear (CBRN) defense
- Security services
- Air base commander functions

MWSS training operations involve extended periods in the training areas and ranges and extensive use of combat vehicles and heavy equipment, construction and convoy operations in austere environments, and EAF construction and operations. An example of squadron training area usage is the construction of aircraft runways and parking areas using aluminum matting.

Marine Fighter Training Squadron (VMFT)-401

VMFT-401, a reserve squadron, is the Marine Corps' only adversary squadron. Its mission is to provide instruction to active and reserve fleet Marine forces and fleet squadrons through dissimilar adversary combat tactics. Operating 13 adversary F-5 aircraft out of MCAS Yuma, VMFT-401 supports Fleet Replacement Squadron (VMFAT- 101) in Fleet Squadron Core readiness training, and supports the WTI course. Squadron operations require extensive use of local Yuma training areas and airspace, and unrestricted availability of those training areas is considered mission-critical for the squadron.

Marine Air Control Squadron (MACS)-1

MACS-1 is an aviation command and control squadron that provides aerial surveillance, air traffic control, ground-controlled intercept, and aviation data-link connectivity for the 1st Marine Expeditionary Force. Squadron training in the Yuma area. It deploys systems, vehicles, and equipment into the ranges and training areas and runs field operations for extended periods. Access through these areas, use of the ranges in field training, and unrestricted system operations within the training areas are essential to MWSS-372 combat readiness.

Combat Logistics Company-16

Combat Logistics Company (CLC)-16 is a subordinate unit of 1st Marine Logistics Group, Camp Pendleton, California. It provides tactical logistics to MCAS Yuma aviation and ground operating units and MAWTS-1. When deployed, it continues this mission and remains the tactical logistics conduit for a reinforced MAG and other units operating in the area. CLC-16 also provides intermediate maintenance and supply support for tactical engineer, motor transport, ordnance, and utilities equipment for tenant and augmented commands in the greater Yuma area. CLC-16 training operations require extended field exercises within the Yuma ranges and training areas, supporting bi-annual WTI and Desert Talon Exercises and providing intermediate maintenance support for all service branches, including DoD units conducting training in the Yuma area.

Marine Unmanned Aerial Vehicle Squadron 4 (VMU-4)

VMU-4 began operations out of MCAS Yuma in September 2010. The squadron currently operates four RQ-7B Shadow unmanned aircraft with a detachment of 40 Marines. Eventually, the unit will grow to more than 200 Marines and sailors and 12 aircraft. VMU-4’s certificate of authority from the FAA allows operations from the Barry M. Goldwater Range, through civilian airspace, and into the Chocolate Mountain ranges.

Joint Strike Fighter (JSF) Introduction

The plan for basing the F-35B Joint Strike Fighter at MCAS Yuma over the next six years represents a 39-percent increase in personnel, a 15-percent increase in airfield operations, and a 17-percent increase in airspace and range use. The plan establishes five operational F-35B squadrons and one operational test and evaluation squadron at MCAS Yuma for a total of 88 F-35Bs to replace 56 Harriers and 491 additional military personnel. The transition of five of the six new squadrons would occur between 2012 and 2016. The new infrastructure increases—in station and range improvements—is estimated to total nearly $1 billion in construction requirements.

Utility services

Accounts, meters, tariff rates and/or negotiated contracts, and third-party energy supply

Table A.6 – Chocolate Mtn. AGR Utility Overview	
Measure	**Quantity**
Annual Consumption (MWh)	1,300
Monthly High Consumption (MWh)	130
Monthly Low Consumption (MWh)	80
Monthly High Demand (MW)	0.3
Monthly Low Demand (MW)	0.2

Chocolate Mtn. AGR has one main electricity meter connected with the IID that is served under the large general service utility rate schedule for bundled generation and distribution service. It also has a meter with much lower electricity usage served under IID's general service rate schedule. The installation does not take any competitive or third-party generation supply. The utility's charges for the main meter consist of a relatively modest peak demand charge, usage-based ―consumption" and ―energy cost adjustment" charges that comprise the vast majority of the bills, and small state charges.

On its main meter, Chocolate Mtn. AGR annually consumes approximately 1,300 MWh, has a peak demand of 0.3 MW, and spends about $170,000 on electricity. Its average, combined generation and distribution rate is about $126/MWh (or $0.126/kWh). Over the reference period of November 2009 to October 2010, the installation's monthly electricity consumption recorded on its utility bills varied from a low of about 80 MWh to a high of about 130 MWh. The installation's peak demand varied monthly from approximately 0.2 to 0.3 MW. This installation's electricity consumption and demand is the smallest of any of the installations in this study.

Renewable Energy

Because of its remote location and minimal electricity usage, Chocolate Mtn. AGR has no existing solar projects within its boundaries and no firm plans to locate any future solar energy projects at the range.

Status of Withdrawn Lands

The current military withdrawal for the Chocolate Mtn. AGR expires in October 2014. Because the DoD sees a continuing military need for the range, the Department of Navy is initiating a request to Congress to renew the land withdrawal and continue the military reservation for another 25 years; the renewal request process requires the preparation of a legislative EIS.

The land jurisdiction map of the Chocolate Mtn. AGR closely resembles a checkerboard, where every other section (640 acres or 1 square mile) is managed under either the Department of the Navy or BLM jurisdiction. The Department of the Navy owns 232,116 acres of the checkerboard, while the alternate sections of the range (226,711 acres) are made up of withdrawn lands managed by the BLM. The public lands administered by the BLM are reserved for military uses for 20 years under the terms of the California Military Lands Withdrawal and Overflight Act of 1994 (Withdrawal Act). Because there is both a continuing military need for the

Chocolate Mtn. AGR and the current land withdrawal is set to expire in 2014, the Department of the Navy is initiating the process set forth in the California Military Lands Withdrawal and Overflights Act of 1994 to request Congress to renew the land withdrawal and continue the military reservation for another 25 years.

To support the land withdrawal application, the Department of the Navy is preparing a legislative EIS. In addition to an alternative to renew the land withdrawal using the current land boundary, which approximates but does not directly follow certain prominent geographic features, the EIS will assess alternatives that would align part of the Chocolate Mtn. AGR boundary to closely parallel but no longer cross features such as the Bradshaw Trail and Coachella Canal. Also, while all of the modern environmental laws apply to both the BLM and DoD, the Navy manages its environmental stewardship responsibilities through the Sikes Act, while then BLM manages its responsibilities through Federal Land Policy and Management Act (FLPMA). Because the management goals and procedures of these acts differ, two separate resource management plans are required to administer the checkerboard land jurisdiction pattern of the range. To provide for more unified management, alternatives in the EIS will also consider assigning the natural and cultural resource management responsibilities to the Secretary of the Navy rather than continuing to split these functions between the DoD and BLM (USMC 2011).Because the final EIS is still under development, additional or different alternatives may be developed by the DoD and DOI for how to managed the Chocolate Mtn. AGR withdrawn lands.

Table A.7 – Withdrawn Lands Renewal Alternatives

Alternative	Description of Alternative
Alternative 1	Renewal of Status Quo - Renew the land withdrawal for another 25 years (without the restructured boundaries). The management of the military activities would remain with Navy and the management of the natural and cultural resources would remain with BLM.
Alternative 2	Full Administrative Jurisdiction to the Navy - Renew the land withdrawal for another 25 years with restructured boundaries. Allocate full administrative jurisdiction to the Department of the Navy, in which case Marine Corps Air Station Yuma would manage the natural and cultural resources in addition to the military activities.
Alternative 3	Transfer of Title to the Navy - The BLM public land within the current withdraw and the land within the restructured boundaries would be transferred to the Navy
Alternative 4	Shared Administrative Jurisdiction - Renew the land withdrawal for another 25 years with the restructured boundaries. The management of the military activities would remain with the Navy, and the management of the natural and cultural resources would remain with BLM.
No Action	No Renewal of Withdrawal - The lands would return to BLM as public lands managed by FLPMA (and the Northern and Eastern Colorado Desert Coordinated Management Plan). No training would be conducted per the California Desert Protection Act, California Military Lands Withdrawal and Overflights Act of 1994 (§ 808(e)(2), P.L. 103-433). The Department of the Navy would finish expiration responsibilities in accordance with § 808(e), P.L. 103-433 and any other applicable range closure requirements.

Marine Corps Range Environmental Vulnerability Assessment (REVA)

The REVA program meets the requirements of the current DoD Directive 4715.11 Environmental and Explosives Safety Management on Operational Ranges within the United States and DoD Instruction 4715.14 Operational Range Assessments. The purpose of the REVA program is to identify whether there is a release or substantial threat of a release of munitions constituents (MC) from the operational range or range complex areas to off-range areas. This determination is accomplished through a baseline assessment of operational range areas, development of conceptual site models (CSM), and, where applicable, screening-level fate and transport modeling of the REVA indicator MC. Indicator MC selected for the REVA program include octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX), hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), trinitrotoluene (TNT), and perchlorate. The REVA report presents the assessment results for the operational land-based ranges and training areas managed by MCAS Yuma, which include the Chocolate Mtn. AGR located in Riverside and Imperial counties, California, and the western portion of the BMGR West. This report is the first comprehensive report on MC associated with the operational ranges at MCAS Yuma and provides a baseline assessment of environmental conditions and potential vulnerabilities associated with the operational ranges.

Subsequent vulnerability assessments will be conducted on operational ranges at MCAS Yuma on a five-year cycle or when significant changes are made to existing ranges that potentially affect the determinations made during this baseline assessment, as described in the REVA Reference Manual (Malcolm Pirnie, 2006).

Mission Activities

Chocolate Mtn. AGR activities include aircraft operations supporting pilot training in air combat maneuvering and tactics; close air support (pilot training to practice the techniques of air-to-ground ordnance being fired to directly support friendly forces engaged in ground combat); airborne laser system operations; air-to-air gunnery in the airspace above the range; and air-to-ground bombing, rocketry, and strafing in the designated target areas. Ground-based training is also conducted within the range for non-aviation forces including artillery, demolitions, small arms, and naval special warfare training.

Chocolate Mountain Utilization

The Chocolate Mtn. AGR supports approximately 12,000 aviation training events annually which includes the use of approximately 480,000 expendables (chaff and flares) and approximately 10,000 aviation ordnance delivery events that often utilize Joint Direct Attack Munitions (GBU 31, 32, and 38) and Laser Guided Bombs (GBU 12, 16, and 10), which includes the 2,000-lb. high explosive variant of both weapons. Additionally, ground unit tenant training activities in the Chocolate Mtn. AGR by Naval Special Warfare Command (NSWC) total approximately 1,300 ground-based live-fire and maneuver training events annually, heavily concentrated along the western boundary of the Chocolate Mtn. AGR. Generally, the Chocolate Mtn. AGR continues to be a critical military training asset and is expected to be used to support new aircraft including the MV-22 (also known as the Osprey) and the F-35 (also known as the Joint Strike Fighter). The F-35 introduction is forecasted to increase airspace and range use by 17 percent. In addition, the Chocolate Mtn. AGR supports air combat training needed by Air Force, Army, National Guard, and land-based training by Navy special warfare units.

Mission Compatibility

The type of training activities involving live and inert ordnance employed by aviation and ground units training at the Chocolate Mtn. AGR are incompatible with the development of solar energy development on the range. The air-to-surface, artillery, small arms, machinegun, low-level flight, and combined arms training conducted in these areas have inherent hazards and risks that would preclude the development of solar energy projects. A more detailed mission compatibility discussion can be found in the Mission Compatibility Chapter (Chapter 4).

Biological Issues

The Chocolate Mtn. AGR comprises approximately 463,623 acres and is a live-fire aviation training range that is located to the east of the Salton Sea in Imperial and Riverside counties, California. The Chocolate Mtn. AGR is situated in the Lower Colorado River Valley Subdivision of the Sonoran Desert, although many of the flora species found in the range are representative of Mojave Desert floral assemblages. The Chocolate Mtn. AGR is broadly ecotonal between the more northerly Mojave Desert and the Sonoran Desert.

Three basic vegetation types occur on the Chocolate Mtn. AGR: creosote bush scrub, microphyll woodland, and alkali/saltbush swale. Special status plants that occur within the Chocolate Mtn. AGR include fairy duster (*Calliandra eriophylla*) and Munz's cholla (*Opuntia munzii*). The Chocolate Mtn. AGR is inhabited by an abundance of wildlife species, including but not limited to mule deer, bobcat, black-tailed jackrabbit, red-tailed hawk, Gambel's quail, desert iguana, and zebra-tailed lizard. Sensitive wildlife within the Chocolate Mtn. AGR include the prairie falcon (*Falco mexicanus*), LeConte's thrasher (*Toxostoma lecontii*), Gila woodpecker (*Melanerpes uropygialis*), chuckwalla (*Sauromalus obesus*), rosy boa (*Lichanura trivirgata*), Colorado Desert fringe-toed lizard (*Uma notata*), desert tortoise (*Gopherus agassizii*), pallid bat (*Antrozous pallidus*), Townsend's western big-eared bat (*Plecotus townsendii*), pocketed free-tailed bat (*Tadarida femorosaccus*), California leaf-nosed bat (*Macrotus californicus*), fringed myotis (*Myotis thysanodes*), and desert bighorn sheep (*Ovis canadensis*). This region typically supports a higher diversity of wildlife than many other parts of the Colorado Desert. The hydrology in this area promotes development of microphyll woodlands within the extensive wash systems throughout the region.

Creosote bush scrub covers the vast majority of the Chocolate Mtn. AGR including most of the Chocolate Mountains themselves. This vegetation type consists of open stands of scattered low shrubs including evergreen sclerophyllous shrubs (e.g., creosote bush) and semi-shrubs (e.g., white bursage), and leaf and stem succulents (e.g., agave and cacti, respectively). Species composition within the type shifts with terrain and from north to south in the Chocolate Mountains. Shrubs occurring in most stands throughout the Chocolate Mtn. AGR include creosote bush (*Larrea tridentata*), white bursage (*Ambrosia dumosa*), ocotillo (*Foquieiria splendens*), and brittlebush (*Encelia farinosa*). In the northeasterly portion of the Chocolate Mtn. AGR, species such as the Nevada joint-fir, short-leaved baccharis, and Mojave yucca give this area an aspect similar to that of the Mojave Desert.

Occurring along watercourses in the Chocolate Mtn. AGR, microphyll woodlands consist largely of tall shrubs; small, mostly leguminous trees; and an under story of smaller shrubs. Species composition in microphyll woodlands shifts from north to south. At the northern boundary of the Chocolate Mountain Range, smoke tree, desert willow, blue palo verde, and ironwood are abundant with cheese bush as a common understory shrub. In the southern portion of the Chocolate Mtn. AGR, microphyll woodlands are dominated by blue palo verde, ironwood, and Anderson thorn bush. Most of the bajadas of the southern Chocolate Mountain Range have a mixture of creosote bush scrub with microphyll woodland vegetation concentrated along finely dissected arroyos with inter washes of desert pavement. In this portion of the Chocolate Mountain Range, microphyll woodlands are characteristically interspersed with nearly barren desert pavement. The alluvial fans on the north and west sides of the Chocolate Mtn. AGR lacking in desert pavement consist of more broadly dissected arroyos with associated microphyll woodlands and open stands of creosote bush scrub.

Finally, bunchgrass/catclaw swale consists largely of alkali sacaton with velvet mesquite and catclaw. Distribution of this type is extremely limited; it is found only at the divide between the Salt Creek and Milpitas Wash drainages, and areas south of Black Hill, and along the north side of the Little Mule Mountains. This type occurs in depressions with fine soils where water accumulates following periods of substantial rainfall. Visually, the dominant species is the coarse grass, alkali sacaton, which forms an almost solid cover in the central part of the depression. Larger woody species tend to be concentrated around the edges.

Invasive/non-native species within the Chocolate Mtn. AGR include Sahara mustard (*Brassica tournefortii*) Mediterranean grass (*Schismus* sp.), and tamarisk (*Tamarix* sp). Sahara mustard and Mediterranean grass are annuals that die each year, and their seeds lie dormant for long periods of time in the soil. During wet periods these species erupt and cover much of this portion of the desert. These annuals pose a threat to the native community by increasing risk of wildfire by providing light transmission fuels. These species can also compete with native plants. Tamarisk is usually found in association with moisture, either in washes or riparian areas. It can pose a major threat to native plant life by depleting subsurface water and increasing soil salinity. With enough water available, tamarisk would grow in dense monoculture stands and provide little benefit to most wildlife.

In the Chocolate Mtn. AGR surface drainage is divided, on western slopes drainage is toward the Salton Sea whereas drainage from the east slopes of the central portion of the Chocolate Mtn. AGR is by several passes through the mountains and these passes carry ephemeral flows to the Salton Sea. Drainage from the eastern slope of the southern portion of the Chocolate Mountains is northeastward into Milpitas Wash and to the Colorado River.

Cultural Issues

Anthropological and historical evidence suggests that the part of the Chocolate Mountains encompassed by Chocolate Mtn. AGR has generally been a peripheral area, somewhat removed from the main centers of both Native American and Euro-American historical development. Nevertheless, archaeological surveys conducted since the 1970s have recorded more than 200 sites at Chocolate Mtn. AGR. Common site types include lithic scatters and flaking stations, rock rings and cleared circles, and trail segments.

A number of Native American groups lived in the general vicinity of the Chocolate Mountains and visited them or traveled through them from time to time; however, the ethnographic literature makes little specific mention of these mountains, and they were not among the core areas of any groups in the late prehistoric and early historic periods. Historic tribes associated with the regional study area are defined as the Kamia (also known as Desert Kumeyaay), Quechan, Halchidhoma, and Mojave (groups that speak languages of the Yuman family of the

Hokan language stock); the Cahuilla (who are a Cupan group of the Takic family of the Uto-Aztecan language stock); and Chemehuevi (a recent offshoot of Southern Paiute who speak a language from the Numic family of the Uto-Aztecan stock). A cultural affiliation study is in progress to help identify appropriate tribes with which to consult. No Traditional Cultural Properties (TCPs) have been identified by tribes with historic ties to the region. The Chocolate Mountains appear to be a place people traveled through on their way to the Colorado River or the Coachella Valley.

Some recorded sites within the Chocolate Mtn. AGR include the historic Kaiser Industrial Railroad, which has not been formally recorded nor evaluated for the National Register of Historic Places. The railroad was constructed in 1947-1948 to haul iron from the Eagle Mountain Mine to Durmid, California, where it met the Southern Pacific Railway on its way to the Kaiser Steel Works in Fontana, California. The railroad, which runs along the northern boundary of the Chocolate Mtn. AGR, is currently in disrepair, having been abandoned in 1983. The Bradshaw Trail is a historic trail that provided access from San Bernardino, California, to the gold mines in La Paz, Arizona. The portion of the trail closest to the Chocolate Mtn. AGR runs roughly parallel to the historic railroad. Bradshaw developed this trail in 1862 along parts of an old Indian trail. In 1931 Malcolm Rogers recorded 80 miles of a prehistoric foot trail from Palo Verde along the northern boundary of the Chocolate Mtn. AGR to the Coachella Valley.

MCAS Yuma has developed a Regional Archaeological Research Design to assist in the National Register evaluation of these sites. Archaeological survey efforts are ongoing; however, access to the Chocolate Mtn. AGR to conduct surveys is typically restricted to a brief window each year when training is shut down to allow ordnance cleanup work to occur.

A.7 Edwards Air Force Base (AFB)

Introduction

Edwards AFB is located on 308,123 acres (481 square miles) acres in the Antelope Valley in southern California and lies in the western Mojave Desert in portions of Kern, Los Angeles, and San Bernardino counties. The base is approximately 100 miles northeast of Los Angeles, about 90 miles northwest of San Bernardino, and about 80 miles southeast of Bakersfield. It is bounded by State Highways 14 to the west, 58 to the north, and 395 to the east, with county road Avenue E near the southern boundary of the base.

Edwards AFB is the second largest military installation in the United States, and it operates like a modest-sized Mojave Desert town. Approximately 11,200 military and civilian personnel work at Edwards AFB, many of whom live either on the base or in the nearby larger communities of California City, Lancaster, Palmdale, and Rosamond. The base consists of largely undeveloped or semi-improved land that is used predominantly for aircraft test ranges and maintained and unmaintained landing sites (i.e., Rogers and Rosamond dry lake beds). The developed portion of the base includes approximately 6 percent of the total area and is concentrated on the west side of Rogers Dry Lake and includes North Base, South Base, Main Base, and Family Housing areas.

History and Historic Mission

Early homesteaders thought of Rogers Dry Lake bed as a wasteland; however, Lieutenant Colonel Henry ―Hap” Arnold, saw it as a one-of-a-kind ―natural aerodrome” and in September 1933, Arnold established the Muroc Bombing and Gunnery Range. This remote training site was established on the east shore of Rogers Dry Lake bed, now a small enclave within present-day Edwards AFB, served the Army Air Corps’ bombers and fighters for several years. With the arrival of World War II, a permanent military installation sprang up for the training of combat flight crews. In July 1942, it was activated as a separate post and designated Muroc Army Air Base.

In the meantime, wartime development of military aviation overwhelmed Wright Field in Ohio with an immense volume of flight test work. It was necessary to find a remote location with good flying weather where a new top-secret airplane could safely undergo tests. In the spring of 1942, a site was chosen alongside the north shore of Rogers Dry Lake bed, about 6 miles away from the training base at Muroc.

In December 1949, Muroc was renamed Edwards AFB in honor of Captain Glen W. Edwards, who was killed a year earlier in the crash of the YB-49 Flying Wing. By that time, the base had already become the reigning center of American flight research and on June 25, 1951, this fact was finally officially recognized when its test community was designated the Air Force Flight Test Center (AFFTC). That same year, the Air Force Test Pilot School moved to Edwards from Wright Field, Ohio.

Over the years, the Air Force and the world of aerospace have continued to meet the future, and every single aircraft to enter the Air Force’s inventory—and a great many that failed to do so—has been tested at Edwards AFB. Some Navy and Army aircraft have been tested here as well.

Arguably, more major milestones in flight have occurred at this military installation than anywhere else in the world. The turbojet revolution, the space revolution, the systems revolution, and now the unmanned aircraft systems revolution have imposed seemingly insurmountable obstacles. The AFFTC's unique blend of natural, technical, and human resources has transformed it into something much more than a benefit to the Air Force; it is an irreplaceable national asset.

Present-Day Mission

The AFFTC at Edwards AFB is the Air Force Materiel Command center of excellence for conducting and supporting RDTE of aerospace systems from concept to combat. It operates the Air Force Test Pilot School and provides considerable test activity conducted by America's commercial aerospace industry. With the center's capability of just-in-time testing, Edwards AFB can provide real-time solutions during combat operations, and this establishes the AFFTC's direct and tangible link to the warfighter. AFFTC staff agencies include contracting, financial management, history office, inspector general, personnel, plans and programs, public affairs, safety, small-business office, and the staff judge advocate office. The two major organizations supported by the center are the 412th Test Wing and the 95th Air Base Wing. A significant portion of Edwards AFB that is used and operated by the AFFTC is the Precision Impact Range Area (PIRA), which is used for a wide variety of RDTE operations. Finally, other tenants units include: NASA Dryden Flight Research Center (DFRC); the Air Force Research Laboratory (AFRL) Propulsion Directorate, Detachment 7; Marine Aircraft Group 46, Detachment Bravo; and the FAA High Desert Terminal Radar Approach Control (TRACON). Although much of the base is undeveloped land, the combined mission and operations of the AFFTC and the various tenant units creates significant land use restrictions as described for each operational area in the following sections.

412th Test Wing and 95th Air Base Wing

The 412th Test Wing plans, conducts, analyzes, and reports on all flight and ground testing of aircraft, weapons systems, software, and components as well as modeling and simulation for the Air Force. In doing so, it manages all engineering support for manned and unmanned aerospace vehicle test programs. The test wing maintains and flies an average of 90 aircraft with roughly 30 different aircraft designs and performs more than 7,400 missions (more than 1,900 test missions) on an annual basis. The Airborne Laser YAL-1 747 test platform is currently undergoing development and modifications for testing, and four variants of the F-35 Joint Strike Fighter aircraft are presently being tested.

