Argonne
NATIONAL LABORATORY

ANL/EVS/R-13/5

An Overview of Potential Environmental, Cultural, and Socioeconomic Impacts and Mitigation Measures for Utility-Scale Solar Energy Development

Environmental Science Division

Cover credit:
Hosoya, N., et al., 2008, Wind Tunnel Tests of Parabolic Trough Solar Collectors, March 2001—August 2003, Subcontract Report NREL/SR-550-32282, May.

Research conducted by Argonne National Laboratory with funding from the U.S. Department of Energy, Solar Energy Technologies Program and U.S. Department of the Interior, Bureau of Land Management

About Argonne National Laboratory
Argonne is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC under contract DE-AC02-06CH11357. The Laboratory's main facility is outside Chicago, at 9700 South Cass Avenue, Argonne, Illinois 60439. For information about Argonne and its pioneering science and technology programs, see www.anl.gov.

ANL/EVS/R-13/5

An Overview of Potential Environmental, Cultural, and Socioeconomic Impacts and Mitigation Measures for Utility-Scale Solar Energy Development

Compiled and edited by
T. Patton, L. Almer, H. Hartmann, and K.P. Smith
Environmental Science Division, Argonne National Laboratory

June 2013

ACKNOWLEDGEMENTS

The information presented in this document is based on the findings of the *Final Programmatic Environmental Impact Statement (PEIS) for Solar Energy Development in Six Southwestern States*, prepared by the U.S. Department of the Interior, Bureau of Land Management, and the U.S. Department of Energy, Solar Energy Technologies Program. The following individuals from Argonne National Laboratory are acknowledged for their contributions to the PEIS analyses:

- Timothy Allison, socioeconomic and environmental justice;
- Lynn Almer, water resources;
- Bruce Biwer, transportation impacts;
- Matthew Braun, cultural resources;
- Adrianne Carr, water resources;
- Youngsoo Chang, air quality, air emissions, and noise;
- Mark A. Grippo, ecological resources;
- Yuki Hamada, water resources;
- Heidi M. Hartmann, project manager and health and safety assessments;
- Leslie Kirchler, visual impacts;
- Ronald Kolpa, hazardous materials and waste management;
- Kirk E. LaGory, ecological resources and threatened and endangered species;
- James E. May, lands and realty, specially designated areas, and other land use considerations;
- Ben L. O'Connor, water resources;
- Terri Patton, geological resources and mineral assessments;
- Albert E. Smith, air quality;
- Robert Sullivan, visual impacts;
- Robert A. Van Lonkhuyzen, ecological resources;
- Bruce Verhaaren, Native American concerns;
- William S. Vinikour, ecological resources;
- Leroy J. Walston, Jr., special status species; and
- Konstance L. Wescott, paleontology, cultural resources, and Native American concerns.

This page intentionally left blank.

CONTENTS

CONTENTS (Cont.)

CONTENTS (Cont.)

CONTENTS (Cont.)

FIGURES

1 INTRODUCTION

This report describes the potential environmental, social, and economic effects of various solar energy technologies at utility-scale on lands within the southwestern United States, where the solar energy resources are among the nation's best. The report also provides mitigation strategies for minimizing these impacts on a resource-by-resource basis. The information presented here is based on the findings of the Final Programmatic Environmental Impact Statement (PEIS) for Solar Energy Development in Six Southwestern States prepared by the U.S. Department of the Interior (DOI) Bureau of Land Management (BLM) and the U.S. Department of Energy (DOE) (BLM and DOE 2010, 2012). Because much of the land (over 115 million acres) in the southwestern states is administered by the BLM, the discussion of mitigation measures in Chapter 3 draws on BLM (among other) requirements and guidance, as applicable.

Several technologies are currently in use and are being refined for the utility-scale capture of solar energy. For the purposes of this report, utility-scale development includes projects that generate electricity for delivery into the electricity transmission grid.[1] This report evaluates concentrating solar power (CSP) technologies, which include parabolic trough, power tower, and dish engine systems; and photovoltaic (PV) technologies. The main component that all the technologies have in common is a large solar field where solar collectors capture the sun's energy. In the parabolic trough and power tower systems, the energy is concentrated in a heat transfer fluid (HTF) and transferred to a power block, where steam-powered turbine systems generate electricity using technology similar to that used in fossil fuel–fired power plants. In contrast, the dish engine and PV systems are composed of many individual units or modules that generate electricity directly and whose output is combined; these systems do not use a central power block. Figure 1-1 shows a typical solar field for each of these technology types.

Commercially feasible utility-scale solar energy development requires adequate direct normal insolation (DNI) and large areas of land. Under clear sky conditions, about 85% of sunlight is DNI, and 15% is scattered light that comes in at many different angles. DNI can be used by all solar energy systems, whereas the scattered light can only be used by PV systems. Because the solar resources in the southwestern United States have high solar insolation levels, they are highly suitable for utility-scale solar power plants. DNI levels in the six southwestern states are depicted in Figure 1-2.

1 Although the information presented in this report is derived from analyses of large projects (e.g., 20 megawatts [MW] or greater), it is relevant to much smaller utility-scale projects.

FIGURE 1-1 Typical Solar Fields for Various Technology Types: (a) Solar Parabolic Trough (Source: Hosoya et al. 2008), (b) Solar Power Tower (Credit: Sandia National Laboratories. Source: NREL 2010), (c) Dish Engine (Credit: R. Montoya. Source: Sandia National Laboratories 2008), and (d) PV (Credit: Arizona Public Service. Source: NREL 2010)

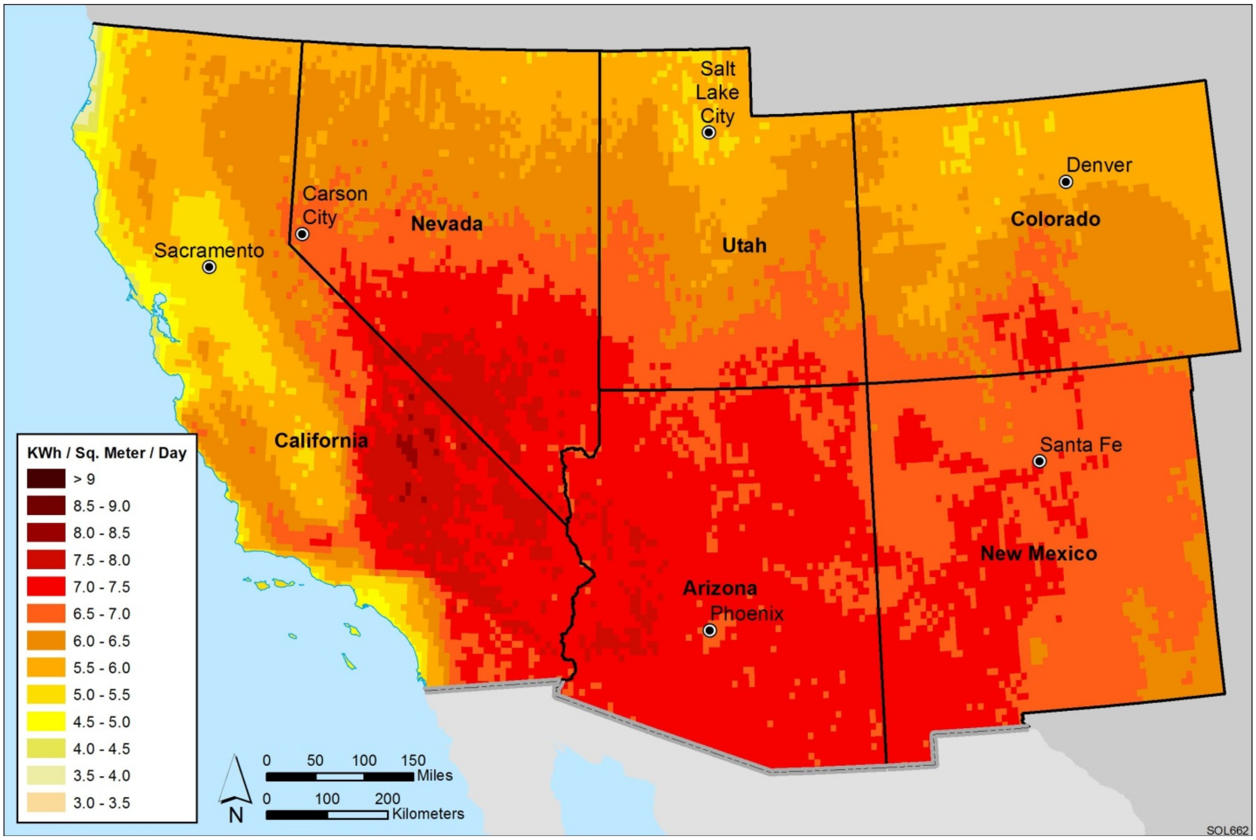

FIGURE 1-2 Solar Direct Normal Insolation Levels in the Southwestern United States (BLM and DOE 2010)

This page intentionally left blank.

2 POTENTIAL IMPACTS OF SOLAR DEVELOPMENT

2.1 INTRODUCTION

This chapter discusses the environmental, social, and economic impacts of utility-scale solar energy development. Its purpose is to describe a broad possible range of impacts for individual solar facilities and related infrastructure (e.g., access roads) that might be required to support utility-scale solar energy development. The types of solar technologies evaluated include those considered most likely to be developed at the utility scale over the next 20 years, such as parabolic trough, power tower, dish engine, and PV technologies.

The assessment of impacts in the following sections covers both direct and indirect impacts of solar energy development by resource. Direct impacts are those potential effects that result solely and directly from a utility-scale project, such as soil disturbance, habitat fragmentation, or noise generation. Indirect impacts are those potential effects that are related to the project but are the result of some intermediate step or process, such as changes in surface water quality because of soil erosion at the construction site. The potential impacts presented here are common to all types of utility-scale solar energy facilities. Impacts of a particular project will depend on factors such as the number and size of solar arrays, the amount of land disturbed by construction activities, the amount of land occupied by the solar facility over the long term, and the location of the site relative to other resources (e.g., surface water bodies). Such impacts would vary by project and should be analyzed at the project level.

2.2 ACOUSTICS (NOISE)

Solar energy facilities could produce noise impacts on nearby residents in the areas where they are built. Whether noise levels exceed U.S. Environmental Protection Agency (EPA) guidelines or local ordinances would depend, in part, on the distance to the nearest residence.

2.2.1 Site Characterization

Typically, potential noise impacts from site characterization activities would be negligible, because these activities are short term, generate minimum noise, and can be conducted with a small crew and small equipment. In some instances, deep soil corings to obtain information necessary for the design of structure foundations (e.g., power towers) or extensive drilling for installation of monitoring/sampling wells and piezometers for on-site groundwater characterization may be required. These activities may require larger equipment and could generate substantial noise. However, the potential noise impacts from such activities on neighboring communities would be much lower than those of construction activities.

2.2.2 Construction

Construction activities would last about 2 to 3 years, or 4 at most, for most solar facilities. Major heavy equipment used during construction would include chainsaws, chippers, dozers, scrapers, end loaders, trucks, cranes, rock drills, and equipment for blasting if required. Vehicles would include cranes, end loaders, backhoes, dozers, trucks, and a temporary concrete batch plant if substantial amounts of concrete are needed and/or premixed concrete is unavailable from nearby vendors (e.g., for foundations for a solar power tower or the power block). Standard construction activities would create noise; noise levels would depend on the level of activity, the number of pieces of equipment operating, and the location and type of activity. Noise levels would be highest during the early phase of construction when most of the noisy and heavy equipment would be used for land clearing, grading, and road construction over a short time period. Solar facilities constructed in desert environments require less preparation; therefore, noise levels at these sites are expected to be lower (Beacon Solar, LLC 2008).

Noise impacts associated with the construction phase may include the following:

- *Intermittent noise along traffic routes created by commuter/delivery/support vehicular traffic around the facility and along the traffic routes.* The contribution to noise from these sources would be local and minor compared to contributions from other noise sources (e.g., dozers).

- *Diesel engines (dominant noise if used without sufficient muffling and pile driving or pavement breaking is involved).* The average noise levels for typical construction equipment at a distance of 50 ft (15 m) from a source range from 74 dBA for a roller to 101 dBA for a pile driver (Hanson et al. 2006). Except for pile drivers and rock drills, most construction equipment has noise levels ranging from 75 to 90 dBA at a distance of 50 ft (15 m).

- *Power block areas.* Noise levels in these areas would be around 95 dBA. Considering geometric spreading and ground effects, noise levels would attenuate to about 40 dBA at a distance of 1.2 mi (1.9 km) from the construction site. This noise level is typical of daytime rural background levels. In addition, mid- and high-frequency noises (e.g., those generated from construction activities) are significantly attenuated by atmospheric absorption under high-temperature and low-humidity conditions that would be typical for utility-scale solar facilities; thus, noise attenuation to background levels would occur at distances of less than 1.2 mi (1.9 km) from the construction site. Most construction activities would occur during the day, when noise is better tolerated due to the masking effects of background noise. Nighttime noise levels would drop to the background levels of a rural environment, because construction activities would cease by nightfall.

Depending on the equipment and methods employed, ground-borne vibration could occur in the immediate vicinity of construction sites. Except for dish engine facilities, no major vibration-causing construction equipment (e.g., pile drivers or rock drills) would be used in constructing solar facilities. As a rule, for solar energy facilities located in relatively remote areas far from vibration-sensitive structures, potential vibration impacts on surrounding communities and vibration-sensitive structures would likely be negligible. For example, the vibration level at receptor locations beyond 230 ft (70 m) from a vibratory roller (94 VdB at 25 ft [7.6 m]) would diminish below the threshold of perception of 65 VdB for humans (Hanson et al. 2006).

2.2.3 Operation

Noise-generating activities common to all types of solar facilities include those from site inspection; maintenance and repair (e.g., mirror washing, replacement of broken mirrors) at the solar field; commuter/support/delivery vehicles within and around the solar facility; and activities associated with control/administrative buildings, warehouses, and other auxiliary buildings/structures. Diesel-fired emergency power generators and fire-water pump engines would be another source of noise, but their operations would be limited to several hours per month.

Noise sources from the solar field of solar facilities would include the following:

- *Solar tracking devices and vehicular traffic used for inspection, maintenance, and repair.* Typically, tracking devices make little noise and are relatively unobtrusive. Individual dish engines are additional sources of noise that should be considered for Stirling solar dish engine technology. Noise-generating activities in the solar field area are generally minimal, with the possible exception of the Stirling solar dish engine technology.

- *Transformers, typically located in the power block area or near the site boundary.* The primary transformer noise is a constant low-frequency humming tone with a fundamental frequency of 120 Hz and even harmonics of line frequency of 60 Hz, such as 240 Hz, 360 Hz, and up to 1,200 Hz or higher, primarily due to the vibration of its core (Wood 1992). The core's tonal noise should be uniform in all directions and continuous when in operation. In addition, cooling fans and oil pumps at large transformers produce broadband noise from the cooling system fan and pump when in operation; however, this noise is usually less noticeable than tonal noise. The average A-weighted core sound level at a distance of 150 m (492 ft) from a transformer would be about 51 dBA for 938 million volt-amperes (MVA), assuming a power factor of 0.8 for a solar plant of 750 MW (Wood 1992), which is the upper limit of power generation being analyzed. For geometric spreading only, the noise level at a distance of about 1,800 ft (550 m) would be about 40 dBA, typical of the daytime rural background level. For other attenuation mechanisms, such as ground effects and air absorption and/or for facilities with capacities of less than 750 MW, daytime rural background levels would occur at distances of less than 1,800 ft (550 m) from the site.

- *Stationary and steady noise sources from a power block (limited to parabolic trough and solar power tower technologies only).* These would include steam turbine generators (STGs), various pumps for circulating water and HTFs, small-scale boilers to maintain a minimum temperature of HTF during power downtime, and a heat-rejection system such as wet-cooling towers or air-cooled condensers. Periodic short-term noise increases would occur during start-up or shutdown, load transition, or opening of steam relief valves. Noise levels from the power block would be attenuated considerably at the site boundaries, to about 30 to 40 dBA, and levels would be much more attenuated at the nearest communities (Beacon Solar, LLC 2008). For "solar only" facilities, these noise levels would be limited to daytime hours only, when noise is better tolerated than at night. Therefore, potential noise impacts on neighboring communities associated with the power block areas of parabolic trough and power tower facilities would be expected to be minor.

No major equipment causing ground vibration would be used during the operation phase. Therefore, potential vibration impacts on surrounding communities and vibration-sensitive structures during operation of any solar facility would be minimal.

2.2.4 Decommissioning/Reclamation

Decommissioning requires many of the same procedures and equipment used in traditional construction. Decommissioning would include dismantling of solar facilities and support facilities such as buildings/structures and mechanical/electrical installations; disposal of debris; grading; and revegetation as needed. Activities for decommissioning would be similar to those for construction but on a more limited scale. Potential noise impacts on surrounding communities would be correspondingly less than those for construction activities. Decommissioning activities would last for a short period, and their potential impacts would be minor and temporary in nature.

As for noise, potential vibration impacts on surrounding communities and vibration-sensitive structures during decommissioning of any solar facility would be less than those during construction, and thus would be minimal.

2.3 AIR QUALITY

Solar energy development could affect air quality in the areas where it occurs, as well as in areas that would benefit from reductions in emissions due to reduced use of fossil energy. Construction impacts would be distinct from operation impacts, while impacts on climate would be primarily associated with reductions in CO_2 emissions from displaced fossil energy sources.

2.3.1 Site Characterization

Typically, potential air quality impacts from site characterization activities would be negligible, because these activities are short term, require minimum site disturbance, and can be conducted with a small crew and small equipment. In some instances, deep soil corings to obtain information necessary for the design of substantial structural foundations (e.g., power towers) or extensive drilling for the installation of monitoring/sampling wells and piezometers for on-site groundwater characterization may be required. These activities could result in substantial ground disturbance and require large equipment. However, the potential impacts of site characterization activities on ambient air quality would be much lower than those of construction activities. Developers might elect to delay site characterization activities that would result in more extensive impacts until the construction phase of development.

2.3.2 Construction

Construction activities would involve a number of separate operations, including mobilization/staging, land clearing (grubbing and tree removal), on-site burning of cleared biomass, topsoil stripping, cut-and-fill operations (i.e., earthmoving), road construction, ground excavation, drilling and blasting if required, foundation treatment, building/structure erection, electrical and mechanical installation, landscaping, testing, and shakedown. Construction would, in large part, be divided into two phases: site preparation and construction.[2] For most utility-scale solar facilities, the site preparation phase would be of relatively short duration (e.g., a few months), and would be followed by a much longer construction phase (e.g., a few years).

Major heavy equipment used in the site preparation phase would include chainsaws, chippers, dozers, scrapers, end loaders, trucks, cranes, rock drills, and equipment for blasting operations if required. The major equipment used in the construction phase would include cranes, end loaders, backhoes, dozers, trucks, and a temporary concrete batch plant if substantial amounts of concrete are needed and/or premixed concrete is unavailable from nearby vendors (e.g., for foundations for a solar power tower or the power block).

Fugitive dust from soil disturbances and engine exhaust from heavy equipment and commuter/delivery/support vehicular traffic within and around the facility would contribute to air emissions of criteria pollutants, volatile organic compounds (VOCs), greenhouse gases (GHGs; e.g., CO_2), and small amounts of hazardous air pollutants (HAPs) (e.g., benzene). Typically, potential impacts of fugitive dust emissions on ambient air quality would be higher than those of engine exhaust emissions.

For most construction projects, soil disturbance during the site preparation phase, which involves the intense use of heavy equipment over a short time period, has the greatest potential for air emissions and adverse air quality impacts (through the release of large amounts of fugitive dust). In addition, soil disturbance from heavy equipment used for access road construction and/or recontouring of land results in a greater potential for emissions and adverse air quality

[2] The construction phase includes all activities from after site preparation to the onset of operation.

impacts. However, the construction of solar facilities would generally occur in desert environments with relatively flat, hard surfaces, and thus site preparation might be minimal. Therefore, air emissions during the construction phase, such as from the erection of structures and equipment installation, could be higher than those from the site preparation phase (Beacon Solar, LLC 2008).

Under unfavorable dispersion conditions, infrequent high concentrations of PM_{10} or $PM_{2.5}$ (particulate matter with a mean aerodynamic of 10 μm or less, or 2.5 μm or less, respectively) could exceed the standards at the site boundaries. However, for solar facilities located in remote areas (which is expected to be the case for most facilities), construction activities would probably contribute minimally to concentrations of air pollutants at the nearest residence or business. In addition, most states condition construction permits by requiring mitigation measures to reduce fugitive dust emissions.

Particularly in areas with highly erodible soils, such as sandy soils, fugitive dust from construction could cause unavoidable impacts due to dust emissions for the duration of the site preparation and construction phases (2 to 4 years). Disturbance of areas with biological soil crusts and desert pavement can also generate dust. In areas with more stable soils (e.g., areas covered with nonerodible elements such as stones or vegetation), dust emissions would be comparatively less. Fugitive dust emissions would be caused by site preparation, construction activities, and wind erosion and would cause unavoidable localized impacts. Construction activities would be limited to a portion of the site at any time and would occur during the daytime, when conditions generally favor dispersion of dust; both of these factors would reduce impacts. However, the large total area disturbed during construction could be exposed to wind erosion. Stabilizing soils in an area at the completion of construction would reduce these emissions. However, given that stabilization is never fully effective and disturbed soils sometimes cannot be stabilized, wind erosion from disturbed areas could continue throughout the remainder of the construction period and beyond into the operation and reclamation phases, particularly in case of the highly erodible soils.

2.3.3 Operation

In general, air emissions associated with generating electricity from solar technologies are negligible. Parabolic trough and power tower technologies may combust some fossil fuels during start-up to prevent freezing the HTF. Other technologies do not use fossil fuels routinely.

Solar facilities would generate very low levels of air emissions directly from the solar fields. Emissions from the solar fields would include fugitive dust and engine exhaust emissions from vehicles and heavy equipment associated with regular site inspections and infrequent maintenance activities (e.g., mirror washing, replacement of broken mirrors), and from bare grounds and access roads by wind erosion. The types of emission sources and pollutants would be similar to those in the construction phase, but the amounts would be small and impacts would be negligible.

For parabolic trough and solar power tower technologies only, power block emissions would include those from small-scale boilers for processing (e.g., for maintaining HTF temperatures) and from wet-cooling towers, if in use. Process boilers would emit typical combustion-related criteria pollutants and HAPs, and cooling towers would emit small amounts of particulate matter (PM)[3] as drift, although drift eliminators could be used to minimize emissions. Other combustion sources would include space-heating boilers, diesel-fueled emergency power generators (typically operating only a few hours per month for preventive maintenance purposes), and emergency fire-water pump engines. Storage tanks, including fuel tanks, would emit VOCs and small amounts of HAPs. Engine exhaust from commuter, delivery, and support vehicular traffic would also contribute emissions within and around the solar facility. These air emissions during operation would be minimal in comparison with those from fossil fuel–fired power plants.