There are three core components to the 412th's mission: flying operations, maintenance, and engineering. The Air Force Test Pilot School, also part of the test wing, is where the Air Force's top pilots, navigators, and engineers learn how to conduct flight tests and generate the data needed to carry out test missions. The Engineering Division and the Electronic Warfare Division provide the central components in the conduct of the test and evaluation mission. They provide the tools, personnel, and equipment for the core disciplines of aircraft structures, propulsion, avionics, and electronic warfare evaluation of the latest weapon system technologies. The Project and Resource Management Divisions provide the foundation for the successful program management of test missions. The 412th Test Wing also programs, develops, operates, and maintains engineering technical services and facilities, which conduct and support testing, as well as operates and manages logistic support.

The test wing's support-side counterpart, the 95th Air Base Wing, led by the Installation Commander, is responsible for operating Edwards AFB, including the infrastructure, communication systems, security, fire protection, transportation, supply, finance, contracting, legal services, personnel and manpower support, housing, education, chapel, and quality-of-life programs.

The entire airspace (e.g., R-2515) over Edwards AFB is used for a variety of flight test operations that require a high degree of eyes-in-the-cockpit flying as well as special-use areas (e.g., spin areas, supersonic corridors, drop zones).

The northwest area of Edwards AFB north of Rosamond Boulevard, extending across the Rosamond Hills towards the northern fence line and west of the main cantonment area. This area is designated as a Military Exercise and Test Area. The area is essentially undeveloped with the exception of having numerous radar, telemetry, tracking, and telecommunications stations on several prominent hilltops. The ground surface within this area has an extensive network of dirt roads and trails that originate from both the early homestead days to historic period infrastructure projects. These operational projects include the installation of the northern Radar Fidelity and Geometric Range (RADFAG) Facility, which is a passive radar reflector array consisting of 80 trihedral corner reflectors enclosed in a 6,000 square-foot area. This site uses corner reflectors and Luneberg lenses to test and evaluate forward-looking and side-looking radar systems and was designed to support the B-1B Real Beam and High Resolution Radar test programs. Also in this area is the Prime Base Emergency Engineering Force (BEEF) unimproved landing strip that is 800 feet long by 300 feet wide and was used for landings, takeoffs, and night-vision goggle (NVG) operations. The runway area was devegetated, scarified, and then lined with aluminum matting. Also, a large designated off-road vehicle recreation park in the upper northwest corner of this area is used by base personnel.

Edwards AFB contains five Spin Control Facilities (denoted as North, East, South, West, and Lake Bed) that each exist as a cylindrical airspace that is nearly 5 miles in diameter and extends from ground-level to an unlimited altitude and occupies a significant operational footprint of land on base. This three-dimensional airspace is where aircraft are intentionally stalled and/or induced into a flat spin during which time the pilot recovers the aircraft and returns to normal flight. This is a standard flight test operation for which pilots from the AFTTC and Air Force Test Pilot School conduct training and test missions within this air space on a regular basis. These operations may also involve the test and evaluation of avionics systems and their ability to automatically recover proper flight control under adverse flight test operations. Given the purpose of these airspace areas and a need to keep the area below clear from potential aircraft crashes, these areas would not be suitable for any permanent development or infrastructure projects.

The southwest area of Edwards AFB, south of Rosamond Boulevard, extending across Rosamond Dry Lake bed towards the southern fence lines and west of Lancaster Boulevard to include Buckhorn Dry Lake, which is also undeveloped. Unlike the area to the north, however, this southern region is dominated by Rosamond Dry Lake bed, which is often flooded in the rainy season. Additionally, the area extending east from Rosamond Dry Lake bed, across Buckhorn Dry Lake bed, and over to the south base entry point is covered by thousands of clay pans that also flood during the rainy season. Therefore, this entire area has had very little use from an on-ground operational perspective. Instead, the area contains several drop zones that are used to test pallet drops from cargo aircraft, jettison areas that are used to drop external tanks (e.g., non-munitions) during emergencies, and the small-arms combat range. The small-arms combat range has a large buffer area for safety reasons. The South RADFAG is located on Buckhorn Lake approximately 6 miles southwest of the main base runway and is a passive reflector range to test and evaluate forward-looking and side-looking radar systems. Finally, when Rosamond Dry Lake bed is dry, it is used as an unimproved landing area for test and evaluation purposes.

The Precision Impact Range Area (PIRA) is an active bombing range where a wide variety of test and evaluation activities are conducted. Munitions deliveries on the PIRA are inert, and live bombing is restricted. The single exception is the allowance of 25 AGM-114 Hellfire air-to-ground missile tests that can be conducted each calendar year on a specific target. Also, various Precision Bombing (PB) targets, such as the Dual Air-To-Ground Range (DAGRAG) can be used for air-to-ground strafing and as such large areas have been demarcated as safety zones during these tests. Some PB targets have significant areas around their epicenter that is graded on a regular basis to keep the surface free of vegetation, which assists with ordinance fragment recovery and to help prevent the risk of shrub fires. In addition, certain PB targets are designated as high-elevation drop targets and during these tests, entire range closure is common. The PIRA extends east and north around the edge of the AFRL to include the east range, which also includes several additional PB targets that are used on a regular basis. The PB-6 target in the east range is close to the northeast base boundary corner, and the lands around this target will be maintained without any infrastructure improvements.

In addition to the conventional weapons tests, the PIRA is actively used for laser systems test and evaluation activities. These tests include lasing of PB targets, thermal calibration panels, and other objects on the ground. The tests often use high-energy laser emitters, which necessitate the treatment of lasing targets with the same degree of concern as with munitions tests and therefore large safety zones are established. Thus, the PIRA is often closed during these tests and is only open to essential AFFTC personnel. Other non-conventional weapons testing programs on the PIRA may include directed energy and microwave weapons testing programs.

The PIRA is also used for imaging tests where aircraft mounted sensors are tested to evaluate their capabilities to acquire and image fixed targets. Within the PIRA, Photo Resolution Road extends from the western edge of the PIRA across the eastern most boundary and a wide variety of objects (e.g., aircraft, tanks, black and white image panels) have been placed at regular intervals along this road. At present, these tests often involve use of UAVs, but these tests have been conducted over the past 50 years dating back to the U-2 and SR-71 programs. Imaging tests on the PIRA have also included acquisition and training of imaging sensors on moving targets that drive along Photo Resolution Road within the range. During imaging tests, many of the roads within the PIRA are closed to non-essential vehicle traffic to avoid mission conflict.

The main operational area of Edwards AFB is the main cantonment. This area is composed of the main base, south base, and the historic north base, which was established in 1942. Since that time, this area has been progressively developed and has a wide array of infrastructure, mostly buildings and test facilities, that are either presently used or are abandoned. Presently, more than 4,000 buildings are used for the AFFTC and its primary units, the 412th Test Wing and the 95th Air Base Wing.

The western side of the main base contains the entire Edwards AFB family housing community and all associated infrastructure, including all housing for base personnel, which contains single/duplex/multi-family homes, enlisted personnel quarters, K-12 schools, numerous retail and shopping areas (e.g., BSX,), and a medical clinic. This area of the base has a layout and function essentially like a small city. The eastern side of the main base contains offices, test facilities, hangars, logistics and supply facilities, and the main operational offices for the AFFTC. These facilities include a wide range of building types such as aircraft hangars, indoor turbine tests cells, a large anechoic facility, engine test stands, and hundreds of affiliated support buildings. From a mission standpoint, Rogers Dry Lake bed (and to a lesser extent Rosamond and Buckhorn) is one of the factors that has influenced the development of the base into a major center for testing and mission support of aircraft and spacecraft. Because of their uniqueness, these lake beds will continue to be used to support aircraft and space mission activities. Minimizing ground disturbance and development in the dry lake beds, especially Rogers Dry Lake, is particularly important in order to minimize impacts to the surface of the dry lake, which is critical for aircraft test activities. Use and maintenance of the runways and associated activities are planned and implemented to minimize impacts to the lake bed.

The south base area extends south of the runway and main operational area along the western edge of Rogers Dry Lake bed and down the south gate area. The south base encompasses an area formerly known as the Muroc Army Airfield, which was the center of base activities until the 1950s. Today, the south base area contains the Birk Flight Test Center, the System Integration Laboratory (SIL) building, several large hangars, an abandoned runway, a collection of antique aircraft, a wide-spread area of munitions bunkers, radar facilities, a fire training facility, and the base water treatment facility (and associated evaporation ponds). At the southern edge of this area lies the old infrastructure elements associated with an abandoned rocket-sled track that extended nearly 2 miles and a cargo pallet drop area that is in active use. The south base complex served an integral role in the development of the B-1 bomber and today serves as the primary research and development site for the YAL-1 Airborne Laser (ABL) Program. Other activities include ongoing B-1, B-2, and B-52 RDTE programs that provide continuous upgrade and improvement of the avionics, weapons, and associated flight systems on these aircraft. Much of the area within the south base has been heavily disturbed tracing back to former Muroc Army Airfield days and a wide variety of test programs that have been implemented since that time.

The North Base area is located immediately adjacent to the northwest edge of Rogers Dry Lake bed. Similar to other areas of the Main Base, the North Base region has undergone numerous changes since its establishment in 1942. At present, the area contains a large building to house the Edwards AFB security forces, a few relic hangars, relic support buildings, and a series of abandoned solid-rocket propellant manufacturing bunkers. Some RDTE are ongoing at north base facilities.

Air Force Research Laboratory (AFRL)

The AFRL, Propulsion Directorate maintains a rocket engine test facility on and around Leuhman Ridge, just east of Rogers Dry Lake. This facility traces its roots to early Army Air Corps activities and at present contains two-thirds of the nation's high-thrust static rocket stands. A major expansion of the facilities in 1957 created the basis for today's full spectrum research facility encompassing more than 65 square miles (41,599 acres) of the northeast corner of Edwards AFB.

During the 1990s era, Air Force laboratories across the nation consolidated into four main laboratories. The Edwards rocket testing facilities, by then known as the Astronautics Lab, became an integral part of the Phillips Laboratory, combining with the Geophysics Laboratory, Space Technology Center, and the Weapons Laboratory. The facility was renamed the Phillips Laboratory, Propulsion Directorate, and research has focused on furthering rocket propulsion technologies through efforts such as Space Based Interceptors that were in support of the Theater High Altitude Air Defense (THAAD) program.

The AFRL eventually combined all four laboratories and the Air Force Office of Scientific Research (AFOSR) into a single laboratory commanded by Wright-Patterson AFB, Ohio. The configuration of the nationwide laboratory is based on research and development topics. The Edwards AFB facility is part of the new Propulsion Directorate, which combines Wright-Patterson (Aero propulsion) and Edwards (Rocket Propulsion) research efforts. The rocket propulsion group leads the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) to identify needs, timetables, and demonstrable goals for improvements to rocket propulsion technology. Participants include all military services, industry, and NASA. Other efforts at the AFRL include electric and solar propulsion research, High Energy Density Matter (HEDM) propellant research, and Theater Missile Defense testing.

At present, the Edwards AFB rocket propulsion facility employs approximately 500 researchers, engineers, technicians, and support staff, split almost 50/50 between government/military employees and support contractors. Like other areas of Edwards AFB, land within this facility is highly protected to avoid mission conflicts and to provide substantial safety buffer zones around these full-scale rocket test activities. Access in this facility is highly controlled, and clearance is often required depending on the nature of the active test mission.

NASA Dryden Flight Research Center (DFRC)

The DFRC, located inside Edwards AFB, is an aeronautical research center operated by NASA, named in honor of the late Hugh L. Dryden in 1976. First known as the National Advisory Committee for Aeronautics Muroc Flight Test Unit, the DFRC has also been known as the High-Speed Flight Research Station (1949) and the High-Speed Flight Station (1954).

The DFRC is NASA's primary center for atmospheric flight research and operations and plays a critical role in carrying out the agency's missions of space exploration, space operations, scientific discovery, and aeronautical research and development. The facility helps validate space exploration concepts, conduct airborne remote sensing and science missions, and support operation of the International Space Station. The present-day mission includes management of the launch abort systems testing and integration, in partnership with the Johnson Space Center and Lockheed Martin, for the Crew Exploration Vehicle that will replace the Space Shuttle. Dryden also provides orbital support for the International Space Station.

In partnership with Ames Research Center and the German Aerospace Center, the DFRC manages the Stratospheric Observatory for Infrared Astronomy (SOFIA) program—a flying telescope aboard a Boeing 747 aircraft. The DFRC plays a key role in many aspects of the Fundamental Aeronautics and Aviation Safety programs, including the X-48 Blended Wing Body and Ikhana (Predator B) in support of subsonic and Adaptive Flight Controls, part of the Aviation Safety Program.

Along with research and support aircraft, DFRC assets include simulation laboratories; a high-temperature and loads-calibration laboratory; aircraft flight-instrumentation capability; a flow-visualization facility to study air-flow patterns; a data-analysis facility to process flight research data; and remotely piloted vehicle flight research expertise. In addition, DFRC's Research Aircraft Integration Facility simultaneously checks aircraft flight controls, avionics, electronics, and other systems. This facility is the only one of its type in NASA and is designed to speed up and enhance systems integration and preflight checks on research aircraft. At present, the DFRC employs about 1,000 civil service and contract workers. Most of the land occupied by the DFRC is developed with infrastructure as described previously; there is very little undeveloped land within the facility.

Detachment 7, Marine Aircraft Group 46, Detachment Bravo

Two Marine Corps Reserve helicopter squadrons and the detachment headquarters support staff representing the command at Marine Corps Air Station Miramar, north of San Diego, relocated to Edwards AFB in May 1999, following the closure of Marine Corps Air Station El Toro, California. More than 350 Marines and sailors are stationed there, about half of which are active duty and living in the local area and the other half reservists commuting from their homes throughout California and the United States. Marine Heavy Helicopter Squadron 769 (HMH-769) operates 8 CH-53E Super Stallions. Its mission is to transport heavy equipment, weapons, and supplies during ship-to-shore movements and amphibious assaults. Marine Medium Helicopter Squadron 764 (HMM- 764) operates 12 CH-46E Sea Knights. Its mission is to transport combat troops in initial assault waves and follow-on stages of amphibious operations ashore. Both squadrons primarily support Marines at the nearest Marine Corps installations, Camp Pendleton, and Twentynine Palms, while assisting Edwards AFB with VIP transport, medical evacuations, photo and shuttle landing support, and other assistance during base and community emergencies. The facilities and infrastructure associated with these squadrons are located along the main flight line within a heavily developed area of the main base.

FAA High-Desert Terminal Radar Approach Control (TRACON)

The FAA's TRACON, radio call sign Joshua Approach, provides mission-related air traffic control services to the DoD and DoD-sponsored aircraft within the entire R-2508 airspace complex, encompassing nearly 25,000 square miles. The TRACON's Department of Transportation, FAA civilian personnel also provide air traffic control services to civil aircraft within and outside the special-use airspace. This facility is composed of a large building in the main base operational area, and there is little undeveloped space associated with this tenant facility.

Utility services

Accounts, meters, tariff rates and/or negotiated contracts, and third-party energy supply

Table A.8 – Edwards AFB Utility Overview	
Measure	**Quantity**
Annual Consumption (MWh)	182,000
Monthly High Consumption (MWh)	18,200
Monthly Low Consumption (MWh)	13,400
Monthly High Demand (MW)	36
Monthly Low Demand (MW)	25

Edwards AFB has three large electricity meters connected with SCE; one for the Main Base, one for South Base, and one for AFRL. The base also has six smaller meters with SCE; five of which are for schools and one for a building. All three of the base's large meters are served under SCE TOU-8-DBP utility rate schedules and participate in SCE's Direct Access program, whereby the base contracts for the generation portion of its electricity supply with WAPA in the competitive market. WAPA also serves other installations in this study (MCAGCC Twentynine Palms and MCLB Barstow). WAPA competitive supply can provide the base with greater choice in establishing its rates and greater certainty in budgeting for the generation portion of its electricity costs than if the base remained on full, bundled tariff service with SCE. Competitive supply, like that from WAPA, may additionally offer savings opportunities compared to bundled utility service, but such savings are not certain. From SCE, Edwards AFB receives distribution service (the utility moves the power procured by WAPA from the edge of the SCE system to the base's meters and maintains its distribution system reliability).

Combined across its three main meters, Edwards AFB annually consumes approximately 182,000 MWh, has a peak demand of 36 MW, and spends roughly $10 million on electricity. Edwards AFB receives a special electricity rate from WAPA that is lower than the WAPA rate assessed to MCAGCC Twentynine Palms and MCLB Barstow. Its average, combined generation and distribution, rate is about $49/MWh (or $0.049/kWh). This total cost can be divided into about $30/MWh in distribution charges from SCE[135] and $19/MWh in generation charges from WAPA.[136] Over the reference period of June 2010 to May 2011, the base's monthly electricity consumption recorded on its utility bills varied from a low of about 13,400 MWh to a high of about 18,200 MWh. The base's peak demand varied monthly from approximately 25 to 36 MW. Among its three main meters, the Main Base account represented 38 percent of annual total consumption, South Base accounted for 50 percent of consumption, and AFRL accounted for the remaining 12 percent of consumption.

The utility distribution charges at Edwards AFB are not uniform across its three main meters because the meters are served at different voltages—Main Base at 4,000 volts and South Base and AFRL at 115,000 volts. The higher voltages at the latter two meters are associated with much lower distribution rates. South Base and AFRL have average annual distribution rates of about $25/MWh, while Main Base's average distribution rate is about $37/MWh.

---

[135] Additionally, Edwards AFB incurs about $32,000 in monthly miscellaneous charges from SCE for added service, which, on average, is equivalent to about to 7 percent of its monthly SCE distribution bill.
[136] In addition to the WAPA generation charges described here, there are competitive transition charges (CTCs) assessed by SCE in some months that can add roughly 2% on an annual basis to competitive electricity supply costs.

Renewable Energy

Currently, Edwards AFB has a small amount of distributed solar energy installed on base, primarily from solar panels mounted on light poles throughout the main section of the base. In 2010, Edwards AFB reached an agreement to lease 3,288 acres of land at the base to Fotowatio Renewable Ventures for the private development of a solar energy facility that could be as large as 500 MW in capacity. Currently, the Air Force and Fotowatio are assessing the potential suitability of using land in the northwest corner of the base as the site for the solar energy facility and to arrive at satisfactory leasing terms for the project. Because of the size of the proposed facility, the Air Force would use its enhanced use leasing authority to contract with Fotowatio for the development of the solar facility.

Status of Withdrawn Lands

Approximately 83,110 acres of Edwards AFB's 307,516 acres of land is designated as withdrawn lands. But unlike other military installations in the Mojave Desert, none of these withdrawn lands are subject to periodic Congressional renewal as the most recent land withdrawal occurred more than 50 years ago in 1961. Other land withdrawals at Edwards AFB stretch back as far as 1940. In each case, these land withdrawals are to last so long as the Air Force has a need for the land.

Mission Activities

The AFFTC continues to support the mission of the USAF by conducting and supporting tests of aerospace vehicles; evaluating flight and recovery of research vehicles; participating in developmental test and evaluation programs for the DoD and other government agencies; operating the Air Force Test Pilot School; and developing, operating, staffing, and supporting other developmental test and evaluation programs for contractors and foreign governments. Range 2515 is the main range complex used for Edwards AFB RDTE, training, and other operational activities. It is a restricted airspace range that encompasses the underlying land area to ensure the safety of personnel, structures, and the public from expended weapons, laser and electromagnetic emissions, and target debris. The range is located at the southern portion of the Range 2508 Complex.

Edwards Utilization

Edwards AFB is home to a diverse array of key RDTE and training activities. These activities include air-to-air, air-to-surface, surface-to-air, live air-to-air gunnery, and electronic combat and countermeasures RDTE and training. The Edwards AFB R-2515 range contains various instrument range areas and special use areas (e.g., spin areas, supersonic corridors, drop zones) to support these activities. The range is also used for a variety of flight test operations that require a high degree of eyes-in-the-cockpit flying and numerous UAS operations. In more recent times, this range has been used extensively for the RDTE of the following systems: B-1B, B-2, B-52, C-130, C-17,C-5, F-15, F-16, F-22, F-35 Joint Strike Fighter, RQ-4 Global Hawk, CV-22 Osprey, and the YAL-A1 Airborne Laser. In addition, numerous weapon systems such as the GBU-38 Joint Direct Attack Munitions (JDAM) and a significant amount of the RDTE operations for weapons delivery testing is conducted in the Precision Impact Range Areas (PIRA) found in the East and West Ranges. The Air Force Research Laboratory contains a wide variety of static test facilities that are used for RDTE activities of rockets and their associated propellant systems. Finally, the NASA Dryden Flight Research Center conducts extensive aerospace RDTE that is in support of both military and non-military air and space systems. Across Edwards AFB and its tenant facilities, UASs/UAVs also comprise a significant amount of RDTE range utilization time and space.

Mission Compatibility

The test mission of Edwards AFB can be negatively affected by large-scale solar development. Encroachment onto the land ranges denies Edwards AFB the pristine test environment and important safety buffer required for aircraft test flights and test pilot training. Spectral conflicts close to the distributed sensor network in use also threatens the ability to track and control vital test programs. In spite of these issues, Edwards AFB hosts several small solar energy projects and is contemplating a large solar project in the northwest corner of the base that could total as much as 500 MW. Detailed analysis of range activities and range utilization is required to fully assess which Edwards AFB ranges and activities would be most impacted; however, Air Force Headquarters had not released range usage data and installation activity data on Air Force bases at the time of this writing.

<u>Biological Issues</u>

Edwards AFB contains 58 wildlife and plant species considered of special concern by the CDFG. Of these 58, four are reptiles, eight are mammals, 34 are birds, and 12 are plants. Edwards AFB also contains several sensitive ecosystems including floodplains, yardangs (wind-eroded dunes), mesquite woodlands, and the Piute Ponds complex, an important aquatic habitat for migratory birds. The floodplains support aquatic life during the rainy season and serve as stop-over points for migratory birds. The primary zonal terrestrial ecosystems at Edwards AFB are divided into upland areas that consist of two main plant communities, creosote bush scrub and Joshua tree woodland. The lowland communities consist of the alkali sink and saltbush communities. Azonal plant communities are those of limited geographic area but not necessarily limited by elevation. The primary azonal communities at Edwards AFB include desert wash scrub, alkaline meadow, mesquite woodland, ruderal (cleared areas with invasive plants), and turf and landscaped areas (mostly within the cantonment area).

Edwards AFB is home to the federally and state-listed threatened desert tortoise and designated desert tortoise critical habitat. Between 1991 and 1994, Edwards AFB conducted four major surveys throughout the base to determine relative density estimates of the desert tortoise. With some exceptions, the results indicate that the species occurs throughout the base; however, desert tortoise signs (e.g., live and dead tortoises, shell and other remains, scat, tracks) were not distributed uniformly. The Edwards AFB desert tortoise management program complies with the USFWS terms and conditions listed in its active Biological Opinions.

The Mohave ground squirrel is a California state-listed threatened species. In September 2005, the Defenders of Wildlife petitioned the USFWS to list the Mohave ground squirrel, endemic to California, as an endangered species pursuant to the Federal ESA. Currently, there is no official Federal protection status for the Mohave ground squirrel. In 2010 the USFWS agreed to review the species for listing as endangered however in October of 2011 the USFWS released a decision to not list the species as endangered. Despite the lack of Federal protection for the Mohave ground squirrel, Edwards AFB continues to take measures to manage the species populations that occur on the base.

Many bird species of concern migrate through the area and, on occasion, can be observed at Piute Ponds, in the southwestern corner of Edwards AFB, which is the largest body of surface water on Edwards AFB and largest marsh in the Antelope Valley. Piute Ponds contains aquatic vegetation that attracts a variety of wildlife species, including 13 sensitive bird species, more than 10,000 shorebirds in the summer, and 5,000 waterfowl in the winter. The ponds are fed by effluent from the Lancaster Water Reclamation Plant, which provides secondary treatment, and by occasional flooding of Amargosa Creek and Little Rock Wash.

Edwards AFB contains known populations of 11 sensitive plant species referred to here as CDFG species of concern. Extensive biological surveys have been conducted for three sensitive plant species on base: the Barstow woolly sunflower, alkali mariposa lily, and desert cymopterus. Desert cymopterus is more intensely managed than the remaining 10 species of concern as it was proposed for listing as endangered a few years ago because the majority of the known populations occurred on Edwards AFB and historic populations could not be found off base.