Fugitive dust emissions from wind erosion and vehicle travel could cause impacts during operation. In areas with highly erodible soils, such as sandy soils (see Section 2.7.1), wind erosion of disturbed soils could affect particulate air quality. In areas where soils are more stable (for example, areas with nonerodible elements such as stones or vegetation), or where disturbed soils have been stabilized, fugitive emissions would be comparatively less. Based on the large area that could be disturbed and the fact that stabilization is never fully effective, wind erosion during operation needs to be addressed in site-specific assessments of the severity of wind erosion impacts. Traffic from workers, deliveries, and support is expected to be minimal during operation, with correspondingly small emissions.

2.3.4 Decommissioning/Reclamation

Decommissioning would include the dismantling of solar facilities and support facilities, such as buildings/structures and mechanical/electrical installations; disposal of debris; grading; and revegetation as needed. Activities for decommissioning would be similar to those for construction but on a more limited scale. Potential impacts on ambient air quality would be correspondingly less than those for construction activities. The area disturbed during decommissioning/reclamation could be exposed to wind erosion. Stabilizing disturbed soils would reduce these emissions. However, given that stabilization is never fully effective and disturbed soils sometimes cannot be stabilized, wind erosion from disturbed areas could continue after decommissioning/reclamation, particularly in case of the highly erodible soils.

2.4 CULTURAL RESOURCES

Solar energy facilities could produce diverse impacts on cultural resources in and around the areas where they are built. Impacts could occur during both facility construction and operation. Significant cultural resources, including historic properties listed or eligible for

---

[3] After the evaporation of drift droplets, PM is formed by the crystallization of dissolved solids, which consist of mineral matter, chemicals used as biocides, corrosion/scale inhibitors, and the like.

listing on the *National Register of Historic Places* (NRHP), could be affected by utility-scale solar energy development regardless of the technology employed.

The potential for impacts on cultural resources from solar energy development, including ancillary facilities, such as access roads, is directly related to the amount of land disturbance and the location of the project. Indirect effects, such as impacts on the cultural landscape resulting from the erosion of disturbed land surfaces and from increased accessibility to possible site locations, are also considered.

There are several ways impacts on cultural resources could result, as described below.

- Complete destruction of historic properties could result from the clearing, grading, and excavation of the project area and from construction of facilities and associated infrastructure if archaeological sites, historic structures, or traditional cultural properties are located within the footprint of the project.

- Degradation and/or destruction of historic properties could result from the alteration of topography, alteration of hydrologic patterns, removal of soils, erosion of soils, runoff into and sedimentation of adjacent areas, and oil or other contaminant spills if sites are located on or near the project area. Such degradation could occur both within the project footprint and in areas downslope or downstream. While the erosion of soils could negatively affect historic properties downstream of the project area by potentially eroding materials and portions of downstream archaeological sites, the accumulation of sediment could serve to protect some downstream sites by increasing the amount of protective cover. Erosion can also destabilize historic structures. Agents of erosion and sedimentation include wind, water, downslope movements, and both human and wildlife activities. Contaminants could affect the ability to conduct an analysis of material present at the site and thus the ability to interpret site components.

- Increases in human access and subsequent disturbance (e.g., looting, vandalism, and trampling) of cultural resources could result from the establishment of corridors or facilities in otherwise intact and inaccessible areas. Increased human access (including off-highway vehicle [OHV] use) exposes archaeological sites and historic structures and features to greater probabilities of impacts from a variety of stressors. In addition, sensitive cultural resources, such as rock art, can be exposed to impacts from dust and vibrations caused by vehicular traffic and the use of heavy machinery.

Degradation of settings associated with significant cultural resources could take place as a result of both visual and auditory impacts from the presence of a utility-scale solar energy development, associated land disturbances, and ancillary facilities. This could affect significant cultural resources for which visual integrity and/or a quiet setting is a component of a site's significance, such as trails, sacred sites and landscapes, historic structures, traditional cultural properties, and historic landscapes.

Cultural resources are nonrenewable and, once damaged or destroyed, are not recoverable. Therefore, if a cultural resource is damaged or destroyed during solar energy development, this particular cultural location, resource, or object would be irretrievable. Cultural resources can have different values for different groups. For example, for cultural resources that are significant for their scientific value, data recovery is one way in which some information can be salvaged should a cultural resource site be adversely affected by development activity. Certain contextual data would invariably be lost, but new cultural resources information would be made available to the scientific community. Cultural resources can also be valuable for their benefits to education, heritage tourism, or traditional uses. These types of impacts are less easily mitigated; however, by initiating consultation with State Historic Preservation Offices (SHPOs), affected Native American tribes, and other stakeholders early in the planning process, the impact may be lessened or avoided.

2.5 ECOLOGICAL RESOURCES

Solar energy development could affect a wide variety of ecological resources in the areas where it occurs. The following sections discuss the common impacts on vegetation, wildlife, aquatic biota, and special status species.

2.5.1 Vegetation (Plant Communities and Habitats)

Potential impacts on terrestrial and wetland plant communities and habitats from the development of utility-scale solar energy projects would include direct impacts from habitat removal as well as a wide variety of indirect impacts: changes in soil moisture and temperature, changes in hydrological conditions, changes in community structure and function, habitat degradation, changes in productivity, and reduced diversity (e.g., spread of invasive species). Impacts would be incurred during initial site preparation and would continue throughout the operational life of the facility, typically extending over several decades. Plant communities and habitats affected by direct or indirect impacts from project activities could incur short- or long-term changes in species composition, abundance, and distribution. Some impacts may also continue after the decommissioning of a solar energy facility.

2.5.2 Wildlife (Amphibians and Reptiles, Birds, and Mammals)

All utility-scale solar energy facilities that would be constructed and operated have the potential to affect wildlife. Overall, impacts from site characterization, construction, operation, and decommissioning of a solar energy facility on wildlife populations would depend on the following:

- The type and amount of wildlife habitat that would be disturbed;
- The nature of the disturbance (e.g., long-term reduction because of project structure and access road placement; complete, long-term alteration due to

transmission line, gas pipeline, and water pipeline placement; or temporary disturbance in construction staging areas);

- The wildlife that occupy the facility site and surrounding areas; and

- The timing of construction activities relative to the crucial life stages of wildlife (e.g., breeding season).

In general, impacts on most wildlife species would be proportional to the amount of their specific habitats directly and indirectly disturbed. Potential impacts on wildlife species resulting from solar energy development include the following:

- direct mortality of individuals,
- behavioral disturbance,
- harassment,
- nest abandonment,
- territory adjustments,
- reduction in carrying capacity,
- genetic isolation,
- increased collision mortality risk,
- uptake of toxic materials,
- reproductive impairment, and
- increased predation rates.

2.5.3 Aquatic Biota and Habitats

Utility-scale solar energy facilities that would be constructed and operated have the potential to affect aquatic biota and habitats. Impacts on aquatic biota and habitats from solar energy projects could occur in a number of ways, including (1) habitat loss, alteration, or fragmentation; (2) disturbance and displacement of aquatic organisms; (3) mortality; and (4) increase in human access. Aquatic biota and habitats may also be affected by human activities not directly associated with a solar energy project or its workforce, but associated with the potentially increased access by the public to areas that previously received little use.

Overall, impacts from site characterization, construction, operation, and decommissioning of a utility-scale solar energy project on aquatic habitats and aquatic biota would depend on the following:

- The type and amount of aquatic habitat that would be disturbed;
- The nature of the disturbance (e.g., long-term reduction due to project structure and access road placement; complete, long-term alteration due to transmission line, gas pipeline, and water pipeline placement; or temporary disturbance in construction staging areas); and
- The types, numbers, and uniqueness of the aquatic biota that occupy the facility site and surrounding areas.

Potential impacts on aquatic resources (without mitigation) from the various impacting factors associated with solar energy development include the following:

- direct mortality of individuals;
- change in distribution and structure of aquatic, wetland, and riparian habitat and communities;
- habitat degradation;
- introduction of non-native species;
- genetic isolation;
- loss of access to important habitats;
- behavioral disturbance;
- reproductive impairment;
- physiological stress; and
- reduction in productivity.

2.6 ENVIRONMENTAL JUSTICE

Solar energy development could raise environmental justice concerns in the affected area around the development, nominally a 50-mi (80-km) radius, if minority or low-income populations are present. Such concerns would result from potential impacts on many of the environmental resources discussed in this chapter.

The areas of concern potentially affecting low-income or minority populations (as defined by the Council on Environmental Quality [CEQ] guidelines) are noise and dust generated during the construction of utility-scale solar facilities and the associated access roads; visual impacts of solar generation and auxiliary facilities; noise and electric and magnetic field (EMF) effects associated with solar project operations; access to land used for economic, cultural, or religious significance; and property values. Because such impacts are location-dependent, a detailed analysis should be a part of the project-level environmental assessment.

Noise and dust impacts during construction of solar generation and other facilities would be minor and temporary, even given the amount of land typically disturbed (the remoteness of some locations used for solar facilities could mitigate some of these impacts). Access roads required during construction for the delivery of equipment and materials to energy project sites could affect low-income or minority populations, depending on the terrain across which these roads would be constructed, access road length, the length of time they would be used for construction traffic, and the proximity to these populations.

Visual impacts from generation and auxiliary facilities associated with each solar technology may also affect low-income or minority populations. Solar development may also potentially alter the scenic quality in areas of traditional or cultural significance to these populations. Although likely to be minor, noise and EMF impacts from project operation could also create impacts affecting low-income or minority populations. The extent to which these effects are issues would depend on the size of the energy facilities and on their proximity to these populations.

Access to lands that contain animals or vegetation of cultural or religious significance to certain population groups or that form the basis for subsistence agriculture may be restricted because of the development of solar facilities. The curtailment of various economic uses of federal lands due to solar energy facility development, such as leasing for mineral, energy, and forestry resource development, may also affect low-income or minority populations if individuals involved in specific resource developments are concentrated in affected local communities.

Property value impacts on private land in the vicinity of solar facilities may affect low-income or minority populations, depending on the extent to which these population groups are concentrated in affected local communities. The precise nature of the impact would depend on current property values and the perceived value of costs (visual impacts, traffic congestion, noise and dust pollution, and EMF effects) and benefits (infrastructure upgrades, utility hookups, cheap and reliable energy supplies, and local tax revenues) relative to a property’s proximity to a solar facility.

2.7 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

2.7.1 Construction

The array of hazardous materials used in solar facility construction is generally the same for all solar technologies and is quite similar to those used in the construction of any industrial facility. Impacts from the hazardous materials present during construction include increased risks of fires and contamination of environmental media from improper storage and handling leading to spills or leaks.

Construction-related wastes include various fluids from the on-site maintenance of construction vehicles and equipment (used lubricating oils, hydraulic fluids, glycol-based coolants, and spent lead-acid storage batteries); incidental chemical wastes from the maintenance of equipment and the application of corrosion-control protective coatings (solvents, paints, and coatings); construction-related debris (e.g., dimension lumber, stone, and brick); and dunnage and packaging materials (primarily wood and paper). All such materials are expected to be initially accumulated on-site and ultimately disposed of or recycled through off-site facilities. Some construction-related waste (e.g., spent solvents and corrosion control coatings that are applied in the field) may qualify as characteristic hazardous waste or state- or federal-listed hazardous waste. Short-term accumulation and storage of hazardous waste on-site would be subject to the generator regulations in 40 CFR Part 261 promulgated under the authority of the Resource Conservation and Recovery Act (RCRA). However, any hazardous waste is likely to be transported to off-site RCRA-permitted treatment, storage, and disposal facilities (TSDF) prior to the time when the RCRA regulations would require a permit for their on-site management.

Potential impacts from the generation of such wastes include potential contamination of environmental media from improper collection, containerization, storage, and disposal. As with hazardous materials, appropriate waste management strategies, supported by the availability of appropriate waste containers and properly designed storage areas and implemented by worker training and adherence to established and disseminated waste management policies and appropriate in-house spill response capabilities,[4] can be expected to successfully avert adverse impacts while the wastes are being accumulated on-site and during delivery to off-site disposal or recycling facilities.

2.7.2 Operation

Unlike the construction phase, there are substantial differences among the solar technologies in the types of hazardous materials needed to support their operational phases. All solar technologies can be expected to have substantial quantities of dielectric fluids contained in

---

4 Because of the expected remoteness of some facilities, responses by external resources may not be immediate, and in-house spill/emergency response capabilities sufficient to stabilize the upset condition are considered essential.

various electrical devices such as switches, transformers, and capacitors, as well as several types of common industrial cleaning agents. All solar facilities also can be expected to engage in some degree of noxious weed and vegetation management that would result in approved and registered herbicides being applied on the site and some wastes being generated as a result of such activities.

Wastes common to all solar technologies include (1) domestic solid wastes and sanitary wastewaters from workforce support and (2) industrial solid and liquid wastes from routine cleaning and equipment maintenance and repair. Volumes of domestic solid wastes and sanitary wastewaters would be limited and proportional to the relatively small size of the operating workforce. Various options would be available for the management and disposal of domestic solid waste and sanitary waste. In all instances, solid wastes would likely be accumulated on-site for short periods until they are delivered to permitted off-site disposal facilities, typically by commercial waste disposal services. Options for sanitary wastewaters range from on-site disposal in septic systems, when circumstances allow, to off-site treatment and disposal in publically owned treatment works. All such treatment or disposal options, properly implemented, would preclude adverse environmental impacts. Some industrial wastes (e.g., spent cleaning solvents) may exhibit hazardous character, but well-established procedures for the management, disposal, and/or recycling of all industrial wastes should be readily available and would keep adverse impacts to a minimum. Wastes from herbicide applications would likely include empty containers and possibly some herbicide rinsates.[5]

Unless major malfunctions occur, dielectric fluids can be expected to remain in their devices throughout the active life of the facility, and no dielectric wastes are expected except as a result of unplanned spills or leaks. Adverse impacts would include potential worker exposure to hazardous materials and wastes and contamination of environmental media resulting from spills or leaks of hazardous materials or from improper waste management techniques.

2.7.3 Decommissioning/Reclamation

During decommissioning, the same hazardous materials would be present to support vehicles and equipment as were present during facility construction. Wastes generated during decommissioning would largely be derived from the maintenance of vehicles and equipment and can expected to be managed in much the same manner as during construction, with the same potential for adverse impacts. However, in addition to wastes generated in support of vehicles and equipment, other large-volume wastes would be generated as a result of draining and purging of plant systems. Spent HTF, dielectric fluids, thermal energy storage (TES) salts, and steam amendment chemicals would be produced in large quantities. Much of the volume of this waste would have recycling options, but subsequent flushing (with water or appropriate organic

---

5 Pesticide application is likely to be a contracted service. Typically, pesticide contractors will be responsible for removing any wastes from the operation to off-site treatment or disposal facilities. Use of proper techniques in developing field-strength solutions from pesticide concentrates typically results in a triple-rinsed container that can be disposed of as solid waste and rinsates that will have been incorporated into the solution to be applied. Application equipment is typically cleaned at the contractor’s off-site location.

solvents) and cleaning of the systems from which they were removed would generate wastes in need of disposal. Impacts during facility dismantlement and draining would include spills and leaks and releases to the environment from improper temporary on-site storage of recovered fluids.

Substantial quantities of solid materials would also be produced during facility dismantlement. Some would need to be managed as solid waste (e.g., broken concrete and masonry from on-site buildings and foundations); however, much of the material produced (e.g., steel and aluminum infrastructures, reflecting mirrors, power cables, pipes, and pumps) is likely to be recyclable after short-term on-site storage.[6]

Finally, for PV facilities using high-performance solar cells, special handling of solar panels containing toxic metals would be required to prevent their accidental breakage and to preserve any opportunities for the recycling of the solar cell materials (at off-site facilities).

2.8 HUMAN HEALTH AND SAFETY

Solar energy development could produce occupational health impacts on workers and environmental health concerns in the area around the facilities. Such impacts and concerns would result from the construction and operation of a solar project and its ancillary facilities.

2.8.1 Occupational Health and Safety

Occupational health and safety considerations related to typical solar energy projects include the following:

- Physical hazards;
- Risks of injuries and/or fatalities to workers during construction and operation of facilities and associated transmission lines;
- Risks resulting from exposure to weather extremes (e.g., occupational heat stress or stroke, frostbite);
- Risks of harmful interactions with plants and animals;
- Risks associated with working at extreme heights;

6 Given the volumes of materials produced during facility dismantlement, it is possible that laydown areas used during initial construction would be re-established as temporary storage areas for materials awaiting delivery to recycling areas. Waste materials would ideally be stored in areas used for hazardous materials and waste storage during facility operation before being transported to off-site TSDF.

- Fire hazards;

- Risks associated with retinal exposures to high levels of glare;

- A small risk of exposures to hazardous substances used at or emitted from the facilities;

- Risk of electrical shock; and

- The possibility of increased cancer risk if exposure to magnetic fields of exceptionally high strength were to occur.

Potential occupational health and safety risks would be very limited during the site characterization phase because of the limited extent of activities. Occupational hazards would be greater during the construction, operation, and decommissioning phases of a solar energy project but could be minimized by strict adherence to safety standards, including the use of appropriate protective equipment. However, fatalities and injuries from on-the-job accidents can still occur, especially in association with heavy construction activities.

Physical hazards associated with the construction of solar facilities are similar to those from construction in any industry and include possible injuries or deaths due to machinery malfunctions, falls, overexertion, and so on. Statistics for work-related injuries and deaths show a rate of approximately 6.4 injuries per 100 workers and 11.6 deaths per 100,000 workers annually for construction work (NSC 2006). For operation, the injury and fatality rate for solar facilities can be assumed to be similar to that for the manufacturing industry, which has an injury rate of 6.6 injuries per 100 workers and a fatality rate of approximately 2.5 deaths per 100,000 workers annually (NSC 2006).

In general, the volumes of hazardous substances used at solar facilities are small, so potential occupational exposures would be minimal and not associated with adverse health impacts. A substance used and/or stored at higher volumes at solar facilities is dielectric fluid, which is used as an insulating fluid for electrical devices such as transformers, switches, capacitors, and bushings. Petroleum-based mineral oil is often used as a dielectric fluid; in high-voltage capacitors, however, vegetable-based oils with higher dielectric constants (e.g., castor oil) may be used for better performance. These oils are not volatile and have low oral and dermal toxicity; thus spills could be contained and cleaned up with little potential for exposure or adverse health effects to workers. In some equipment, the dielectric medium is sulfur hexafluoride (SF_6) gas. This heavier-than-air gas is nontoxic but can act as an asphyxiant and irritant and, when involved in a fire circumstance, may engage in certain chemical reactions that can produce hazardous substances such as hydrogen fluoride (HF). In addition, SF_6 is ranked as a high global warming potential gas by the EPA (2010), so even small releases could result in adverse global warming impacts. However, SF_6 is often preferred over mineral oil dielectric media because of its superior performance.

Other potentially hazardous substances that could be present in high volumes at solar facilities include HTFs and TES media at parabolic trough and power tower facilities, compressed hydrogen at dish engine facilities, and toxic heavy metals in semiconductors (albeit in sealed solar panels in very small amounts) at PV facilities.

There is also a potential for retinal damage if glare from solar receivers is viewed from a close distance and more than momentarily. This hazard requires evaluation for parabolic trough, power tower, and dish engine facilities that concentrate solar energy through the reflection of sunlight from mirrors and heliostats as the mechanism of power production. The hazard potential from these types of facilities was recently evaluated by Ho et al. (2009).

2.8.2 Public Health and Safety

Health and safety risks to the general public can include the following:

- Physical hazards from unauthorized access to construction or operational areas of solar facilities;
- Increased risk of traffic accidents in the vicinity of solar facilities;
- Risk of eye damage from glare from mirrors, heliostats, and power tower receivers;
- Increased release of fungal spores (in desert regions where valley fever is present); and
- Aviation safety interference.

Because of the remote nature of most solar facilities, these health and safety risks would be generally low.

Risks from public exposure to hazardous substances through air emissions from solar facilities are low, because the few substances that are stored and used at the facilities in large quantities have low volatility and low inhalation toxicity. Small quantities of combustion-related hazardous substances may be emitted from diesel-burning construction equipment. In addition, during operation there may be emissions of similar contaminants from steam boilers using natural gas or coal as an energy source at certain times. However, because these would be supplemental boilers using small amounts of fuel, emissions and corresponding health risks are likely to be small. Nevertheless, the health risks of such emissions should be evaluated at the project-specific level.

Electrically energized equipment and conductors associated with solar facilities and the transmission lines that serve them represent electrical hazards. Proper signage and or engineered barriers (e.g., fencing) would be necessary to prevent access to these electrical hazards by unauthorized individuals or wildlife.

Public exposures to magnetic fields associated with solar facilities would be expected to be negligible, because setback zones would require homes and occupied buildings to be located well away from solar facilities.

2.8.3 Credible Events

2.8.3.1 Natural Events

There is a potential for natural events to affect human health and the environment during all phases of development of solar facilities. Such events include tornadoes, earthquakes, severe storms, and fires. Depending on the severity of the event, fixed components of a solar facility could be damaged or destroyed, resulting in economic, safety, and environmental consequences. The probability of a natural event occurring is location-specific and would differ among solar project locations. Such differences should be taken into account during project-specific studies and reviews.

2.8.3.2 Sabotage or Terrorism

In addition to the natural events, there is a potential for intentional destructive acts to affect human health and the environment. In contrast to natural events, for which it is possible to estimate event probabilities based on historical statistical data and information, it is not possible to accurately estimate the probability of sabotage or terrorism. Consequently, discussion of the risks from sabotage or terrorist events generally focuses on the consequences of such events.

The consequences of a sabotage or terrorist attack on a solar facility would be expected to be similar to those discussed above for natural events. Depending on the severity of the event, fixed components of a solar facility could be damaged or destroyed, resulting in economic, safety, and environmental consequences. The potential impacts of such events should be evaluated on a project- and site-specific basis.

2.9 LAND USE

Land-related impacts common to all types of utility-scale solar projects result from changes to existing uses within the project footprint and on public, state, and private lands that surround or are near solar energy facilities. Examples include conversion of land in and around local communities from agricultural, open space, or other uses to provide services and housing for employees and families who move to the region in support of solar energy development. Increased traffic and increased access to previously remote areas also could change the overall character of the landscape, including the visual quality of large areas. There are no impacts on lands and realty specific to construction, operation, or decommissioning of solar energy facilities. Impacts on other uses of lands are discussed below.

- *Fragmentation of large blocks of land.* Because large areas of land are needed for utility-scale solar facilities, solar energy development could fragment large blocks of land. Topography, land ownership pattern, existing land use designations (e.g., wilderness), and new access routes or transmission facilities are examples of features that could all combine with a solar energy project to create fragmentation of lands. Lands in close proximity to solar energy facilities could also be affected. There is also the potential to sever access routes to adjacent lands, thus affecting their use. The potential nature and magnitude of these impacts should be considered in project-level analyses.

- *Creation of industrial landscapes.* If built on undeveloped landscapes, solar facilities would create an industrial landscape that lies in stark contrast to the original landscape character (especially if adjacent to lands with special designations based on wilderness and scenic values). In these cases, solar projects would be visually intrusive and could substantially alter the long vistas of lands that were once undeveloped.

- *Changes in land values.* Land values could be reduced due to aesthetic concerns, changes in the amount of vehicular traffic, or changes in existing operations (e.g., the removal of a substantial or critical part of a grazing operation). Alternatively, land values could increase because of additional demand for developable private lands to support solar development. Potential impacts on land values are further discussed in Section 2.17.

Access to electrical transmission facilities is a major factor in siting utility-scale solar facilities, and availability of established and adequate transmission corridors is becoming critical, especially as the demand for renewable energy sources increases.

2.10 PALEONTOLOGICAL RESOURCES

Solar energy facilities could produce impacts on paleontological resources in and around the areas where they are built. Impacts would occur primarily during facility construction due to surface disturbance, but indirect impacts from facility operation could also occur.

Significant paleontological resources could be affected by utility-scale solar energy development. The potential for impacts on paleontological resources from solar energy development, including ancillary facilities such as access roads, is directly related to the location of the project (regardless of the technology employed) and the amount of land disturbance in areas where paleontological resources could be present. Indirect effects, such as impacts resulting from the erosion of disturbed land surfaces and from increased accessibility to possible site locations, could also occur.

Impacts on paleontological resources could result in several ways, as described below.

- Complete destruction of the resource and loss of valuable scientific information could result from the clearing, grading, and excavation of the project area and from construction of facilities and associated infrastructure if paleontological resources are located within the development area.

- Degradation and/or destruction of near-surface paleontological resources and their stratigraphic context could result from the alteration of topography; alteration of hydrologic patterns; removal of soils; erosion of soils; runoff into and sedimentation of adjacent areas; and oil or other contaminant spills if near-surface paleontological resources are located on or near the project area. Such degradation could occur both within the project footprint and in areas downslope or downstream. While the erosion of soils could negatively affect near-surface paleontological localities downstream of the project area by potentially eroding materials and portions of sites, the accumulation of sediment could serve to remove from scientific access, but otherwise protect, some localities by increasing the amount of protective cover. Agents of erosion and sedimentation include wind, water, downslope movements, and both human and wildlife activities.

- Increases in human access and subsequent disturbance (e.g., looting and vandalism) of near-surface paleontological resources could result from the establishment of corridors or facilities in otherwise intact and inaccessible areas. Increased human access (including OHV use) exposes paleontological sites to a greater probability of impacts from a variety of stressors.

Paleontological resources are nonrenewable and, once damaged or destroyed, cannot be recovered. Therefore, if a paleontological resource (specimen, assemblage, or site) is damaged or destroyed during utility-scale solar energy development, this scientific resource would become irretrievable. Data recovery and resource removal are ways in which at least some information can be salvaged should a paleontological site be affected, but certain contextual data would invariably be lost. The discovery of otherwise unknown fossils would be beneficial to science and the public good, but only as long as sufficient data can be recorded.

2.11 SOCIOECONOMICS

Construction and operation of utility-scale solar energy facilities and construction of or upgrades to transmission lines in the area would produce direct and indirect economic impacts. Direct impacts would occur as a result of expenditures on wages and salaries, procurement of goods and services required for project construction and operation, and the collection of state sales and income taxes. Indirect impacts would occur as project wages and salaries, procurement expenditures, and tax revenues subsequently circulate through the economy of each state, creating additional employment, income, and tax revenues. Facility construction and operation would also require in-migration of workers and their families into each state, which would affect rental housing, public services, and local government employment. Because such impacts are location-dependent, a detailed analysis should be part of the project-level environmental assessment.

2.11.1 Construction and Operation

2.11.1.1 Recreation Impacts

Estimating the impact of solar facilities on recreation is problematic, because it is not clear how solar development in a given state would affect recreational visitation and nonmarket values (the value of recreational resources for potential or future visits). A simple way to estimate the economic impact of recreation as a whole is to identify sectors in the state economy in which expenditures on recreational activities occur, and assume solar development would affect some portion of the activity in each of these sectors. Impact estimates then could be focused on direct effects, that is, loss of employment in recreation sectors, and indirect effects such as the impact on the state's economy as a result of declining recreation employee wage and salary spending and declining recreation expenditures on materials, equipment, and services.

2.11.1.2 Property Value Impacts

There is concern that solar facilities affect property values in nearby communities. Property values might decline in some locations as a result of the deterioration in aesthetic quality, increases in noise, real or perceived health effects, congestion, or social disruption. In other locations, property values might increase because of access to employment opportunities associated with solar development.

In general, potentially hazardous facilities can directly affect property values in two ways (Clark et al. 1997; Clark and Allison 1999). First, negative imagery associated with these facilities could reduce property values if potential buyers believed that any given facility might produce an adverse environmental impact. Negative imagery could be based on individual perceptions of risk associated with proximity to these facilities or on perceptions at the community level that the presence of such a facility might adversely affect local economic development prospects. Even though a potential buyer might not personally fear a potentially hazardous facility, the buyer might still offer less for a property in the vicinity of a facility if there was fear that the facility would reduce the rate of appreciation of housing in the area. Second, there could be a positive influence on property values associated with accessibility to the workplace for workers at the facility, with workers offering more for property close to the facility to minimize commuting times. Workers directly associated with a solar facility would probably also have much less fear of the technology and operations at the facility than would the population as a whole. The importance of this influence on property values would likely vary with the size of the workforce involved.

Although there is no evidence that solar facilities affect local property values, there is limited evidence of the impact of energy development in general on property values. In western

Colorado communities adjacent to oil and gas drilling activities, for example, property values declined with the announcement of drilling, and during the first stages of extraction the values rebounded, at least partly, once production was fully underway (BBC Research and Consulting 2006). Other studies have assessed the impacts of other potentially hazardous facilities—such as nuclear power plants and waste facilities (Clark and Nieves 1994; Clark et al. 1997; Clark and Allison 1999) and hazardous material and municipal waste incinerators and landfills (Kohlhase 1991; Kiel and McClain 1995)—on, for example, local property markets. Many of these studies used a hedonic modeling approach to take into account the wide range of spatial influences, including noxious facilities, crime (Thaler 1978), fiscal factors (Stull and Stull 1991), and noise and air quality (Nelson 1979), on property values.

The general conclusion from these studies is that while there may be a small negative effect on property values in the immediate vicinity of noxious facilities (i.e., less than 1 mi [1.6 km]), this effect is often temporary and associated with announcements related to specific project phases, such as site selection, the start of construction, or the start of operations. At larger distances or over longer project durations, no significant, enduring, negative property value effects have been found. Depending on the importance of the employment effect associated with the development of the various activities analyzed in these studies, a positive impact on property values was found to be associated with increases in demand for local housing.

Under conditions of moderate population growth and housing demand, it appears that property values could increase with the expansion in local employment opportunities resulting from solar development. However, with larger scale construction in each state, increases in population and associated congestion (in the absence of adequate private-sector real estate investment and appropriate local community planning) might adversely affect property values. Various energy development studies have suggested that once the annual growth in population is between 5 and 15% in smaller rural communities, a breakdown in social structures would occur; alcoholism, depression, suicide, social conflict, divorce, and delinquency would increase; and levels of community satisfaction would deteriorate (BLM 1980, 1983, 1996). The resulting deterioration in local quality of life would adversely affect property values.

2.11.1.3 Environmental Amenities and Economic Development

Solar development may affect environmental amenities, including environmental quality, stable rural community values, or cultural values, near solar facilities. Consequently, some local communities may have difficulty in attracting businesses that are highly sensitive to actual or perceived changes in environmental amenities. Over recent decades, many areas of the southwestern United States have been able to diversify their economies away from largely extractive industries toward knowledge-based industries; the professional and service sector; and retirement, recreation, and tourism (Bennett and McBeth 1998). It is apparent, therefore, that growth in some parts of the economy has become highly sensitive to changes in environmental amenities. Although other factors, including the cost and availability of labor resources and the prevailing relative cost of doing business, may be more important than environmental amenities to some sectors, extensive literature indicates that perceived deterioration in the natural environment and in amenities in particular locations may have an important impact on the ability of communities in adjacent areas to foster sustainable economic growth (Rudzitis and Johansen 1989; Johnson and Rasker 1995; Rasker 1994; Power 1996; Rudzitis 1999; Rasker et al. 2004; Chipeniuk 2004; Holmes and Hecox 2005; Reeder and Brown 2005).

Since the 1980s, many rural areas in the southwest have diversified their economies toward tourism and recreation, much of which is based on natural amenities, notably hunting, fishing, bird watching, and skiing. To the extent that existing and potential new economic activities are sensitive to changes in environmental quality and the amenity-based activities they support in each state, solar energy development may create conflicts with the ability of adjacent areas in states to attract future economic growth in economic activities that are sensitive to environmental amenities. In addition to amenity values, however, various other economic and demographic factors would have to be favorable in any given solar development area for additional economic growth to occur, in particular, the economic development potential of infrastructure and human resources in the area and the cost of doing business relative to that in other comparable locations. However, it is unlikely that high amenity values alone would be sufficient to encourage local economic growth or that businesses, once established in a given location, would necessarily relocate because of changes in amenity values.

2.11.1.4 Social Change and Social Disruption

Although there is an extensive literature in sociology documents, the most significant components of social change in energy boomtowns, the nature and magnitude of the social impact of energy development projects in small rural communities are still unclear. While some degree of social disruption is likely to accompany large-scale in-migration during the boom phase, there is insufficient evidence to predict the extent to which specific communities are likely to be affected, which population groups within each community are likely to be most affected, and the extent to which social disruption is likely to persist beyond the end of the boom period (Smith et al. 2001). Accordingly, because of the lack of adequate social baseline data, it has been suggested that social disruption is likely to occur once an arbitrary population growth rate associated with solar energy development projects has been reached, with an annual rate of between 5 and 10% growth in population assumed to result in a breakdown in social structures, an increase in alcoholism, depression, suicide, social conflict, divorce, and delinquency, and deterioration in levels of community satisfaction (BLM 1980, 1983).

In overall terms, the in-migration of workers and their families would represent a relatively small increase in a given state's population during construction of the trough technology, with smaller increases for the power tower, dish engine and PV technologies, and during the operation of each technology. It is possible that some construction and operation workers will choose to locate in communities closer to each solar development; however, because of the lack of available housing in smaller rural communities in the region of influence (ROI) of each solar development to accommodate all in-migrating workers and families and the insufficient range of housing choices to suit all solar occupations, many workers are likely to commute to the solar development from larger communities elsewhere, reducing the potential impact of solar development projects on social change. Regardless of the pace of population growth associated with the commercial development of solar resources, the number of new residents from outside the region is likely to lead to some demographic and social change in small rural communities. Communities hosting these development projects are likely to be required to adapt to a different quality of life, with a transition away from a more traditional lifestyle of ranching in small, isolated, close-knit, homogenous communities with a strong orientation toward personal and family relationships, toward a more urban lifestyle with increasing cultural and ethnic diversity and increasing dependence on formal social relationships within the community.

2.12 SOIL RESOURCES

Common impacts on soil resources encompass a range of impacts that would be expected to occur mainly as a result of ground-disturbing activities, especially during the construction phase of a solar energy project, regardless of the type of facility under development. Common impacts include soil compaction, soil horizon mixing, soil erosion and deposition by wind, soil erosion by water and surface runoff, sedimentation, and soil contamination, as described below. Implementing mitigation measures to preserve the health and functioning of soils at the project site would reduce the likelihood of soil impacts becoming impacting factors on other resources (such as air, water, vegetation, and wildlife), and would contribute to the success of future reclamation efforts.

- *Soil compaction.* Soil compaction occurs when soil particles are compressed, increasing their density by reducing the pore spaces between them (USDA 2004). It is both an intentional engineering practice that uses mechanical methods to increase the load-bearing capacity of soils underlying roads and site structures and an unintentional consequence of activities occurring in all phases of project development. Unintentional soil compaction is usually caused by vehicular (wheel) traffic on unpaved surfaces, but it can also result from animal and human foot traffic. Soils are more susceptible to compaction when they are moist or wet. Other factors, such as low organic content and poor aggregate stability, also increase the likelihood that compaction will occur. Soil compaction can directly affect vegetation by inhibiting plant growth because reduced pore spaces restrict the movement of nutrients and plant roots through the soil. Reduced pore spaces can also alter the natural flow of hydrological systems by causing excessive surface runoff, which in turn may increase soil erosion and degrade the quality of nearby surface water. Because soil compaction is difficult to correct once it occurs (USDA 2004), the best mitigation is prevention to the extent possible.

- *Soil horizon mixing.* Soil horizon mixing is another form of soil damage that occurs as a result of construction activities like excavation and backfilling that displace topsoil and disturb the existing soil profile. When topsoil is removed, stabilizing matrices, such as biological crusts and desert pavement, are destroyed, increasing the susceptibility of soils to erosion by both wind and water. Such disturbances also directly affect vegetation by disrupting indigenous plant communities and facilitating the growth of invasive plant species.

- *Soil erosion and deposition by wind.* Exposed soils are susceptible to wind erosion. Wind erosion is a natural process in which the shear force of wind is the dominant eroding agent, resulting in significant soil loss across much of the exposed area. Project-related activities such as vegetation clearing, excavating, stockpiling soils, and truck and equipment traffic (especially on unpaved roads and surfaces) can significantly increase the susceptibility of soils to wind erosion. Because wind dispersion and deposition of eroded soils can be geographically widespread, this process is an important impacting factor for air quality, water quality, vegetation, and all wildlife. State and local governments may also have specific air permitting requirements regarding the control of fugitive dust and windborne particulates.

- *Soil erosion by water and surface runoff.* Exposed soils are also susceptible to erosion by water. Water erosion is a natural process in which water (in the form of raindrops, ephemeral washes, sheets, and rills) is the dominant eroding agent. The degree of erosion by water is generally determined by the amount and intensity of rainfall, but is also affected by the cohesiveness of the soil (which increases with organic content), its capacity for infiltration, vegetation cover, and slope gradient and length (USDA 2004). Activities such as vegetation clearing, excavating, and stockpiling soils significantly increase the susceptibility of soils to runoff and erosion, especially during heavy rainfall events. Surface runoff caused by soil compaction also increases the likelihood of erosion. Soil erosion by surface runoff is an important impacting factor for the natural flow of hydrological systems, surface water quality (due to increased sediment loads), and all wildlife. State and local governments may also have specific flood control requirements that directly affect what surface runoff is allowed and how it should be controlled.

- *Sedimentation.* Soil loss during construction (by wind or water erosion) is a major source of sediment that ultimately makes its way to surface water bodies such as reservoirs, irrigation canals, rivers, lakes, streams, and wetlands. When sediment settles out of water (a process called sedimentation), it can clog drainages and block navigation channels, increasing the need for dredging. By raising streambeds and filling in streamside wetlands, sedimentation increases the probability and severity of floods. Sediment that remains suspended in surface water can degrade water quality, damaging aquatic wildlife habitat and commercial and recreational fisheries. Sediment in water also increases the cost of water treatment for municipal and industrial users (USDA 2004).

- *Soil contamination.* Soil contamination in the project area could result from the general use of trucks and mechanical equipment (fuels, oils, and the like) during all project phases. Facility-specific operations involve the use of hazardous materials such as dielectric fluids and cleaning solvents and would likely generate waste streams such as sanitary wastewater. Improper storage and handling of hazardous materials could result in accidental spills, leaks, and fires. Maintenance-related activities could also contaminate soils in the project area. These activities include the applications of herbicides (for weed control) and chemical stabilizers (for dust control) to the soil surface. Contaminated soil can become a source of contamination for other resources, including vegetation (through uptake), wildlife (through inhalation and ingestion), and water quality (surface water through deposition and groundwater through leaching and infiltration).

Potential indirect impacts of soil disturbance include the reduction of the carbon-fixing function of biological soil crusts and playa crusts (in desert environments); the release of soil-borne diseases or toxins (such as fungal spores); and mineral dust deposition on alpine snowpack.

2.12.1 Site Characterization

Site characterization would involve little or no ground disturbance; therefore, activities during this project phase would result in only small or negligible impacts on soil resources. However, some ground-disturbing activities, such as drilling deep soil cores, installing monitoring wells, clearing and excavating areas to create surface impoundments for drilling fluids, and building access roads (in remote locations), would occur and could result in impacts on soil resources. Direct adverse impacts from these activities relate mainly to the increased potential for soil compaction, soil horizon mixing, soil erosion and deposition by wind, and soil erosion by water and surface runoff, and sedimentation of nearby surface water bodies. The degree of impact would depend on the size and design of the project (i.e., the extent of ground-disturbing activities) and on site-specific factors such as soil properties, slope, vegetation cover, weather conditions (i.e., precipitation rate and intensity; prevailing wind direction and speed), and distance to surface water bodies.

2.12.2 Construction

Construction of a solar facility could result in significant impacts on soil resources over an area equivalent to the sum of the footprints of all structures (e.g., solar collectors, cooling systems, and TES) and related infrastructure (e.g., on-site roads, access roads, parking areas, and fencing). Soil-related impacts during the construction phase may extend beyond the site boundary as a result of increased erosion by wind or water. Ground-disturbing activities would include vegetation clearing and grubbing; excavating for foundations, footings, and trenches for buried piping and electrical connections; pile driving (foundations); stockpiling excavated material for backfilling; drilling rock to set foundations and footings; drilling and installing groundwater supply wells; grading for roads and staging and laydown areas; and installing surface impoundments (e.g., evaporation ponds). The construction of other facilities, such as the central control building, electrical substations, meteorological towers (if not done during site characterization), concrete batching plant, sanitary facilities and temporary offices, and an area for minor maintenance and storage of equipment and parts, also would have the potential to result in adverse impacts on soil resources, because they involve some degree of ground disturbance.

Direct adverse impacts of construction activities relate mainly to the increased potential for soil compaction, soil horizon mixing, soil erosion and deposition by wind, soil erosion by water and surface runoff, and sedimentation of nearby surface water bodies. Soil contamination could also result from the release of contaminants related to the use of trucks and mechanical equipment, from improper storage and handling, and from the application of chemical stabilizers to control fugitive dust emissions. The degree of impact would depend on the size and design of the project (i.e., the extent of ground-disturbing activities) and on site-specific factors, such as soil properties, slope (e.g., along gullies and on alluvial fan surfaces), vegetation, weather, and distance to surface water.

2.12.3 Operation

Direct adverse impacts of operation are expected to be small, because project activities (e.g., monitoring controls and inspecting equipment, maintenance, and mirror washing) would not involve extensive ground disturbances (beyond that which has already occurred during construction) that increase the potential for soil compaction, soil horizon mixing, soil erosion and deposition by wind, soil erosion by water and surface runoff, and sedimentation of nearby surface water bodies. Soil erosion would still occur during the operation phase, however, because soil surfaces exposed by vegetation clearing, grading, and excavation during the site preparation and construction phase would continue to be exposed throughout the life of the project. The risk of erosion would be greatest when exposed soils are subjected to high wind conditions or intense rainfall and surface runoff along roads is channeled into natural drainages. Soil compaction could also occur but would not be significant because most routine vehicle traffic would be limited to paved or graveled roads. Soil contamination could result from the release of contaminants related to the use of trucks and mechanical equipment or improper storage and handling and through the sustained applications of herbicides and chemical stabilizers to control vegetation and fugitive dust emissions.

2.12.4 Decommissioning/Reclamation

Project activities during the decommissioning/reclamation phase could result in significant impacts on soil resources, because they would involve ground disturbances that increase the potential for soil compaction, soil horizon mixing, soil erosion and deposition by wind, soil erosion by water and surface runoff, and sedimentation of nearby surface water bodies. Ground-disturbing activities would include removal of most if not all equipment, removal of permanent structures and improvements (including on-site and access roads), and closure of on-site wells (belowground cables would be left in place). Direct adverse impacts would be smaller than during construction, because the objective of this project phase is to return the site to its native condition (e.g., by re-establishing native vegetative communities) and the use of existing access roads would reduce impacts such as compaction and erosion (e.g., fugitive dust generation). However, given the long timeframe needed to re-establish desert vegetation, soils would remain susceptible to erosion throughout the decommissioning/reclamation phase and beyond, especially if subjected to high wind conditions or intense rainfall. Soil contamination is less likely during this phase, but it could result from fuel and oil releases related to the use of trucks and mechanical equipment and toxic metal releases if solar cells are broken during facility dismantling.

2.13 TRANSPORTATION

Transportation-related impacts are related to the solar project location; the project size; the delivery of equipment, materials, and supplies; and the daily commute of workers. The primary impacts are expected to occur on the road network. Workers would likely commute to work over local roads, and shipments to and from the solar energy facilities would likely be by truck, although rail transport to the closest intermodal facility for materials could be used. The major potential impact is the degradation of the level of service of local roads around a solar energy facility as a result of increased traffic volumes.

2.13.1 Site Characterization

The location of large solar energy facilities could have direct impacts on the local road network. Facilities exceeding an area of 1,000 acres (4.05 km^2) could pose an impediment to travelling from off-site locations on one side of the facility to destinations on another. Additional travel times and added traffic congestion could result.

The proximity of the site to major roads would determine to some extent the traffic congestion problems anticipated from construction worker commuters. Some of the best solar resources are located in remote areas that may be served by only one major road (e.g., a state highway) providing access from two directions, while other locations may have multiple access routes. Limited access can lead to more significant impacts should delays occur due to inclement weather, road maintenance or construction, higher vehicle volumes, or traffic accidents.

The location of the project site with respect to the electric grid will determine where the electric transmission line from the site will connect to the grid and the route and length of the transmission line. Likewise, gas and water utility lines must also be determined if required by the solar energy plant design. The construction and operation of the transmission, water, and gas lines would not be expected to result in any significant transportation impacts, but the addition of any construction workers associated with them could increase impacts coupled with those of the construction workers associated with the solar energy facility itself.

Utility-scale solar projects are expected to have an insignificant impact on railroad operations. However, potential conflicts could arise if there are rail crossings near roads heavily involved with site traffic, especially during the construction period. An increased risk of a collision between a train and a vehicle could occur, most notably as a result of drivers trying to beat a train because of frustration with site-related traffic congestion.

With respect to air traffic, electric transmission lines with heights up to about 150 ft (45 m)[7] could pose a hazard to low-flying aircraft. Installation of a new transmission line to connect the site to the electric grid would need to take civil and military considerations into account to avoid runway approach patterns, low-altitude flight corridors, and military exercise areas.