Joshua trees are the most prominent and widespread naturally occurring treelike species on base. Joshua trees occur in creosote and saltbush scrub habitats throughout Edwards AFB but not typically in dense stands. Edwards AFB encourages conservation of Joshua trees wherever feasible and recommends replacement or replanting of Joshua trees to maintain the diversity of natural habitats on base. Additionally, mesquite trees on Edwards AFB constitute a rare habitat within Los Angeles County and have been designated as a Significant Ecological Area by the county's Department of Regional Planning.

Edwards AFB is also home to the burrowing owl, a small ground-dwelling migratory bird that lives in modified rodent holes. Burrowing owls have been observed on base in colonies near the museum, landfill borrow pit, main runway, and NASA/Dryden. Unique among North American owls in many respects, this bird is active both day and night and frequently nests in loose colonies in suburban and farmyard environments, making it a familiar owl and one generally appreciated by base residents.

Edwards AFB is also home to numerous pest species. The California ground squirrel, a non-native species of the Mojave Desert, is a burrowing rodent that occurs in and around the developed areas within the Mojave Desert, along with other native ground squirrel species, such as the white-tailed antelope squirrel and Mohave ground squirrel. Since their introduction at Edwards AFB many years ago, California ground squirrels have spread to all landscape areas within Main Base, the housing area, and South Base.

Another pest species is the common raven, which preys on the threatened desert tortoise, which Edwards AFB is actively managing, protecting, and attempting to recover within the base boundaries. Evidence indicates that ravens are preying on tortoise hatchlings and juvenile tortoises throughout the Mojave Desert. In this situation, the raven is considered a pest species with respect to the survival of the juvenile desert tortoise population. Other aggressive species introduced on base include bullfrogs and African clawed frogs, which are found primarily at

Piute Ponds. The western toad and the red-spotted toad, native to this area, use ponds on base to lay their eggs and are subject to displacement by the introduced pest species.

Cultural Issues

Edwards AFB's is responsible for the development and implementation of all base cultural resource programs and activities designed to meet the requirements of the National Historic Preservation Act (NHPA) (16 U.S.C. 470, et seq.). Management activities for on-base cultural resources may include the identification, evaluation, documentation, protection, stabilization, monitoring, and curation of all collected artifacts resulting from these activities. The program also has a protocol for consultations with Native Americans regarding issues of interest to these groups. Education of on-base personnel and contractors, as well as the general public, represents an extremely important aspect of Edwards AFB Cultural Resources Management program.

Edwards AFB has divided the archaeological resources into three broad time periods: prehistoric, historic, and military. A small number of Paleo-Indian artifacts have been identified on base, suggesting that the prehistoric period may have begun as early as 12,000 years before the present. Although Spanish entry into California was initiated along the coast in the mid 1500s, the historic period does not appear in the Antelope Valley and Edwards AFB specifically until the late 1800s. The military period is ushered in during the late 1920s with the establishment of East Camp on the eastern shore of Rogers Lake.

Much of Edwards AFB has already been surveyed for cultural resources. As of 2008, 173,000 acres have been inventoried, and a total of 3,667 archaeological sites have been recorded. Eligibility rankings on these sites have been determined as follows: one is a National Landmark; 254 are eligible for nomination to the National Register of Historic Places; 844 are ineligible for National Register nomination; and 2,569 sites have not been evaluated and must be managed as eligible sites. More sites will likely be identified as a result of ongoing inventory efforts over the next five years. Considering that just over half the base has been surveyed, the actual number of cultural resources, using existing site definitions, will likely double with the completion of the survey effort.

Edwards AFB consults with Native American tribes to deal with issues concerning the Native American Graves Protection and Repatriation Act (NAGPRA). Edwards AFB is also aware of the importance of traditional cultural places and sacred sites, and per Section 106, it has completed an effort to identify those that require Native American consultation. Four federally recognized tribes may be interested parties: Chemehuevi Reservation, Colorado River Agency; Colorado Indian Tribes Tribal Council: Morongo Band of Mission Indians; and San Manuel Band of Mission Indians. The Integrated Cultural Resources Management Plan for Edwards AFB (Edwards AFB Plan 32-7065) presents strategies for prioritizing areas to be surveyed and evaluated based on the potential for disturbance and/or potential for dense or large deposits.

Appendix B – Terms of Reference

Term	Definition	Source
Air Combat Training System (ACTS)	ACTS ranges are instrumented air-to-air or air-to-ground ranges that allow near real-time observation and assessment or recording and playback. 1.4.5.1. Tethered flight instrumentation range systems provide Time-Space-Position-Information (TSPI) and model weapons impact or flyout for aircrew kill notification using ground-based computers, towers, and communications relays and aircraft pods or internal avionics. Rangeless/untethered flight instrumentation range systems use autonomous pods, aircraft avionics or recording devices of participating aircraft to provide capabilities similar to a tethered system. Pod-to-Pod or aircraft datalinks.	(AF Instruction 13-212 Range Planning and Operations 2010)
Air Drop	Air Drop is the delivery of personnel and materiel from an aircraft in flight to a drop zone (DZ). Most airdrop procedures use parachutes to deliver loads to the ground, such as heavy equipment, container delivery systems, and personnel. Another airdrop procedure is free fall delivery. This involves dropping relatively small items, such as packaged meals or unbreakable objects like hay bales without the use of a parachute. Airdrop allows commanders to project and sustain combat power into areas where a suitable ALZ or a ground transportation network may not be available.	(Sustainable Range Initiative 2010)
Air Refueling	The in-flight transfer of fuel between tanker and receiver aircraft.	(Sustainable Range Initiative 2010)
Airspace	Physical volume of airspace with the necessary features such as types of use, configuration, proximity, capacity, amount, etc.	(Sustainable Range Initiative 2009)
Air-to-Air	Air-to-Air operations cover a wide range of mission requirements. Ranges that support, for example, air-to-air operations involving simulated and actual employment of missiles, air-to-air gunnery, aeronautical system testing, unmanned vehicles, and EC require a substantial amount of range space and a sophisticated range infrastructure. This infrastructure may include high fidelity simulators, visual simulators, end-game scoring capabilities, command and control systems, communications networks, data display/processing capabilities, instrumentation systems, flight termination systems, and flight hazard analysis/strike prediction capability.	(AF Instruction 13-212 Range Planning and Operations 2010)
Air-to-Surface	Air-to-Surface ranges may require a substantial amount of range space and a sophisticated infrastructure to support complex, multi-aircraft operations; air-to-surface and cruise missile employment; aeronautical system testing; unmanned vehicles; and battlefield operations. This infrastructure may include high fidelity threat simulators, visual threat simulators, scoring capabilities, realistic target arrays, command and control systems, communication networks, data display/processing capabilities, instrumentation/debrief systems, flight termination systems, and flight hazard analysis/strike prediction capability.	(AF Instruction 13-212 Range Planning and Operations 2010)
Alert Areas	Military Special Use Airspace that may contain a high volume of fixed and rotary wing pilot training activity or an unusual type of aerial activity, which is not hazardous to aircraft.	(Federal Aviation Administration Glossary)

Amphibious Warfare (AMW)	The set of friendly force offensive and defensive tactics and operations associated with providing expeditionary forces capable of projecting power ashore from the sea to accomplish a specific objective. The AMW range function may support establishing and sustaining landing forces ashore for extended periods or putting landing forces ashore only for a short period of time before withdrawing them. The AMW range function supports virtually every type of ship, aircraft, weapon, special operations force, and landing force employed in concerted military efforts described by the Operational Maneuver from the Sea (OMFTS) doctrine, which includes Expeditionary Maneuver Warfare, and Ship to Objective Maneuver. As a result, the AMW range function supports tactics and operations associated with all phases of ESG and MEU missions using OMFTS, including both amphibious assault and vertical assault tactics. The AMW range function does not support specific post-landing tactics and operations.	(Sustainable Range Initiative 2010)
Anti-Air Warfare (AAW)	The set of friendly force offensive and defensive surface-to-air (S-A) and air-to-air (A-A) tactics and operations associated with defending friendly air, surface, and land forces from emergent hostile air threats, whether launched from air, surface, or subsurface platforms. The AAW range function also supports the set of friendly force offensive A-A tactics and operations associated with gaining and maintaining air superiority or air supremacy of the battle space. The AAW range function supports the use of electronic decoys and electronic jammers used by friendly forces for the purpose of counter-targeting against airborne threats.	(Sustainable Range Initiative 2010)
Anti-Submarine (ASW)	The set of friendly force air, surface, and subsurface offensive and defensive tactics and operations associated with countering hostile and potentially hostile submarine threats. The ASW range function may support open-ocean, choke point, and littoral anti-submarine missions, including detection, classification, surveillance, localization, tracking, and attack.	(Sustainable Range Initiative 2010)
Anti-Surface Warfare (ASUW)	The set of friendly force air, surface, and subsurface offensive and defensive tactics and operations associated with detection, surveillance, and engagement of contacts, critical contacts of interest, and hostile at-sea surface forces. In addition to traditional training against large ships, the ASUW range function also supports a variety of training activities against small boats, swarm attacks, and fast-moving surface vessels. The ASUW range function may also support offensive tactics and operations against designated surface targets located in ports, harbors, and anchorages.	(Sustainable Range Initiative 2010)
AR Route. Aerial Refueling Track	Military Special Use Airspace refueling route flown under visual flight rules.	(Federal Aviation Administration Glossary)
Army Energy Security Implementation Strategy (AESIS)	A U. S. Army program to promote energy efficiency and energy security. Efforts of the AESIS include solar energy facilities, procuring electric and hybrid-electric vehicles for peacetime and wartime use, establishing the Army Energy Security Task Force to assess Army energy planning and Army energy initiatives, initiating six prototype projects to jump-start Army energy security, developing a new hybrid-electric powered ground combat vehicle, developing Army energy metrics and objectives, chartering a new Senior Energy Executive and a new Senior Energy Council to coordinate and direct Army energy security initiatives, and publishing energy security implementation plans by Army commands.	(U.S. Army Corps of Engineers, Ft Irwin Solar Energy EUL)
At risk species	At-risk species are those classified under FESA as threatened or endangered. Threatened means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range	http://www.fs.fed.us/openspace/fote/at-risk-maps/gtr_nrs73.pdf

Base	1. A locality from which operations are projected or supported. 2. An area or locality containing installations which provide logistic or other support. 3. Home airfield or home carrier. See also base of operations; facility.	(JP 4-0)
Base Boundary	A line that delineates the surface area of a base for the purpose of facilitating coordination and deconfliction of operations between adjacent units, formations, or areas.	(JP 3-10)
Brownfields	real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant	(US EPA)
Capability	The ability to achieve a desired effect under specified standards and conditions through combinations of means and ways to perform a set of tasks.	(CJCSI 3010.02B)
Class A	A manned, ground-scoring capable range with a Range Control Officer (RCO) present on range and controlling aircraft operations.	(AF Instruction 13-212 Range Planning and Operations 2010)
Class B	A manned or unmanned, ground-scoring capable range where no RCO is present on range for controlling aircraft operations. (Note: Class B ranges include ranges where a remotely sited RCO/RSO actively controls aircraft operations)	(AF Instruction 13-212 Range Planning and Operations 2010)
Class C	An unmanned range with no scoring and no RCO control of aircraft.	(AF Instruction 13-212 Range Planning and Operations 2010)
Class D	An instrumented air-to-air range monitored by a Range Training Officer (RTO) to facilitate training.	(AF Instruction 13-212 Range Planning and Operations 2010)
Collective ranges	Ranges that provide proficiency at the team or unit level (as opposed to individual level) for battlefield operations.	(Sustainable Range Initiative 2009)
Command and Control (C2)	The battlespace management process of planning, directing, coordinating, and controlling forces and operations. It involves the integration of a system of procedures, organizational structures, personnel, equipment, facilities, information, and communications designed to enable a commander to exercise authority and direction across the range of military operations.	(Sustainable Range Initiative 2010)
Condition	Variable of the operational environment, including a scenario that affects task performance.	(CJCSI 3010.02B)
Counterair	Operations to attain and maintain a desired degree of air superiority by the destruction, degradation, or disruption of enemy forces. Counterair's two elements, offensive counterair (OCA) and defensive counterair (DCA), enable friendly use of contested airspace and disable the enemy's offensive air and missile capabilities to reduce the threat posed against friendly forces.	(Sustainable Range Initiative 2010)
Counterland	Air and space operations against enemy land force capabilities to dominate the surface environment and prevent the opponent from doing the same. Counterland is composed of two discrete air operations for engaging enemy land forces: air interdiction, in which air maneuver indirectly supports land maneuver or directly supports an air scheme of maneuver, and close air support (CAS), in which air maneuver directly supports land maneuver.	(Sustainable Range Initiative 2010)

Countersea	Specialized collateral tasks performed in the maritime environment such as sea surveillance, antiship warfare, protection of sea lines of communications through antisubmarine and antiair warfare, aerial minelaying, and air refueling in support of naval campaigns with the objective of gaining control of the medium and, to the extent possible, dominating operations either in conjunction with naval forces or independently.	(Sustainable Range Initiative 2010)
Counterspace	Kinetic and nonkinetic operations conducted to attain and maintain a desired degree of space superiority by the destruction, degradation, or disruption of enemy space capability. Counterspace operations have an offensive and a defensive component.	(Sustainable Range Initiative 2010)
Cultural resources	Constraints placed on training due to legal and/or regulatory requirements and/or Military Service guidance to manage and maintain cultural resources. This compatibility area is being addressed in an additional area of the report.	(Sustainable Range Initiative 2009)
Danger Areas	The Danger Area is the composite area of the Hazard Area and all active LSDZs and active Directed Energy Weapons Danger Zones (DEWDZs). When the range is in use, access to those portions of the Danger Area comprised only of active LSDZs or active DEWDZs is limited to Mission Essential Personnel. When the range is not in use, access does not need to be restricted.	(AF Instruction 13-212 Range Planning and Operations 2010)
Designators	Very narrow band, pulse-coded Lasers used for marking, or designation, of targets and the terminal guidance of air-to-ground weapons	
Discount Rate	The rate of interest charged by a central bank (Federal Reserve) when lending to other financial institutions.	(The Economist Glossary)
Electromagnetic radiation	Radiation made up of oscillating electric and magnetic fields and propagated with the speed of light. Includes gamma radiation, X-rays, ultraviolet, visible, and infrared radiation, and radar and radio waves.	(DoD Military Dictionary 2010)
Electronic Combat (EC)	The set of friendly offensive and defensive tactics and operations associated with Electronic Attack and Electronic Protect activities. The EC range function supports identifying, degrading, or denying hostile forces the effective use of their battlefield surveillance, targeting radar and electro-optical systems, communications, counter-fire equipment, and electronically fused munitions. It is a subset of Command and Control Warfare.	(Sustainable Range Initiative 2010)
Electronic Combat Range (ECR)/Electronic Scoring Site (ESS)	ECRs/ESSs provide a simulated electronic threat environment for aircrew combat training. ECR/ESS facilities and equipment can be located at air-to-air or air-to-surface ranges, under or near a Military Training Route (MTR) or a Military Operations Area (MOA), or outside of USAF ranges and Special Use Airspace (SUA).	(AF Instruction 13-212 Range Planning and Operations 2010)
Electronic Combat Support	Actions involving the use of electromagnetic and directed energy to control the electromagnetic spectrum or to attack the enemy across the electromagnetic battlespace. The operational elements of electronic warfare operations are electronic attack, electronic protection, and electronic warfare support.	(Sustainable Range Initiative 2010)
Endangered species	Means any species which is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of this Act would present an overwhelming and overriding risk to man.	http://epw.senate.gov/esa73.pdf
Energy intensity	Energy consumption per square foot of building space, including industrial or laboratory facilities.	(Executive Order 13423)

EUL. Solar Energy Enhanced Use Leasing	U.S. Army Corps of Engineers solar energy program, at Fort Irwin, CA, to develop, construct and manage a flexible, phased, multi-technology approach to delivering up to 1,000 MW of power generation while advancing the transformation of Fort Irwin's overall energy security.	
Explosive ordnance	All munitions containing explosives, nuclear fission or fusion materials, and biological and chemical agents. This includes bombs and warheads; guided and ballistic missiles; artillery, mortar, rocket, and small arms ammunition; all mines, torpedoes, and depth charges; demolition charges; pyrotechnics; clusters and dispensers; cartridge and propellant actuated devices; electro-explosive devices; clandestine and improvised explosive devices; and all similar or related items or components explosive in nature.	(DoD Military Dictionary 2010)
Federal building	An energy or water conservation measure or any building, structure, or facility, or part thereof, including the associated energy and water consuming support systems, which is constructed, renovated, leased, or purchased in whole or in part for use by the Federal government. This term also means a collection of such buildings, structures, or facilities and the energy and water consuming support systems for such collection.	(Federal Acquisition Regulations: Federal Energy Management and Planning Programs DOE Part 436)
Fire Support	The related tasks and systems that move forces to achieve a position of advantage in relation to the enemy. It includes those tasks associated with employing forces in combination with direct fire or fire potential (maneuver), force projection (movement), and mobility and counter-mobility. Movement and maneuver are the means by which commanders concentrate combat power to achieve surprise, shock, momentum, and dominance.	(Sustainable Range Initiative 2010)
Flag officer	A term applied to an officer holding the rank of general, lieutenant general, major general, or brigadier general in the US Army, Air Force or Marine Corps or admiral, vice admiral, or rear admiral in the US Navy or Coast Guard.	(DoD Military Dictionary 2010)
General aviation aircraft	One of the two categories of civil aviation. It refers to all flights other than military and scheduled airline and regular cargo flights, both private and commercial. General aviation flights range from gliders and powered parachutes to large, non-scheduled cargo jet flights. The majority of the world's air traffic falls into this category, and most of the world's airports serve general aviation exclusively.	(Federal Aviation Administration)
Glare	A continuous source of bright light	(Federal Aviation Administration)
Glint	A momentary flash of bright light	(Federal Aviation Administration)
Hazard Areas	The Hazard Area is a composite of all WDZs and surface danger zones (SDZs) for all authorized weapon delivery events against targets or DMPIs approved for actual ordnance expenditures. Public access to Hazard Areas is prohibited unless specifically authorized by the ROA. All live munitions must be accounted for in a Hazard Area or the applicable portion of a Hazard Area before public access is authorized. Access to active Hazard Areas is limited to Mission Essential Personnel. Access to inactive Hazard Areas is limited to Essential Personnel. Hazard Areas may be segmented based upon the targets, weapons, and tactics being utilized at a given time. If Hazard Areas are segmented, ROAs will ensure segment borders are readily identifiable by ground personnel. Access to Hazard Areas will be determined locally based on an ORM analysis per paragraph 4.14. On ranges where another agency controls Hazard Area access, the ROA will establish procedures to verify access control and inform that agency of potential hazards.	(AF Instruction 13-212 Range Planning and Operations 2010)

Impact Areas	The Impact Area is that area on a range immediately surrounding the target(s) or designated mean point(s) of impact approved for actual ordnance delivery. Public access to Impact Areas is prohibited at all times. Access to Impact Areas when the range is inactive will be limited to Essential Personnel. The Impact Area demarcation will be determined locally using ORM analysis IAW paragraph 4.14., but should normally be no less than either a) 500 feet from the center of a target or designated mean point of impact (DMPI) approved for live ordnance, or b) 300 feet from the center of a target or DMPI used solely for inert or practice ordnance.	(AF Instruction 13-212 Range Planning and Operations 2010)
Individual Level Training	The set of core and core plus skills associated with the USMC Individual Training Standards (ITS) for each element of a Marine Air Ground Task Force (MAGTF). Accordingly, the Individual Level training range provides and supports the most basic training environment associated with the MAGTF Aviation Combat Element (ACE), Ground Combat Element (GCE)—and Combat Service Support Element (CSSE)—The Individual Level training range also reinforces basic infantry combat skills and supports those specific training requirements and skills associated with progressive USMC ITS and the program of instruction at each USMC Formal School.	(Sustainable Range Initiative 2010)
Inflation Rate	The rate at which the general level of prices for goods and services rise	(The Economist Glossary)
Information Operations	Actions taken to influence, affect, or defend information, systems, and/or decision-making of an adversary's ―observe-orient-decide-act" (OODA) loop while protecting our own.	(Sustainable Range Initiative 2010)
Infrared sensors	That imagery produced as a result of sensing electromagnetic radiations emitted or reflected from a given target surface in the infrared position of the electromagnetic spectrum (approximately 0.72 to 1,000 microns).	(DoD Military Dictionary 2010)
Instrument Flight Route (IR Route)	Military Special Use Airspace corridor used for low-altitude navigation and tactical training below 10,000 feet and flown at airspeeds in excess of 250 knots at night and in inclement weather conditions, under instrument flight rules (IFR).	(Federal Aviation Administration Glossary)
Intelligence	The related tasks and systems that provide collective and coordinated use of Army indirect fires, joint fires, and offensive information operations. It includes those tasks associated with integrating and synchronizing the effects of these types of fires with the other operating functions to accomplish operational and tactical objectives.	(Sustainable Range Initiative 2010)
Intelligence, Surveillance, & Reconnaissance	Activities involving the systematic observation of air, space, surface, or subsurface areas, places, persons, or things, by visual, aural, electronic, photographic, or other means; obtaining specific information about the activities and resources of an enemy or potential enemy through visual observation or other detection methods; or by securing data concerning the meteorological, hydrographic, or geographic characteristics of a particular area; and the resulting product of such activities.	(Sustainable Range Initiative 2010)
Internal Rate of Return (IRR)	A rate of return used in capital budgeting to measure and compare the profitability of investments.	
International Dark Skies protocol	The International Dark-sky Association received a grant in 2000 from the Southwest Parks and Monuments Association (now called the Western National Parks Association) to develop a light pollution measurement protocol for the national parks.	