2.13.2 Construction

In general, the heavy equipment and materials needed for site access, site preparation, and solar array footing or foundation construction are typical of road construction projects and do not pose unique transportation considerations. However, local road improvements may be necessary if access routes are not built to support heavy truck traffic up to the federal limit of 80,000 lb (36,280 kg) gross vehicle weight for the National Network (23 CFR Part 658). In addition, it is likely that a small number of one-time oversized and/or overweight shipments may be required for larger earthmoving equipment required for site preparation. In cases of previously disturbed areas, demolition of existing structures might be necessary prior to grading and project construction. Any resulting debris would be required to be shipped off-site to an appropriate disposal facility.

Shipments of overweight and/or oversized loads can be expected to cause temporary disruptions on the secondary and primary roads used to access a construction site. It is possible that local roads might require fortification of bridges and removal of obstructions to accommodate overweight or oversized shipments. The need for such actions must be determined on a site-specific basis. Moreover, the solar facility access road must be constructed to accommodate such shipments. Overweight and oversized loads typically require tractor-trailer combinations with multiple axles, special local/county/state permits, advance and trailing warning vehicles, and possible police escorts. Travel during off-peak hours and/or temporary road closures may also be necessary. Most of the construction equipment (e.g., heavy earthmoving equipment, cranes) would remain at the site for the duration of construction activities. Because such construction equipment is routinely moved on U.S. roads and there will be only a limited number of one-time shipments, no significant impact is expected from these movements to and from the construction site.

The movement of other equipment and materials to the site during construction would cause a small increase in the level of service of local roadways during the construction period. Shipments of materials, such as gravel, concrete, water, and solar components, would not be expected to significantly affect local primary and secondary road networks. For larger projects (e.g., >200 MW), the average number of deliveries could be on the order of 20 to 30 per day (BrightSource Energy, Inc. 2007; Beacon Solar, LLC 2008; SES Solar Two, LLC 2008) or higher (Carrizo Energy, LLC 2007) and could be as high as approximately 85 per day (Topaz Solar Farms, LLC 2008) during peak construction activities. Deliveries are more likely to occur during morning work hours but could occur anytime during the day. Assuming that all deliveries

---

7 For a potential range of typical high-voltage transmission line towers and their height ranges, see Great River Energy (2008).

occur during the morning between 8:00 a.m. and noon, the average traffic volume on local roads would increase by about 20 vehicles per hour during peak construction periods. This increase is not enough to change a route's level of service and thus is considered to be an insignificant impact.

On the other hand, significant impacts could arise from workers commuting to the construction site for larger projects. Peak construction workforces for such projects have been estimated to range from about 400 to 1,400 daily workers (see BrightSource Energy, Inc. 2007; Carrizo Energy, LLC 2008; Beacon Solar, LLC 2008), with averages from about 100 to 400 or more workers (Beacon Solar, LLC 2008; Topaz Solar Farms, LLC 2008) over construction periods ranging from 2 to 4 years. In the worst case, if workers were to drive individually to the project site during peak construction periods, 700 or more additional vehicles per hour (1,400 workers arriving on-site between 7:00 and 9:00 a.m.) could severely degrade an access route's level of service.

2.13.3 Operation

Transportation activities during solar energy production would involve commuting workers, material shipments to and from the facility, and on-site work and travel. Operation crews may number more than 150 for larger projects but are anticipated to number on the order of 10 to 50 workers during daytime hours (see Carrizo Energy, LLC 2008; Topaz Solar Farms, LLC 2008; SES Solar Two, LLC 2008), with a minimal crew of a few personnel during the nighttime in most cases. At most, a few daily truck shipments to or from a site are expected. Deliveries of materials during operation could include hazardous materials such as fuels for backup generators or maintenance vehicles. Shipments of hazardous materials require proper route selection as well as appropriate operator training and qualifications. However, all types of hazardous materials transported for use at solar energy facilities are routinely shipped in the United States for other applications and pose no unusual hazards. Thus, no significant impacts are expected from hazardous material shipments. Shipments from facilities would also include wastes for disposal.

With some facility sizes on the order of thousands of acres, on-site operations would include travel to various locations for repairs and maintenance, including dust suppression and cleaning operations. If on-site water is not available for these latter operations, shipments of water to the facility location would be required as well.

Consequently, transportation activities during operation would be limited to a small number of daily trips by personal vehicles and a few truck shipments at most. It is possible that large components may be required for equipment replacement in the event of a major equipment malfunction. However, such shipments would be expected to be infrequent. The level of transportation activity during operation is expected to have an insignificant impact on the local transportation network.

The electrical interference of transmission lines or solar array control systems with aircraft operations is remote but should be evaluated for any new installation. Interactions with low-altitude aircraft avionics or communications have the potential to occur if corona discharges from the transmission lines are not minimized and if specific electric frequencies are not avoided. In addition, the potential for glare from solar energy facilities (reflection of the sun off of mirrors or PV panels) to interfere with pilot vision is not expected to be a significant impact. Aircraft flying over these facilities receive diffuse reflections as they are well away from the focal point of any parabolic mirrors or trough reflectors. Past experience with flights over solar facilities likens the visual impact to the reflection of the sun off large ponds or lakes (Carrizo Energy, LLC 2007; Beacon Solar, LLC 2008). In the case of heavily traveled air routes, such as airport approach routes, the solar array patterns could be adjusted to minimize interference.

2.13.4 Decommissioning/Reclamation

With some exceptions, transportation activities during site decommissioning/reclamation would be similar to those during site development and construction. Heavy equipment and cranes would be required for dismantling solar arrays, breaking up array foundations if necessary, and regrading and recontouring the site to the original grade. Aside from any construction equipment, oversized and/or overweight shipments are not expected during decommissioning activities, because any major components can be disassembled, segmented, or reduced in size prior to shipment.

2.14 VISUAL RESOURCES

Because of the experiential nature of visual resources, the human response to visual changes in the landscape cannot be quantified, even though the visual changes associated with a proposed utility-scale solar energy development can be described (Hankinson 1999). There is, however, some commonality in individuals' experiences of visual resources, and while it may not be possible to quantify subjective experience and values, it is possible to systematically examine and characterize commonly held visual values and to reach consensus about visual impacts and their trade-offs.

2.14.1 Site Characterization

Potential visual impacts that could result from site characterization activities include contrasts in form, line, color, and texture resulting from vegetation clearing. Ruts, windblown dust, and visible vegetation damage may occur from cross-country vehicle traffic if existing or new roads are not utilized for site characterization activities. If road upgrading or new road construction is required for site characterization activities, visual contrasts may be introduced, depending on the routes relative to surface contours and the widths, lengths, and surface treatments of the roads. Improper road maintenance could lead to the growth of invasive species or erosion, both of which could introduce undesirable contrasts in line, color, and texture, primarily for foreground and near-middleground views. Site characterization visual impacts are generally temporary; however, impacts due to road construction, erosion, or other landform altering or vegetation clearing in arid environments may be visible for extended periods.

2.14.2 Construction

Potential visual impacts that could result from construction activities include contrasts in form, line, color, and texture resulting from vegetation clearing of the solar field and other areas such as building pads (with associated debris); road building/upgrading; construction and use of staging and laydown areas; lighting (especially on night skies in non-industrialized landscapes); fencing (around construction site); solar energy collector and support facility construction; vehicle, equipment, and worker presence and activity; and associated vegetation and ground disturbances, dust, and emissions. The presence of litter or debris could also produce visual effects. Construction visual impacts would vary in frequency and duration throughout the course of construction, which for a utility-scale solar project may last several years.

2.14.3 Operation

The operation and maintenance of solar facilities could potentially have substantial long-term visual effects. Some impacts are common to utility-scale solar energy projects, regardless of solar technology employed; however, the solar energy collectors and associated structures differ in terms of visual impacts. Power tower projects generally have larger visual impacts than the other technologies because of the relatively tall and brightly illuminated receiver towers. PV projects generally have lower visual impacts than the other technologies because of the low profile of the collector arrays and the lower reflectivity of the PV panels, when compared to the highly reflective mirrors used by the other technologies. However, all utility-scale solar facilities could create strong visual contrasts for nearby viewers. Site operation impacts would generally occur throughout the life of the facility, with some impacts (e.g., impacts resulting from land forming and vegetation clearing) potentially continuing many years beyond the lifetime of the project.

2.14.4 Decommissioning/Reclamation

During decommissioning/reclamation, the immediate visual impacts would be similar to those encountered during construction, but likely of shorter duration. Such impacts could include road redevelopment, removal of aboveground structures and equipment, the presence of workers and equipment with associated dust and possibly other emissions and litter, and the presence of idle or dismantled equipment, if allowed to remain on-site. Deconstruction activities would involve heavy equipment, support facilities, and lighting. The associated visual impacts would be substantially the same as those in the construction phase, but of shorter duration. Decommissioning likely would be an intermittent or phased activity persisting over extended periods of time and would include the presence of workers, vehicles, and temporary fencing at the worksite.

Restoring a decommissioned site to pre-project conditions would also entail recontouring, grading, scarifying, seeding, and planting, and perhaps stabilizing disturbed surfaces. This might not be possible in all cases; that is, the contours of restored areas might not always be identical to pre-project conditions. In arid conditions where utility-scale solar development is likely to occur, newly disturbed soils might create visual contrasts that could persist for many seasons before revegetation would begin to disguise past activity. Invasive species might colonize reclaimed areas, likely producing contrasts of color and texture. If a lack of proper management led to the growth of invasive species in the reseeded areas, noticeable color and texture contrasts might remain indefinitely. The unsuccessful reclamation of cleared areas could also result in soil erosion, ruts, gullies, or blowouts, which could cause long-term negative visual impacts.

2.15 WATER RESOURCES

A utility-scale solar project can affect surface water and groundwater in several ways, including the use of water resources, modification of the natural surface water and groundwater flow systems, alteration of the interactions between groundwater and surface waters, contamination of aquifers, wastewater treatment either on- or off-site, and water quality degradation by runoff or excessive withdrawals, as well as from leaks and spills of chemicals used for the project. While some impacts on water resources (e.g., water use) are dependent upon the solar technologies themselves, impacts on water resources associated with land disturbance and construction activities would be expected to occur regardless of the type of solar technology used.

2.15.1 Site Characterization

Activities during site characterization that could potentially affect water resources include modification or construction of access roads to transport drilling equipment and a meteorological tower, groundwater exploration drilling and testing to evaluate water availability, and deep soil coring to gather information necessary for the design of substantial structure foundations. Water also would be used for dust suppression and the workforce’s potable supply.

The impacts on water resources resulting from site characterization activities are considered minor because they are limited in extent and duration. Access road modification and construction could require the modification of natural drainage systems, which could (1) increase sediment and dissolved solid loads in the water downstream from disturbed areas and (2) lead to flooding. Any alteration of a water of the United States would require a Section 404 permit.[8] During investigation of groundwater and deep soil sampling for geotechnical purposes, water would likely be trucked in. Mud pits would be dug to contain drilling mud for reuse. Cuttings from drilling should be managed according to federal and state regulations on containment and disposal of waste. The extent of ground disturbance, which could cause soil erosion and degrade the quality in downstream surface waters, would likely be very small.

---

8 The U.S. Army Corps of Engineers is authorized by Section 404 of the Clean Water Act to issue permits for certain activities conducted in wetlands or other U.S. waters.

2.15.2 Construction

2.15.2.1 Use of Water Resources

Water would be needed for various activities in the construction phase, including concrete preparation for foundations of the support structures for solar reflectors and PV panels and buildings, drinking water for site workers, vehicle washing, road construction, and dust control on roads and construction sites. Major water use activities during construction relate to fugitive dust control and the workforce potable supply. Water sources are likely to be local groundwater, surface water, or recycled water, depending upon availability of those resources. Water may also be trucked in from distant municipal water supplies.

Groundwater withdrawn from local aquifers could lower water levels of the source aquifer. Depending on site-specific geology, withdrawals exceeding the sustainable yield of the groundwater basin could cause permanent loss of storage capacity in the aquifer, as well as land subsidence. Impacts of reduced groundwater flow magnitude and timing of groundwater flows to streams, springs, seeps, and wetlands would depend upon the connectivity of surface water and groundwater in the region.

If surface water were used, withdrawal of surface water from a stream would reduce its flow. Replenishment of aquifers that are hydraulically connected and recharged by the stream would also be reduced.

2.15.2.2 Modification of Streams and Groundwater Flow Systems

Construction activities could affect natural surface water and groundwater flow systems by diverting and/or channelizing on-site and nearby streams to accommodate access road and facility construction. The level of impacts resulting from alterations of natural drainage patterns for elevated roadbeds would depend on road orientation, drainage structure, and the type of landscape that the roads cross. Hard structures, such as foundations, could increase erosion around such structures. In some cases, upstream drainage would be altered such that flow would be routed around the site and through stormwater infrastructure. Excavation (trenching) or horizontal boring activities to bury pipes or wires might alter surface overland flow and allow subsurface flow to follow the filled trenches or borings. Construction activities could also damage or destroy desert pavement and biological crusts (if present), thus increasing the rate of soil erosion.

The modification of streams, washes, and drainages would alter surface runoff timing and drainage patterns and could increase peak flows and water flow velocities of downgradient streams. All these processes could lead to increased erosion, sediment transport, and sediment deposition impacts. The discharge of wastewater and stormwater could also increase the flow rates of the receiving surface waters. Land disturbance impacts are expected to be greater in areas occupied by an alluvial fan or other landscape features with topography than in flat regions. The modification of ephemeral water bodies could also result in some areas of the landscape receiving less water as the result of concentrating drainage patterns. The loss or modification of ephemeral water bodies either by erosion or drainage alterations could result in the loss of vegetation and landscape features that generate critical habitat for desert wildlife.

2.15.2.3 Floodplains and Other Surface Water Features

Adverse effects on existing floodplains, wetlands, playas, and riparian areas could result from land disturbance activities. The land disturbance activities can alter the natural drainage patterns (described previously) that feed into these receiving areas. Land disturbance activities could affect floodplains, wetlands, and riparian areas on-site as well as downstream of the development site. Modification to these areas could cause flooding and erosion issues and could destroy critical habitats for plants and animals. Reductions to the connectivity of these areas with existing surface waters and groundwater could (1) affect wildlife corridors and (2) limit water availability and thus alter the ability of the area to support vegetation, resulting in impacts on aquatic habitat quality. In addition, increases in water and sediment transport to floodplains, wetlands, and riparian areas could result in localized erosion and sedimentation that can have detrimental effects on the ecological and hydrological functioning of these habitats. Potential effects on habitat include inhibiting growth of vegetation, clogging groundwater recharge areas, and changing the overall stability of the natural landscape.

2.15.2.4 Degradation of Water Quality

Both groundwater and surface water quality could be affected by construction activities. These activities include land disturbance–related soil erosion and sedimentation; fuel and chemical spills; storage and potential treatment of wastewater; and the potential application of pesticides, herbicides, and dust suppressant chemicals. Surface water quality could be adversely affected in areas hydraulically downstream and downwind from disturbed areas, including staging areas, construction sites, access roads, soil piles, foundation excavation, trenching, and borrow pits. Sediments from these disturbed areas can be transported by wind or water to adjacent water bodies (including streams, lakes, playas, wetlands, and washes) and degrade water quality through the addition of sediments, dissolved solids, metals, and organics.

Improperly designed groundwater wells could create conduits for poor-quality groundwater, as well as contaminants, to move between aquifers. Chemical and fuel spills could infiltrate to groundwater and could spread by surface runoff to surface water features. Wastewater will most likely be contained in portable toilets, on-site sewage lagoons, or septic tanks with leach fields. Leaky wastewater storage containers could degrade groundwater and surface water quality and introduce pathogens. The leaching or transport of pesticides and herbicides, if used, could negatively affect downstream waters or groundwater. Dust suppression by water or water mixed with dust suppression chemicals could degrade water quality by increasing total dissolved solids (TDS) concentrations in nearby water bodies and groundwater through evaporation or through the use of poor-quality groundwater or recycled water.

2.15.3 Operation

Potential impacts on water resources during the operation phase of a solar project include land disturbance-related issues, water use, wastewater generation, and potential chemical releases affecting water quality. Land disturbance activities include truck traffic, soil disturbance while servicing and cleaning mirrors/panels, and surface runoff and erosion resulting from the altered hydrology imposed by the solar facility structures. Impacts associated with land disturbance from truck traffic and maintenance are considered minor given the limited temporal and spatial extent over which these activities would occur during the operation phase.

Groundwater or surface water withdrawals would likely continue in the operation phase to meet project water needs once the solar facility was constructed, unless recycled water was available for use by the facility. Water needs would depend on the solar technologies and their associated structures and operational activities. Groundwater withdrawals cause a cone of depression around a pumping well to expand until groundwater inflow is balanced by the rate of water extraction. If stream water were used, water withdrawal would lower streamflow downstream from water intake areas. Loss of streamflow could reduce groundwater recharge and floodplain interaction affecting riparian vegetation and could affect habitat (i.e., certain flow and sediment conditions) that fish rely on to survive.

Sanitary wastewater would be generated by the solar facility workforce, and additional industrial wastewater can come from blowdown water for technologies that use wet cooling. It is likely that these two sources of wastewater would be contained or treated separately and would comply with federal, state, and local regulations regarding wastewater. Wastewater generated during the operation phase could be contained in portable toilets for smaller facilities not generating blowdown water, on-site sewage lagoons, or septic tanks with leach fields. On-site treatment of wastewater may be accomplished by using evaporation ponds (industrial wastewater only) or septic tank-leach fields. In addition, any wastewater or treated effluent from on-site wastewater treatment discharged to a surface water body would need National Pollutant Discharge Elimination System (NPDES) permitting. Off-site treatment of wastewater would require managers to coordinate with local wastewater treatment facilities and comply with federal, state, and local regulations regarding the storage and transport of wastewater. Impacts from the storage and potential treatment of wastewater on-site are primarily associated with the leakage of wastewater from storage containers. Wastewaters could introduce organics, salts, metals, and pathogens to nearby surface waters and groundwater, resulting in degraded water quality and potential public health concerns.

Water quality could also be degraded during the operation phase as a result of the application of herbicides and pesticides used for controlling on-site vegetation. In addition, accidental spills of chemicals from a solar energy facility (e.g., HTFs, TES medium, and dielectric fluids) could contaminate nearby surface waters and groundwater.

2.15.4 Decommissioning/Reclamation

During the removal of surface structures, the on-site water needs would be on the same order of magnitude as those for construction. Water would most likely be used to restore the vegetation on-site as well. Any groundwater wells no longer in use would be sealed and abandoned in place following practices established by the local and state regulations.

If water withdrawal from an aquifer were discontinued, groundwater surface elevations would start to recover if the capacity of the aquifer has not been lost due to excessive withdrawals in the basin. Aquifer recovery could take a much longer period of time than other decommissioning activities and is dependent upon many factors relating to the geology of the aquifer, other water extractions in the basin, and even climate conditions. The time lag for aquifer recovery could be substantial depending on the conditions of the aquifer and the extent and duration of the pumping. If withdrawals from a stream were discontinued, the streamflow would return to preconstruction levels. However, the potential impacts due to soil disturbance would largely be the same as those described for the construction phase.

This page intentionally left blank.

3 MITIGATION MEASURES

3.1 INTRODUCTION

General and resource-specific mitigation measures can be implemented to avoid or reduce impacts from solar energy development. Project- and site-specific factors should be evaluated to determine whether an impact can be mitigated, what specific mitigation measures can be taken, and how effective and costly such measures might be.

The following sections present mitigation measures in general terms, based on the discussion of general impacts on potentially affected resources discussed in Chapter 2. The mitigation measures are presented here by resource and should be viewed as being over and above the requirements of applicable laws and regulations (although there may be some overlap).

Many impacts can be mitigated when considered during the siting and design phase. A final set of mitigation measures for any project should be developed in consultation with the appropriate federal resource management agencies and stakeholders. These consultations should be conducted early in the project development process, preferably before the project siting and design are finalized.

3.2 ACOUSTICS (NOISE)

Noise-related impacts are related to the source of the noise (e.g., vehicles, construction equipment, workers, explosives, and project facility components), its proximity to the noise receptor (e.g., humans and wildlife), and the times of day at which noise-producing activities are taking place.

3.2.1 Siting and Design Mitigation Measures

Siting and design considerations that mitigate noise-related impacts include the following:

- Take measurements to assess the existing background noise levels at a given site and compare them with the anticipated noise levels associated with the proposed project. Nearby residences and likely sensitive receptors should be identified at this time.

- Locate all stationary construction equipment (i.e., compressors and generators) as far as practicable from nearby residences and other sensitive receptors.

- Locate permanent sound-generating facilities (e.g., compressors, pumps) away from residences and other sensitive receptors. In areas of known conflicts, consideration should be given to the installation of acoustic screening.

- Locate noise sources to take advantage of topography and distance, and construct engineered sound barriers and/or berms.

- Incorporate low-noise systems, such as ventilation systems, pumps, generators, compressors, and fans.

3.2.2 General Mitigation Measures

General mitigation practices and principles that could apply to any or all phases of a solar project include the following:

- Limit noisy activities (including blasting) to the least noise-sensitive times of day (weekdays only, between 7 a.m. and 10 p.m.).

- Schedule different noisy activities (e.g., blasting and earthmoving) to occur at the same time, since additional sources of noise generally do not add a significant amount of noise. That is, less-frequent noisy activities would be less annoying than frequent less-noisy activities.

- All equipment should have sound-control devices no less effective than those provided on the original equipment. Muffle and maintain all construction equipment used.

- Use exhaust silencers, quieter cooling fans, and optimized acoustical pipe lagging (acoustical wrapping) to minimize compressor noise.

- Place noisy equipment, such as steam turbine generators, in enclosures.

- If a wet cooling tower is in use, locate the louvered side facing away from sensitive receptors. If possible, locate the cooling tower in such a manner that nearby equipment can act as a barrier and provide additional noise reduction. Select quieter fans in the design and operate fans at lower speed, particularly if operating at night. If a high degree of noise reduction is required, install silencers on the fan stacks.

- Notify nearby residents in advance when blasting or other noisy activities are required.

- Route heavy truck traffic away from residences and other sensitive receptors.

- Operate vehicles traveling within and around the project area in accordance with posted speed limits to reduce vehicle noise levels.

- Post warning signs in high-noise areas and implement a hearing protection program for work areas where noise exceeds 85 dBA.

- Implement a noise complaint process and hotline, including documentation, investigation, evaluation, and resolution of legitimate project-related noise complaints.

3.2.3 Project Phase-Specific Mitigation Measures

3.2.3.1 Construction

Project-specific mitigation practices and principles that could apply to the construction phase of a solar project include the following:

- Schedule construction activities and traffic to minimize disruption to nearby residents and existing operations surrounding the project area.

- Implement noise control measures (e.g., erection of temporary wooden noise barriers) if noisy activities are expected near sensitive receptors.

- Limit low-altitude (under 1,500 ft. [457 m]) helicopter flights for installation of transmission lines near noise-sensitive receptors to locations where only helicopter activities can perform the installation.

3.2.3.2 Operation

Project-specific mitigation practices and principles that could apply to the operation phase of a solar project include the following:

- If noise from a transformer becomes an issue, a new transformer with reduced flux density, which generates lower noise levels, could be installed. Alternatively, barrier walls, partial enclosures, or full enclosures could be adopted to shield or contain the transformer noise.

- Manage noise levels from cooling systems equipped with TES and dish engine technology so levels at the nearest residences and sensitive receptor areas near the facility boundary are kept within applicable guidelines.

3.2.3.3 Decommissioning/Reclamation

Project-specific mitigation practices and principles that could apply to the decommissioning/reclamation phase of a solar project include the following:

- Apply the same mitigation measures as during construction.

3.3 AIR QUALITY

Impacts on air quality are related to project emissions (e.g., fugitive dust, air releases).

3.3.1 Siting and Design Measures

Siting and design considerations that mitigate impacts on air quality include the following:

- Surface access roads and on-site roads with aggregate materials, wherever appropriate. Pave the access road to the main power block and maintenance building.

- Minimize the amount of disturbance and areas cleared of vegetation. Stage construction to limit the area exposed at any one time.

3.3.2 General Mitigation Measures

General mitigation practices and principles that could apply to any or all phases of a solar project include the following:

- Use equipment that meets emission standards specified in the state code of regulations and meets the applicable EPA Tier 3 and Tier 4 emissions requirements.

- Minimize on-site vehicle use and require routine preventive maintenance, including tune-ups to meet the manufacturer's specifications, to ensure efficient combustion and minimal emissions.

- Prepare a project- and location-specific dust abatement plan.

- Use dust abatement techniques on unpaved, unvegetated surfaces to minimize airborne dust and during earthmoving activities; prior to clearing; before excavating, backfilling, compacting, or grading; and during blasting.

- Install wind fences around disturbed areas that could affect the area beyond the site boundaries (e.g., nearby residences).

- Avoid chemical dust suppressants that emit volatile organic compounds within or near ozone nonattainment areas.

- Keep dust palliatives out of sensitive soils and streams.

- Require emission control devices on drilling equipment and project vehicles and specify use of low-sulfur fuels to reduce emissions.

- Post and enforce speed limits to reduce airborne fugitive dust from vehicular traffic. Limit travel to stabilized roads.

- Schedule construction activities during periods of low winds to reduce fugitive dust. Site-specific wind speed thresholds should be determined on the basis of soil properties determined during site characterization.

- Conduct slash burning, if necessary, in compliance with open burning permit requirements.

- Cover construction materials, storage piles, and stockpiled soils if they are a source of fugitive dust.

- Use compatible native vegetative plantings to limit dust generation from stockpiles that will be inactive for a relatively long period.

- Train workers to handle construction materials and debris during construction and dismantlement to reduce fugitive emissions.

- Keep soil moist while loading into dump trucks.

- Keep soil loads below the freeboard of the truck.

- Minimize drop heights when loaders dump soil into trucks.

- Tighten gate seals on dump trucks.

- Cover vehicles that transport loose materials before traveling on public roads.

- Power compressors and pumps by electric motors where strict air emission rules would preclude the use of gas or oil.

- Access transmission lines from public roads and designated routes to minimize fugitive dust emissions.

3.3.3 Project Phase-Specific Mitigation Measures

3.3.3.1 Construction

Project-specific mitigation practices and principles that could apply to the construction phase of a solar project include the following:

- Limit access to the construction site and staging areas to authorized vehicles only through the designated treated roads.
- Stage construction to limit the amount of exposed area.
- Shut down idling construction equipment.
- Inspect and clean the tires of construction-related vehicles to be free of dirt before they enter paved public roadways, and clean any visible trackout dirt.
- Salvage topsoil from excavation and construction activities and reapply during reclamation or any interim reclamation in areas not needed for facility operation.
- Limit all soil-disturbing activities and travel on unpaved roads under high-wind events.

3.3.3.2 Operation

Project-specific mitigation practices and principles that could apply to the operation phase of a solar project include the following:

- Comply with state emission standards for all sources of combustion.
- Monitor and implement dust control mitigation measures (as given in Sections 3.3.2 and 3.3.3.1 above) for portions of facilities that are maintained as free of any vegetation.
- Use alternative fuel, electric, or latest model-year vehicles as facility service vehicles.

3.3.3.3 Decommissioning/Reclamation

The decommissioning/reclamation phase of a solar project should apply the same mitigation measures as during construction.

3.4 CULTURAL RESOURCES

Impacts on cultural resources (which also may be related to Native American concerns) are related to the project footprint (e.g., land disturbance, erosion, changes in runoff patterns, and hydrological alterations) and project emissions (e.g., sediment runoff, water releases).

3.4.1 Siting and Design Mitigation Measures

Siting and design considerations that mitigate impacts on cultural resources include the following:

- Locate the facility on previously disturbed lands, and lands determined by archeological inventories to be devoid of historic properties.

- Conduct a records search to determine the presence of known archaeological sites and historic structures within the area of potential effect. Identify the need for an archaeological and/or architectural survey. Conduct a survey, if needed.

- Determine whether sites and structures within the area of potential effect (APE) meet the significance criteria for listing as eligible sites in the NRHP. The APE is the geographic area or areas within which an undertaking (project activity, program, or practice) may cause changes in the character or use of any cultural resources that are present.

- Consult with State Historic Preservation Offices, Native American governments, and any other consulting parties early in the planning process to identify issues and concerns regarding the proposed solar energy project.

- Evaluate the visual impacts on historic trails if the project includes remnants of a National Historic Trail, is located within the viewshed of a National Historic Trail's designated centerline, or includes or is within the viewshed of a trail eligible for listing on the NRHP. Include mitigation measures for visual impacts as stipulations in the Plan of Development.

- Restrict or prohibit surface disturbance within the viewshed of traditional cultural properties, sacred sites, or historic trails when their NRHP eligibility is tied to their visual setting.

- Prepare a cultural resources management plan, if cultural resources are present at the site or if areas with a high potential to contain cultural material have been identified.

3.4.2 General Mitigation Measures

General mitigation practices and principles that could apply to any or all phases of a solar project include the following:

- Follow guidance in the cultural resources management plan. For example:
  - If resources eligible for listing on the NRHP are present, modify the Plan of Development to avoid significant cultural resources. If avoidance is not possible, conduct appropriate cultural resource recovery operations or alternative mitigations as determined in consultation with the appropriate SHPOs and Native American tribes, as required under the National Historic Preservation Act.
  - Periodic monitoring of significant cultural resources in the vicinity of the development (including areas where new road access has been provided) may be required to reduce the potential for looting and vandalism. Should loss or damage be detected, consult with the appropriate SHPOs and Native American tribes immediately to determine additional protective measures or further action to mitigate the impact.
  - An unexpected discovery of cultural resources during any phase of the project shall result in a work stoppage in the vicinity of the find until the resources can be evaluated by a professional archaeologist. The area of the find shall be protected to ensure that the resources are not removed, handled, altered, or damaged while they are being evaluated and to ensure that appropriate mitigative or protective measures can be developed and implemented.

- Use training/educational programs for solar company workers to reduce occurrences of disturbances, vandalism, and harm to nearby historic properties. Educate workers and the public on the consequences of unauthorized collection of artifacts.

- During all phases of the project, keep equipment and vehicles within the limits of the initially disturbed areas.

- Employ standard noise mitigation measures for solar facilities located near sacred sites to minimize the impacts of noise on culturally significant areas.

- Employ health and safety mitigation measures for the general public for solar facilities located near Native American traditional use areas in order to minimize potential health and safety impacts on Native Americans.

- Avoid known human burial sites. Work with Native American tribes for general guidance on the treatment of any cultural items (as defined by NAGPRA) that might be exposed.

- Avoid visual intrusion on sacred sites through the selection of the solar facility location and solar technology. When complete avoidance is not possible, the affected tribe(s) shall be consulted to formulate a mutually acceptable plan to mitigate or reduce adverse effects.

- Avoid rock art (panels of petroglyphs and/or pictographs). When avoidance is not possible, mitigation plans shall be formulated in consultation with the appropriate tribal cultural authorities.

- Avoid springs and other water sources that are or may be sacred or culturally important. When avoidance is not possible, develop mitigation in consultation with the appropriate Native American tribe(s).

- Avoid culturally important plant species and wildlife species and their habitats. When avoidance is not possible, develop mitigation and monitoring procedures in consultation with the affected Native American tribe(s).

- Avoid activities incompatible with the nature and purposes of designated National Scenic and Historic Trails.

- Train facility personnel regarding their responsibilities to protect any known resources of importance to federally recognized Native American tribes.

3.4.3 Project-Specific Mitigation Measures

3.4.3.1 Construction

- Employ cultural field monitors (appropriate for the anticipated resource) to monitor ground-disturbing activities.

- Halt work and protect the area in the vicinity of an unexpected cultural resource discovery.

3.4.3.2 Operation

- Train facility personnel regarding their responsibilities to protect historic properties and any known resources of importance to federally recognized Native American tribes.

3.4.3.3 Decommissioning/Reclamation

- Confine reclamation and decommissioning activities to previously disturbed areas and existing access roads.

- Evaluate structures to be demolished for their significance, employing professionally qualified architects or historic architects. If structures slated for demolition are found to be eligible for listing on the NRHP, they should be recorded to Historic American Building Survey and/or Historic American Engineering Record standards before alteration or removal.

3.5 ECOLOGICAL RESOURCES

Impacts on ecological resources are related to the project footprint (e.g., land disturbance, habitat destruction, erosion, changes in runoff patterns, and hydrological alterations), project emissions (e.g., fugitive dust, sediment runoff, air releases, water releases), and resource use (e.g., water extraction).

3.5.1 Siting and Design Mitigation Measures

Siting and design considerations that mitigate impacts on ecological resources include the following:

- Review existing information on species and habitats in the project area. Contact appropriate agencies early in the planning process to identify potentially sensitive ecological resources that may be present in the project area.

- Conduct pre-disturbance surveys to identify and delineate the boundaries and buffers for important, sensitive, or unique habitats in the project vicinity. These surveys should be conducted by qualified biologists following accepted protocols established by the U.S. Army Corps of Engineers (USACE), BLM, U.S. Fish and Wildlife Service (USFWS), or other federal or state regulatory agencies, as determined appropriate by the managing agency.

- Conduct pre-disturbance surveys and locate staging, site facilities, and parking areas away from important ecological resources (e.g., wetlands; water bodies; important upland habitats; sensitive species populations including nesting birds, raptors, and bats; Areas of Critical Environmental Concern). Flag areas of active nests and keep activity away from active nests.

- Design projects to avoid, minimize, mitigate, and monitor impacts on wetlands, waters of the United States, and aquatic habitats (e.g., streams and springs with unique flora or fauna).

- Avoid surface water or groundwater withdrawals that affect sensitive habitats and habitats occupied by special status species. The capability of local surface water or groundwater supplies to provide adequate water should be considered early in project siting and design.

- Minimize habitat loss, habitat fragmentation, and resulting edge habitat due to project development. Locate staging and parking areas within the site of the facility to minimize habitat disturbance.

- Ensure protection of important resources by establishing protective buffers to exclude unintentional disturbance.

- Use existing facilities and previously disturbed areas (e.g., access roads, graded areas) to the extent possible to minimize the amount of new disturbance. New access roads and rights-of-way (ROWs) should be configured to avoid high-quality habitats and minimize habitat fragmentation.

- Develop a site and ROW reclamation plan that addresses both interim and final reclamation requirements and that identifies vegetation, soil stabilization, and erosion reduction measures.

- Monitor and eradicate invasive species, including aquatic species, to prevent them from spreading. For example:
  - Use certified weed-free seed and mulching;
  - Wash vehicles;
  - Decontaminate equipment used in surface water, especially equipment used to convey water (e.g., pumps);
  - Educate project personnel on weed identification, the manner in which weeds spread, and methods for treating infestations;
  - Limit vegetation maintenance and perform maintenance mechanically rather than with herbicides;
  - Retain short (i.e., less than 7 inches tall) native plant species during operation and maintenance activities; and
  - Prohibit the use of fill materials from areas with known invasive vegetation problems.

- Minimize the amount of land disturbance and develop and implement stringent erosion and dust control practices.

- Minimize the number of stream crossings when locating access roads. When stream crossings cannot be avoided, use fill ramps rather than stream bank cutting. Design stream crossings to provide instream conditions that allow for and maintain movement and safe passage of fish.

- Develop site fencing in conjunction with appropriate natural resource agencies (e.g., to either allow or prevent site access by wildlife species such as the kit fox or desert tortoise).

- Do not plant species that would attract wildlife along high-speed or high-traffic roads.

- Locate tall structures to avoid known flight paths of birds and bats.

- Transmission line conductors should span important or sensitive habitats within limits of standard structure design.

- Install cattle guards and fences to exclude livestock and wildlife from project facilities and control their access to roads.

- Identify surface water runoff patterns and avoid placing facilities or roads in drainages. Use construction methods that will prevent or minimize soil deposition and erosion.

- Design pipelines that transport hazardous liquids that will pass through habitats containing sensitive species with block or check valves on both sides of the habitat.

- Design stream crossings to maintain uninterrupted movement and safe passage of fish during all project periods.

- Locate and design individual project facilities to minimize disruption of animal movement patterns and connectivity of habitats.

- Design water intake facilities to minimize the potential for aquatic organisms from surface waters to be entrained in cooling water systems.

- Avoid siting solar facilities near open water or other areas that are known to attract large numbers of birds.

- Design transmission facilities to discourage perching and nesting and to minimize the potential for raptors and other birds to collide with or be electrocuted by them.

3.5.2 General Mitigation Measures

General mitigation practices and principles that could apply to any or all phases of a solar energy project include the following:

- Consult with the USFWS upon discovery of federally listed threatened and endangered species during any phase of the project, and determine an appropriate course of action to avoid, minimize, or mitigate impacts.

- Designate a qualified biologist to oversee compliance with all mitigation measures related to the protection of ecological resources throughout all project phases. Inform project personnel that only qualified biologists are permitted to handle listed species according to specialized protocols approved by the USFWS.

- Establish compensatory mitigation and monitoring of significant direct, indirect, and cumulative impacts on, and loss of habitat for, special status plant and animal species.

- Develop a Nuisance Animal and Pest Control Plan; an Integrated Vegetation Management Plan; an Ecological Resources Mitigation and Monitoring Plan; a Water Resources Monitoring and Mitigation Plan; a Spill Prevention and Emergency Response Plan; a Stormwater Pollution Prevention Plan; a Fire Management and Protection Plan; and a Trash Abatement Plan for each project.

- Educate workers regarding the occurrence of important resources in the area and the importance of their protection, including the appropriate regulatory requirements.

- Schedule activities to avoid disturbance of resources during critical periods of the day (e.g., night) or year (e.g., periods of courtship, breeding, nesting, lambing, or calving).

- Instruct employees, contractors, and site visitors to avoid harassment and disturbance of wildlife, especially during reproductive (e.g., courtship and nesting) seasons. In addition, do not allow pets at the project site.

- Report observations of potential wildlife problems, including traffic delays caused by wildlife in roads and wildlife mortality, to the appropriate wildlife agency.

- Instruct project personnel that only qualified biologists are permitted to handle listed species.

- Prohibit project personnel from bringing firearms to project sites.

- Employ noise reduction devices (e.g., mufflers). Explosives should be used only within specified times and at specified distances from sensitive wildlife or surface waters.

- Establish buffer zones around raptor nests, bat roosts, and other biota and habitats of concern such as rare plants, if site studies show that proposed facilities would pose a significant risk to these species.

- Use low water crossings as a last resort, and then only during the driest time of the year.

- Maintain native vegetation cover and soils to the extent possible. Grading should be minimized.

- Reduce habitat disturbance by keeping vehicles on established access roads, limiting speeds in areas occupied by special status species, and by minimizing foot traffic in undisturbed areas.

- Minimize the number of areas where wildlife could hide or be trapped.

- Avoid the spread of invasive nonnative plants by keeping vehicles and equipment clean. Reseed disturbed areas with native plants during interim and final reclamation.

- Regularly monitor the solar field, access roads, and ancillary facilities for invasive nonnative plant species establishment. Initiate control measures immediately upon evidence of invasive species introduction or spread.

- Limit vegetation management and use mechanical controls in preference to herbicides/pesticides. Where required, limit herbicide/pesticide use to non-persistent, immobile herbicides/pesticides and apply only in accordance with label and application permit directions and stipulations for terrestrial and aquatic applications.

- Apply erosion controls that comply with local, state, or federal standards. Apply practices such as jute netting, silt fences, and check dams near disturbed areas.

- Use dust abatement techniques on unpaved, unvegetated surfaces to minimize airborne dust.

- Apply spill prevention practices and response actions in refueling and vehicle-use areas to minimize accidental contamination of habitats.

- Address spills immediately per the appropriate spill management plan, and initiate soil cleanup and soil removal if needed.

- Turn off all unnecessary lighting at night to avoid attracting migratory birds.

- Avoid the take of golden eagles and other raptors.

- Require an adequate number of biological monitors to be on-site during initial site preparation and during the construction and decommissioning periods to monitor, capture, and relocate animals that could be harmed and unable to leave the site on their own.

- Conduct seasonally appropriate inspections by a qualified biologist or team of biologists to ensure that important or sensitive species or habitats are not present in or near project areas.

- Avoid the use of guy wires to minimize impacts on birds and bats. If guy wires are necessary, install permanent markers (e.g., bird flight diverters) to increase their visibility.

3.5.3 Project Phase-Specific Mitigation Measures

3.5.3.1 Site Evaluation

Project phase-specific mitigation practices and principles that could apply to the site evaluation phase of a solar energy project include the following:

- Avoid entering aquatic habitats such as springs and seeps until surveys have been completed by qualified biologists.

- Locate meteorological towers and solar sensors to avoid sensitive habitats (e.g., wetlands, springs, seeps, ephemeral streams) or areas where wildlife is known to be sensitive to human activities.

- Clearly mark habitats or locations to be avoided.

3.5.3.2 Construction

Project phase-specific mitigation practices and principles that could apply to the construction phase of a solar energy project include the following:

- Conduct blasting for raw materials only within specified times and at specified distances from sensitive wildlife or surface waters as specified by state or federal agencies.

- Roll and compact on-site construction access routes. Keep vehicles on access roads and limit foot and vehicle traffic through undisturbed areas. After construction is completed, rake and reseed with seeds from low-stature plant species.

- Maintain noise-reduction devices (e.g., mufflers) in good working order on vehicles and construction equipment.

- Refuel in a designated fueling area that includes a temporary berm to limit the spread of any spill. Use drip pans during refueling to contain accidental releases and under fuel pump and valve mechanisms of any bulk fueling vehicles parked at the construction site.

- Establish a controlled inspection and cleaning area to visually inspect arriving construction equipment if it is arriving from locations with known invasive vegetation problems. Clean the vehicles to remove and collect noxious weed seeds that may be adhering to tires and other equipment surfaces.

- Store construction debris where it will not be in contact with aquatic habitats.

- Construct trench breakers and/or seal the trench bottom where a pipeline trench may drain a wetland. Backfill any open trenches as quickly as possible.

- Salvage Joshua trees (*Yucca Brevifolia*), other Yucca species, and most cactus species.

- Place mechanisms to visually warn birds (permanent markers or bird flight diverters) on transmission lines at regular intervals to prevent birds from colliding with the lines.

- Construct, improve, and maintain access roads to minimize potential wildlife/vehicle collisions and facilitate wildlife movement through the project area.

- Advise personnel to minimize stopping and exiting their vehicles in the winter ranges of large game while there is snow on the ground.

- Use appropriate personnel (e.g., project or agency wildlife biologist) to move live, injured, or dead wildlife off roads, ROWs, or the project site.

- Close roads or implement other travel modifications (e.g., lower speed limits, no foot travel) during crucial periods (e.g., extreme weather conditions, calving/fawning seasons, raptor nesting).

- Cut trees in stream buffers that would grow into a transmission line conductor clearance zone within 3 to 4 years.

- Use helicopters where access roads do not exist or where access roads could not be constructed without significantly impacting habitats.

- Initiate interim site reclamation activities as soon as possible after construction activities are completed. Reclaim these areas using weed-free native shrubs, grasses, and forbs. Use local designed seed mixes in re-vegetation/stabilization efforts. Revegetate the project area with grasses or forbs to limit dust generation.

3.5.3.3 Operation

Project phase-specific mitigation practices and principles that could apply to the operation phase of a solar energy project include the following:

- Depending on the ecological resources present, consider steps to minimize the amount of vehicular traffic and human activity.

- Reestablish and maintain as many areas as possible in conditions that are as natural as possible.

- Minimize lighting to what is needed for safety and security objectives. Turn off all unnecessary lighting at night to limit attracting migratory birds or special status species.

- Use audio visual warning system (AVWS) technology for any structures exceeding 200 ft (60 m) in height to minimize bird strikes.

- Fence and net evaporation ponds to prevent use by wildlife, and implement a mosquito abatement program.

- Install fish screens on cooling water intakes.

- Use drip pans during refueling to contain accidental releases.

- Conduct translocation and post-translocation monitoring for special status species in coordination with appropriate federal and state agencies. Release individuals to approved protected off-site locations.

- Monitor predation of special status species from ravens and other species attracted to developed areas.

- Monitor and report bird mortality species (e.g., raptors) associated with transmission lines.

- Monitor groundwater withdrawal effects on plants.

- Monitor unavoidable impacts on wetlands and waters of the United States.

- Inform personnel of the potential for wildlife interactions around facility structures.

- Notify the appropriate wildlife agency when raptor nests are located on a transmission line support structure. Remove raptor nests only when they are inactive (e.g., no eggs or young). Report relocated or destroyed nests to the appropriate wildlife agency.

- Remove raven nests only when they are inactive. An MBTA take permit is required from the USFWS.

- Minimize removal of deadfall or overhanging vegetation at stream crossings.

3.5.3.4 Decommissioning/Reclamation

Project phase-specific mitigation practices and principles that could apply to the decommissioning/reclamation phase of a solar energy project include the following:

- Develop and implement a Decommissioning and Site Reclamation Plan specific to the project.

- Apply mitigation measures developed for the construction phase to similar activities during the decommissioning and reclamation phase.

- Maximize the area reclaimed to minimize habitat loss and fragmentation.

- Expedite the re-establishment of vegetation for site stabilization.

- Leave facility fencing in place for several years to preclude large mammals and vehicles from disturbing revegetation efforts.

- Remove all aboveground structures from the site and avoid leaving debris on the ground where wildlife regularly moves.

- Backfill any foundations, pits, and trenches, preferably with excess excavation material generated during prior ground-disturbing activities.