Investment costs	The initial costs of design, engineering, purchase, construction, and installation exclusive of sunk costs.	(Federal Acquisition Regulations: Federal Energy Management and Planning Programs DOE Part 436)
Investment Tax Credit (ITC)	Tax credit paid out to eligible renewable energy projects based on the total amount of investment required initially for the project.	(NREL Renewable Energy Project Finance Glossary)
Joint Function	Related capabilities and activities grouped together to help joint force commanders synchronize, integrate, and direct joint operations. Functions that are common to joint operations at all levels of war fall into six basic groups -- command and control, intelligence, fires, movement and maneuver, protection, and sustainment.	(JP 3-0)
Landspace	Physical land area that has features such as topography, vegetative cover, configuration, proximity, capacity, usability, acreage, etc. necessary to meet training requirements.	(Sustainable Range Initiative 2009)
Life cycle cost	The total cost of owning, operating and maintaining a building over its useful life (including its fuel and water, energy, labor, and replacement components), determined on the basis of a systematic evaluation and comparison of alternative building systems, except that in the case of leased buildings, the life cycle cost shall be calculated over the effective remaining term of the lease.	(Federal Acquisition Regulations: Federal Energy Management and Planning Programs DOE Part 436)
Life-cycle cost-effective	The life-cycle costs of a product, project, or measure are estimated to be equal to or less than the base case (i.e., current or standard practice or product)	(Executive Order 13423)
Live Air-to-Air Gunnery Operations	Towed targets and drones are used for live air-to-air gunnery operations. The aircraft performance capabilities and the appropriate munitions ballistic tables determine the airspace and surface area required for safe accomplishment.	(AF Instruction 13-212 Range Planning and Operations 2010)
Major Range and Test Facility Base (MRTFB)	DODD 3200.11, Major Range and Test Facility Base (MRTFB) and AFI 99-109, Major Range and Test Facility Base (MRTFB) Test and Evaluation Resource Planning, govern specific DoD Test & Evaluation activities. Although MRTFB activities function primarily to enable DoD test and evaluation support missions, they may also perform other missions (operations, training, R&D, etc.). USAF MRTFB activities include: The Air Force Flight Test Center (Edwards AFB); the Air Armament Center (Eglin AFB); the Nevada Test and Training Range (NTTR); the Utah Test and Training Range (UTTR); the 30th Space Wing; and the 45th Space Wing.	(AF Instruction 13-212 Range Planning and Operations 2010)
Marine Air-Ground Task Forces (MAGTFs)	A scalable, task-organized force consisting of the following elements: Ground Combat Element, Aviation Combat Element, Logistics Combat Element, and Command Element	
Marine Expeditionary Brigade Level Training	The set of friendly force offensive and defensive tactics and operations associated with small-scale contingency expeditionary MAGTF forces against hostile or potentially hostile forces. The MEB Level training range supports all types of aircraft, weapons, special operations forces, landing forces, and ground forces that will be employed in concerted crisis response military efforts that are characterized by high-density, high-risk operations.	(Sustainable Range Initiative 2010)

Marine Expeditionary Unit Level Training	The set of friendly force offensive and defensive tactics and operations associated with expeditionary MAGTF forces against hostile or potentially hostile forces. The MEU Level training range supports all types of aircraft, weapons, special operations forces, landing forces, and ground forces employed in concerted military presence and engagement efforts described by the USMC's EMW doctrine, to include OMFTS and STOM.	(Sustainable Range Initiative 2010)
Means	Forces, units, equipment, and resources.	
Measure	The basis for describing varying levels of task performance.	(CJCSI 3010.02B)
Military Operations Area (MOA)	Military Special Use Airspace designated for non-hazardous military activity such as acrobatics, air combat tactics, and formation training. Visual flight rules aircraft are not restricted from operating in military operations areas.	(Federal Aviation Administration Glossary)
Military operations in urban terrain (MOUT)	Terrain complexes that replicate urban environments.	(Sustainable Range Initiative 2009)
Military Training Route (MTR)	Military Special Use Airspace corridors for military low-level flight training at airspeeds in excess of 250 knots. There are two types: Instrument Flight Rules Route (IR) -- for low-altitude navigation and tactical training below 10,000 feet and at airspeeds in excess of 250 knots at night and in foul weather; and Visual Flight Rules Route (VR) -- for low-altitude navigation and tactical training below 10,000 feet at airspeeds in excess of 250 knots under visual flight rules.	(Federal Aviation Administration Glossary)
Mine Warfare (MW)	The set of friendly force air, surface, and subsurface offensive and defensive tactics and operations associated with mine-laying and Mine Counter Measures (MCM). Offensive minelaying operations aim to dislocate the enemy war efforts and improve the security of friendly sea lines of communications by destroying, or threatening to destroy, enemy seaborne forces. MCM includes active measures (to locate and clear mined areas), passive measures (to include small object avoidance and ship routing around high threat areas), and self-protective measures (ship signature reduction).	(Sustainable Range Initiative 2010)
Mission	1. The task, together with the purpose, that clearly indicates the action to be taken and the reason therefore. (JP 3-0) 2. In common usage, especially when applied to lower military units, a duty assigned to an individual or unit; a task. (JP 3-0) 3. The dispatching of one or more aircraft to accomplish one particular task.	(JP 3-30)
Mission areas	Groups of tasks and systems (people, organizations, information, and processes) united by a common purpose that commanders use to accomplish mission and training objectives	
Modified Accelerated Cost Recovery System (MACRS)	The current tax depreciation system in the United States. Under this system, the capitalized cost (basis) of tangible property is recovered over a specified life by annual deductions for depreciation.	
Movement and Maneuver	The related tasks and systems that move forces to achieve a position of advantage in relation to the enemy. It includes those tasks associated with employing forces in combination with direct fire or fire potential (maneuver), force projection (movement), and mobility and counter-mobility. Movement and maneuver are the means by which commanders concentrate combat power to achieve surprise, shock, momentum, and dominance.	(Sustainable Range Initiative 2010)

Naval Special Warfare (NSW)	The set of friendly force air, surface, subsurface, and land-based offensive and defensive tactics and operations associated with the five principal NSW missions: Combating Terrorism, Counter Proliferation, Special Reconnaissance, Direct Action, and Unconventional Warfare. The NSW range function supports identifying, targeting, and engaging fixed, mobile, and time sensitive land-based targets using the entire inventory of NSW weapons.	(Sustainable Range Initiative 2010)
Net Explosive Weight (NEW)	The actual weight in pounds of explosive mixtures or compounds, including the trinitrotoluene equivalent of energetic material, that is used in determination of explosive limits and explosive quantity data arcs. Also called NEW.	(DoD Military Dictionary 2010)
Net Present Value (NPV)	The NPV indicates an investment's net value in today's dollars. A positive NPV means that the investment can be justified by the expected returns, and vice versa.	(The Economist Glossary)
New renewable sources	Sources of renewable energy placed into service after January 1, 1999.	(Executive Order 13423)
Non-fuel operation and maintenance costs	Material and labor cost for routine upkeep, repair and operation exclusive of energy cost.	(Federal Acquisition Regulations: Federal Energy Management and Planning Programs DOE Part 436)
Non-recurring costs	Costs that are not uniformly incurred annually over the study period.	(Federal Acquisition Regulations: Federal Energy Management and Planning Programs DOE Part 436)
Objective	(1) The clearly defined, decisive, and attainable goal toward which every operation is directed. (2) The specific target of the action taken (for example, a definite terrain feature, the seizure or holding of which is essential to the commander’s plan, or an enemy force or capability without regard to terrain features).	(JP 1-02, 9 Nov 06)
Off-Peak	The electric energy generated for the remaining hours that are not on-peak. (See on-peak).	(FERC: Guide to Market Oversight – Glossary)
On-Peak	Hours in each week-day when electricity demand is at its peak. On-peak definitions vary by North America Electric Reliability Council (NERC) Region.	(FERC: Guide to Market Oversight – Glossary)
Operating areas	An overarching term encompassing more descriptive terms for geographic areas in which military operations are conducted. Operational areas include, but are not limited to, such descriptors as area of responsibility, theater of war, theater of operations, joint operations area, amphibious objective area, joint special operations area, and area of operations. Also called OA. See also amphibious objective area; area of operations; area of responsibility; joint operations area; joint special operations area; theater of operations; theater of war. (JP 3-0)	(DoD Military Dictionary 2010)
Operational training and readiness	Those activities which are necessary to establish or maintain an agency's capability to perform its primary mission. Included are major activities to provide essential personnel strengths, skills, equipment/supply inventory and equipment condition. General administrative and housekeeping activities are not included.	(Federal Acquisition Regulations: Federal Energy Management and Planning Programs DOE Part 436)

Ordnance	Includes Bombs, Missiles, projectiles and ammunition. It can be classified as live or inert. Live ordnance typically contains a high explosive (HE) warhead or a high velocity projectile. Inert ordnance does not have a live warhead but may contain a fuze sensor, spotting charge, or other energetic materials that may pose a safety hazard.	(Naval Air Warfare Center Weapons Division Operational Requirements Document April 2011)
Payloads and Expendables	These include broad variety of objects that may be intentionally released during open-air RDTE and training operations. Examples include but are not limited to missiles, bombs, rockets, gun ammunition, fuel-air explosives, explosive charges, fuels, countermeasures (e.g., flare, chaff, smokes, decoys, experimental shapes, etc.), common household or janitorial products (proxies), chemical releases associated with some DE systems, and similar items required to support test or training events.	(Naval Air Warfare Center Weapons Division Operational Requirements Document April 2011)
Power Purchase Agreement (PPA)	A contract between a power generator and a power consumer (or distributor), which usually lists the price at which the power is being purchased and sometimes also the price of the renewable attributes associated with that power.	(NREL Renewable Energy Project Finance Glossary)
Primary Training Range (PTR)	PTRs are normally located in close proximity to their primary users, accommodate basic to intermediate air-to-surface, electronic combat (EC), or air-to-air training and consist of a limited land area (typically 5,000-100,000 acres). Typical PTRs contain target arrays, threat simulators, and weapons scoring systems and provide Class A, B, C and/or D service.	(AF Instruction 13-212 Range Planning and Operations 2010)
Production Tax Credit (PTC)	Tax credits paid out to a renewable project owner on a cent per kilowatt hour generated basis. Therefore the amount of tax credit depends on the amount of renewable energy produced.	(NREL Renewable Energy Project Finance Glossary)
Prohibited areas	A specified area within the land areas of a state or its internal waters, archipelagic waters, or territorial sea adjacent thereto over which the flight of aircraft is prohibited. May also refer to land or sea areas to which access is prohibited. See also restricted area. (JP 3-52)	(DoD Military Dictionary 2010)
Protection	The related tasks and systems that provide support and services to ensure freedom of action, extend operational reach, and prolong endurance. Sustainment facilitates uninterrupted operations through means of adequate logistic support. It is accomplished through supply systems, maintenance, and other services that ensure continuous support throughout an operation.	(Sustainable Range Initiative 2010)
Range areas	1. The distance between any given point and an object or target. 2. Extent or distance limiting the operation or action of something, such as the range of an aircraft, ship, or gun. 3. The distance that can be covered over a hard surface by a ground vehicle, with its rated payload, using the fuel in its tank and its cans normally carried as part of the ground vehicle equipment. 4. Area equipped for practice in shooting at targets. In this meaning, also called target range.	(DoD Military Dictionary 2010)
Range Operations and Classifications	The land or sea encompassed within the Danger Area or underlying an air-to-air range used for actual weapon employment must be protected by purchase, lease, or other means to ensure the safety of personnel, structures, and the public from expended weapons, laser and electromagnetic emissions, and target debris.	(AF Instruction 13-212 Range Planning and Operations 2010)
Range support	Personnel, software, and hardware that support daily operations, maintenance, communication networks for command and control, scheduling, and range safety as examples. Communications networks include inter- and intra-range systems point-to-point; range support networks; fiber optic and microwave backbones; information protection systems such as encryption, radio, and data link; and instrumentation frequency management systems.	(Sustainable Range Initiative 2009)

Range transients	Constraints placed on training due to the unannounced or unauthorized presence of individuals, livestock, aircraft, or watercraft transiting ranges. This conflict area is related to the chapter's discussion of Environs / Shared-Use exclusions.	(Sustainable Range Initiative 2009)
Rankine Cycle	A thermodynamic cycle which converts heat into work.	
Real-time	Pertaining to the timeliness of data or information which has been delayed only by the time required for electronic communication. This implies that there are no noticeable delays.	(DoD Military Dictionary 2010)
Recurring costs	Future costs that are incurred uniformly and annually over the study period.	(Federal Acquisition Regulations: Federal Energy Management and Planning Programs DOE Part 436)
Renewable energy	Energy produced by solar, wind, biomass, landfill gas, ocean (including tidal, wave, current and thermal), geothermal, municipal solid waste, or new hydroelectric generation capacity achieved from increased efficiency or additions of new capacity at an existing hydroelectric project.	(Executive Order 13423)
Renewable Energy Credit (REC)	An environmental attribute that is created with (usually) 1 MWh of renewable energy. RECs are used to track the environmental attributes associated with renewable energy, and are also used to track compliance with state renewable energy standards.	(NREL Renewable Energy Project Finance Glossary)
Renewable Portfolio Standard (RPS)	Legal mandates that require utilities to procure a certain percentage or a flat amount of electricity sourced from renewable generators. In many cases, utilities can demonstrate compliance by simply purchasing RECs without purchasing the actual electrical power.	(NREL Renewable Energy Project Finance Glossary)
Replacement costs	Future cost to replace a building energy system or building water system, an energy or water conservation measure, or any component thereof.	(Federal Acquisition Regulations: Federal Energy Management and Planning Programs DOE Part 436)
Research & Development	R&D supports all phases of weapon systems development, from the earliest concepts of a weapon, to engineering and manufacturing, to Fleet use, and finally to the disposal of systems no longer needed by the military. The goal of weapons R&D is to explore the use of promising technology to solve emerging war-fighter needs. For the purpose of this study, research activities focus in the areas of weapons guidance and control, warheads, explosives, propellants, pyrotechnics, propulsion systems, airframes, and the basic chemistry and physics that support these areas.	(Naval Air Warfare Center Weapons Division Operational Requirements Document April 2011)
Restricted Area	Military Special Use Airspace designated for hazardous military activities including live-firing of weapons. Flight restrictions are placed on all non-participating air traffic.	(Federal Aviation Administration Glossary)
Retrofit	Installation of a building energy system or building water system alternative in an existing Federal building.	(Federal Acquisition Regulations: Federal Energy Management and Planning Programs DOE Part 436)
Scoring and feedback systems	Equipment that provides information for training event reconstruction, debriefing, and replay - virtual or live - through the collection and storage of time and space position information (TSPI), weapons accuracy, systems and operator accuracy, assessment and monitoring of operator performance, and communications network information flow.	(Sustainable Range Initiative 2009)

Small arms	Man portable, individual, and crew-served weapon systems used mainly against personnel and lightly armored or unarmored equipment.	(DoD Military Dictionary 2010)
Spacelift	The delivery of satellites, payloads, and materiel to space.	(Sustainable Range Initiative 2010)
Special Operations	The use of special airpower operations (denied territory mobility, surgical firepower, and special tactics) to conduct the following special operations functions: unconventional warfare, direct action, special reconnaissance, counterterrorism, foreign internal defense, psychological operations, and counter-proliferation.	(Sustainable Range Initiative 2010)
Standard	(1) Quantitative or qualitative measures for specifying the levels of performance of a task. (CJCSI 3010.02B). (2) An energy conservation measure determined by DOE to be applicable to a particular agency or agencies. Once established as a standard, any variance or decision not to adopt the measure requires a waiver.	(Federal Acquisition Regulations: Federal Energy Management and Planning Programs DOE Part 436).
Strategic Attack	Offensive action conducted by command authorities aimed at generating effects that most directly achieve our national security objectives by affecting the adversary's leadership, conflict-sustaining resources, and strategy.	(Sustainable Range Initiative 2010)
Strategic Attack	Offensive action conducted by command authorities aimed at generating effects that most directly achieve our national security objectives by affecting the adversary's leadership, conflict-sustaining resources, and strategy.	(Sustainable Range Initiative 2010)
Strike Warfare (STW)	The set of friendly force air, surface, subsurface, and land-based offensive tactics and operations associated with identifying, targeting, and engaging fixed, mobile, and time-sensitive land-based targets using air-to-ground (A-G) weapons. The STW range also supports tactics and operations associated with manned and unmanned Tactical Airborne Reconnaissance, Unmanned Combat Air Vehicles, Suppression of Enemy Air Defenses (SEAD), Close Air Support (CAS), and engagement of fixed and mobile land-based targets using naval surface gunfire and sealaunched cruise missiles.	(Sustainable Range Initiative 2010)
SUA. Military Special Use Airspace	The military uses some airspace below 10,000 feet for training operations and frequently flies at speeds of more than 250 knots. High-speed flight operations include aircraft intercepts, air-to-air combat, close-air support for ground forces and aerial reconnaissance. NOTE: Military Special Use Airspace is depicted on aeronautical charts.	(Federal Aviation Administration Glossary)
Sunk costs	Costs incurred prior to the time at which the life cycle cost analysis occurs.	(Federal Acquisition Regulations: Federal Energy Management and Planning Programs DOE Part 436)
Surface Danger Zone (SDZ)	The ground and airspace designated within the training complex (to include associated safety areas) for vertical and lateral containment of projectiles, fragments, debris, and components resulting from the firing, launching, or detonation of weapons systems to include explosives and demolitions.	(Combat Center Order 3500.4H SOP for Range Training Areas and Airspace, August 6, 2010)

Surface-to-Air	Surface-to-Air operations cover a wide range of mission requirements. Ranges that support, for example, endo-atmospheric and exo-atmospheric missile intercepts, aeronautical system testing, and ballistic missiles require a substantial amount of range space and a sophisticated range infrastructure. This infrastructure may include high fidelity simulators, visual simulators, end-game scoring capabilities, command and control systems, communication networks, data display/ processing capabilities, instrumentation systems, flight termination systems, and flight hazard analysis/strike prediction capability.	(AF Instruction 13-212 Range Planning and Operations 2010)
Sustainment	The related tasks and systems that facilitate understanding of the enemy, terrain, weather, and civil considerations. It includes those tasks associated with intelligence, surveillance, and reconnaissance. The intelligence operating function is a flexible and adjustable architecture of procedures, personnel, organizations, and equipment that provide relevant information and products relating to the threat, civil populace, and environment to commanders.	(Sustainable Range Initiative 2010)
Targets	Targets are essential to testing and ensure the accuracy and effectiveness of the weapon systems, ordnance, sensors, and other military equipment being developed or trained with. Targets may be involved in both static and dynamic operations and will be engaged from both the air and ground. They must often be constructed according to specific customer requirements and are designed to replicate theater relevant threats. Some targets may be enhanced with Radio Frequency (RF), infrared (IR), or other electromagnetic and visual features to further increase the realism of such threats. While some targets will be consumable (i.e., destroyed) others will be fabricated or selected to be intentionally missed.	(Naval Air Warfare Center Weapons Division Operational Requirements Document April 2011)
Task	An action or activity (derived from an analysis of the mission and concept of operations) assigned to an individual or organization to provide a capability	(CJCSI 3010.02B)
Test & Evaluation	T&E is a continuous process throughout the weapons system life cycle. Weapon systems and components are tested and evaluated under natural operating conditions to replicate realistic employment and operational scenarios to the maximum extent practicable. General categories of T&E operations include but are not limited to air and surface launched weapons, communications, DE, electromagnetics, electronic warfare and countermeasures, ordnance T&E, sensor, weapons survivability, and track tests.	
Thermal plume	Large parcels of hot air rising from a surface.	
Threat	Physical and simulated threat presentations such as emitters, opposing adversary forces, battlefield effect simulators, etc.	(Sustainable Range Initiative 2009)

Training	1. Common training. Training that is not unique to a particular DoD Component; training that has no special distinction or quality to an individual DoD Component and is widely required. 2. Embedded training (ET). Training accomplished through the use of the trainee's operational system within a live virtual constructive (LVC) training environment. 3. In-lieu-of (ILO) cross-Service training. Training driven by: (a) A sourcing requirement to perform missions outside of traditionally assigned roles and functions for a Service; (b) An operational requirement outside the normal scope of duties for an individual, unit, or staff when there is no organic Service capability to fulfill the requirement; or (c) A training venue offered by another DoD Component that meets a sourcing requirement. 4. Integrated operations. The synchronization, coordination, and/or integration of DoD and other U.S. Government agencies' activities, in coordination with partner nations, and non-Governmental entities across the full range of military operations, which achieves a comprehensive approach that advances U.S. Government goals and objectives. 5. Joint training. Training, including mission rehearsals, of individuals, units, and staffs using joint doctrine or tactics, techniques, and procedures to prepare joint forces or joint staffs to respond to strategic, operational, or tactical requirements that the Combatant Commanders (CCDRs) consider necessary to execute their assigned or anticipated missions.	(DODD 1322.18, January 13, 2009)
Unit Level Training	The set of friendly force small unit offensive and defensive tactics and operations associated with expeditionary MAGTF forces against hostile or potentially hostile forces. The Unit Level training range supports all types of aircraft, weapons, special operations forces, landing forces, and ground forces employed in concerted military efforts described by the Marine Corps' Expeditionary Maneuver Warfare (EMW) doctrine, which includes Operational Maneuver from the Sea (OMFTS) and Ship to Objective Maneuver (STOM). It includes tactics and operations associated with all training phases of small unit level mission of a MAGTF.	(Sustainable Range Initiative 2010)
Unmanned Aircraft Systems (UAS) or Unmanned Aerial Vehicle (UAV)	The term 'Unmanned Aerial Vehicle' was changed to 'Unmanned Aircraft System' to reflect the fact that these complex systems include ground stations and other elements besides the actual air vehicles. The term UAS, however, is not widely used as the term UAV has become part of the modern lexicon. The UAV is an acronym for, which is an aircraft with no pilot on board. UAVs can be remote controlled aircraft (e.g. flown by a pilot at a ground control station) or can fly autonomously based on pre-programmed flight plans or more complex dynamic automation systems. UAVs are currently used for a number of missions, including reconnaissance and attack roles. To distinguish UAVs from missiles, a UAV is defined as being capable of controlled, sustained level flight and powered by a jet or reciprocating engine. In addition, a cruise missile can be considered to be a UAV, but is treated separately on the basis that the vehicle is the weapon. The FAA has adopted the acronym UAS (Unmanned Aircraft System) to reflect the fact that these complex systems include ground stations and other elements besides the actual air vehicles.	(Federal Aviation Administration)
VFR Helicopter Refueling Track (AR Route)	Military refueling route flown under visual flight rules (VFR)	(Federal Aviation Administration Glossary)
Visual Flight Route (VR Route)	Military Special Use Airspace corridor used for low-altitude navigation and tactical training below 10,000 feet and flown at airspeeds in excess of 250 knots, under visual flight rules.	(Federal Aviation Administration Glossary)

Warning Area	Military Special Use Airspace in International airspace designated for military activities in which these activities may be hazardous to non-participating aircraft, although general aviation flight in Warning Areas is not prohibited.	
Ways	Doctrine, tactics, techniques, and procedures, competencies, and concepts.	
Weapon system	A combination of one or more weapons with all related equipment, materials, services, personnel, and means of delivery and deployment (if applicable) required for self-sufficiency.	(DoD Military Dictionary 2010)
Weapons Danger Zone (WDZ)	The WDZ encompasses the ground and airspace for lateral and vertical containment of a user-determined percentage of projectiles, fragments, debris, and components resulting from the firing, launching, and/or detonation of aviation delivered ordnance. This three-dimensional zone accounts for weapon accuracy, failures, ricochets, and broaches (resurfacing) of a specific weapon/munition type delivered by a specific aircraft type.	(AF Instruction 13-212 Range Planning and Operations 2010)
Wien's Displacement Law	States that the wavelength distribution of thermal radiation from a black body at any temperature has essentially the same shape as the distribution at any other temperature	
Withdrawn Lands	The term “withdrawal” means withholding an area of Federal land from settlement, sale, location, or entry, under some or all of the general land laws, for the purpose of limiting activities under those laws in order to maintain other public values in the area or reserving the area for a particular public purpose or program; or transferring jurisdiction over an area of Federal land, other than “property” governed by the Federal Property and Administrative Services Act, as amended (40 U.S.C. 472) from one department, bureau or agency to another department, bureau or agency. Public lands may be withdrawn and reserved for military training and testing in support of national defense requirements. Such withdrawals and reservations are authorized by Act of Congress (for withdrawals of over 5,000 acres) or by order of the Secretary of the Interior (for withdrawals of less than 5,000 acres). Lands so designated are usually withdrawn from all forms of appropriation under the public land laws, including the mining laws and the mineral leasing and geothermal leasing laws. The most recent legislative withdrawals of public lands for military purposes are: P.L. 106-65, October 5, 1999, which extended the withdrawal for: • Alaska -- Fort Greely and the Yukon Range at Fort Wainwright (Army) • Arizona -- Barry M. Goldwater Range (Air Force and Marine Corps) • Nevada -- Nellis Air Force Range and the Naval Air Station Fallon Ranges • New Mexico -- McGregor Range, associated with Fort Bliss (Army) Public Law 107-107, Title XXIX, December 28, 2001, withdrew and reserved for military purposes an additional 110,000 acres for Fort Irwin, CA (BLM Website)	(BLM Website)

Appendix C – Acronyms

Abbreviation	Complete Term
AAR	After Action Review
AATCAA	Air Traffic Control Assigned Airspace
ABL	Airborne Laser
AC	Alternating Current
ACC	Air-Cooled Condenser
ACM	Air Combat Maneuvering
ACORE	American Council On Renewable Energy
ADT&E	Aviation Development, Tactics and Evaluation Department
AE	Ammunition and Explosives
AFB	Air Force Base
AFC	Application for Certification
AFCESA	Air Force Civil Engineer Support Agency
AFFTC	Air Force Flight Test Center
AFOSR	Air Force Office of Scientific Research
AFRL	Air Force Research Laboratory
AGL	Above Ground Level
AGS	Aviation Ground Support
AIC	Airspace Information Center
AIRFA	American Indian Religious Freedom Act
AM	Amplitude Modulation
ANL	Argonne National Laboratory
AO	Air Operations
AOC	Areas of Concern
AOR	Area of Responsibility
APZ	Accident Potential Zone
ARFF	Airfield Rescue and Fire Fighting
ARM	Anti-Radiation Homing Missiles
ARNG	Army National Guard
ARRA	American Recovery and Reinvestment Act
ASP	Ammunition Supply Point
AT/IDT	Annual Training/Inactive Duty Trainings
ATCAA	Air Traffic Control Assigned Airspace
AWEC	Alta Wind Energy Center
BDA	Battlefield Damage Assessment
BEEF	Base Emergency Engineering Force
BHPO	Base Historic Preservation Officer