- Reclaim access roads when they are no longer needed.

- Use topsoil removed during the beginning of the project or during decommissioning activities to reclaim disturbed areas.

- Reestablish the original grade and drainage pattern to the extent practicable.

- Implement the site reclamation plan. For example:
  - Reclaim all areas of disturbed soil using weed-free native shrubs, grasses, and forbs.
  - Restore the vegetation cover, composition, and diversity to values commensurate with the ecological setting.
  - Review reclamation efforts and weed control periodically until the site is determined to have been successfully reclaimed.

3.6 ENVIRONMENTAL JUSTICE

Mitigation of environmental justice impacts, specifically those associated with visual impacts, may be required. A final set of mitigation measures for any solar project should be developed in consultation with the appropriate federal resource management agencies and stakeholders. These consultations should be conducted early in the project development process, preferably before the project siting and design are finalized.

3.6.1 Siting and Design Mitigation Measures

Siting and design considerations that mitigate environmental justice impacts include the following:

- Locate facilities to minimize contrast with scenic views and use construction materials that minimize scenic contrast.

- Avoid traditional and cultural sites important to low-income and minority populations.

3.6.2 General Mitigation Measures

General mitigation practices and principles that could apply to any or all phases of a solar energy project include the following:

- Mitigate any impact that has been determined to adversely affect and cause a disproportionate effect on minority or low-income populations through appropriate measures, specific to the impact. For example, if water quality impacts are causing a disproportionate adverse effect on minority or low-income populations, mitigate the water quality impacts to address the environmental justice issue.

- Develop and implement focused public information campaigns to provide technical and environmental health information directly to low-income and minority groups or to local agencies and representative groups. Key information would include the scale and time line of the project and extent of any likely impact on air quality, drinking water supplies, subsistence resources, public services, and the relevant preventative measures that may be taken. Other information such as planning activities that may be initiated to provide local infrastructure, public services, education, and housing should also be provided, as appropriate.

- Provide financial support to local libraries in low-income and minority communities for the development of information repositories on solar energy.

- Provide vocational training for the local low-income and minority workforce to develop skills required by the solar energy industry.

- Provide community health screenings for low-income and minority groups.

- Develop instructional materials for use in area schools to educate the local communities on the solar energy industry.

3.7 HAZARDOUS MATERIALS AND WASTE MANAGEMENT

Hazardous materials and waste impacts are related to the types and amount of equipment and machinery used for the project, the wastes they produce, and material shipments and construction waste.

3.7.1 Siting and Design Mitigation Measures

Siting and design considerations that mitigate hazardous materials and waste management related impacts include the following:

- Prepare a comprehensive list of all hazardous materials to be used, stored, transported, or disposed of during all phases of activity.

- Develop a hazardous materials management plan addressing storage, use, transportation, and disposal (interim and final) for each item in the comprehensive list. The plan should identify specifics regarding local and federal emergency response.

- Develop a waste management plan identifying anticipated solid and liquid waste streams and addressing determination, inspection and waste minimization procedures, storage locations, and waste-specific management and disposal requirements. Include a recycling strategy to be practiced by workers during all project phases.

- Develop a spill prevention and response plan for addressing storage locations of hazardous wastes, spill prevention measures, training requirements, waste-specific spill response actions, spill response kits, and notifications to authorities.

- Develop a fire management and protection plan to minimize the potential for fires associated with substances used and stored on the site, particularly the flammability of the specific heat transfer fluid used at the facility.

- Develop a stormwater management plan to ensure compliance with regulations and prevent off-site migration of contaminated stormwater or increased soil erosion.

- Develop a vegetation management plan (if the facility will use pesticides/herbicides).

- Investigate the historical use of the area to be disturbed with regard to the potential presence of hazardous materials.

- Survey project sites for unexploded ordnance, especially if projects are within 20 miles of a current U.S. Department of Defense installation or formally used defense site.

- Design and operate systems containing hazardous materials in a manner that limits the potential for their release.

- Establish measures for construction with compatible materials in safe conditions.

3.7.2 General Mitigation Measures

General mitigation practices and principles that could apply to any or all phases of a solar project include the following:

- Conduct all site characterization, construction, operation, and decommissioning activities in compliance with applicable federal and state laws and regulations.

- Implement plans for hazardous materials management, waste management spill prevention and response, stormwater management, and pesticide management. Train employees to promptly contain, report, and/or clean up any oil or hazardous material spill.

- Designate hazardous materials and waste storage areas and facilities. Limit access to designated areas to authorized personnel only. Identify authorized users for each type of hazardous material.

- Provide secondary containment for all on-site hazardous materials and waste storage, including fuel.

- Containerize and periodically remove wastes for recycling or for disposal at appropriate off-site permitted disposal facilities.

- Employ "just in time" ordering procedures to limit the amounts of hazardous materials present on the site.

- Provide portable spill containment and cleanup equipment in all vehicles.

- Select pesticides/herbicides that are low in human toxicity, known to be effective against the target species, and have minimal effects on non-target species and the environment.

- Keep vehicles and equipment in good working order to prevent oil and fuel leaks.

- Maintain appropriate fire and spill response materials at equipment fueling stations; provide emergency shutoffs for fuel pumps; prohibit smoking, welding, or open flames in fuel storage and dispensing areas; and equip the area with fire suppression devices.

- Document accidental releases as to cause, corrective actions taken, and resulting environmental or health and safety impacts.

- Locate refueling areas on paved surfaces away from surface water locations.

- Establish procedures for fuel storage and dispensing that consider health and safety of personnel and methods for safe use (i.e., fire safety, authorized equipment use).

3.7.3 Project Phase-Specific Mitigation Measures

3.7.3.1 Construction

Project phase-specific mitigation practices and principles that could apply to the site evaluation phase of a solar energy project include the following:

- Dispose of construction materials, especially treated wood, in such a way that it does not come in contact with aquatic habitats.

3.7.3.2 Operation

Project phase-specific mitigation practices and principles that could apply to the operation phase of a solar energy project include the following:

- Establish schedules for the regular removal of wastes (including sanitary wastewater) for delivery by licensed haulers to appropriate off-site treatment or disposal facilities.

- Install sensors or other devices to monitor system integrity. Implement robust site inspection and repair procedures.

3.7.3.3 Decommissioning/Reclamation

Project phase-specific mitigation practices and principles that could apply to the decommissioning/reclamation phase of a solar energy project include the following:

- Apply mitigation measures developed for the construction phase to similar activities during the decommissioning and reclamation phase.

- Maintain emergency response capabilities throughout the decommissioning period as long as hazardous materials and wastes remain on-site.

- Properly designate, design, and equip temporary waste storage areas.

- Remove aboveground project components from the project area and recycle, sell as scrap, or properly dispose of at licensed waste disposal facilities.

- Remove all hazardous materials and waste and survey the area for contamination. Remediate as necessary.

3.8 HUMAN HEALTH AND SAFETY

3.8.1 Siting and Design Mitigation Measures

Siting and design considerations that mitigate health and safety related impacts include the following:

- Conduct a safety assessment to describe potential safety issues (site access, construction, work practices, hazardous materials, security, transportation of heavy equipment, traffic management, emergency procedures, wildlife encounters, and fire control and management) and measures to mitigate them.

- Develop and implement a health and safety program for workers and the public, addressing all of the safety issues identified in the assessment and all applicable safety standards, including Occupational Safety and Health Administration standard practices for the safe use of explosives and blasting agents; measures for reducing EMF exposures; and the establishment of fire safety evacuation procedures.

- Develop a glint and glare assessment, mitigation, and monitoring plan. Site and design the solar facilities to eliminate glint and glare effects on roadway users, nearby residences and commercial areas, or other sensitive viewing locations.

- Consult with local planning authorities regarding traffic and traffic hazards. Address specific issues (e.g., school bus routes and stops) in a traffic management plan or in the health and safety program.

- Address any potential adverse impacts of the solar facility and associated transmission lines and substations on nearby residences and occupied buildings from noise, sun reflections, or EMF in the project design.

- Comply with Federal Aviation Administration (FAA) regulations, including lighting requirements, to avoid potential safety issues associated with proximity to airports, military bases or training areas, or landing strips.

- Design electrical systems to meet all applicable safety standards.

- Fence the site to prevent public access.

3.8.2 General Mitigation Measures

General mitigation practices and principles that could apply to any or all phases of a solar project include the following:

- Conduct all site characterization, construction, operation, and decommissioning activities in compliance with applicable federal and state occupational safety and health standards.

- Follow the health and safety program.

- Evaluate potential cancer and noncancer risks to workers from exposure to facility emission sources during construction and operation in a health risk assessment.

- Use appropriate procedures for storage and transportation of blasting equipment and explosive materials, including appropriate signage indicating its location.

- Document any event of an accidental release of hazardous substances to the environment, including a root cause analysis, appropriate corrective actions taken, and the resulting health and safety impacts.

- Reduce occupational EMF exposures, through practices such as backing electrical generators with iron, shutting down generators when work is being done near them, and limiting exposure time while generators are running.

- Require the use of alternative dielectric fluids that do not have high global warming potential, as does sulfur hexafluoride (SF_6).

- Work with appropriate agencies (e.g., DOE and the Transportation Security Administration) to address critical infrastructure and key resource vulnerabilities at solar facilities, and to minimize and plan for potential risks from natural events, sabotage, and terrorism.

- Establish safety zones or setbacks for solar facilities and associated transmission lines to prevent accidents resulting from various hazards during all phases of development.

- Conduct health and safety training activities.

- Report serious accidents to appropriate agencies.

- Implement measures to reduce site emissions and exposure risk to workers and the public.

3.9 LAND USE

Land use impacts are related to the project footprint (e.g., land disturbance, habitat destruction, erosion, changes in runoff patterns, and hydrological alterations), project emissions (e.g., fugitive dust, sediment runoff, air releases, water releases), noise levels, and resource use (e.g., water extraction).

3.9.1 Siting and Design Mitigation Measures

Siting and design considerations that mitigate land use impacts include the following:

- Contact local stakeholders early in the process to identify sensitive land uses, issues, and local plans and ordinances.

- Provide adequate public notice of planned activities.

- Evaluate current transportation systems and access routes.

- Contact the FAA early in the process to determine whether there might be potential impacts on aviation and whether any mitigation might be required to protect military or civilian aviation use.

- Minimize the amount of land disturbance and develop and implement stringent erosion and dust control practices. Site the project on previously disturbed or altered landscapes whenever possible.

- Consider alternatives if a proposed project might have an adverse effect on prime and unique farmland.

- Consolidate infrastructure requirements for efficient use of land.

- Minimize gravel placement.

- Establish a reclamation plan that addresses both interim and final reclamation requirements and ensures all impact areas are restored.

- Install site fencing to prevent public access and access by livestock and wild horses and burros. In addition, coordinate with appropriate natural resource agencies to either allow or prevent site access by certain wildlife species such as the kit fox or desert tortoise.

- Site, design, and construct solar facilities to avoid, minimize, and or mitigate impacts on the following:
  - Land use planning designations.
  - Specially-designated areas and lands with wilderness characteristics.
  - Areas of unique or important recreation resources.

- Site and design solar facilities to minimize the risk of wildland fire. Provide sufficient room for fire management within the ROW and its facilities to minimize the risk of fire moving outside the ROW and the risk of fire threatening the facility from outside.

- Develop and implement active and passive (e.g., vegetation manipulation) management actions to minimize the frequency of wildland fires and prevent the establishment of non-native, invasive species on the solar energy facility and its transmission lines and roads.

3.9.2 General Mitigation Measures

General mitigation practices and principles that could apply to any or all phases of a solar project include the following:

- Retain legal access to private, state, and public lands surrounding the solar facilities to avoid creating areas that are inaccessible to the public.
- Implement a reclamation plan.
- Evaluate the hazards associated with the heights of facilities and the glare from reflective surfaces with local airport operators.
- Depending on the individual site, consider steps to minimize the amount of vehicular traffic and human activity.
- Keep gates and fences closed and in good repair to contain livestock.
- Compensate farmers or ranchers for crop or forage losses.
- Compensate property owners for relocation of their homes, in the event that relocation is unavoidable.
- Restore lost agricultural lands at the end of the project.
- Construct, improve, and maintain roads to minimize their impact on grazing operations. Install fencing, cattle guards, speed control, and information signs where appropriate.
- Delineate management areas and provide movement corridors for wild horses and burros. Implement traffic management measures (e.g., vehicle speed limits). Maintain access to or replace water sources.
- Develop and implement wildland fire management measures, including worker training and inspection and monitoring measures to respond to fire risk during all phases of the project.
- Replace lost recreation use acreage.
- Provide access through or around a solar energy facility to provide for adequate public access and/or recreation.

3.10 PALEONTOLOGICAL RESOURCES

Impacts on paleontological resources are related to the project footprint (e.g., land disturbance, erosion, changes in runoff patterns, and hydrological alterations) and erosion (due to sediment runoff).

3.10.1 Siting and Design Mitigation Measures

Siting and design considerations that mitigate impacts on paleontological resources include the following:

- Determine whether paleontological resources exist in the project area based on the sedimentary context, a records search of finds in the area, and/or a professional paleontological survey.

- Develop a paleontological resources management plan for areas with a high potential to contain significant fossils of scientific value.

- Prepare a mitigation plan for avoiding or removing fossils, or for monitoring construction activities.

3.10.2 General Mitigation Measures

General mitigation practices and principles that could apply to any or all phases of a solar project include the following:

- Follow guidance in the paleontological resources management plan. For example:
  - Monitoring of all excavation and earthmoving in sensitive areas by a professional paleontologist may be required.
  - A discovery of a paleontological specimen during any phase of the project could result in a work stoppage in the vicinity of the find until it can be evaluated by a professional paleontologist. The area of discovery shall be protected to ensure specimens are not removed, handled, altered, or damaged.
  - Periodic monitoring of known significant paleontological resources in the vicinity of the development (including areas where new road access has been provided) may be required to reduce the potential for looting and vandalism. Should loss or damage be detected, additional protective measures or further action (e.g., resource removal by a professional paleontologist) may be needed to mitigate the impact.

- Educate workers and the public on the consequences of unauthorized collection or sale of fossils.

- Use existing roads to the maximum extent feasible to avoid additional surface disturbance.

- During all phases of the project, keep equipment and vehicles within the limits of the previously disturbed construction area.

3.11 SOCIOECONOMICS

The economic impacts from a solar project can be positive effects of increases in employment and local revenue whereby few, if any, mitigation measures would be necessary. However, with large solar projects there are situations where existing infrastructure and social services are inadequate to meet the needs of large workforces that are not local to the area.

3.11.1 General Mitigation Measures

General mitigation practices and principles that could apply to any or all phases of a solar project include the following:

- Energy companies could work with state and local agencies/governments to develop community monitoring programs that will be sufficient to identify and evaluate socioeconomic impacts resulting from solar energy development. Monitoring programs should collect data reflecting economic, fiscal, and social impacts of the development at both the state and local level. Parameters to be evaluated could include impacts on local labor and housing markets, local consumer product prices and availability, local public services (e.g., police, fire, and public health), and educational services. Programs could also monitor indicators of social disruption (e.g., crime, alcoholism, drug use, and mental health) and the effectiveness of community welfare programs in addressing these problems.

- Energy companies could work with state and local agencies to develop community outreach programs that would help communities adjust to changes triggered by solar energy development. Such programs could include any of the following activities:
  - Establishing vocational training programs for the local workforce to promote development of skills required by the solar energy industry;
  - Developing instructional materials for use in area schools to educate the local communities on the solar energy industry;
  - Supporting community health screenings; and
  - Providing financial support to local libraries for development of information repositories on solar energy, including materials on the hazards and benefits of commercial development. Electronic repositories established by the operators could also be of great value.

3.12 SOIL RESOURCES

The main objective of the mitigation measures for soil resources is to preserve the health and functioning of project area soils by reducing or controlling the ground-disturbing activities that cause the soil impacts described in Section 2.12. Preserving the health and functioning of project area soils is also an essential step in reducing impacts on other important resources. Erosion control measures would be based on an assessment of site-specific conditions and would include minimizing the extent of disturbed areas, stabilizing disturbed areas, and protecting slopes and channels in the project area. Measures to control sedimentation would focus on retaining sediment on-site and implementing controls along the project site perimeter (CASQA 2004).

The following mitigation measures address a range of site conditions and may not be applicable to every solar project. Project developers should implement these measures, as applicable, and develop others that address unique site conditions not anticipated here. Routine site inspections should be conducted to identify and correct improperly installed, damaged, or ineffective measures. Inspections should be made more frequently during the rainy season and during and following intense rainfall events to ensure the timeliness of corrective actions.

3.12.1 Siting and Design Mitigation Measures

Siting and design considerations that mitigate impacts on soils include the following:

- Contact mineral developers early in the process to identify mineral development activities in proximity to a proposed project.

- Identify soil erosion and geologic hazard concerns onsite and in proximity to the project. Apply special siting, design, and engineering strategies in areas that involve high seismic activity or have potential for flooding or debris flow.

- Locate projects to minimize conflicts with valid mineral rights and/or ongoing mineral development.

- Minimize the footprint of disturbed areas, including the number and size/length of roads, fences, borrow areas, and laydown and staging areas, and clearly delineate the boundaries of disturbed area footprints on the ground (e.g., through the use of construction fencing).

- Site project structures and facilities to avoid disturbance in areas with existing biological soil crusts or other protective surfaces to the extent possible.

- Replant project areas with native vegetation at spaced intervals to the extent possible to break up areas of exposed soil and reduce soil loss by wind erosion.

- Avoid land disturbance (including crossings) in natural drainage systems and groundwater recharge zones, specifically ephemeral washes and dry lake beds. Locate and construct any structures crossing drainages so that they do not decrease channel stability or increase water volume or velocity. Obtain all applicable federal and state permits.

- Avoid siting solar facilities or components (e.g., heliostats, panels, dishes, and troughs) in natural drainageways.

- Maintain adequate space (i.e., setbacks) between solar facilities and natural washes to preserve their hydrological function and provide a buffer for flood control.

- Use existing roads, disturbed areas, and borrow pits to the extent possible.

- Design new roads to follow natural land contours, avoid or minimize hill cuts in the project area, and avoid existing desert washes.

- Design roads on the basis of local meteorological conditions, soil moisture, and erosion potential in order to avoid erosion and changes in surface water runoff.

- Design temporary roads with eventual reclamation in mind.

- Avoid areas with unstable slopes and identify local factors that can cause slope instability (e.g., groundwater conditions, precipitation, earthquake activity, slope angles, and the dip angles of geologic strata).

- Avoid excessive grades on roads, road embankments, ditches, and drainages, especially in areas with erodible soils.

- Avoid creating excessive slopes during site preparation and construction. Use special construction techniques, where applicable, in areas of steep slopes, erodible soil, and drainageways.

- Conduct construction in stages to limit the areas of exposed soil at any given time. For example, only land that will be actively under construction in the near term (e.g., within the next 6 to 12 months) should be cleared of vegetation.

3.12.2 General Mitigation Measures

General mitigation practices and principles that could apply to any or all phases of a solar project include the following:

- Control potential soil erosion at culvert outlets with appropriate structures.
- Clean and maintain catchment basins, roadway ditches, and culverts regularly.
- Scarify abandoned roads and roads no longer needed to increase infiltration and reduce soil compaction, then recontour and revegetate.
- Minimize ground-disturbing activities, especially during the rainy season.
- Stockpile originally excavated materials and use for backfill.
- Control the speed of vehicles and equipment on unpaved surfaces to reduce dust emissions.
- Control runoff from slope tops and direct it to settling or rapid infiltration basins (temporarily) until disturbed slopes are stabilized. Disturbed slopes should be stabilized as quickly as possible.
- Stabilize drainage crossings as quickly as possible and prevent channel erosion from runoff caused by the project.
- Retain sediment-laden waters from disturbed, active areas within the project site through the use of barriers and sedimentation devices (e.g., berms, straw bales, sandbags, jute netting, or silt fences). Such barriers and devices should not be installed in wildlife crossing areas.
- Place barriers and sedimentation devices around drainages and wetlands to prevent contamination by sediment-laden water.
- Remove sediment from barriers and sedimentation devices to restore sediment control capacity.
- Conduct routine site inspections to assess the effectiveness and maintenance requirements for erosion and sediment control systems.
- Maintain, repair, or replace barriers and sedimentation devices as necessary to ensure optimum control.
- Prepare a spill prevention plan to identify sources, locations, and quantities of potential chemical releases (through spills, leaks, or fires) and define response measures and notification requirements to be developed and followed to reduce the potential for soil contamination. The plan should also identify individuals and their responsibilities for implementing the plan.

3.12.3 Project Phase-Specific Mitigation Measures

3.12.3.1 Construction

Project phase-specific mitigation practices and principles that could apply to the construction phase of a solar energy project include the following:

- Conduct construction in stages to limit the areas of exposed soil; construction should take place over as short a timeframe as possible once ground disturbance has occurred.

- Avoid clearing and disturbing sensitive areas (e.g., steep slopes and natural drainages) and other areas outside the construction zone.

- Avoid areas with intact biological soil crusts.

- Avoid construction on wet soils.

- Bury electrical lines from solar collectors along existing features (e.g., roads) to minimize area of surface disturbance.

- Avoid creating excessive slopes during excavation and blasting operations.

- Obtain borrow material from authorized and permitted sites.

- Grade in compliance with good industry practice (e.g., the American Society for Testing and Materials [ASTM] international standard methods).

- Dispose of excess excavation materials in approved areas to control erosion and minimize leaching of hazardous materials.

- Save topsoil removed during construction and use to reclaim disturbed areas, as soon as it is possible to do so.

- Stabilize disturbed areas not actively under construction with erosion matting or soil aggregation to limit wind erosion and dust emissions.

- Stabilize soils during final landscaping of project site.

- Add erosion control structures (rock lining or apron) at culvert outlets to reduce flow velocity.

- Lessen fugitive dust emissions and site soils compaction by avoiding unpaved surfaces with construction equipment.

- Restore native plant communities by seeding and transplanting weed-free native grasses, forbs, and shrubs.

3.12.3.2 Operation

All appropriate mitigation measures developed for the construction phase should be applied to similar activities during the operation phase. In general, the area disturbed by operation of a solar energy project should be minimized (e.g., by using existing roads). In addition:

- Maintain catch basins, roadway ditches, and culverts with regular removal of sediment and debris.

3.12.3.3 Decommissioning/Reclamation

All mitigation measures developed for the construction phase should be applied to similar activities during the decommissioning/reclamation phase. In addition:

- Backfill any foundations and trenches, preferably with excess excavation material generated during the construction phase.

- Use topsoil removed during the beginning of the project or during decommissioning activities to reclaim disturbed areas.

- Reestablish the original grade and drainage pattern to the extent practicable.

- Stabilize all areas of disturbed soil using weed-free native shrubs, grasses, and forbs.