BLM	Bureau of Land Management
BMGR	Barry M. Goldwater Air Force Range
BSTRC	Bob Stump Training Complex
C2W	Command and Control Warfare
CADC	California Department of Conservation
CAEATFA	California Alternative Energy and Advanced Transportation Financing Authority
CAES	Compressed Air Energy Storage
CAISO	California Independent System Operator
CALFEX	Combined Arms Live Fire Exercise
CalPIF	California Partners in Flight
CAS	Close Air Support
CAX	Combined Arms Exercise
CBRN	Chemical, Biological, Radiological, and Nuclear
CBU	Cluster Bomb Unit
CCD	Campaign for the California Desert
CCDCP	Clark County Department of Comprehensive Planning
CDPA	California Desert Protection Act
CDFG	California Department of Fish and Game
CdTe	Cadmium Telluride
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CESA	California Endangered Species Act
CFIT	Controlled Flight Into Terrain
CHP	Combined Heat and Power
CIED	Counter Improvised Explosive Devices
CIEE	California Institute for Energy and Environment
CIGS	Copper Indium Gallium Diselenide
CIP	Common Installation Picture
CIS	Copper Indium Diselenide
CJCS	Chairman, Joint Chiefs of Staff
CLC	Combat Logistics Company
CLUMP	Comprehensive Land Use Management Plan
CM	Collateral Material
CMAGR	Chocolate Mountain Aerial Gunnery Range
CMO	Civil-military operations
CNATRA	Chief of Naval Air Training
CNDDB	California Natural Diversity Database
CNIC	Commander, Navy Installations Command

CNPS	California Native Plant Society
COB-V	Civilian on the Battlefield Vehicles
CPTG	California Transmission Planning Group
CPUC	California Public Utilities Commission
CPV	Concentrating Photovoltaic
CREZ	Competitive Renewable Energy Zone
CSI	California Solar Initiative
CSM	Conceptual site models
CSP	California State Parks
CSP	Concentrating Solar Power
CT	Combustion turbine
CTC	Competitive transition charge
CTPG	California Transmission Planning Group
CUP	Conditional Use Permit
CWA	Clean Water Act
CWC	California Wilderness Coalition
DA PAM	Department of the Army Pamphlet
DC	Direct Current
DDESB	Department of Defense Explosive Safety Board
DDS	Display and Debriefing Subsystem
DE	Directed Energy
DEIS	Draft Environmental Impact Statements
DFRC	Dryden Flight Research Center
DLA	Defense Logistics Agency
DMG	Desert Manager's Group
DoD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
DOW	Defenders of Wildlife
DRECP	California Desert Renewable Energy Conservation Plan
DRMO	Defense Reutilization and Marketing Office
DSIRE	Database of State Incentives for Renewables and Efficiency
DSN	Deep Space Network
EA	Electronic Attack
EA	Environmental Assessment
EAF	Expeditionary Airfield Facilities
ECI	Electrical Consultants, Inc.
ECIP	Energy Conservation Investment Program
EEI	Edison Electric Institute

EERE	Energy Efficiency and Renewable Energy Program
eGRID	Emissions and Generation Resource Integrated Database
EIR	Environmental Impact Review
EIS	Environmental Impact Statements
EISA	Energy Independence and Security Act
EJV	Energy Joint Venture
EM	Electromagnetic
EMI	Electromagnetic Interference
ENS	Environmental News Service
EO	Executive Order
EOD	Explosive Ordnance Disposal
EPA	Environmental Protection Agency
EPAct	Energy Policy Act
EPF	Environmental Planning Function
EPS	Electrical Power System
ERCOT	Electric Reliability Council of Texas
ERP	Environmental Restoration Program
ES	Electronic Support
ESCO	Energy Service Company
ESPC	Energy Savings Performance Contracts
ESQD	Explosives Safety Quantity Distance
ESRI	Environmental Systems Research Institute
EUL	Enhanced Use Lease
EW	Electronic Warfare
FAA	Federal Aviation Administration
FARP	Forward Arming and Refueling Point
FASFAC	Fleet Area Control and Surveillance
FASP	Field Ammunition Storage Points
FCC	Federal Communications Commission
FEIS	Final Environmental Impact Statements
FEMP	Federal Energy Management Program
FERC	Federal Energy Regulatory Commission
FESA	Federal Endangered Species Act
FINEX	Final Exercise
FIPP	Financial Institution Partnership Program
FIT	Feed-In Tariff
FLIR	Forward Looking Infrared
FM	Frequency Modulation
FMF	Fleet Marine Forces

FONSI	Finding of No Significant Impact
FOV	Field of View
FP	Floodplain
FPA	Federal Power Act
FRS	Fleet Replacement Squadrons
FSF	Flight Safety Foundation
FTHL ICC	Flat-Tailed Horned Lizard Interagency Coordinating Committee
FTP	File Transfer Protocol
GAO	U.S. Government Accountability Office
GDSCC	Goldstone Deep Space Communications Complex
GHG	Greenhouse Gas
GIS	Geographic Information System
GP	General Purpose
GPS	Global Positioning System
GTT	Ground Troop Training
GWh	Gigawatt Hour
H&HS	Headquarters and Headquarters Squadron
HEDM	High Energy Density Matter
HEL	High Energy Laser
HF	High Frequency
HMMWV	High Mobility Multi-purpose Wheeled Vehicle
HPL	High Power Laser
HPM	High Powered Microwave
Hz	Hertz
IBD	Inhabited Building Distance
ICRMP	Integrated Cultural Resources Management Plan
IDIQ	Indefinite Delivery, Indefinite Quality
IED	Improvised Explosive Devices
IEEE	Institute of Electrical and Electronics Engineers
IFF	Identification, Friend or Foe
IHPRPT	Integrated High Payoff Rocket Propulsion Technology
IID	Imperial Irrigation District
ILD	Intraline Distance
IMD	Intermagazine Distance
INRMP	Integrated Natural Resource Management Plan
IO	Information Operations
IOU	Investor Owned Utility
IPM	Integrated Pest Management
IPM®	Integrated Planning Model

IR	Infrared
IRP	Integrated Resource Plan
IRR	Internal Rate of Return
IRST	Infrared Search and Tracking Systems
ITAM	Integrated Training Area Management
ITC	Investment tax credit
JDAM	Joint Direct Attack Munitions
JIIM	Joint, Interagency, Intergovernmental, Multinational
JSF	Joint Strike Fighter
JUMPS	Joint Mission Planning Suite
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt hour
LADWP	Los Angeles Department of Water and Power
LF	Live Fire
Li-Ion	Lithium Ion
LOS	Line-of-Sight
LURS	Land Use Requirements Study
LZ	Landing Zone
MACRS	modified accelerated cost-recovery system
MAD	Marine Aviation Detachment
MAGTF	Marine Air Ground Task Force
MAGTFTC	Marine Air Ground Task Force Training Command
MATES	Mobilization and Training Equipment Site
MAWTS	Marine Aviation Weapons and Tactics Squadron
MBTA	Migratory Bird Treaty Act
MC	Maintenance Center
MC	Munitions constituents
MCAGCC	Marine Corps Air to Ground Combat Center
MCAS	Marine Corps Air Station
MCDS	Marine Corps Depot of Supplies
MCI	Marine Corps Institute
MCLB	Marine Corps Logistics Base
MEB	Marine Expeditionary Brigade
MEF	Marine Expeditionary Force
MEU	Marine Expeditionary Unit
MILCON	Military Construction
MOA	Military Operations Area
MOS	Military Occupational Specialties

MOU	Memorandum of Understanding
MPF	Maritime Prepositioned Force
MPR	Market Price Referent
MRAP	Mine Resistant Ambush Protected (Vehicle)
MRTFB	Major Range and Test Facility Base
MSHCP	Multiple Species Habitat Conservation Plan
MSW	Municipal solid waste
MW	Megawatt
MWh	Megawatt hour
NACC	NTC Airspace Control Center
NAF	Naval Air Facility
NAGPRA	Native American Graves Protection and Repatriation Act
NaS	Sodium-Sulfur
NASA	National Aeronautic and Space Administration
NAVAIR	Naval Air Systems Command
NAVFAC	Naval Facilities Engineering Command
NAWCWD	Naval Air Warfare Center Weapons Division
NAWS	Naval Air Weapons Station
NCAA	National Defense Authorization Act
NCCP	Natural Communities Conservation Plan
NCSU	North Carolina State University
NDOW	Nevada Division of Wildlife
NEM	Net Energy Metering
NEPA	National Environmental Policy Act
NERC	North American Electric Reliability Council
NEW	Net Explosive Weight
NFWO	Nevada Fish & Wildlife Office
NGO	Non-Governmental Organization
NHPA	National Historic Preservation Act
NHT	National Historic Trail
NHZ	Nominal Hazard Zones
NiMH	Nickel Metal Hydride
NLCS	National Lands Conservation System
NOA	Notice of Availability
NOHD	Nominal Ocular Hazard Distance
NOI	Notice of Intent
NOSSA	Naval Ordnance Safety and Security Activity
NOTS	Naval Ordnance Test Station
NPR	National Public Radio

NPS	National Park Service
NPV	Net Present Value
NREEEA	Nevada Renewable Energy and Energy Efficiency Authority
NREL	National Renewable Energy Laboratory
NRHP	National Register of Historic Places
NRS	Nevada Regulatory Statutes
NRS	Nevada Revised Statute
NSC	Net surplus compensation
NSTTF	National Solar Thermal Test Facility
NTC	National Training Center
NTTR	Nevada Test and Training Range
NVD	Night Vision Devices
NVDWR	Nevada Division of Water Resources
NVG	Night-vision goggle
NVSOE	Nevada State Office of Energy
NVTREC	Nevada Tracks Renewable Energy Credits
NWR	National Wildlife Refuge
O&M	Operation and maintenance
OATT	Open Access Transmission Tariff
OCWD	Orange County Water District
OHV	Off-highway vehicle
OMB	Office of Management and Budget
OP	Observation Point
OPFOR	Opposing force
OSD	Office of the Secretary of Defense
PACOM	Pacific Command
PB	Precision Bombing
PbA	Lead Acid
PBI	Performance Based Incentive
PEC	Portfolio energy credit
PEI	Principle End Item
PES	Potential Explosive Site
PG&E	Pacific Gas & Electric
PIRA	Precision Impact Range Area
PNNL	Pacific Northwest National Laboratory
POC	Point of contact
POD	Point of Delivery
POI	Point of Interconnection
POR	Point of Receipt

PPA	Power purchase agreements
PPF	Participatory Politics Foundation
PREPO	Prepositioned
PSA	Power sales agreement
PTC	Production tax credit
PTRD	Public Transit Route Distance
PUCN	Public Utilities Commission of Nevada
PV	Photovoltaic
QD	Quality Distance
R&D	Research and Development
RADFAG	Radar Fidelity and Geometric Range
RAM	Renewable Auction Mechanism
RC-OPT	Reserve Component Operations, Plans & Training
RCS	Radar Cross-Section
RCS	Recovery Crediting Systems
RDTE	Research, Development, Testing, and Evaluation
REAT	Renewable Energy Action Team
REC	Renewable Energy Credit
RETAAC	Renewable Energy Transmission Access Advisory Committee
RETI	Renewable Energy Transmission Initiative
REVA	Range Environmental Vulnerability Assessment
RF	Radiofrequency
RFI	Radiofrequency Interference
RFP	Requests for proposals
RMP	Resource Management Plan
ROD	Record-of-Decision
ROW	Right of way
RPS	Renewable Portfolio Standard
RTAM	Range and Training Area Management Division
RTI	Renewable Transmission Initiative
RTO	Regional Transmission Organizations
RWQCB	Regional Water Quality Control Board
S/N	Signal to Noise Ratio
SAM	Systems Advisor Model
SAR	Search and rescue
SATCOM	Satellite Communication
SCE	Southern California Edison
SDG&E	San Diego Gas and Electric
SDZ	Surface Danger Zone

SEGS	Solar Electric Generating Systems
SEIA	Solar Energy Industries Association
SERDP	Strategic Environmental Research and Development Program
SES	Stirling Energy Systems
SEZ	Solar energy zone
SFHA	Special Flood Hazard Area
SHPO	State Historic Preservation Office
SIL	System Integration Laboratory
SME	Subject Matter Expert
SMES	Superconducting Magnet Energy Storage
SMUD	Sacramento Municipal Utility District
SNL	Sandia National Laboratories
SNORT	Supersonic Naval Operations Research Track
SOFIA	Stratospheric Observatory for Infrared Astronomy
SOI	Solicitation of Interest
SOP	Standard Operating Procedure
SPEIS	Solar Programmatic Environmental Impact Statement
SSRI	Supply System Responsibility Item
STEP	Southwest Transmission Expansion Planning
SWAT	Special Weapons and Tactics
SWRCB	State Water Resources Control Board
T&E	Testing and Evaluation
TA	Training Areas
TACTS	Tactical Aircrew Combat Training System
TCP	Traditional cultural property
TECOM	Marine Corps Training and Education Command
TEEIC	Tribal Energy and Environmental Information Clearinghouse
TEPPC	Transmission Expansion Planning Policy Committee
THAAD	Theater High Altitude Air Defense
TMY	Typical Meteorological Year
TNT	Trinitrotoluene
TOU	Time of Use
TRACON	Terminal Radar Approach Control
TRTP	Tehachapi Renewable Transmission Project
TSA	Transmission Service Agreement
TTECG	Tactical Training Exercise Control Group
UAS	Unmanned Aircraft Systems
UAV	Unmanned Aerial Vehicle
UDP	Unit Deployment Program

UEPA	Utility Environmental Protection Act
UESC	Utility Energy Services Contracts
UGS	Unmanned Ground Systems
ULI	Urban Land Institute
UPS	Uninterruptible Power Supplies
URTD	Upper Respiratory Tract Disease
USACE	U.S. Army Corps of Engineers
USAF	U.S. Air Force
USATCES	U.S. Army Technical Center for Explosives Safety
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGPO	U.S. Government Printing Office
USGS	U.S. Geological Survey
USMC	U.S. Marine Corps
USN	U.S. Navy
UV	Ultraviolet
VAR	Volt-ampere reactive
VMFT	Marine Fighter Training Squadron
VRM	Visual Resource Management
VSTOL	Vertical Short Take-off and Landing
VX	Air Test and Evaluation Squadron
WAPA	Western Area Power Administration
WBCSD	World Business Council for Sustainable Development
WDE	Washington Department of Ecology
WDZ	Weapon Danger Zones
WECC	Western Electricity Coordinating Council
WGA	Western Governors' Association
WIPP	Waste Isolation Pilot Plant
WREZ	Western Renewable Energy Zone
WRI	World Resources Institute
WSL	Weapons Survivability Laboratory
WTI	Weapons and Tactics Instructor
YRTC	Yuma Range Training Complex

Bibliography

Abengoa Solar. (2008). *Concentrating Solar Power: Parabolic Trough Technologies.* Retrieved from http://www.abengoasolar.com/corp/web/en/technologies/concentrated_solar_power /parabolic_trough/index.html.

Abrams, Michael (2003). *IEEE Spectrum Online.* Retrieved from http://www.spectrum.ieee.org/WEBONLY/publicfeature/nov03/1103ebom.html.

ACORE (American Council On Renewable Energy). (2011a). *Renewable Energy in California*. Retrieved from http://www.acore.org/files/pdfs/states/California.pdf.

ACORE. (2011b). *Renewable Energy in Nevada*. Retrieved from http://www.acore.org/files/pdfs/states/Nevada.pdf.

Adiboina, Gangadhar. (2010). *Thin-Film Photovoltaic (PV) Cells Market Analysis to 2020.* Global Business Intelligence Research. Retrieved from http://www.altenergymag.com/emagazine.php?art_id=1557.

AES. (2011). *AES Energy Storage Projects*. Retrieved from www.aesenergystorage.com/projects.html.

AFFTC. (2009). *Final Integrated Cultural Resources Management Plan for Edwards, Air Force Base, California, Edwards AFB Plan 32-7065*.

ANL (Argonne National Laboratory). (2010). *Solar Draft Programmatic Environmental Impact Statement – Chapter 3*. Retrieved from http://solareis.anl.gov/documents/dpeis/Solar_DPEIS_Chapter_3.pdf.

ANL (Argonne National Laboratory). (2010). *Solar Draft Programmatic Environmental Impact Statement – Chapter 3.* Retrieved from http://solareis.anl.gov/documents/dpeis/Solar_DPEIS_Chapter_3.pdf.

Appleyard, D. (2009). *Utility-Scale Thin Film: Three new plants in Germany total almost 50 MW.* Renewable Energy World.com. Retrieved from http://www.renewableenergyworld.com/rea/news/article/2009/03/utility-scale-thin-film-three-new-plants-in-germany-total-almost-50-mw.

Bagley, M. (2011). *Desert Cymopterus.* Bureau of Land Management. Retrieved from http://www.blm.gov/ca/pdfs/cdd_pdfs/Destcymop1.PDF.

Baldwin, B.G., Boyd, S., Errter, B.J., Patterson, R.W., Rosatti, T.J., and D.H. Wilen (Eds). (2002). ―The Jepson Desert Manual: Vascular Plants of Southeastern California." Los Angeles: University of California Press. Retrieved from http://books.google.com/books?id=SRU8v_1glgsC&printsec=frontcover&dq=baldwin+-+the+jepson+desert+manual:+vascular+plants+of+southeastern+california&source=bl&ots=581vazftws&sig=75fuX3-Bdcs_Lm9HAJZzvCtcNgM&hl=en&ei=4_umTYWbK4WltwfykbWFAQ&sa=X&oi=book_result&ct=result&resnum=3&ved=0CCkQ6AEwAg#v=onepage&q&f=false.

Battery Ground. (2011). *High Capacity, High Rate NiMH Rechargeable Batteries*. Retrieved from www.batteryground.com.

Baxter, R. J. (1988*). Spatial Distribution of Desert Tortoises (Gopherus agassizii) at Twentynine Palms, California: Implications for Relocations.* U.S. Forest Service. Retrieved from http://www.fs.fed.us/rm/pubs_rm/rm_gtr166/rm_gtr166_180_189.pdf.

Belnap, J., Phillips, S.L., Herrick, J.E., and J.R. Johansen. (2007). *Wind erodibility of soils at Fort Irwin, California (Mojave Desert), USA, before and after trampling disturbance: implications for land management.* U.S. Department of Agriculture. Retrieved from http://ddr.nal.usda.gov/bitstream/10113/14274/1/IND44052938.pdf.

Belote, Dave. (2011). *2011 NDAA and DoD's Energy Siting Clearinghouse* [PowerPoint Presentation]. Retrieved from http://www.usafnevadaforum.com/process_meeting_nov2010/proceedings/Belote_OSD%20ESC_Nevada%20Process%20NDAA%20Brief%20010711%20v3%20-%20final.pdf.

Bengtson, H. (2010). *Concentrating Solar Power Technologies 2: Parabolic Dish Stirling Engine Systems.* Bright Hub. Retrieved from http://www.brighthub.com/environment/renewable-energy/articles/65860.aspx.

Black and Veatch. (2011, April 13). *Renewable Energy Transmission Initiative (RETI) Cost of Generation Calculator.* Retrieved from http://www.energy.ca.gov/reti/documents/index.html.

BLM (Bureau of Land Management). (2001). *Nevada Water Rights Fact Sheet*. Retrieved from http://www.blm.gov/nstc/WaterLaws/nevada.html.

BLM (U.S. Navy and Bureau of Land Management). (2004). *Environmental Impact Statement: For Proposed Military Operational Increases and Implementation of Associated Comprehensive Land Use and Integrated Natural Resources Management Plans: NAWS China Lake.*

BLM. (2005). *Final Environmental Impact Report and Statement for the West Mojave Plan.* Retrieved from http://www.blm.gov/ca/pdfs/cdd_pdfs/wemo_pdfs/plan/wemo/Vol-1-Chapter1_Bookmarks.pdf.

BLM. (2006). *California Desert Conservation Area*. Retrieved from http://www.blm.gov/pgdata/etc/medialib/blm/ca/pdf/caso/publications.Par.67970.File.dat/CDCA.pdf.

BLM. (2007). *Mojave Desert Tortoise.* Retrieved from http://www.blm.gov/ca/st/en/fo/cdd/deserttortoise.html.

BLM. (2010a). *Plan Amendment/Final EIS for the Blythe Solar Power Project (Vol.1)*. Executive Summary.

BLM. (2010b). *Carrizo Plain National Monument – Wildflowers*. Retrieved from http://www.blm.gov/ca/st/en/fo/bakersfield/Programs/carrizo/cpnmflowers1.html.

BLM. (2010c). *California Desert Conservation Area*. Retrieved from http://www.blm.gov/ca/st/en/fo/cdd/cdca_q_a.html.

BLM. (2010d). *Special Status Plants*. Retrieved from http://www.blm.gov/ca/st/en/prog/ssp.html.

BLM. (2010e). *Solar Energy Interim Rental Policy*. Retrieved from http://www.blm.gov/wo/st/en/info/regulations/Instruction_Memos_and_Bulletins/national_instruction/2010/IM_2010-141.html.

BLM. (2011a). *West Mojave Plan*. Retrieved from http://www.blm.gov/ca/st/en/fo/cdd/wemo.html.

BLM. (2011b). *The Bureau of Land Management: Who We Are, What We Do*. Retrieved from http://www.blm.gov/wo/st/en/info/About_BLM.html.

BLM. (2011c). *Off-Highway Vehicle Recreation*. Retrieved from http://www.blm.gov/ca/st/en/prog/recreation/ohv.html.

BLM. (2011d). *Interior Releases Updated Roadmap for Solar Energy Development*. Retrieved from http://solareis.anl.gov/documents/docs/Supplement_to_Draft_PEIS_PressRelease.pdf.

BLM. (2011e). *Approved Renewable Energy Projects*. Retrieved from http://www.blm.gov/wo/st/en/prog/energy/renewable_energy/approved_projects.html.

BLM. (2011f). *Renewable Energy Priority Projects*. Retrieved from http://www.blm.gov/wo/st/en/prog/energy/renewable_energy/priority_projects.html.

BLM. (2011g). *Federal Reserved Water Rights*. Retrieved from http://www.blm.gov/nstc/WaterLaws/fedreservedwater.html on June, 20, 2011.

Blow, Maj. Craig (2010). *ACCIONA Nevada Solar One Facility Assessment: Potential Effects and Recommendations on FOB Miami Aviation Operations*. ACCIONA North America.

Bolder Canyon Project. (2011). *Timeline Summary*. Retrieved from http://www.wapa.gov/dsw/pwrmkt/BCP_Remarketing/BCP/TimelineSummaries.html on June 20, 2011.

Booth, S., J. Barnett, K. Burman, J. Hambrick and R. Westby. (2010). *Net Zero Energy Military Installations: A Guide to Assessment and Planning*. NREL Technical Report NREL/TP-7A2-48876. Retrieved from http://www.nrel.gov/docs/fy10osti/48876.pdf.

BP Solar. (2010). *USMC Twentynine Palms*. Retrieved from http://www.bp.com/liveassets/bp_internet/solar/bp_solar_usa/STAGING/local_assets/downloads_pdfs/29PalmsTag.pdf.

BrightSource Energy. (2010). *How LPT Works*. Retrieved from http://www.brightsourceenergy.com/technology/how_lpt_works.

BrightSource Energy. (2011). *How LPT Works*. Retrieved from http://www.brightsourceenergy.com/technology/how_lpt_works.

Brown, A. (2004a). *Analysis of Marine Expeditionary Brigade Training Areas (CRM D0010418.A2/Final)*. The CNA Corporation.

Brown, A. (2004b). *MEB Training Exercise Study: Final Report (CRM D0010872.A2/Final)*. The CNA Corporation.

Brown, A., Ezring, J., and Geis, L. (2004). *MEB Training Exercise Study: Identifying MEB Training Requirements (CAB D0009618.A1/Final)*. The CNA Corporation.

CADC (California Department of Conservation). (2005). *California Geological Survey – Gold Discovery.* Retrieved from http://www.consrv.ca.gov/cgs/geologic_resources/gold/CA_GoldDiscovery_files/Pages/GoldDiscovery.aspx.

CAEATFA (California Alternative Energy and Advanced Transportation Financing Authority). (2010). *Advanced Transportation and Alternative Source Manufacturing Sales and Use Tax Exclusion Program.* Retrieved from http://www.treasurer.ca.gov/caeatfa/sb71/fact.pdf.

CAISO (California Integrated System Operator). *Transmission Planning Process: Business Process Manual*. Retrieved from https://bpm.caiso.com/bpm/bpm/list.