3.13 TRANSPORTATION

Transportation impacts are related to the amount and types of vehicular traffic associated with a solar project. Appropriate mitigation measures should be developed as part of the transportation plan and traffic management plan.

3.13.1 Siting and Design Mitigation Measures

Siting and design considerations that mitigate transportation related impacts include the following:

- Prepare an access road siting study and management plan incorporating road design, construction, and maintenance standards.

- Plan to use existing roads to the extent possible.

- Develop a transportation plan, particularly for oversized or overweight components specific to a solar energy development (steam turbine generators, transformers). The plan should consider component sizes, weights, origin, destination, and unique handling requirements. It should also evaluate alternate transportation approaches (barge, rail).

- Develop a traffic management plan for site access roads and for use of main public roads. The plan should incorporate consultation with local planning authorities regarding general and specific traffic issues, such as school bus routes and stops.

- Require easements for public roadway corridors through a site to maintain proper traffic flows and retain more direct routing for the local population.

- Take civil and military considerations into account to avoid runway approach patterns, low-altitude flight corridors, and military exercise areas when siting power tower–based facilities.

3.13.2 General Mitigation Measures

General mitigation practices and principles that could apply to any or all phases of a solar project include the following:

- Limit traffic to roads indicated specifically for the project. Limit use of unimproved roads to emergency use only.

- Instruct and require all personnel and contractors to adhere to speed limits to ensure safe and efficient traffic flow.

- Implement local road improvements, provide multiple site access locations and routes, stagger work schedules for different work functions (e.g., site preparation, array foundation installation, array assembly, and electrical connections), and/or implement a ride-sharing or shuttle program to minimize daily commutes of construction workers.

- Implement traffic control measures to reduce hazards for incoming and outgoing traffic and streamline traffic flow. For example, realign intersections and reduce speed limits; install traffic lights and/or other signage; and add acceleration, deceleration, and turn lanes on routes with site entrances.

- Limit construction vehicle traffic on public roadways to off-peak commuting times to minimize impacts on local commuters.

3.14 VISUAL RESOURCES

Impacts on visual resources are related to the project footprint (e.g., land disturbance); the amount and types of equipment, machinery, and vehicles; standing structures; and project emissions (e.g., fugitive dust, air releases).

3.14.1 Siting and Design Mitigation Measures

Siting and design considerations that mitigate impacts include the following:

- Involve the public in decision making regarding visual site design elements for the proposed solar energy project. Possible approaches include conducting public forums; offering tours; using computer simulation and visualization techniques in public presentations; and conducting surveys regarding public perceptions and attitudes about solar energy projects.

- Integrate the site design with the surrounding landscape. Minimize the profile of all facility-related structures to reduce visibility and visual dominance within the viewshed, particularly for facilities proposed within the foreground/middleground distance zone (0–5 miles) of sensitive viewing locations. For example:
  - Avoid placing large operations buildings on high land features and along “skylines” that are visible from nearby sensitive viewpoints. Conceal these developments or make them less conspicuous. Design and construct conspicuous components of the project to harmonize with desirable or acceptable characteristics of the surrounding environment.
  - Do not site projects and their elements next to prominent land features.
  - Site projects to avoid altering the visual setting and reducing the historic significance or function of a national park, national historic site or trail, or a cultural resource of tribal concern.
  - Minimize the number of structures and collocate facility components to the extent possible.
  - Bury electrical lines and pipelines on the site in a manner that minimizes additional surface disturbance.
  - Take advantage of both topography and vegetation as screening devices to restrict views of projects from visually sensitive areas.

- Integrate design of the solar field and associated facilities with the surrounding landscape. Incorporate the following design elements to achieve this integration:
  - If the project will be viewed against an earthen or other non-sky background, select appropriately colored materials for structures, or apply appropriate stains/coatings to blend with the project’s backdrop.
  - Employ materials and surface treatments to repeat and/or blend with the existing form, line, color, and texture of the landscape.

- Whenever possible, use materials, coatings, or paints that have little or no reflectivity.
- Assess and quantify the potential glint and glare effects on roadway users, nearby residents, commercial areas, or other highly sensitive viewing locations, and site the project properly to eliminate glint and glare effects.
- Deploy and operate mirrors to avoid high-intensity light (glare) being reflected toward off-site ground receptors. Where off-site glare is unavoidable, install fencing with privacy slats or similar screening materials.
- Provide lighting for hazard marking, safety, and other necessary needs while minimizing impacts on the night sky and nocturnal wildlife.
- Ensure that lighting for facilities does not exceed the minimum required for safety and security. Select designs that minimize upward light scattering (light pollution). Direct and shield lighting from off-site view to the extent possible. Where feasible, use timers and sensors to minimize the amount of time lights are on.
- Fully shield all permanent lighting except for collision markers required by the FAA or other emergency lighting triggered by alarms. Mount lighting so no light is emitted above an imaginary horizontal plane through the fixture.
- Prohibit the use of red or white strobe lighting.

- Consider aesthetic offsets as a mitigative option in situations where visual impacts are unavoidable, or where alternative mitigation options are only partially effective or uneconomical.

- Design linear features to follow natural land contours rather than straight lines.

- Locate linear developments at edges of natural clearings or natural lines of transition between vegetation type and topography.

- Design access in visually sensitive areas to preserve the natural landscape conditions between tower locations.

- Design and locate structures and roads to minimize cut and fill.

- Design and install natural-looking earthwork landforms, or vegetative or architectural screening, for adaptation to the surrounding landscape.

- Color treat solar panel/mirror/heliostat backs/supports and solar towers to reduce visual contrast with the landscape setting.

- Use multiple-color camouflage technology application within sensitive viewsheds and with a visibility distance that is between 0.25 and 2 miles (0.40 and 3.20 kilometers).

- Incorporate visual design elements when planning for grubbing and clearing, vegetation thinning and clearing, grading, revegetation, drainage, and structural measures.

3.14.2 General Mitigation Measures

General mitigation practices and principles that could apply to any or all phases of a solar project include the following:

- Use dust suppression techniques to minimize impacts of vehicular traffic and wind on roads and exposed soils.

- Depending on the situation, consider minimizing the amount of vehicular traffic and human activity.

- Minimize the use of signs and project construction signs. Necessary signs should be made of non-glare materials and unobtrusive colors.

- Install retro-reflective or luminescent markers in lieu of permanent lighting.

3.14.3 Project Phase-Specific Mitigation Measures

3.14.3.1 Construction

- Develop a Decommissioning and Site Reclamation Plan before construction and implement immediately after construction is completed to reduce visual contrasts associated with erosion and invasive weeds.

- Preserve existing rocks, vegetation, and drainage patterns.

- Utilize protective surface matting, brush-beating, or mowing rather than removing vegetation.

- Minimize ground disturbance and control erosion by avoiding steep slopes and by minimizing the amount of surface disturbance needed for infrastructure (e.g., roads, electrical lines). Keep equipment and vehicles within the limits of the initially disturbed areas.

- Round road-cut slopes and vary the cut-and-fill pitch to reduce contrasts in form and line. Vary the slope to preserve specimen trees and nonhazardous rock outcroppings.

- Sculpt and shape excavated bedrock landforms and color treat with a rock stain to remove any color contrast from the excavated rock faces.

- Reduce visual color contrast of graveled surfaces with approved color treatment practices.

- Restore disturbed surfaces as closely as possible to their original contour and revegetate them immediately after or contemporaneously with disturbance activities whenever possible.

- Paint culvert ends to reduce color contrasts with the existing landscape.

- Paint or coat aboveground pipelines to match their surroundings.

- Clearly delineate construction boundaries. Avoid applying paint or permanent discoloring agents to rocks or vegetation to indicate surveyor construction activity limits, and remove all stakes and flagging from the construction area and dispose of them in an approved facility.

- Use nonspecular conductors and nonreflective coatings on insulators on transmission lines.

- Mulch and spread slash from vegetation removal over fresh soil disturbances.

- Remove piles of slash and topsoil from sensitive viewing areas.

- Restore disturbed areas by spreading excess cut and fill material and revegetating with weed-free native grasses, forbs, and shrubs. Segregate cut-and-fill material to reduce color contrast. Haul away excess cut-and-fill materials.

3.14.3.2 Operation

- Maintain the site during operation of the facility. Inoperative or damaged equipment and poor housekeeping, in general, creates a poor image of the activity in the eyes of the public.

- Repaint or color-treat as needed any painted facilities and color-treated solar panel/mirror backs/supports.

- Maintain revegetated surfaces until a self-sustaining stand of vegetation is re-established, and control for noxious weeds.

- Avoid blading existing forbs and grasses adjacent to roads during road maintenance activities.

- Implement dust abatement and noxious weed control in maintenance activities.

- Use vehicle-mounted lights rather than permanently mounted lighting for nighttime maintenance activities. When possible, aim vehicle-mounted lighting toward the ground to avoid causing glare and skyglow.

3.14.3.3 Decommissioning/Reclamation

- Develop and implement a decommissioning plan (prior to construction) that includes the removal of all aboveground facilities and full reclamation of the site.

- Restore the project area to predevelopment visual conditions. Implement treatments such as enhanced contour grading, using salvaged topsoil and landscape materials from within construction areas, and thinning and feathering vegetation along project edges and establishing a native vegetation composition consistent with the form, line, color, and texture of the surrounding undisturbed landscape.

- Return access roads and the project site to as near natural contours as feasible; randomly scarify and roughen cut slopes to reduce texture contrasts with existing landscapes and aid in revegetation.

- Salvage and reapply topsoil from all decommissioning activities.

- Remove or bury gravel and other surface treatments.

- Revegetate all disturbed areas with plant species appropriate to the site, and restore rocks, brush, and forest debris to pre-existing visual conditions.

3.15 WATER RESOURCES

The main objectives of mitigation measures for water resources are (1) to promote the sustainable use of water resources through appropriate technology selection and conservation practices and (2) to protect the quality of natural water bodies (including streams, wetlands, ephemeral washes, and floodplains, as well as groundwater aquifers) in and around solar energy facilities. An important aspect of implementing these measures is coordination with federal, state, and local agencies that regulate the use of water resources to meet the requirements of permits and approvals needed (1) to obtain water for development and (2) to alter the land surface.

3.15.1 Siting and Design Mitigation Measures

Siting and design considerations that mitigate impacts on water resources include the following:

- Identify and avoid unstable slopes and local factors that can cause slope instability (groundwater conditions, precipitation, seismic activity, slope angles, and geologic structure).
- Research local hydrogeology. Identify areas of groundwater discharge and recharge and their potential relationships with surface water bodies and groundwater quality. Avoid creating hydrologic conduits between two aquifers.
- Identify sustainable yields of groundwater and nearby surface water bodies.
- Limit the withdrawal of water at the facility so it does not exceed the sustainable yield.
- Develop a contingency plan to prevent potential groundwater and surface water contamination or depletion.
- Develop and implement the appropriate water resources monitoring and mitigation plan if groundwater or surface water is going to be used.
- Develop a drainage, erosion, and sedimentation control plan to identify surface water runoff patterns and develop mitigation measures to prevent soil deposition and erosion.
- Develop a stormwater management plan to ensure compliance with regulations and prevent off-site migration of contaminated stormwater or increased soil erosion.
- Direct runoff from parking lots, roofs, or other impervious surfaces into on-site retention or detention basins.
- Create or improve landscaping used for stormwater treatment to capture runoff.
- Maximize the use of permeable pavement or other pervious surfaces.
- Maintain natural drainages.
- Maintain pre-development flood hydrograph for all storms up to and including the 100-year rainfall event.

- Prevent the release of project waste materials into stormwater discharges.

- As much as possible, minimize the planned amount of land to be disturbed. Use existing roads, borrow pits, and quarries.

- Avoid streams, wetlands, and drainages where possible. Locate access roads to minimize stream crossings and to minimize impacts where crossings cannot be avoided.

- Where access roads would cross a dry wash, the road gradient should be 0% to avoid diverting surface waters from the channel.

- Use special construction techniques in areas of steep slopes, erodible soils, and stream crossings.

- Construct drainage ditches only where necessary. Use appropriate structures at culvert outlets to prevent erosion.

- Avoid altering or restricting existing drainage systems, especially in sensitive areas such as erodible soils or steep slopes. Cross water bodies at right angles to the channel and/or at points of minimum impact.

- Implement water management practices to maintain aquatic, riparian, and other water-dependent resources.

- Avoid impacts on sole source aquifers.

- Design stormwater facilities to route flow through or around the facility using existing washes when feasible, instead of concrete-lined channels.

- Design culverts and water conveyances to comply with state and local standards, or to accommodate the runoff of a 100-year storm, whichever is larger.

- Design stormwater retention and/or infiltration and treatment systems for storm events up to and including the 100-year storm event.

- Install geotextile matting to stabilize disturbed channels and streambanks.

- Prevent work-site runoff from entering streams by using earth dikes, swales, and lined ditches.

- Place sediment control devices so sediment-laden water can pond, allowing sediment to settle out.

3.15.2 General Mitigation Measures

General mitigation practices and principles that could apply to any or all phases of a solar project include the following:

- Identify measures to prevent potential groundwater and surface water contamination as part of a Spill Prevention and Emergency Response Plan.
- Apply erosion controls relative to possible soil erosion from vehicular traffic and during construction activities (e.g., jute netting, silt fences, and check dams). Regularly monitor ROWs, access roads, and other project areas for indications of erosion.
- Use dust suppression techniques to minimize impacts of vehicular traffic and wind on roads and exposed soils.
- Reclaim or apply protective covering (e.g., vegetative cover) on disturbed soils as quickly as possible.
- Clean and maintain catch basins, drainage ditches, and culverts regularly.
- Refuel in a designated fueling area that includes a temporary berm to limit the spread of any spill.
- Use drip pans during refueling to contain accidental releases and under the fuel pump and valve mechanisms of any bulk fueling vehicles parked at the project site.
- Keep all equipment and vehicles within the limits of the previously disturbed areas.
- Construct entry and exit pits in work areas to trap sediments from vehicles and prevent them from entering into streams at stream crossings.
- Develop a Nuisance Animal and Pest Control Plan and an Integrated Vegetation Management Plan to ensure that applications entail only the use of EPA-registered pesticides/herbicides that also comply with state and local regulations.
- Limit herbicide/pesticide use to nonpersistent, immobile herbicides/pesticides.
- Remove wastewater generated in association with sanitary facilities by a licensed hauler.

3.15.3 Project Phase-Specific Mitigation Measures

3.15.3.1 Site Evaluation

Project phase-specific mitigation practices and principles that could apply to the site evaluation phase of a solar energy project include the following:

- If drilling activities are required, any drilling fluids or cuttings should be not come in contact with aquatic habitats. Temporary impoundments should be lined to minimize the infiltration of runoff into groundwater or surface water.

3.15.3.2 Construction

Project phase-specific mitigation practices and principles that could apply to the construction phase of a solar energy project include the following:

- Save topsoil removed during construction and use to reclaim disturbed areas upon completion of construction activities whenever possible.
- Avoid land disturbance in ephemeral washes and dry lakebeds.
- Avoid creating excessive slopes during excavation and blasting operations.
- Closely monitor construction near aquifer recharge areas to reduce potential contamination of the aquifer.
- Obtain borrow material from authorized and permitted sites.
- Dispose of excess excavation materials in approved areas to control erosion and minimize leaching of hazardous materials.
- Install check dams across constructed swales to reduce the velocity of flowing water.
- Avoid washing equipment in streams or wetlands.
- Develop good waste management practices for handling, storing, or disposing of wastes.
- Transport, store, and dispose of all hazardous materials in accordance with all applicable regulations.
- Backfill foundations and trenches with originally excavated material.

3.15.3.3 Operation

Project phase-specific mitigation practices and principles that could apply to the operation phase of a solar energy project include the following:

- Minimize water use by implementing conservation practices, such as treating spent wash water and storing it for reuse.

- Comply with federal, state, and local regulations in the treatment of sanitary and industrial wastewater.

- Use berms and other controls to prevent off-site migration of any leaked or spilled HTF, TES fluids, or any other chemicals stored or used at the site.

- Monitor water quality in areas adjacent to or downstream from developed areas during the life of the project to ensure that water quality is protected.

- Monitor water usage to ensure that long-term water use during operations does not contribute to long-term decline of groundwater levels or surface water flows and volumes.

3.15.3.4 Decommissioning/Reclamation

Project phase-specific mitigation practices and principles that could apply to the decommissioning/reclamation phase of a solar energy project include the following:

- Develop and implement a decommissioning plan that includes the removal of all aboveground facilities and full reclamation of the site.

- Reestablish the original grade and drainage pattern to the extent practicable.

- Restore the banks of water bodies to their natural condition.

- Backfill any foundations and trenches, preferably with excess excavation material generated during construction.

- Adhere to groundwater and/or surface water monitoring activities as outlined in the established Water Resources Monitoring and Mitigation Plan for the site.

- Contour soil borrow areas, cut-and-fill slopes, berms, water bars, and other disturbed areas to approximate naturally occurring slopes.

- Feather edges of vegetation to reduce form and line contrasts with the existing landscapes.

- Salvage and reapply topsoil from all decommissioning activities during final reclamation.

4 REFERENCES

BBC Research and Consulting, 2006, *Garfield County Land Values and Solutions Study: Final Report*, June.

Beacon Solar, LLC, 2008, *Application for Certification of the Beacon Solar Energy Project*, submitted to the California Energy Commission, March. Available at http://www.energy.ca.gov/sitingcases/beacon/index.html. Accessed Jan. 18, 2009.

Bennett, K., and M.K. McBeth, 1998, "Contemporary Western Rural USA Economic Composition: Potential Implications for Environmental Policy and Research," *Environmental Management* 22:371–381.

BLM (Bureau of Land Management), 1980, *Green River—Hams Fork Draft Environmental Impact Statement: Coal*, Denver, Colo.

BLM, 1983, *Final Supplemental Environmental Impact Statement for the Prototype Oil Shale Leasing Program*, Colorado State Office, Denver, Colo.

BLM, 1996, *White River Resource Area Proposed Resource Management Plan and Final Environmental Impacts Statement*, Craig District, Colo.

BLM and DOE (U.S. Department of Energy), 2010, *Draft Programmatic Environmental Impact Statement for Solar Energy Development in Six Southwestern States*, DES 10-59, DOE/EIS-0403, Dec.

BLM and DOE, 2012, *Final Programmatic Environmental Impact Statement (PEIS) for Solar Energy Development in Six Southwestern States*, FES 12-24, DOE/EIS-0403, July.

BrightSource Energy, Inc., 2007, *Application for Certification for the Ivanpah Solar Energy Generating System*, submitted to the California Energy Commission, Aug. Available at http://www.energy.ca.gov/sitingcases/ivanpah/documents/index.html. Accessed Nov. 14, 2008.

Carrizo Energy, LLC, 2007, *Application for Certification, Carrizo Energy Solar Farm*, submitted to the California Energy Commission, Oct. Available at http://www.energy.ca.gov/sitingcases/carrizo/documents/index.html. Accessed July 15, 2008.

Carrizo Energy, LLC, 2008, *Supplement to the Carrizo Energy Solar Farm Application for Certification*, submitted to the California Energy Commission, Sacramento, Calif., July.

CASQA (California Stormwater Quality Association), 2004, *California Stormwater BMP Handbook—Construction*, published Jan. 2003, Errata 9-04.

Chipeniuk, R., 2004, "Planning for Amenity Migration in Canada: Current Capacities of Interior British Columbian Mountain Communities," *Mountain Research and Development* 24:327–335.

Clark, D.E., and T. Allison, 1999, "Spent Nuclear Fuel and Residential Property Values: The Influence of Proximity, Visual Cues and Public Information," *Papers in Regional Science* 78:403–421.

Clark, D., and L. Nieves, 1994, "An Interregional Hedonic Analysis of Noxious Facility Impacts on Local Wages and Property Values," *Journal of Environmental Economics and Management* 27:235–253.

Clark, D., et al., 1997, "Nuclear Power Plants and Residential Housing Prices," *Growth and Change* 28:496–519.

EPA (Environmental Protection Agency), 2010, *High GWP Gases and Climate Change*, July 13. Available at http://www.epa.gov/highgwp/scientific.html.

Great River Energy, 2008, *How Reliable Energy Is Transmitted to You*. Available at http://www.greatriverenergy.com/about/brochure1.html. Accessed Dec. 19, 2008.

Hankinson, M., 1999, "Landscape and Visual Impact Assessment," in *Handbook of Environmental Assessment, Volume 1: Environmental Impact Assessment Process, Methods, and Potential*, J. Petts (editor), Blackwell Scientific Ltd., Oxford, United Kingdom.

Hanson, C.E., et al., 2006, *Transit Noise and Vibration Impact Assessment*, FTA-VA-90-1003-06, prepared by Harris Miller Miller & Hanson Inc., Burlington, Mass., for U.S. Department of Transportation, Federal Transit Administration, Washington, D.C., May. Available at http://www.fta.dot.gov/documents/FTA_Noise_and_Vibration_Manual.pdf.

Ho, C., et al., 2009, "Hazard Analyses of Glint and Glare from Concentrating Solar Power Plants," Solar PACES 2009, Berlin, Germany, Sept. 15–18.

Holmes, F.P., and W.E. Hecox, 2005, "Does Wilderness Impoverish Rural Regions?" *International Journal of Wilderness* 10:34–39.

Hosoya, N., et al., 2008, *Wind Tunnel Tests of Parabolic Trough Solar Collectors, March 2001–August 2003*, Subcontract Report NREL/SR-550-32282, May 2008. Available at http://www.nrel.gov/csp/troughnet/pdfs/32282.pdf. Accessed June 16, 2008.

Johnson, J.D., and R. Rasker, 1995, "The Role of Economic and Quality of Life Values in Rural Business Location," *Journal of Rural Studies* 11:405–416.

Kiel, K., and K. McClain, 1995, "House Prices during Siting Decision Stages: The Case of an Incinerator from Rumor through Operation," *Journal of Environmental Economics and Management* 28:241–255.

Kohlhase, J., 1991, "The Impact of Toxic Waste Sites on Housing Values," *Journal of Urban Economics* 30:1–26.

Nelson, J., 1979, "Airport Noise, Location Rent and the Market for Residential Amenities," *Journal of Environmental Economics and Management* 6:357–369.

NSC (National Safety Council), 2006, *Injury Facts*, Itasca, Ill.

NREL (National Renewable Energy Laboratory), 2010, *Photographic Information eXchange*, NREL Photo # 01701. Available at http://www.nrel.gov/data/pix/searchpix.php?getrec=01701&display_type=verbose&search_reverse=1. Accessed July 26, 2010.

Power, T.M., 1996, *Lost Landscapes and Failed Economies*, Island Press, Washington, D.C.

Rasker, R., 1994, "A New Look on Old Vistas: The Economic Role of Environmental Quality in Western Public Lands," *University of Colorado Law Review* 65:369–399.