California Biodiversity Council. (2009). *Renewable Energy in California: Implementing the Governors Renewable Energy Executive Order*. Presentation at the Joint Public Workshop. March 12, 2009. Sacramento, California. Retrieved from http://biodiversity.ca.gov/Meetings/elcentro09/kevinhunting.pdf.

California Legislature. (2011). *Senate Bill No. 2*. Retrieved from http://www.leginfo.ca.gov/pub/11-12/bill/sen/sb_0001-0050/sbx1_2_bill_20110331_enrolled.pdf.

California Legislature. (2011b). *Revenue and Taxation Code, Section 70-74.7*. Retrieved from http://www.leginfo.ca.gov/cgi-bin/displaycode?section=rtc&group=00001-01000&file=70-74.7.

CalPIF (California Partners in Flight & PRBO Conservation Science). (2009). *The Desert Bird Conservation Plan.* Retrieved from http://www.prbo.org/calpif/pdfs/desert.v-1.pdf.

Carden, M. (2010). *Official Explains Approach to Climate Change, Energy*. U.S. Department of Defense. Retrieved from http://www.defense.gov/news/newsarticle.aspx?id=59294.

Caterpillar. (2011). *Standby 3516 (1750 eKW, 2187 kVA) Engine Generator Set Specification Sheet.*

CBI (Conservation Biology Institute). (2010). *Protected Areas Database US 1.1 (CBI Edition)*. Retrieved from http://www.databasin.org/protected-center/features/PAD-US-CBI.

CCD (Campaign for the California Desert). (2011). *Maps of California Desert Wilderness*. Retrieved from http://www.californiadesert.org/maps.

CCDCP (Clark County Department of Comprehensive Planning). (2000). *Final Clark County Multiple Species Habitat Conservation Plan and Environmental Impact Statement for Issuance of a Permit to Allow Incidental Take of 79 Species in Clark County, Nevada*. Retrieved from http://www.nv.blm.gov/LandRecords/map.php?county=clark_county.

CDFG (California Department of Fish and Game). (2009). *Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Natural Communities*. Retrieved from http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/Protocols_for_Surveying_and_Evaluating_Impacts.pdf.

CDFG. (2011). *Mojave Desert – Overview.* Retrieved from http://www.dfg.ca.gov/wildlife/wap/region-mojave.html.

CDFG. (2011a). *Colorado Desert – Overview.* Retrieved from http://www.dfg.ca.gov/wildlife/WAP/region-colorado.html.

CDFG. (2011b). *The Colorado Desert Region*. Retrieved from http://www.dfg.ca.gov/wildlife/WAP/docs/report/ch8-colorado.pdf.

CDFG. (2011c). *The Mojave Desert Region*. Retrieved from http://www.dfg.ca.gov/wildlife/WAP/docs/report/ch7-mojave.pdf.

CEC (California Energy Commission). (2008). *U.S. Department of Energy Solar Programmatic Environmental Impact Statement.* Retrieved from http://www.energy.ca.gov/siting/solar/peis/index.html.

CEC. (2011). *Large Solar Energy Projects*. Retrieved from http://www.energy.ca.gov/siting/solar/index.html.

CEC. (2011b). *California Renewable Energy Overview and Programs*. Retrieved from http://www.energy.ca.gov/renewables/ on June 20, 2011.

CEC. (2011c). *Renewable Energy Transmission Initiative* (RETI). Retrieved from http://www.energy.ca.gov/reti/index.html.

Chatelin, A. (2011, June 15). Range Operations Director, MCAGCC Twentynine Palms. Interview.

CIEE (California Institute for Energy and Environment). (2009). *Final Project Report: Transmission Benefit Quantification, Cost Allocation and Cost Recovery – Appendix B: Benefit Assessment Methodologies.* Retrieved from http://ciee-dev.eecs.berkeley.edu/piertrans/documents/TCAM_Final_Report_AppendixB.pdf.

CJCS (Chairman, Joint Chiefs of Staff). (2000). *Instruction: Electromagnetic Spectrum Use in Joint Military Operations (CJCSI 3320.01*). Defense Technical Information Center.

Clean Power. (2011). *Pony Express*. Retrieved from http://clearpower.biz/4322.html.

Clevenger, J., Kelley, B., and McGraw, K. (2009). *Cost Analysis of Utilizing Electric Vehicles and Photovoltaic Solar Energy in the United States Marine Corps Commercial Vehicle Fleet.* Naval Postgraduate School (NPS). Retrieved from http://www.dtic.mil/dtic/tr/fulltext/u2/a514205.pdf.

Climate Progress. (2009, April 29). *The secret to low-water use, high efficiency concentrating solar power.* Message posted to http://climateprogress.org/2009/04/29/csp-concentrating-solar-power-heller-water-use.

CNET News. (2008, August 27). *Compressed-air storage coming to wind power*. Posted to http://news.cnet.com/8301-11128_3-10026958-54.html.

CNPS (California Native Plant Society). (2011). *Inventory of Rare and Endangered Plants (online edition, v8-01a)*. Retrieved from http://www.cnps.org/inventory.

Committee on Armed Services, House of Representatives. (2010). *Report on H.R. 5136 with Additional Views.* Retrieved from http://www.dtic.mil/congressional_budget/pdfs/FY2011_pdfs/HASC_111-491.pdf.

Consumer Energy. (2011). *Ludington Pumped Storage*. Retrieved from http://www.consumersenergy.com/content.aspx?id=1830.

Cotton, L. (2011, June 30). Safety Engineer, Department of Defense Explosive Safety Board. Interview.

Council on Environmental Quality. (2010). *Federal Greenhouse Gas Accounting and Reporting Guidance.* Retrieved from http://www.whitehouse.gov/sites/default/files/microsites/ceq/GHG%20Guidance%20Document_0.pdf.

CPUC (California Public Utility Commission). (2004). *Decision 04-07-029 July 8, 2004*. Retrieved from http://docs.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/38287.htm.

CPUC. (2010a). *Decision 10-12-048 December 16, 2010*. Retrieved from http://docs.cpuc.ca.gov/word_pdf/FINAL_DECISION/128432.pdf.

CPUC. (2010b). *RPS Program Update*. Retrieved from http://www.cpuc.ca.gov/PUC/energy/Renewables/hot/RPS+Program+Update.htm.

CPUC. (2011a). *California Solar Initiative Cost Effectiveness Evaluation.* Retrieved from http://ethree.com/documents/CSI/CSI%20Report_Complete_E3_Final.pdf.

CPUC. (2011b). *California Renewables Portfolio Standard (RPS).* Retrieved from http://www.cpuc.ca.gov/PUC/energy/Renewables/index.htm.

CPUC. (2011c). *Order Instituting Rulemaking Regarding Implementation and Administration of the Renewable Portfolio Standard Program*. Retrieved from http://docs.cpuc.ca.gov/word_pdf/FINAL_DECISION/134980.pdf.

CPUC. (2011d). *Renewable Portfolio Standard Quarterly Report: 1st Quarter 2011*. Retrieved from http://www.cpuc.ca.gov/NR/rdonlyres/62B4B596-1CE1-47C9-AB53-2DEF1BF52770/0/Q12011RPSReporttotheLegislatureFINAL.pdf.

CSP (California State Parks). (2011). *SVRA Parks*. Retrieved from http://ohv.parks.ca.gov.

CTPG (California Transmission Planning Group). (2011). *Website*. Retrieved from http://www.ctpg.us/public/index.php.

CWC (California Wilderness Coalition). (2011). *Feinstein Bill to Protect California's Spectacular Desert Heritage for Future Generations.* Retrieved from http://www.calwild.org/news/bills-in-congress.html.

Danelski, D. (2011). *Mojave Desert: Military seeks OHV area for exercises*. The Press Enterprise. Retrieved from http://www.pe.com/localnews/stories/PE_News_Local_D_expansion26.23407cb.html.

DARPA (Defense Advanced Research Projects Agency). (2010). *DARPA Workshop on Geothermal Energy for Military Operations Report (DRP90T1).* Presented May 2010 by LMI, Michael E. Canes, Roger A. Lueken, and Nathan J. Shepherd.

DHS (Department of Homeland Security). (2005). *National Planning Scenarios: Executive Summaries Created for Use in National, Federal, State, and Local Homeland Security Preparedness Activities.*

DMG (Desert Manager's Group). (2011). *Desert Manager's Group: Partners*. Retrieved from http://www.dmg.gov/about.php.

DoD (Department of Defense). (2004a). *Directive: DoD Management Policy for Energy Commodities and Related Services (Number 4140.25*). Defense Technical Information Center. Retrieved from http://www.dtic.mil/whs/directives/corres/pdf/414025p.pdf.

DoD. (2004b). *DoD Ammunition and Explosives Safety Standards (6055.09-M STD*).

DoD. (2005). *Title 32: National Defense. Part 651-Environmental Analysis of Army Actions (AR 200-2).* Retrieved from http://www.access.gpo.gov/nara/cfr/waisidx_02/32cfr651_02.html.

DoD. (2006). *Department of Defense Metering plan as required by the Energy Policy Act of 2005.* The Office of the Secretary of Defense. Retrieved from http://www.acq.osd.mil/ie/energy/library/DoD_plan_7-24-06.pdf.

DoD. (2007). *Report to Congress on Sustainable Ranges*. Submitted by The Office of the Secretary of Defense, Under Secretary of Defense (Personnel and Readiness).

DoD. (2008*). Report of the Defense Science Board Task Force on DoD Energy Strategy: ―More Flight – Less Fuel."* The Office of the Secretary of Defense. Retrieved from http://www.acq.osd.mil/dsb/reports/ADA477619.pdf.

DoD. (2008a). *Report of the Defense Science Board on DoD Energy Strategy: More Fight – Less Fuel*. Washington, DC: Defense Science Board, Office of the Secretary of Defense.

DoD. (2009). *Instruction: Installation Energy Management (Number 4170.11*). Defense Technical Information Center. Retrieved from http://www.dtic.mil/whs/directives/corres/pdf/417011ppdf.

DoD. (2010a). *Defense Energy Support Center Fact Book: Includes Fiscal 2009 Facts and Statistics.* Defense Logistics Agency. Retrieved from http://www.desc.dla.mil/DCM/Files/FY09%20Fact%20Book%20(8-10-10).pdf.

DoD. (2010b). *Report to Congress on Sustainable Ranges.* Submitted by The Office of the Secretary of Defense, Under Secretary of Defense (Personnel and Readiness).

DoD. (2010c). *DoD ARRA 2009: Energy Conservation Investment Program Plan.* Retrieved from http://www.defense.gov/recovery/plans_reports/2010/pdfs/DoD%20ECIP%20Program%20Plan%20Update_FINAL_062110.pdf.

DoD. (2010d). *Annual Energy Management Report.* Retrieved from http://www.acq.osd.mil/ie/energy/library/aemr_fy_09_may_2010.pdf (accessed September 27, 2011).

DoD. (2010e). *Greenhouse Gas Targets Announcement for DoD*. Retrieved from http://www.defense.gov/releases/release.aspx?releaseid=13276.

DoD. (2010f). *Quadrennial Defense Review Report*. Retrieved from http://www.defense.gov/qdr/images/QDR_as_of_12Feb10_1000.pdf

DoD. (2011a). *Commanders Guide to Renewable Energy.* Range Commanders Council.

DoD. (2011b). *DoD Announces Renewable Energy Project Review Results*. Retrieved from http://www.defense.gov/Releases/Release.aspx?ReleaseID=14653.

DoD. (2011c). *National Defense Authorization Act for Fiscal Year 2011*. Retrieved from http://www.alpost21.org/2011NDAA.pdf.

DoD. (2011d). *Energy for the Warfighter: Operational Energy Strategy*. Retrieved from http://energy.defense.gov/OES_report_to_congress.pdf.

DOE (Department of Energy). (1996). *Final Environmental Impact Statement for the Nevada Test Site and Off Site Locations in the State of Nevada.* August, 1996.

DOE. (2003). *CHP and PV Increase Power Reliability at Twentynine Palms MAGTFTC.* Energy Efficiency and Renewable Energy. Retrieved from http://www.ornl.gov/sci/femp/pdfs/fs-5903_29palms_usmc.pdf.

DOE. (2007). *Parabolic Trough Systems; Guide to Tribal Energy Development.* Energy Efficiency and Renewable Energy. Retrieved from http://www1.Energy Efficiency and Renewable Energy.energy.gov/tribalenergy/guide/sc_parabolic.html.

DOE. (2008a). *P.L. 110-140 (H.R. 6) Energy Independence and Security Act (EISA) of 2007*. Energy Efficiency and Renewable Energy. Retrieved from http://www1.eere.energy.gov/femp/pdfs/eisa_femp.pdf.

DOE. (2008b). *Renewable Energy Requirement Guidance for EPAct 2005 and Executive Order 13423: Final.* Federal Energy Management Program. Retrieved from http://www1.eere.energy.gov/femp/pdfs/epact05_fedrenewenergyguid.pdf.

DOE. (2008c). *Market Analysis of Emerging Electric Storage Systems 2008/1330 (Final Report).*

DOE. (2009). *Concentrating Solar Power Commercial Application Study: Reducing Water Consumption of Concentrating Solar Power Electricity Generation.* Energy Efficiency and Renewable Energy Report to Congress. Retrieved from http://www1.Energy Efficiency and Renewable Energy.energy.gov/solar/pdfs/csp_water_study.pdf.

DOE. (2009a). *National Electric Transmission Congestion Study*. Retrieved from http://congestion09.anl.gov/documents/docs/Congestion_Study_2009.pdf.

DOE. (2009b). *Concentrating Solar Power Commercial Application Study: Reducing Water Consumption of Concentrating Solar Power Electricity Generation*. Report to Congress. Retrieved from http://www1.eere.energy.gov/solar/pdfs/csp_water_study.pdf.

DOE. (2009c). *Utility Energy Service Contracts: Enabling Documents*. Energy Efficiency and Renewable Energy. Retrieved from http://www1.eere.energy.gov/femp/pdfs/uesc_enabling_documents09.pdf.

DOE. (2010a). *Procuring Solar Energy: A Guide for Federal Facility Decision Makers.* Energy Efficiency and Renewable Energy. Retrieved from http://www1.Energy Efficiency and Renewable Energy.energy.gov/solar/federal_guide/.

DOE. (2010b). *Procuring Solar for Federal Facilities*. Energy Efficiency and Renewable Energy. Retrieved from http://www1.eere.energy.gov/solar/federal_guide/financing.html.

DOE. (2011a). *Power Tower Systems for Concentrating Solar Power: Energy Basics*. Energy Efficiency and Renewable Energy. Retrieved from http://www.Energy Efficiency and Renewable Energy.energy.gov/basics/renewable_energy/power_tower.html.

DOE. (2011b). *1705*. Retrieved from https://lpo.energy.gov/?page_id=41.

DOE. (2011c). *Concentrating Solar Power Commercial Application Study: Reducing Water Consumption of Concentrating Solar Power Electricity Generation*. Retrieved July 31, 2011, from http://www1.eere.energy.gov/solar/pdfs/csp_water_study.pdf.

DOE. (2011d). *Federal Renewable Production and Consumption Requirements*. Federal Energy Management Program. Retrieved from http://www1.eere.energy.gov/femp/technologies/renewable_requirements.html.

DOE. (2011e). *Federal Interagency Geothermal Activities (Working Draft).* Geothermal Technologies Program, Office of Energy Efficiency and Renewable Energy.

DOE. (2011f). *National Electric Transmission Corridor Report and the Ordered National Corridor Designations.* Retrieved from http://nietc.anl.gov/nationalcorridor/index.cfm.

DOI (Department of the Interior) (2010a). *Draft Programmatic Environmental Impact Statement for Solar Energy Development in Six Southwestern States: Volume 1: Chapter 2: Description of Alternatives and Reasonably Foreseeable Development Scenario.* Retrieved from http://solareis.anl.gov/documents/dpeis/Solar_DPEIS_Chapter_2.pdf.

DOI. (2010b). *Press Release: Salazar Celebrates Groundbreaking of Major Nevada Transmission Line.* Retrieved from http://www.doi.gov/news/pressreleases/Salazar-Celebrates-Groundbreaking-of-Major-Nevada-Transmission-Line.cfm.

DOI. (2011a). *New Energy Frontier: Balancing Energy Development on Federal Lands. Joint Report to Congress from DOI and USDA.* May 6, 2011. Retrieved from http://www.doi.gov/whatwedo/energy/index.cfm.

DOI. (2011b). *Meetings held with DOI at Washington, DC headquarters*. March 29, 2011.

Dominion. (2011). *Bath County Pumped Storage Station*. Retrieved from http://www.dom.com/about/stations/hydro/bath-county-pumped-storage-station.jsp.

DOW (Defenders of Wildlife). (2007). *Economic Oasis: Revealing the True Value of the Mojave Desert.* Retrieved from http://www.defenders.org/resources/publications/programs_and_policy/science_and_economics/conservation_economics/economic_oasis.pdf.

DOW. (2011). *Mohave Ground Squirrel: In the Field*. Retrieved from http://www.defenders.org/programs_and_policy/wildlife_conservation/imperiled_species/mg_squirrel/in_the_field.php.

DRECP (Desert Renewable Energy Conservation Plan). (2011a, March 24). Draft: Species Accounts: Barstow Woolly Sunflower [e-mail correspondence].

DRECP. (2011, March 24). Draft: Desert Renewable Energy Conservation Plan [e-mail correspondence].

DRECP. (2011b, March 24). Draft: Species Accounts: Nelson's Bighorn Sheep [e-mail correspondence].

DRECP. (2011c, March 24). Draft: Species Accounts: Southwestern Willow Flycatcher [e-mail correspondence].

DRECP. (2011d, March 24). Draft: Species Accounts: Flat-tailed Horned Lizard [e-mail correspondence].

DSIRE (Database of State Incentives for Renewables and Efficiency). (2011a). *California – Net Metering*. Retrieved from http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CA02R&re=1&ee=1.

DSIRE. (2011b). Modified Accelerated Cost-Recovery System (MACRS + Bonus Depreciation (2008-2012). Retrieved from http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US06F&State=Federal&currentpageid=1.

Dudley, T.L. (2009). ―The Mojave Desert: Ecosystem Processes and Sustainability." Reno, NV: University of Nevada Press. Retrieved from http://books.google.com/books?id=zHCspn_MpQsC&pg=PA125&lpg=PA125&dq=dudley+2009+-+invasive+plants+in+mojave+desert+riparian+areas&source=bl&ots=orn28PcmN4&sig=yH8YV4rTktadi_hyyJqXOrJhwpA&hl=en&ei=XPymTYG8FYa2tweZ5uGFAQ&sa=X&oi=book_result&ct=result&resnum=1&ved=0CB8Q6AEwAA#v=onepage&q&f=false.

Duncan, D. (2011, May 31). GIS data assistance for SERDP [e-mail correspondence].

Dunn, C. (2008). *How Does Solar Energy Work?* Treehugger. Retrieved from http://www.treehugger.com/files/2008/03/how-solar-energy-works.php?page=2.

ECI (Electrical Consultants, Inc.). (2011). *ECI website*. Retrieved from http://www.ecinc.com.

Edwards, C. (2011, July 19). Explosive Safety Chief, Creech AFB. Interview.

EEI (Edison Electric Institute). (2011). *Pacific Gas & Electric (PG&E).* Retrieved from http://www.eei.org/ourissues/ElectricityTransmission/Documents/Trans_Project_P-S.pdf.

Energy Alternatives. (2011). *Crystalline PV Modules*. Retrieved from http://www.energyalternatives.ca/catalogue/Categories/110.htm.

ENS (Environmental News Service). (2009). *World's Largest Solar Power Tower Starts Generating in Spain*. Retrieved from http://www.ens-newswire.com/ens/apr2009/2009-04-30-02.html.

EPA (U.S. Environmental Protection Agency). (1999a). *Considering Ecological Processes in Environmental Impact Assessments*. Retrieved from http://www.epa.gov/compliance/resources/policies/nepa/ecological-processes-eia-pg.pdf.

EPA. (1999b). *Consideration of Cumulative Impacts in EPA Review of NEPA Documents*. Retrieved from http://www.epa.gov/compliance/resources/policies/nepa/cumulative.pdf.

EPA. (2010a). *Base Case v410*. Retrieved from http://www.epa.gov/airmarkets/progsregs/epa-ipm/BaseCasev410.html.

EPA. (2010b) *Green Remediation and Utility-Scale Solar Development*. Retrieved from http://www.epa.gov/superfund/programs/recycle/pdf/aerojet.pdf.

EPA. (2010c). *National Environmental Policy Act (NEPA) Basic Information*. Retrieved from http://www.epa.gov/oecaerth/basics/nepa.html#publicrole on June 20, 2011.

EPA. (2011). *National Environmental Policy Act (NEPA) Homepage*. Retrieved from http://www.epa.gov/compliance/basics/nepa.html (accessed June 2011).

ESTCP (Environmental Security Technology Certification Program). (2011). *Solar CHP—Combined Heat and Power Using the Infinia Concentrated Solar Power System.* Retrieved from http://www.serdp.org/Program-Areas/Energy-and-Water/Energy/Distributed-Generation/EW-201145/EW-201145/(language)/eng-US.

EzNotice. (2011). Public Notice or Legal Notice #: *2753670*. Retrieved from http://eznotice.com/notices/2753670.

FAA (Federal Aviation Administration). (2000). *Advisory Circular AC 70/7460-1K Obstruction Marking and Lighting*. Retrieved from www.faa.gov.

FAA. (2010). *Aeronautical Information Manual/Federal Aviation Regulations (3-4-2).* Retrieved from http://www.faa.gov/air_traffic/publications/ATpubs/AIM/Chap3/aim0304.html.

Federal Register. (2007). *Executive Order 13423 of January 24, 2007: Strengthening Federal Environmental, Energy, and Transportation Management*. Retrieved from http://edocket.access.gpo.gov/2007/pdf/07-374.pdf.

Federal Register. (2009). *Executive Order 13514 – Federal Leadership in Environmental, Energy, and Economic Performance*. Retrieved from http://edocket.access.gpo.gov/2009/pdf/e9-24518.pdf.

Feinstein, D. (2011). *The California Desert Protection Act.* Retrieved from http://feinstein.senate.gov/public/_named_files/106900_desert_booklet.pdf.

Feller, W. (2011). *Mojave Desert Website.* Retrieved from http://mojavedesert.net/.

FERC. (Federal Energy Regulatory Commission). (2011). *Transmission Planning and Cost Allocation*. Retrieved from http://www.ferc.gov/industries/electric/indus-act/trans-plan.asp.

Flynn, N., Gibbes, S., Griffis, M., Issihiki, T., Killian, S., Palombi, L., Rujanavech, N., Tomsky, S., Tondro, M., and J. Fernandes. (2010). *Renewable Energy in the California Desert: Mechanisms for Evaluating Solar Development on Public Lands*. University of Michigan, April 2010. Retrieved from http://hdl.handle.net/2027.42/69249.

Foster, B. (2011a, August 5). Optony, Inc. Local Permitting Regulations [e-mail correspondence].

Foster, B. (2011b, June 30). Optony, Inc. Policy Chapter Review [e-mail correspondence].

Fraser, James. (2005). *About Parabolic Trough Solar.* The Energy Blog. Posted to http://thefraserdomain.typepad.com/energy/2005/09/about_parabolic.html.

FSF (Flight Safety Foundation). (1991). *Special Use Airspace and Military Training Routes*. Accident Prevention. Vol. 48, No. 11.

FTA (Federation of Tax Administrators). (2011a). *Range of State Corporate Income Tax Rates.* Retrieved from http://www.taxadmin.org/fta/rate/corp_inc.pdf.

FTA. (2011b). *State Sales Tax Rates and Food & Drug Exemptions*. Retrieved from http://www.taxadmin.org/fta/rate/sales.pdf.

FTHL ICC (Flat-Tailed Horned Lizard Interagency Coordinating Committee). (2003). *Flat-tailed horned lizard rangewide management strategy*. Retrieved from http://www.fws.gov/southwest/es/arizona/Documents/SpeciesDocs/FTHL/RMS%20-%20Final%202003.pdf.

GAO. (2010). *Defense Infrastructure: Department of Defense Renewable Energy Initiatives* [PowerPoint slides]. Retrieved from http://www.gao.gov/new.items/d10681r.pdf.

GAO. (U.S. General Accounting Office). (2010). *Defense Infrastructure: Department of Defense's Renewable Energy Initiatives: Briefing for the Committee on Armed Services, United States Senate and House of Representatives*. April 26, 2010. Retrieved from http://www.gao.gov/new.items/d10681r.pdf.

GAO. (U.S. Government Accountability Office). (1998). *DoD Management Issues Related to Chaff (GAO/NSIAD-98-219).*

Genpro Energy Solutions. (2011). *Education Center: Crystalline Silicon Solar Cells*. Retrieved from http://www.genproenergy.com/crystalline.html.

Go Solar California. (2011a). *California Solar Initiative – Statewide Trigger Tracker*. Retrieved from http://www.csi-trigger.com/.

Go Solar California. (2011b). *California Solar Initiative Rebates*. Retrieved from http://www.gosolarcalifornia.ca.gov/csi/rebates.php.

Goldsmith, Wendi. (2011). *Energy Generation. Presentation at ADC Winter Forum, February 14-16, 2011, San Antonio, Texas*. Retrieved from http://www.defensecommunities.org/programs-services/2011-winter-forum/conference-presentations/.

GPO (Government Publishing Office). (2005). *Energy Policy Act of 2005*. Retrieved from http://www.gpo.gov/fdsys/pkg/BILLS-109hr6enr/pdf/BILLS-109hr6enr.pdf.

GPO. (2008). *H.R. 5122 – John Warner National Defense Authorization Act for Fiscal Year 2007.* Retrieved from http://www.gpo.gov/fdsys/pkg/BILLS-109hr5122enr/pdf/BILLS-109hr5122enr.pdf.

GPO. (2009). *H.R. 2647 – National Defense Authorization Act for Fiscal Year 2010*. Retrieved from http://www.gpo.gov/fdsys/pkg/BILLS-111hr2647enr/pdf/BILLS-111hr2647enr.pdf.

GPO. (2010). *National Defense Authorization Act for Fiscal Year 2011*. Retrieved from http://www.gpo.gov/fdsys/pkg/BILLS-111s3454pcs/pdf/BILLS-111s3454pcs.pdf.

Greene, K. (2009). *Nanopatterns Improve Thin-Film Solar Cells*. Technology Review. Retrieved from http://www.technologyreview.com/energy/23755/.

H2PS. (NA). *Thermal Water Dissociation*. Retrieved from http://www.h2powersystems.com/thermolysis.pdf.

Haigh, W., and R. Scott. (2004). *West Mojave Plan: A Multi-Species Habitat Conservation Plan and Federal Plan Amendment*. Retrieved from http://www.dmg.gov/documents/PRS_W_Moj_Pln_HaighW_011204.ppt.

Halpin, S. (2011). Utility Manager, NAWS China Lake. Interview.

Harding, D. (2010). *Stirling Engine Addresses Large-Scale Solar Power Concerns*. CalFinder. Retrieved from http://solar.calfinder.com/blog/products/stirling-engine-addresses-large-scale-solar-power-concerns/.

Henen, B.T., Wood, B., and M. Joia. (2011). *Department of Defense and Desert Tortoise Conservation.* Thirty-sixth Annual Meeting and Symposium the Desert Tortoise Council. Retrieved from http://www.deserttortoise.org/abstract/2011DTCSymposiumAbstracts.pdf.

Ho, Clifford, Ghanbari, Cheryl, Diver, and Richard. (2009). *Hazard Analysis of Glint and Glare from Concentrating Solar Power Plants.* SolarPACES 2009.

Holland, R.F. (1986). *Preliminary descriptions of the terrestrial natural communities of California.* California Department of Fish & Game. Retrieved from http://www.biogeog.ucsb.edu/projects/gap/data/cnddb/34100.html.

Hughes, Emma. (2010). *Project Focus: Sempra Generation completes 48MW Copper Mountain Solar power plant*. PVTech. Retrieved from http://www.pv-tech.org/news/project_focus_sempra_generation_completes_48mw_copper_mountain_solar_power_.

Hunter, John. (2010) *Molten Salt Solar Reactor Approved by California*. Retrieved from http://engineering.curiouscatblog.net/2010/12/18/molten-salt-solar-reactor-approved-by-california/.

Hunwick, R. (2005). *Energy Storage Symposium.* Presented at the Australian Institute of Energy, on November 1, 2005.

ICF International. (2010). *Photovoltaic (PV) Cost and Performance Characteristics for Residential and Commercial Applications*. Washington, DC: Energy Information Administration.

Kearney and Associates. (1992). *Solar Electric Generation System (SEGS) Assessment for Hawaii.* Accessed hawaii.gov/dbedt/info/energy/publications/segs92.pdf

Kelly, T. A. (1999). *The Avian Hazard Advisory System* (*Publication 91-1: Flying Safety*). Washington, DC: United States Air Force.

Kern County. (2011). *Kern County Renewable Energy Projects*. Retrieved from http://www.co.kern.ca.us/planning/renewable_energy.asp on June 20, 2011.

King, Alan D. (2011). *Developing Renewable Energy Projects on DoD Land*. Presentation at ADC Winter Forum, February 14-16, 2011, San Antonio, Texas. Retrieved from http://www.defensecommunities.org/programs-services/2011-winter-forum/conference-presentations/.

Kling Stubbins. (2008). *EPO: Emergency Power On – Business must examine several design and cost considerations before installing on-site generators*. Retrieved from http://www.klingstubbins.com/about/pdfs_articles/Emergency_Power_On_KS_Website.pdf.

Korves, B. (2011, July 19). Explosive Safety Officer, Marine Corps Logistics Base Barstow. Interview.

Laabs, D. (2001). *Mohave Ground Squirrel: West Mojave Plan Species Accounts*. U.S. Department of the Interior, Bureau of Land Management. Retrieved from http://www.blm.gov/ca/pdfs/cdd_pdfs/Mgs1.pdf.

LACDRP (Los Angeles County Department of Regional Planning). (2011) *Zoning Ordinance Update Program.* Retrieved from http://planning.lacounty.gov/zoup on June 20, 2011.

LADWP (Los Angeles Department of Water and Power). (2007). *FERC Order 890 Strawman Proposal for Coordinating, Open, and Transparent Planning*. Retrieved from http://www.oatioasis.com/LDWP/LDWPdocs/LADWP_FERC_890_Strawman_Presentation.pdf

Lakes Town Council. (2009a). *Barren Ridge Renewable Transmission Project*. Retrieved from http://www.lakestowncouncil.com/RegularMeeting-Agenda/Home/barren-ridge-renewable-transmission-project

Lakes Town Council. (2009b) *Power line plan prompts high-voltage protest*. Retrieved from http://www.lakestowncouncil.com/RegularMeeting-Agenda/Home/area-news.

Laudenslayer, W.F. (2011). *Desert Wash. California Department of Fish and Game*. Retrieved from http://www.dfg.ca.gov/biogeodata/cwhr/pdfs/DSW.pdf.

LCSE (Laboratory for Computational Science and Engineering. *The Electromagnetic Spectrum*. Retrieved from http://www.lcse.umn.edu/specs/labs/glossary_items/em_spectrum.html.

Lehl Gmbh Technik & Design. (2010). *Solar-thermal power plants*. Retrieved from http://www.citytramp.com/solar/solar-thermal_plants.html.

Leitner, P. (2008). *Current Status of the Mohave Ground Squirrel*. California Department of Fish and Game. Retrieved from http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentVersionID=29930.

Leonard, Debbie. (2010). *Doctrinal Uncertainty in the Law of Federal Reserved Water Rights: The Potential Impact on Renewable Energy Development*. Natural Resources Journal, 50(3), 611-643.

Lundstrom, T. (2011, May 9). Senior Counsel, U.S. Navy. Interview.

Malcolm Pirnie, Inc. (2008). *Range Environmental Vulnerability Assessment: Marine Corps Air Station Yuma.* Retrieved from http://www.denix.osd.mil/sri/upload/MCAS-Yuma.pdf.

Marshall, R.M., Anderson, S., Batcher, M., Comer, P., Cornelius, S., Cox, R., Gondor, A., Gori, D., Humke, J., Aguilar, R.P., Parra, I.E., and S. Schwartz. (2000). *An Ecological Analysis of Conservation Priorities in the Sonoran Desert Ecoregion*. Conserve Online. Retrieved from http://conserveonline.org/library/SonoranPlan.pdf/view.html.

Maybrier, Angela. (2011). *Developing Renewable Energy Projects on DoD land*. Presentation at ADC Winter Forum, February 14-16, 2011, San Antonio, Texas. Retrieved from http://www.defensecommunities.org/programs-services/2011-winter-forum/conference-presentations.

McFadden, L.D., Wells, S.G., and M.J Jercinovich. (1987). *Influences of eolian and pedogenic processes on the origin and evolution of desert pavements*. Geology. v.15 p. 504-508. Retrieved from http://geomorphology.sese.asu.edu/Papers/McFadden_etal_Geology_87.pdf.

Michaelsen, J. (2009). *Colorado Desert Region Physical Geography*. Santa Barbara, Ca: University of California. Retrieved from http://www.geog.ucsb.edu/~joel/g148_f09/readings/colo_desert/colo_desert.html.

Moore, H. a. (2011). *Five Years of Operating Experience at a Large, Utility-Scale Photovoltaic Generating Plant*. Progress in Photovoltaics: Research and Applications, 249-259.

Moran, E. (2011). *Desert Cymopterus. Desert Tortoise Preserve Committee*. Retrieved from http://www.tortoise-tracks.org/denizens/cymopterus.html.

MSNBC. (2007). *Huge Solar Power Park to Rise in Mojave Desert*. Retrieved from http://www.msnbc.msn.com/id/20068703/ns/us_news-environment/t/huge-solar-power-park-rise-mojave-desert/.

Nadav, E. (2010). *PV O&M Best Practices: Utility/Lab Workshop on PV Technology and Systems*. Electric Power Research Institute. Retrieved from http://www1.eere.energy.gov/solar/pdfs/2010ulw_enbar.pdf.

NAHB Research Center. (1996). *Photovoltaics: A background paper for homebuilders, remodelers, and editors*. Retrieved from http://www.toolbase.org/PDF/CaseStudies/PV_background_paper.pdf.

NatureServe. (2010). ―Barstow Woolly Sunflower." NatureServe Explorer: An Online Encyclopedia of Life [web application]. Version 7.1. Retrieved from http://www.naturserve.org/explorer.

NCSU (North Carolina State University). (2009). *State & Federal Tax Incentives for Commercial Solar Energy.* Retrieved from http://www.ncsc.ncsu.edu/admin/include/_upload/media/docs/factsheets/Incentives_Commercial_Solar_2.pdf.

NDOW (Nevada Division of Wildlife). (2006). *Comprehensive Wildlife Conservation Strategy: Mojave/Sonoran Warm Desert Scrub*. Retrieved from http://www.ndow.org/wild/conservation/cwcs/final/88_93mojave_warmscrub.pdf.

NERC. (North American Electric Reliability Corporation). (2010). *2010 Long Term Reliability Assessment*. Retrieved from http://www.nerc.com/files/2010%20LTRA.pdf.

Nevada Legislature. (2011). *Chapter 701A – Energy-Related Tax Incentives*. Retrieved from http://www.leg.state.nv.us/NRS/NRS-701A.html#NRS701ASec200.

New Energy and Fuel. (2008, March 3). *Sodium-Sulfur (NaS) Battery*. Posted to www.newenergyandfuel.com.

NFWO (Nevada Fish & Wildlife Office). (2011). *Desert Tortoise Habitat & Life History*. Retrieved from http://www.fws.gov/nevada/desert_tortoise/dt_life.html.

NMCWL (New Mexico Center for Wildlife Law). (2011). *Federal Wildlife and Related Laws Handbook: Federal Land Policy and Management Act of 1976*. Retrieved from http://wildlifelaw.unm.edu/fedbook/flpma.html.

NPR (National Public Radio). (2011). *Visualizing the U.S. Grid*. Retrieved from http://www.npr.org/templates/story/story.php?storyId=110997398&start=solar.

NPR. (2010). *A Renewable Energy Debate Heats Up in the Mojave*. Retrieved from http://www.npr.org/templates/story/story.php?storyId=126173547.

NPS (National Park Service). (2009). *Old Spanish National Historic Trail*. Retrieved from http://www.nps.gov/olsp/planyourvisit/upload/200909_OLSP_Map.pdf.

NPS. (2010). *NPS Overview*. Retrieved from http://www.nps.gov/news/loader.cfm?csModule=security/getfile&PageID=387483.

NPS. (2011). *Mojave National Preserve: History & Culture*. Retrieved from http://www.nps.gov/moja/historyculture/index.htm.

NPS. (2011a). *Mojave*. Retrieved from http://www.nps.gov/moja/index.htm.

NREEEA (Nevada Renewable Energy and Energy Efficiency Authority). (2009). *Renewable Energy Tax Abatements.* Retrieved from http://renewableenergy.state.nv.us/TaxAbatement.htm.

NREL (National Renewable Energy Laboratory). (2005). *Potential for Renewable Energy in the San Diego Region (Appendix E: Solar Thermal – Concentrated Solar Power)*.

NREL. (2006). *Parabolic Trough Solar Power Plant Systems Analysis Task 1: Preferred Plant Size (NREL/SR-550-40162)*. Subcontractor Report by B. Kelly, Nexant, Inc.

NREL. (2007). *Andasol 1 & 2 50 MW, 7 Hours Molten Salt Heat Storage* [PowerPoint Presentation]. Presented at NREL Trough Technology Workshop, March 8, 2007. Retrieved from http://www.nrel.gov/csp/troughnet/pdfs/2007/martin_andasol_pictures_storage.pdf.

NREL. (2010). *Parabolic Trough Power Plant Market*, *Economic Assessment and Deployment*. Retrieved from http://www.nrel.gov/csp/troughnet/market_economic_assess.html.

NREL. (2011). *System Advisor Model (SAM) Version 2010.11.9*. Retrieved from https://www.nrel.gov/analysis/sam/.

NREL. (2011a). *Ivanpah Solar Electric Generating System.* Concentrating Solar Power Projects. Retrieved from http://www.nrel.gov/csp/solarpaces/project_detail.cfm /projectID=62.

NREL. (2011b). *Sierra Sun Tower*. Concentrating Solar Power Projects. Retrieved from http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=63.

NREL. (2011c). *About the thin film partnership program*. Thin Film Partnership Program. Retrieved from http://www.nrel.gov/pv/thin_film/about.html.

NREL. (2011d). *Parabolic Trough Thermal Energy Storage Technology*. Retrieved from http://www.nrel.gov/csp/troughnet/thermal_energy_storage.html.

NRS (Nevada Regulatory Statutes). (2011). *Chapter 704 – Regulation of Public Utilities Generally*. Retrieved from http://www.leg.state.nv.us/NRS/NRS-704.html#NRS704Sec820.

NV Energy. (2011a). *Renewable Generations – October 2011 Report.* Retrieved from http://issuu.com/nvenergyrenewablegenerations/docs/renewablegenerations.

NV Energy. (2011b). *2011 Solar Generations Program Handbook*. Retrieved from http://www.nvenergy.com/renewablesenvironment/renewablegenerations/documents/SolarGenerationsHandbook.pdf.

NV Legislature. (2011). *Assembly Bill 416*. Retrieved from http://www.leg.state.nv.us/Session/76th2011/Bills/AB/AB416_EN.pdf.

NV Legislature. (2011b). *Active Nevada Transmission Plans and Projects*. Retrieved from http://www.leg.state.nv.us/Division/Research/Library/Documents/ReportsToLeg/2009-2011/92-11.pdf

NV Power Company. (2011). *NV Energy Tariff – Attachment K*. Retrieved from http://www.oatioasis.com/NEVP/index.html.

NVDWR (State of Nevada Division of Water Resources). (2011). *Water Rights Home*. Retrieved from http://water.nv.gov/waterrights/ on June 20, 2011.

NVSOE (Nevada State Office of Energy). (2010). *2009 Status of Energy in Nevada*. Retrieved from http://energy.state.nv.us/documents/2009-Status-of-Energy-in-Nevada.pdf

NVTREC (Nevada Tracks Renewable Energy Credits). (2011). *Renewable Energy Portfolio Credit Standard Information.* Retrieved from https://www.nvtrec.com/(X(1)S(e0353kjx0at55ayjkp0xes55))/UI/Guest/Homepage.aspx?AspxAutoDetectCookieSupport=1.

OCWD (Orange County Water District). (2008). *Endangered Species: Southwestern Willow Flycatcher.* Retrieved from http://www.ocwd.com/ca-162.aspx.

OMB (Office of Management and Budget). (1992). *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs, Circular A-94 Revised.* Retrieved from http://www.whitehouse.gov/omb/circulars_a094#8 (accessed September 28, 2011).

Ombello, Carlo. (2010). ―The world's first molten salt concentrating solar power plant." Guardian UK. Retrieved from http://www.guardian.co.uk/environment/2010/jul/22/first-molten-salt-solar-power.

OSD RDT&E (Office of the Secretary of Defense, Research Development Test & Evaluation Program). (2011, November 23) Comments Matrix DOTE 21Nov11 [E-mail correspondence].

Pavlik, B.M. (2008). ―The California Deserts: An Ecological Rediscovery." Los Angeles, Ca: University of California. Retrieved from http://books.google.com/books?id=3hqJ1KJmY30C&printsec=frontcover&dq=pavlik+2008+california+deserts:+an+ecological+rediscovery&source=bl&ots=A8u19D9MEA&sig=b0KDv2wsy8O0uSKg-qSXH6oCH_I&hl=en&ei=TAemTfj-E8zogAeaz7WSCg&sa=X&oi=book_result&ct=result&resnum=5&ved=0CDQQ6AEwBA#v=onepage&q&f=false.

Pease, Fred. (2011, March 29). DoD Liaison, Immediate Office of the Secretary of the Interior. Interview.

Pike, J. (2005). *Fort Irwin*. GlobalSecurity.org. Retrieved from http://www.globalsecurity.org/military/facility/fort-irwin.htm.

Pletka, R. B. (2010). *LTPP Solar PV Performance and Cost Estimates* [PowerPoint Presentation]. California Public Utilities Commission. Retrieved from www.cpuc.ca.gov/NR/rdonlyres/...E2C4.../BVE3PVAssessment.ppt.

PNNL (Pacific Northwest National Laboratory). (2011). *Renewable Energy Feasibility Study at Nellis Air Force Base, Creech Air Force Base, and Tonopah Auxiliary Airfield Annex, Nevada.*

Powered By Solar Panels. (2010). *Crystalline silicon solar cells*. Retrieved from http://poweredbysolarpanels.com/crystalline-silicon-solar-cells/.

PPF (Participatory Politics Foundation). (2011). *S.2921 – California Desert Protection Act of 2010*. OpenCongress. Retrieved from http://www.opencongress.org/bill/111-s2921/show.

Prior, B. (2009). *Cost and LCOE by Generation Technology: 2009-2020*. GTM Research. Retrieved from http://www.greentechmedia.com/images/wysiwyg/research-blogs/GTM-LCOE-Analysis.pdf.

PRNewswire. (2011). *ReneSola improves cell efficiency with Virtus wafer.* ElectroIQ. Retrieved from http://www.electroiq.com/index/display/photovoltaics-article-display/4477919655/articles/Photovoltaics-World/silicon-photovoltaics/crystalline-silicon/2011/1/renesola-improves-cell-efficiency-virtus-wafer.html.

PSCWV (Public Service Commission of West Virginia). (2011). *Case No. 10-1824-E-CS-PC.*

Quade, J. (2001). *Desert pavements and associated rock varnish in the Mojave Desert: How old can they be?* Geological Society of America. Retrieved from http://geomorphology.sese.asu.edu/Papers/Quade_desert_pavements_Geology_01.pdf.

Randall, J.M., S.S. Parker, J. Moore, B. Cohen, L. Crane, B. Christian, D. Cameron, J. MacKenzie, K. Klausmeyer, and S. Morrison. (2010). *Mojave Desert Ecoregional Assessment.* The Nature Conservancy. Retrieved from http://conserveonline.org/workspaces/mojave/documents/mojave-desert-ecoregional-2010/@@view.html.

Range Commanders Council Sustainability Group. (2011a). *Meeting notes from Range Commanders Council Sustainability Group meeting held at NCSW, San Diego*. March 13-14, 2011.

Range Commanders Council Sustainability Group. (2011b). *Commanders Guide to Renewable Energy: Draft.*

REAT (Renewable Energy Action Team; California Energy Commission, California Department of Fish and Game, DOI Bureau of Land Management and Fish and Wildlife Service). (2009). *Best Management Practices and Guidance Manual: Desert Renewable Energy Projects.* California Energy Commission, Siting, Transmission, and Environmental Protection Division. CEC-700-2009-016-SD-REV.

Renewable Insight. (2010). *PV Power Plants 2010: Industry Guide*. Renewable Insights-Energy Industry Guides. Retrieved from http://www.pv-power-plants.com/fileadmin/user_upload/PVPP_2010_web.pdf.

RETI (Renewable Energy Transmission Initiative). (2010). *Renewable Energy Transmission Initiative Phase 2B Map.* Retrieved from http://www.energy.ca.gov/reti/documents/phase2B/CA_CREZ_Conceptual_Transmission_Segments_Phase_2B_final.pdf.

REW (Renewable Energy World). (2011). *Solar Shakeout Continues: Stirling Energy Systems Files for Chapter 7 Bankruptcy*. Retrieved from http://www.renewableenergyworld.com/rea/news/article/2011/09/solar-shakeout-continues-stirling-energy-systems-files-for-chapter-7-bankruptcy.

Rief, G. (2011, July 8). Explosive Safety Officer, Edwards AFB. Interview.

Robison, Jennifer. (2010). "Groundbreaking Celebrates One Nevada Transmission Line." Las Vegas Review-Journal. Oct. 19, 2010. Retrieved from http://www.lvrj.com/business/doe-approves-loan-guarantees-to-link-nevada-power-grid-105285143.html.

Robyn, D. (2010). *Testimony before the Senate Committee on Energy and Natural Resources S. 2921, California Desert Protection Act of 2010*. The Office of the Secretary of Defense. Retrieved from http://www.acq.osd.mil/ie/download/s2921_robyn_testimony_052010.pdf

San Bernardino County. (2010). *Initial Study Environmental Checklist Form for Kramer Junction Solar Farm: APN: 0492-221-22-0000*. Retrieved from http://www1.sbcounty.gov/landuseservices/Public%20Notices/Projects/Lightsource%20Renewables%20Kramer%20Junction%20Solar%20Project/Initial%20Study_03262010.pdf.

Sargent & Lundy LLC Consulting Group. (2003). *Assessment of Parabolic Trough and Power Tower Solar Technology Cost and Performance Forecasts (NREL Subcontractor Report FREL/SR-550-34440, 2-1 to 2-9).* Retrieved from http://www.nrel.gov/docs/fy04osti/34440.pdf.

SCE (Southern California Edison). (2010). *El Dorado-Ivanpah Transmission Project*. Retrieved from http://asset.sce.com/Documents/Environment%20-%20Transmission%20Projects/1007_EITPFactSheet.pdf.

Schwartz, David McGrath. (2011). ―Governor Vetoes Controversial Last-Minute Energy Bill." Las Vegas Sun. Retrieved from http://www.lasvegassun.com/news/2011/jun/17/governor-vetoes-controversial-last-minute-energy-b/.

ScienceDaily. (2009). *Solar Power: New SunCatcher Power System Ready For Commercial Production in 2010.* Science News. Retrieved from http://www.sciencedaily.com/releases/2009/07/090709205950.htm.

SDG&E (San Diego Gas and Electric). (2010). *Sunrise Powerlink website*. Retrieved from http://www.sdge.com/sunrisepowerlink/

SECO. (2011). *Texas Solar Energy*. Retrieved from http://www.seco.cpa.state.tx.us/re_solar.htm.

SEDPEIS (Solar Energy Development Programmatic EIS Information Center). (2010a). *Why the Solar Energy Development Programmatic EIS Is Necessary*. Retrieved from http://solareis.anl.gov/eis/why/index.cfm.

SEDPEIS. (2010b). *Frequently Asked Questions (FAQs*). Retrieved from http://solareis.anl.gov/faq/index.cfm.

SEDPEIS. (2010c). *Solar Energy Zones*. Retrieved from http://solareis.anl.gov/sez/index.cfm.

SEDPEIS. (2010d). *What's in the Solar Energy Development Programmatic EIS*. Retrieved from http://solareis.anl.gov/eis/what/index.cfm.

SERDP (Strategic Environmental Research and Development Program). (2011). *Predictive Tools to Manage Altered Fire Regimes Caused by Plant Invasions in the Mojave Desert.* Retrieved from http://www.serdp.org/Program-Areas/Resource-Conservation-and-Climate-Change/Natural-Resources/Arid-Lands-Ecology-and-Management/RC-1723.

SES (Stirling Energy Systems). (2011a). *Power to Perform.* Manufacturing. Retrieved from http://www.stirlingenergy.com/manufacturing.htm.

SES. (2011b). *SunCatcher Technology: How it Works: Technology*. Retrieved from http://www.stirlingenergy.com/how-it-works.htm.

SES. (2011c). *SunCatcher Advantages: Technology*. Retrieved from http://www.stirlingenergy.com/advantages.htm.

Siniscalchi, J. (1998). *Non-Lethal Technologies: Implications for Military Strategy*. Center for Strategy and Technology, Air War College.

SNL (Sandia National Laboratories). (2006). *Advantages of using molten salt*. Retrieved from http://www.sandia.gov/Renewable_Energy/solarthermal/NSTTF/salt.htm.

SNL. (2008). *Solar Grid Energy Integration Systems – Energy Storage (SEGIS-ES) (Program Concept).*

SNL. (2009). *Concentrating Solar Power: CSP Technologies Overview*. Retrieved from http://www.sandia.gov/csp/cspoverview.html.

Solana, A., Russo, B., and Warwick, M. (2011). *Renewable Energy Opportunities at Nellis, Creech, and Tonopah Outbrief* [PowerPoint slides]. Richland, Washington: Pacific Northwest National Laboratory.

Solar Millennium. (2011a). *We're Developing the Future: Press Releases*. Retrieved from http://www.solarmillennium.de/technology/parabolic-trough-power-plants/solar-field/index.html.

Solar Millennium. (2011b). *Parabolic Trough Power Plant Solar Fields: Technology*. Retrieved from http://www.solarmillennium.de/technology/parabolic-trough-power-plants/solar-field/index.html.

Solar Millennium. (2011c). *Parabolic Trough Technology- The Facts: Technology*. Retrieved from http://www.solarmillennium.de/technology/parabolic-trough-power-plants/facts/index.html.

Solarbuzz. (2011). *Understanding Solar Energy Systems: Technologies*. Retrieved from http://www.energyalternatives.ca/catalogue/Categories/110.htm.

SolarByTheWatt.com. (2009). *Solar Energy Land Area Efficiency or How Many Acres per MW, kWp per Acre.* Solar By The Watt.com. Retrieved from http://solarbythewatt.com/2009/03/09/solar-energy-land-area-efficiency-or-how-much-acres-per-mw-kwp-per-acre/.

SolarPACES (Solar Power and Chemical Energy Systems). (2010). *Solar Power Tower*. Retrieved from http://www.solarpaces.org/CSP_ Technology/docs/solar_tower.pdf.

SolarPACES. (2011). *Home Page*. Retrieved from http://www.solarpaces.org/inicio.php.

Stacy, J. (2011, June 20). Senior Explosive Safety Engineer, NOSSA. SERDP Study-Renewable Energy on Department of Defense Land in the Mojave and Colorado-DON Response to Questions from ICF International [e-mail correspondence].

State of California (2008a). *R2508 Joint Land Use Study*. Retrieved from www.opr.ca.gov.

State of California (2008b). *Department of Transportation Letter City of Victorville's Draft Environmental Impact Report for the Victorville General Plan 2030 (SCH# 2008021086*). Retrieved from www.co.san-bernardino.ca.us/.../So%20Calif%20Logistics%20ACLUP.pdf

State of California (2008c). *Department of Energy 2008 Standards Summary of Outdoor Lighting Zones.* Accessed http://www.energy.ca.gov/title24/2008standards/outdoor_lighting/

Stewart, G.R. (2005). *Petition to list the Mohave Ground Squirrel As a Federally Endangered Species.* Retrieved from http://www.defenders.org/resources/publications/programs_and_policy/wildlife_conservation/imperiled_species/mohave_ground_squirrel/petition_to_list_the_mohave_ground_squirrel.pdf.

Sullivan, S. (2009). *World's Largest Commercial Solar Power Tower Goes Online*. Clean Technica. Retrieved from http://cleantechnica.com/2009/04/29/tower-of-power/.

Swartley, J.B. (2010). *Senior Thesis: Solar Development in the Mojave Desert.* Claremont, Ca: Claremont McKenna College. Retrieved from http://scholarship.claremont.edu/cgi/viewcontent.cgi?article=1076&context=cmc_theses&sei-redir=1#search="solar+development+-+mojave+desert".

Szaro, R.C., Severson, K.E., and D.R. Patton (Eds). *General Technical Report RM-166: Management of Amphibians, Reptiles and Small Mammals in North America*. Fort Collins, CO: U.S. Forest Service.

TEEIC (Tribal Energy and Environmental Information Clearinghouse). (2011). *Concentrating Solar Power (CSP) Systems*. Solar Energy System Descriptions. Retrieved from http://teeic.anl.gov/er/solar/restech/desc/index.cfm.

Terra-Gen (Terra-Gen Power). (2009). *Alta-Oak Creek Mojave Project*. Retrieved from http://altawindenergycenter.com/background.html.

TheirEarth. (2008). *Stirling Energy Systems- Solar Dish Engine: New Technology*. Retrieved from http://theirearth.com/index.php/news/csp-stirling-solar-dish-engine-stirling-energy-systems.

Thomas, K., D. Stoms, and F. Davis. (2004). *The Mojave Desert Region*. Santa Barbara, Ca: University of California. Retrieved from http://www.biogeog.ucsb.edu/projects/gap/report/moj_rep.html.

Tournemille, H. (2009). *Award-Winning Solar Reflectors Will Cut Production Costs*. Solar Energy: Energy Boom. Retrieved from http://www.energyboom.com/solar/award-winning-solar-reflectors-will-cut-production-costs.

Troutman, S. (2009). *Green Energy Express Incentives Contingent on CAISO Approval.* Retrieved from http://www.troutmansandersenergyreport.com/2009/12/green-energy-express-incentives-contingent-on-caiso-approval/.

Turchi, C., Wagner, M., Kutscher, C. (2010). *Water Use in Parabolic Trough Power Plants: Summary Results from Worley Parsons' Analyses (NREL/TP-5500-49468*). Golden, CO: National Renewable Energy Laboratory.

U.S. Air Force and U.S. Navy (2007). *Barry M. Goldwater Range: Integrated Natural Resources Management Plan.*

U.S. Army (2003). *Range Safety: Department of the Army Pamphlet 385-63*.

U.S. Army (2003a). *Range Safety: Army Regulation 385-63*.

U.S. Army (2009). *National Training Center Fort Irwin Training Facilities Map Edition 04-ITAM Series V975S*. Military Overprint Information.

U.S. Army (2011). *Range Facility Management Support System (RFMSS) Report for Fort Irwin*.

U.S. Army Corps of Engineers (2011). *Fort Irwin Solar Energy Enhanced Use Lease (EUL).* Retrieved from http://www.clarkenergygroup.com/irwinpressconference/Fort%20Irwin%20Solar%20Energy%20-%20Press%20Kit%20-%20FINAL.pdf.

U.S. Census Bureau. (1990). *Census 1990 Gateway*. Retrieved from http://www.census.gov/main/www/cen1990.html.

U.S. Census Bureau. (2000). *Census 2000 Gateway*. Retrieved from http://www.census.gov/main/www/cen2000.html.

U.S. Census Bureau. (2010). *Census 2010 Gateway*. Retrieved from http://2010.census.gov/2010census/data/.

U.S. Census Bureau. (2011). *American Fact Finder*. Retrieved from http://factfinder.census.gov/home/saff/main.html?_lang+en.

U.S. Census Bureau. (2011a). *State & County Quick Facts: Clark County, Nevada*. Retrieved from http://quickfacts.census.gov/qfd/states/32/32003.html.

U.S. Census Bureau. (2011b). *Population Distribution and Change: 2000 to 2010.* Retrieved from http://www.census.gov/prod/cen2010/briefs/c2010br-01.pdf.

U.S. Federal Register. (2011). *Endangered and Threatened Wildlife and Plants: Withdrawal of Proposed Rule To List the Flat-Tailed Horned Lizard as Threatened*. Retrieved from http://www.federalregister.gov/articles/2011/03/15/2011-5411/endangered-and-threatened-wildlife-and-plants-withdrawal-of-proposed-rule-to-list-the-flat-tailed.

U.S. Library of Congress. (2011). *Bill Summary & Status: S. 138*. Retrieved from http://hdl.loc.gov/loc.uscongress/legislation.112s138.

U.S. Marine Corps Installations West. (2009). *Energy Efficiency and Renewable Energy Initiatives at MCIWEST* [PowerPoint slides]. Retrieved from http://sameoc.org/FD/2010/2-Gilleskie_MCIWEST_Energy.pdf.

U.S. Patent Office. (2008). *Optical detection and location of gunfire. Patent 7409899*. Retrieved from http://www.patentstorm.us/patents/7409899/description.html.

ULI (Urban Land Institute). (2006*). Department of Defense Range Sustainability*. Retrieved from http://www.uli.org/ResearchAndPublications/Reports/%7E/media/Documents/ResearchAndPublications/Reports/AdvisoryServicePanelReports/DoDRangeSustainability%20pdf.ashx.

US Building Digest. (2011). *BrightSource Energy Closes Financing for Ivanpah Project.* Retrieved from http://www.usbuildingdigest.com/news/brightsource-energy-closes-financing-for-ivanpah-project.

USAF (U.S Air Force) (2000). *Briefing to Request for Information Symposium* [PowerPoint Slides]. Air Force Research Laboratory (AFRL) Directed Energy Directorate.

USAF. (2007a). *Air Force Instruction 13-212: Range Planning and Operations (AF/A3O-AR).* Retrieved from http://www.e-publishing.af.mil/shared/media/epubs/AFI13-212.pdf.

USAF. (2007b). *Air Traffic, Airfield, Airspace, and Range Management* (*Air Force Instruction 13-212)*.

USAF. (2008). In*tegrated Natural Resources Management Plan for Edwards Air Force Base, California.* Retrieved from http://adminpress.jllpress.com/Continental_Group/documents/INRMP2008.pdf.

USAF. (2009a). *Environmental Impact Analysis Process*. Retrieved from http://www.aerospacetestingalliance.com/SHE/A8std.pdf.

USAF. (2009b). *Nellis AFB Solar Power System & Renewable Energy*. Retrieved from http://www.nellis.af.mil/shared/media/document/AFD-090501-098.pdf.

USAF. (2010). *R2508 Complex User's Handbook*. Retrieved from http://www.edwards.af.mil/shared/media/document/AFD-070103-052.pdf.

USAF. (2011). *Final Environmental Assessment: Outgrant for Construction and Operation of a Solar Photovoltaic System in Area I, Nellis AFB, Clark County, NV*.

USDA (U.S. Department of Agriculture). (2010). *Assistance to High Energy Cost Rural Communities*. Retrieved from http://www.usda.gov/rus/electric/hecgp/index.htm.

USDA. (2011). *Ecological Subregions of the United States*. Retrieved from http://www.fs.fed.us/land/pubs/ecoregions/ch40.html.

USFWS (U.S. Fish and Wildlife Service). (1999). *Integrated Natural Resources Management Plans Fact Sheet.* Retrieved from http://www.fws.gov/habitatconservation/INRMP%20Fact%20Sheet.pdf.

USFWS. (2002). *Final Recovery Plan: Southwestern Willow Flycatcher.* Retrieved from http://www.fws.gov/southwest/es/arizona/Documents/SpeciesDocs/SWWF/Final%20Recovery%20Plan/ExecSummary_Contents.pdf

USFWS. (2005). *Designation of Critical Habitat for the Southwestern Willow Flycatcher: Final Environmental Assessment.* Retrieved from http://www.fws.gov/southwest/es/arizona/Documents/SpeciesDocs/SWWF/CH_Final_Oct05/EA%20cover-main%20body.pdf.

USFWS. (2010). *Federal Register Vol.75, No. 40.* Retrieved from http://www.regulations.gov/#!documentDetail;D=FWS-R8-ES-2010-0008-0001.

USFWS. (2010a). *Desert Tortoise.* Retrieved from http://library.fws.gov/Pubs/DesertTortoise2010.pdf.

USFWS. (2011). *Endangered Species Program: Overview*. Retrieved from http://www.fws.gov/endangered/about/index.html.

USFWS. (2011a). *Listing and Critical Habitat*. Retrieved from http://www.fws.gov/endangered/what-we-do/critical-habitats.html.

USGPO (U.S. Government Printing Office). (1994). *California Desert Protection Act of 1994*. Retrieved from http://www.gpo.gov/fdsys/pkg/BILLS-103s21enr/pdf/BILLS-103s21enr.pdf.

USGPO. (2011). *California Desert Protection Act of 2011*. Retrieved from http://www.gpo.gov/fdsys/pkg/BILLS-112s138is/pdf/BILLS-112s138is.pdf.

USGS (U.S. Geological Survey). (1997). *Types of Deserts*. Retrieved from http://pubs.usgs.gov/gip/deserts/types/.

USGS. (2004). *Mojave National Preserve: Soda Lake*. Retrieved from http://geomaps.wr.usgs.gov/parks/mojave/sodalake1.html.

USGS. (2006). *Sediment yield and runoff frequency of small drainage basins in the Mojave Desert, California and Nevada.* Retrieved from http://pubs.usgs.gov/fs/2006/3007/.

USGS. (2009). *Human Impacts on the Mojave National Preserve Area*. Retrieved from http://pubs.usgs.gov/of/2004/1007/humans.html.

USMC (U.S. Marine Corps). (2009a). *Marine Corps Logistics Base Barstow, Ranges and Training Areas, Standard Operating Procedure (BO 3570.1A B440*).

USMC. (2009b). *Attachment 3 – Initial Task Order 2, Marine Corps Logistics Base Barstow, CA (N62583-09-R0085).* Retrieved from https://www.neco.navy.mil/upload/N62583/N6258309R0085Attachment_3_Initial_Task_Order_2_MCLB_Barstow.pdf.

USMC. (2009c). *Request for Information (RFI) for Renewable Generation Opportunities at Marine Corps Air Station Yuma: Attachment 1.* Retrieved from https://www.neco.navy.mil/.../N6258310RYUMA_N6258310RYUMA_MCAS_Yuma_RFI_Attachment_1_-_REV1.doc.

USMC. (2010). *Chocolate Mountain Aerial Gunnery Range Propose Land Withdrawal Renewal: Frequently Asked Questions*. Retrieved from http://www.chocolatemountainrenewal.com/documents/FAQ%20Handout.pdf.

USMC. (2010). *FY2011 Marine Aviation Plan*. Retrieved from http://www.marines.mil/unit/aviation/Documents/Compressed%20FY2010%20AvPlan%20(1%20Oct%202009%20Final).pdf.

USMC. (2010a). *MCAGCC Land Acquisition/Airspace Establishment Study*. Retrieved from http://www.marines.mil/unit/29palms/LAS/pages/altmaps.aspx.

USMC. (2010b). *Proposed Land Acquisition/Airspace Establishment in Support of Large-Scale MAGTF Live Fire and Maneuver Training: Project Overview Paper (Issue #5).*

USMC. (2010c). *Combat Center Order 3500.4H: Standing Operating Procedures for Range, Training Areas, and Airspace.*

USMC. (2010d). *Station Order 3710.6I: MCAS Yuma Range and Training Areas Standard Operating Procedures.*

USMC. (2010e). *Proposed 29 Palms Training Land/Airspace Acquisition Project: Public Information Brief* [PowerPoint slides]. Retrieved from http://www.dmg.gov/documents/20110324_PRS_MCAGCC_Lnd_Expnsion.pdf.

USMC. (2010f). *What is the 29 Palms Proposed Training Land Acquisition and Airspace Establishment Project? Frequently Asked Questions.* Retrieved from http://www.marines.mil/unit/29palms/LAS/Documents/V6%20DEIS%20FAQS%20Release%20Final%20110301.pdf.

USMC. (2010g). *Proposed Land Acquisition/Airspace Establishment in Support of Large-Scale MAGTF Live Fire and Maneuver Training: Fact Sheet –Airspace.*

USMC. (2011a). *Official Website of MCAGCC Twentynine Palms, CA*. Retrieved from http://www.marines.mil/unit/29palms/pages/default.aspx.

USMC. (2011b). *Chocolate Mountain Aerial Gunnery Range Draft Legislative Environmental Impact Statement for the Proposed Renewal of the Land Withdrawal.* Retrieved from http://www.chocolatemountainrenewal.com/documents/CMAGR%20Final_ScopingReport_incl%20Apps.pdf.

USMC. (2011c). *Proposed Land Acquisition/Airspace Establishment in Support of Large-Scale MAGTF Live Fire and Maneuver Training: Project Description Paper (Issue #6).*

USMC. (2011d). *MCAGCC Special Use Airspace*. Retrieved from http://www.marines.mil/unit/29palms/G5/Documents/Airspace.pdf.

USMC. (2011e). *Chocolate Mountain Aerial Gunnery Range Draft Legislative Environmental Impact Statement for the Proposed Renewal of the Land Withdrawal*. Retrieved from http://www.chocolatemountainrenewal.com/documents/CMAGR%20Final_ScopingReport_incl%20Apps.pdf.

USMC. (2011f). *Federal Land Withdrawal and NEPA Processes for Renewal of the CMAGR*. Retrieved from http://www.chocolatemountainrenewal.com/documents/Board%201_Withdrawal_NEPA_Process.pdf.

USMC. (2011g). *Military Ranges in the CMAGR Operating Region.* Retrieved from http://www.chocolatemountainrenewal.com/documents/Board%203_Ranges%20in%20Operating%20Region.pdf.

USMC. (2011h). *Proposed Land Acquisition and Airspace Establishment in Support of Large-Scale MAGTF Live Fire and Maneuver Training: Public Information Brief* [PowerPoint slides]. Retrieved from http://www.marines.mil/unit/29palms/LAS/Documents/V6%20DEIS%20Public%20Info%20Brief%20Release%20Final%20110222.pdf.

USMC. (2011i, November 28). SERDP Report Review / USMC Combined Comments [E-mail correspondence].

USMC. (2011j, December 7). David Heinrichs, P.E. Head, Facility Operations and Energy (GF-1) Marine Corps Installations Command Headquarters, U.S. Marine Corps [E-mail correspondence].

USN (U.S. Navy). (2007). *Marine Corps Ammunition and Explosives Safety Program (MCO P8020.10B)*.

USN. (2008a*). Operations and Maintenance Manual: Nebo North Plume Source Area: Air Sparging and Soil Vapor Extraction System*. T N & Associates, Inc. Retrieved from http://www.envirostor.dtsc.ca.gov/regulators/deliverable_documents/6048695206/Attachment%201%20-%20O&M%20Manual.pdf.

USN. (2008b). *Instruction: Navy Laser Hazards Control Program. (OPNAVINST 5100.27).*

USN. (2010a). *NAF El Centro Range Usage Summary* [PowerPoint slides].

USN. (2010b). *Letter: Potential Mission Impacts Posed by Solar Millennium Solar Power Project (Docket Number 09-AFC-9, CACA-490l6).* Naval Air Warfare Center Weapons Division.

USN. (2010c). *NAF El Centro Information Brief, Base Operations*. Received July 18, 2011.

USN. (2010d). *Energy Program for Security and Independence*. Retrieved from http://greenfleet.dodlive.mil/files/2010/04/Naval_Energy_Strategic_Roadmap_100710.pdf.

USN. (2011). *Naval Air Weapons Station China Lake Land Withdrawal EIS/LEIS Website.* Retrieved from http://www.chinalakeleis.com/welcome

USN. (2011a). *Naval Air Warfare Center Weapons Division Operational Requirements Documents DRAFT.*

USN. (2011b). *NAWS China Lake PAO*. Received February 3, 2011.

USN. (2011c). ―Renewable Energy on Navy Installation Lands in the Mojave and Colorado Deserts." Memorandum for Director, Material Readiness and Logistics Deputy Commandant for Installations and Logistics.

UTC Power. (2008). *Model 400 Purecell System Specification Sheet*.

Ventyx. (2011). *Ventyx Velocity Suite Information Services*.

WAPT. (2006). *Nevada Wildlife Action Plan*. Nevada Department of Wildlife. Retrieved from http://www.ndow.org/wild/conservation/cwcs/nwap_07/NV_WAP_pages_cover-p75.pdf.

WDE (Washington Department of Ecology). (2011). *Water Right General Adjudications*. Retrieved from http://www.ecy.wa.gov/programs/wr/rights/adjhome.html#howwork on June 20, 2011.

Webb, R.H., Fenstermaker, L.F., Heaton, J.S., Hughson, D.L., McDonald, E.V., Miller, D.M. (2009). ―The Mojave Desert: Ecosystem Processes and Sustainability." Reno, Nevada: University of Nevada Press. Retrieved from http://books.google.com/books?id=zHCspn_MpQsC&pg=PA313&lpg=PA313&dq=mojave+desert+plants+-+impacted+by+desert+pavement?&source=bl&ots=orn63LbqQ7&sig=DTRnHAG9FYL0qNKzeZA0McuYllk&hl=en&ei=xcXbTZm2GMnTgAee5an4Dw&sa=X&oi=book_result&ct=result&resnum=5&ved=0CD4Q6AEwBA#v=onepage&q&f=false.

WECC (Western Electricity Coordinating Council). (2011). *WECC 10-Year Regional Transmission Plan Summary.* Retrieved from http://www.wecc.biz/committees/BOD/09212011/Lists/Minutes/1/Approval%20Item%20-%20WECC%2010-Year%20Regional%20Transmission%20Plan%20Summary.pdf.

WECC. (2011a). *TEPPC Transmission Project Information Portal*. Retrieved from http://www.wecc.biz/Planning/TransmissionExpansion/Transmission/Pages/default.aspx

Wehausen, J.D. (2006). *Nelson Bighorn Sheep.* BLM. Retrieved from http://www.blm.gov/ca/pdfs/cdd_pdfs/Bighorn1.PDF.

Welsh, B. (2011). *Impact of Photo Voltaic Renewable Energy Installations on the NTTR* [Draft PV White Paper v9]. Air Force Research Laboratory.

WGA (Western Governors' Association). (2011). *Regional Transmission Expansion Report*. Retrieved from http://www.westgov.org/initiatives/rtep.

White House. (2010). *President Obama Sets Greenhouse Gas Emissions Reduction Target for Federal Operations*. Retrieved from http://www.whitehouse.gov/the-press-office/president-obama-sets-greenhouse-gas-emissions-reduction-target-federal-operations.

Wholesale Solar. (2011). *Three photovoltaic technologies: Monocrystalline, Polycrystalline, and Thin Film.* Retrieved from http://www.wholesalesolar.com/Information-SolarFolder/celltypes.html.

Wilson, C. (2004). *High Altitude Electromagnetic Pulse and High Power Microwave Devices: Threat Assessment.*

WIPP (Waste Isolation Pilot Plant). (2011). *Solar Power Towers Deliver Energy Solutions*. Retrieved from http://www.wipp.energy.gov/science/energy/powertower.htm.

Wolff, Eric. (2011). *ENERGY: Local lawmakers say SDG&E rate proposal clouds solar prospects.* North County Times. December 3. Retrieved from http://www.nctimes.com/blogsnew/business/energy/energy-local-lawmakers-say-sdg-e-rate-proposal-clouds-solar/article_53aca3a1-980e-518c-a593-7a0bc8f4d348.html.

Yilancia, A., Dincerb, I., and H.K. Ozturka. (2009). *A review on solar-hydrogen/fuel cell hybrid energy systems for stationary applications*. Progress in Energy and Combustion Science. Volume 35, Issue 3, June 2009, Pages 231-244. Retrieved from http://www.sciencedirect.com/science/article/pii/S0360128508000439.

Zest Energy. (2011). *ZESS Zinc Flow Battery Technology*. Retrieved from www.zestenergy.com/technology.php.

Zeiner, D.C., W.F. Laudenslayer Jr., K.E. Mayer, and M. White, eds. 1990. *CWHR: Life History Accounts and Range Maps.* Retrieved from http://www.dfg.ca.gov/biogeodata/cwhr/cawildlife.aspx.