Rasker, R., et al., 2004, *Public Lands Conservation and Economic Well-Being*, Sonoran Institute, Bozeman, Mont.

Reeder, R., and D.M. Brown, 2005, *Recreation, Tourism, and Rural Well-Being*, U.S. Department Agriculture, Economic Research Report ERR-7, Aug.

Rudzitis, G., 1999, "Amenities Increasingly Draw People to the Rural West," *Rural Development Perspectives* 14:9–13.

Rudzitis, G., and H.E. Johansen, 1989, *Amenities, Migration and Non-Metropolitan Regional Development*, Report to the National Science Foundation, University of Idaho, Moscow, Idaho.

Sandia National Laboratories, 2008, *Stirling Dish Engines at the Stirling Energy Systems Test Facility in Albuquerque, New Mexico*. Available at http://www.sandia.gov/news/resources/releases/2008/solargrid.html. Accessed April 16, 2008.

SES (Stirling Energy Systems) Solar Two, LLC, 2008, Application for Certification, submitted to the Bureau of Land Management, El Centro, Calif., and the California Energy Commission, Sacramento, Calif., June. Available at http://www.energy.ca.gov/sitingcases/solartwo/documents/applicant/afc/index.php. Accessed Oct. 1, 2008.

Smith, M. D., et al., 2001, "Growth, Decline, Stability and Disruption: A Longitudinal Analysis of Social Well-Being in Four Western Communities," *Rural Sociology* 66:425–450.

Stull, W., and J. Stull, 1991, "Capitalization of Local Income Taxes," *Journal of Urban Economics* 29:182–190.

Thaler, R., 1978, "A Note on the Value of Crime Control: Evidence from the Property Market," *Journal of Urban Economics* 5:137–145.

Topaz Solar Farms, LLC, 2008, *Conditional Use Permit Application, Topaz Solar Farm*, submitted to the San Luis Obispo Planning and Building Department, San Luis Obispo County, Calif., July 18. Available at http://www.slocounty.ca.gov/planning/environmental/ EnvironmentalNotices/Optisolar-Topaz_Solar_Farm.htm. Accessed Nov. 7, 2008.

USDA (U.S. Department of Agriculture), 2004, *Understanding Soil Risks and Hazards: Using Soil Survey to Identify Areas with Risks and Hazards to Human Life and Property*, G.B. Muckel (editor).

Wood, E.W., 1992, "Prediction of Machinery Noise," in *Noise and Vibration Control Engineering: Principles and Applications*, L.L. Beranek, and I.L. Vér (editors), John Wiley & Sons, Inc., New York, N.Y.

APPENDIX A:

GLOSSARY

This page intentionally left blank.

APPENDIX A:

GLOSSARY

Air quality: Measure of the health-related and visual characteristics of the air to which the general public and the environment are exposed.

Alluvial fan: A fan-shaped depositional landform consisting of alluvial deposits that formed where a flowing stream slows and spreads out (depositing its load), typically at the base of a mountain range where there is a marked change in slope. Fan deposits tend to be coarse-grained at their mouths, but grade to finer-grained material toward their edges.

Aquatic habitat: Area associated with water that provide food and cover and other elements critical to the completion of an organism's life cycle (e.g., bogs, swamps, riparian areas and streams).

Aquifer: A water-bearing rock that readily transmits water to a well or spring.

Areas of Critical Environmental Concern: These areas are managed by the Bureau of Land Management and are defined by the Federal Land Policy and Management Act of 1976 as having significant historical, cultural, and scenic values, habitat for fish and wildlife, and other public land resources, as identified through the Bureau of Land Management's land-use planning process.

Artifact: An object produced or shaped by human beings and of archaeological or historical interest.

Attenuation: The reduction in level of sound.

Background level noise: Noise in the environment (other than noise emanating from the source of interest).

Biological soil crusts: Commonly found in semiarid and arid environments, biological soil crusts are formed by living organisms and their by-products, creating a crust of soil particles bound together by organic materials. Crusts are predominantly composed of cyanobacteria (formerly called blue-green algae), green and brown algae, mosses, lichens, and bryophytes, which live within or on top of the uppermost millimeters of soil. Biological soil crusts are also known as cryptogamic, microbiotic, cryptobiotic, and microphytic crusts.

Biomass: Combustible solid, liquid, or gas that is derived from biological processes.

Blowdown: Periodic removal of water from an evaporative cooling system (also known as a wet closed-cycle cooling system) to control the buildup of impurities and maintain the concentration of dissolved minerals in the circulating water. Blowdown typically involves the release of less than 10% of the total water volume in the cooling system and typically occurs after completion of as many as five cycles. Blowdown is either discharged to a surface water body under a permit that limits both chemical content and temperature, or directed to an evaporation pond where mineral residues are later collected and removed for disposal.

Blowout: A wind-eroded section of a sand dune caused by a disturbance or removal of the vegetation.

Borrow pit: A pit or excavation area used for gathering earth materials (borrow) such as sand or gravel.

Catchment basin: A topographic region in which all water drains to a common outlet; a watershed.

Clean Water Act (CWA): Requires National Pollutant Discharge Elimination System (NPDES) permits for discharges of effluents to surface waters, permits for storm water discharges related to industrial activity, and notification of oil discharges to navigable waters of the United States.

Closed-loop cooling system: Also known as a wet closed-cycle cooling system, a system that circulates water between a steam condenser and a cooling tower to cool steam condensate at a thermoelectric power plant; the circulating water interacts with a counterflow (or crossflow) of ambient air at the cooling tower and is cooled through the principle of evaporation where a small fraction of the water is evaporated. The evaporated amount is continually replaced to maintain the total volume of water in the system. *See also* Blowdown.

Color: The property of reflecting light of a particular intensity and wavelength (or mixture of wavelengths) to which the eye is sensitive. It is the major visual property of surfaces.

Concentrating solar power (CSP): *See* Concentrating solar power (CSP) technologies.

Concentrating solar power (CSP) technologies: Any of a family of solar energy technologies that reflect and concentrate the sun's energy to produce heat that is subsequently used to produce steam to power a steam turbine-generator (STG), or drive a reciprocating engine, to produce electricity. There are three different types of CSP systems: parabolic trough systems, power tower systems, and solar dish engine systems. Parabolic trough and power tower systems convert sunlight to heat to produce steam, while the solar dish engine system converts sunlight to heat to drive a reciprocating engine.

Corona discharge: Electrical discharge accompanied by ionization of surrounding atmosphere around high-voltage transmission lines, occurring mostly under wet conditions.

Corridor-transmission: *See* Transmission corridor.

Council on Environmental Quality (CEQ): Established by National Environmental Policy Act (NEPA), CEQ regulations (40 CFR Parts 1500-1508) describe the process for implementing NEPA, including preparation of environmental assessments and environmental impact statements, and the timing and extent of public participation.

Criteria air pollutants: Six common air pollutants for which National Ambient Air Quality Standards (NAAQS) have been established by the U.S. Environmental Protection Agency under Title I of the Clean Air Act (CAA). They are sulfur dioxide, nitrogen oxides, carbon monoxide, ozone, particulate matter ($PM_{2.5}$ and PM_{10}), and lead. Standards were developed for these pollutants on the basis of scientific knowledge about their health effects.

Cultural resources: Archaeological sites, structures, or features; traditional use areas; and Native American sacred sites or special use areas that provide evidence of the prehistory and history of a community.

Decibel, A-weighted (dBA): A measurement of sound approximating the sensitivity of the human ear and used to characterize the intensity or loudness of a sound.

Decommissioning: All activities necessary to take out of service and dispose of a facility after its useful life.

Desert pavement: A surface layer of closely packed, loosely cemented pebbles.

Dip: The angle that a planar geologic surface, for example, a fault, is inclined from the horizontal.

Direct impacts: Impacts occurring at the place of origin and at the time of the proposed activity. An effect that results solely from the construction or operation of a proposed action without intermediate steps or processes. Examples include habitat destruction, soil disturbance, and water use.

Direct Normal Insolation (DNI): Sunlight that directly strikes a surface. DNI does not include refracted sunlight that strikes clouds, dust, or the ground first.

Dish engine: The dish engine is a concentrating solar power (CSP) technology that produces electricity, typically in the range of 3 to 25 kilowatts, by using a parabolic array of mirrors to reflect sunlight to heat a working gas (typically hydrogen) in a closed container, causing it to expand and drive a reciprocating engine connected to an electric generator. The dish engine is unique among CSP systems because it uses mechanical energy rather than steam to produce electricity.

Disturbance (land): *See* Land disturbance.

Dry cooling system: Also known as dry closed-loop cooling; a technology for rejecting heat from the steam condensate of a thermoelectric plant. Cooling water circulates in a closed loop between a steam condenser, where it accepts heat from steam condensate, and a dry condenser located in an outdoor location. Fans are used to establish a flow of ambient air across the surface of the dry condenser, allowing the heated cooling water inside the dry condenser to transfer heat to the ambient air before cycling back to the steam condenser.

Dry lake: An ephemeral lake of an arid or semiarid region, typically found at low elevation points in desert valleys. They are topographically flat areas, support sparse vegetation, and contain fine-grained, consolidated sediments that are deposited during precipitation runoff events where the water temporally ponds and then infiltrates to groundwater aquifers or evaporates. The surface sediments of dry lakes can often have high concentrations of dissolved minerals.

Dunnage: Package waste. Loose packing material.

Ecological resources: Biota (fish, wildlife, and plants) and their habitats, which may be land, air, or water.

Edge habitat: The transitional zone where one cover type ends and another begins.

Electric and magnetic fields (EMFs): Electric and magnetic fields are generated when charged particles (e.g., electrons) are accelerated. Charged particles in motion produce magnetic fields. Electric and magnetic fields are typically generated by alternating current in electrical conductors. Also referred to as electromagnetic fields.

Emissions: Substances that are discharged into the air from industrial processes, vehicles, and living organisms. A release into the outdoor atmosphere of air contaminants.

Environmental justice: The fair treatment of people of all races, cultures, incomes, and educational levels with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

Ephemeral stream: A stream that flows only after a storm or during snowmelt and whose channel is, at all times, above the water table; groundwater is not a source of water for the stream. Many desert streams are ephemeral.

Erosion: The wearing away of land surface by wind or water, intensified by land-clearing practices related to farming, residential or industrial development, road building, or logging.

Floodplain: A generally flat, low-lying area adjacent to a water body that is subjected to inundation during high flow or rainfall events. The relative elevation of floodplain areas determines their frequency of flooding, which ranges from rare, severe, storm events to flows experienced several times a year.

Forbs: Herbaceous (nonwoody), broad-leaved flowering plants; non-graminoid (grasses, sedges, and rushes) herbaceous plants.

Form: The mass or shape of an object or objects that appears unified, such as a vegetative opening in a forest, a cliff formation, or a water tank.

Fugitive dust: The dust released from any source other than a definable point source such as stack, chimney, or vent. Sources include construction activities, storage piles, roadways, etc.

Geometric spreading: As the sound moves away from the source, the area that the sound energy covers becomes larger and thus sound intensity decreases. This is referred to as "geometric spreading," which is independent of frequency and plays a major role in sound propagation situations. Due to geometric spreading, the sound level is reduced by 6 dB and 3 dB for each doubling of distance from the point (e.g., fixed equipment) and line (e.g., road traffic) sources, respectively.

Glare: The sensation produced by luminances within the visual field that are sufficiently greater than the luminance to which the eyes are adapted, which causes annoyance, discomfort, or loss in visual performance and visibility. *See als*o Glint.

Glint: A momentary flash of light resulting from a spatially localized reflection of sunlight. *See also* Glare.

Greenhouse gases (GHGs): Heat-trapping gases that cause global warming. Natural and human-made greenhouse gases include water vapor, carbon dioxide, methane, nitrogen oxides, ozone, and chlorofluorocarbons.

Groundwater: The supply of water found beneath the Earth's surface, usually in porous rock formations (aquifers), which may supply wells and springs. Generally, it refers to all water contained in the ground.

Habitat: The place, including physical and biotic conditions, where a plant or animal lives. *See also* Aquatic habitat.

Harassment: The intentional or unintentional disturbance of individual animals causing them to flee a site or avoid use of an area.

Hazardous air pollutants (HAPs): Substances that have adverse impacts on human health when present in ambient air.

Heat transfer fluid (HTF): Fluids that transfer heat generated at the solar collectors to a heat exchanger where steam is produced to run a steam generator.

Hedonic – (modeling approach): The hedonic method is a regression technique used to estimate the prices of qualities or models that are not available on the market in particular periods, but whose prices in those periods are needed in order to be able to construct price relatives.

Herbicide: Chemicals used to kill undesirable vegetation.

Indirect impacts: Impacts that occur away from the place of origin. Effects that are related to, but removed from, a proposed action by an intermediate step or process. An example would be changes in surface-water quality resulting from soil erosion at construction sites.

Industrial waste: Materials discarded from industrial operations or derived from manufacturing processes.

Insolation: The solar power density incident on a surface of stated area and orientation, usually expressed as watts per square meter or btu per square foot per hour.

Invasive species: Any species, including noxious and exotic species, that is an aggressive colonizer and can out-compete indigenous species.

Just-in-time ordering: A strategy for managing materials used at a project that ensures materials become available as needed to support activities, but are not stockpiled at the project location in excess of what is needed at any point in time. The just-in-time approach controls costs by avoiding the accumulation of inflated inventories, reducing the potential for stockpiled materials to go out-of-date or otherwise become obsolete, and minimizing product storage and management requirements. When applied to hazardous chemicals, this approach reduces waste generation, the potential for mismanagement of materials and the overall risk of adverse impacts resulting from emergency or off-normal events involving those materials.

Land disturbance: Discrete event or process that alters soil and/or kills or damages vegetation. From an ecological and hierarchical perspective, disturbance is a change in the minimal structure of an ecosystem caused by a factor external to the reference structure. Examples of disturbance are habitat reduction, habitat fragmentation, and habitat alteration.

Light pollution: Any adverse effect of human-made lighting, such as excessive illumination of night-skies by artificial light. Light pollution is an undesirable consequence of outdoor lighting that includes such effects as sky glow, light trespass, and glare.

Line: The path, real or imagined, that the eye follows when perceiving abrupt differences in form, color, or texture. Within landscapes, lines may be found as ridges, skylines, structures, changes in vegetative types, or individual trees and branches.

Low-income population: Persons whose average family income is below the poverty line. The poverty line takes into account family size and age of individuals in the family. For any family below the poverty line, all family members are considered to be below the poverty line.

Megawatt: A unit of power equal to one million watts (equivalent to one joule per second). One megawatt serves about 300 homes in the western United States based on national data.

Mineral: A naturally occurring inorganic element or compound having an orderly internal structure and characteristic chemical composition, crystal morphology, and physical properties such as density and hardness. Minerals are the fundamental units from which most rocks are made.

Minority population: Includes Hispanic, American Indian, or Alaskan Native; Asian; Native Hawaiian or Other Pacific Islander; Black (not of Hispanic origin) or African American. “Other” races and multi-racial individuals may be considered as separate minorities.

National Historic Preservation Act: A federal law providing that property resources with significant national historic value be placed on the *National Register of Historic Places*. It does not require permits; rather, it mandates consultation with the proper agencies whenever it is determined that a proposed action might impact an historic property.

National Historic Trails: These trails are designated by Congress under the National Trails System Act of 1968 and follow, as closely as possible, on federal land, the original trails or routes of travel that have national historical significance.

National Pollutant Discharge Elimination System (NPDES): A federal permitting system controlling the discharge of effluents to surface water and regulated through the Clean Water Act, as Amended.

***National Register of Historic Places* (NRHP):** A comprehensive list of districts, sites, buildings, structures, and objects that are significant in American history, architecture, archaeology, engineering, and culture. The NRHP is administered by the National Park Service, which is part of the Department of the Interior.

Native American: Of, or relating to, a tribe, people, or culture that is indigenous to the United States.

Natural drainages: Natural systems that convey water (such as a stream channel) that may be perennial, intermittent, or ephemeral.

Noise: Any unwanted sound that interferes with speech and hearing, causes damage to hearing, or annoys a person.

Noxious weeds: Those plants regulated by law or those that are so difficult to control that early detection is important.

Off-highway vehicle (OHV) or off-road vehicle: Any motorized vehicle designed for or capable of cross-country travel on or immediately over land, water, sand, snow, ice, marsh, swampland, or other natural terrain; except that such term excludes (1) any registered motorboat; (2) any military, fire, emergency, or law enforcement vehicle when used for emergency purposes; and (3) any vehicle whose use is expressly authorized by the respective agency head under a permit, lease, license, or contract.

Parabolic trough: A type of CSP solar energy technology that uses parabolic-shaped mirrors to concentrate sunlight on a receiver filled with a heat transfer fluid that subsequently transfers the heat it absorbs to water to produce steam to drive a steam turbine-generator (STG) to produce electricity. Parabolic trough systems typically mount the mirrors on a support that can track the sun's movement across the sky over the course of the day, ensuring maximum solar energy capture.

Parabolic trough system: *See* Parabolic trough.

Particulate matter: Fine solid or liquid particles such as dust, smoke, mist, fumes, or smog, found in air or emissions. The size of the particulates is measured in micrometers (μm). One micrometer is 1 millionth of a meter or 0.000039 inch. Particle size is important because the EPA has set standards for $PM_{2.5}$ and PM_{10} particulates.

Pesticide: Substances or mixtures thereof, intended for preventing, destroying, repelling, or mitigating any pest. Also, any substance or mixture intended for use as a plant regulator, defoliant, or desiccant.

Photovoltaic (PV) cell: The smallest semiconductor element within a PV module that converts incident sunlight into electrical energy (direct current voltage and current). Also called a solar cell.

Photovoltaic (PV) facility: A solar energy facility that uses photovoltaic cells to produce electricity and that includes all components, such as the PV system, power conditioning equipment, monitoring and control capabilities, and other features required for safe connection of the facility to the bulk electricity transmission grid, as well as buildings, access roads, perimeter fence, and other equipment needed for operation and maintenance of the facility.

Photovoltaic (PV) module: An assembly of solar cells (flat-plate type) or receiver(s) and optics (concentrator type) and ancillary parts, such as interconnects and terminals, enclosed in a weatherproof container, intended to generate DC power under unconcentrated sunlight. (Note: A CPV module is a concentrator type PV module.) The structural (load carrying) member of a module can either be the top layer (superstrate) or the back layer (substrate).

Photovoltaic (PV) panel: A collection of modules, either flat-plate or concentrator type, mechanically fastened, electrically interconnected, and designed to provide a field-installable unit. (Note: Not all PV systems will use panelized units during installation. Sometimes the modules are individually attached to a support structure.)

Photovoltaics (PV): Technologies that utilize semiconducting materials that convert sunlight directly into electricity.

Playa: Flat areas that contain seasonal or year-to-year shallow lakes that often evaporate, leaving minerals behind. Playas form in arid basins where rivers merge, but do not drain.

Power block: Portion of the facility at which electrical power is generated.

Power tower: A type of CSP technology composed of many large, sun-tracking mirrors (heliostats) that focus sunlight on a receiver at the top of a centrally located tower. The sunlight heats up a heat transfer fluid in the receiver, which then is used to generate steam (or directly heats water to produce steam) that powers a steam turbine-generator (STG) to produce electricity. Power tower systems can also be equipped with molten salt in which the heat generated at the receiver can be stored for delayed production of electricity.

Raptor: A bird of prey such as a falcon, hawk, or eagle.

Receptor: A location where environmental resources such as air concentration or noise level are evaluated (e.g., property boundaries, residences, schools, hospitals, libraries).

Region of Influence (ROI): Area occupied by affected resources and the distances at which impacts associated with license renewal may occur.

Resource Conservation and Recovery Act (RCRA): An amendment to the Solid Waste Disposal Act, RCRA (42 U.S.C. 6901 et seq.) authorized the development of federal regulations for the definition, storage, treatment, and disposal of solid wastes and hazardous wastes, as well as the process by which states may obtain primacy for implementation of the federal program.

Right-of-way (ROW): The legal right to cross the lands of another. Also used to indicate the strip of land for a road, railroad, or power line. In BLM, a permit or an easement which authorizes the use of public lands for certain specified purposes. Also, the lands covered by such an easement or permit. The authorization to use a particular parcel of public land for specific facilities for a definite time period. Authorizes the use of a ROW over, upon, under, or through public lands for construction, operation, maintenance, and termination of a project.

Rinsate: Water that is used to rinse or clean equipment or reaction vessels and that may, as a result, become contaminated and require special handling and disposal.

Riparian: Relating to, living in, or located on the bank of a river, lake, or tidewater.

Roost: An area where birds or bats rest or sleep. Birds often use branches or tree cavities for roosts while bats use tree bark, tree hollows, caves, mines, buildings, bridges, or rock crevices.

Sanitary waste: Nonhazardous, nonradioactive liquid and solid waste generated by normal housekeeping activities.

Sanitary wastewater: Wastewater (includes toilet, sink, shower, and kitchen flows) generated by normal housekeeping activities.

Scarify: Loosening topsoil or breaking up the forest floor to improve conditions for seed germination or tree planting. Also refers to nicking or abrading the hard seed coat of some species to aid germination.

Sedimentation: The removal, transport, and deposition of sediment particles by wind or water.

Seeps: Wet areas, normally not flowing, arising from an underground water source. Any place where liquid has oozed from the ground to the surface.

Semiconductor: Any material that has a limited capacity for conducting an electric current. Certain semiconductors, including silicon, gallium arsenide, copper indium diselenide, and cadmium telluride, are uniquely suited to the photovoltaic conversion process.

Shear strength: Internal resistance to stress (or movement) that comes from friction and cohesion of the sediment.

Silencer: A device used for reducing noise within air and gas flow systems.

Silt: A rock or mineral fragment of any composition that has a diameter ranging from 0.002 to 0.05 millimeter. Moist silt has a floury feel and is gritty when placed between the teeth.

Socioeconomics: The social and economic conditions in the study area.

Soil compaction: Compression of the soil which results in reduced soil pore space (the spaces between soil particles), decreased movement of water and air into and within the soil, decreased soil water storage, and increased surface runoff and erosion.

Soil deposition: A general term for the accumulation of sediments by either physical or chemical sedimentation.

Soil horizon: A layer of soil developed in response to localized chemical and physical processes resulting from the activities of soil organisms, the addition of organic matter, precipitation, and water percolation through the layer.

Soil horizon mixing: Soil horizon mixing occurs when soil is disturbed by activities such as excavation.

Solar collector: A component of a solar energy facility that receives solar energy and converts it to useful energy forms, typically heat. Major components include the mirrors or reflectors, additional features designed to further concentrate the incident sunlight (in some facilities), and a receiver containing a heat transfer fluid.

Solar tracking device: Device that moves solar panels using the electric motors to follow the path of the sun exactly in the course of the day to maximize the yields.

Special status species (threatened, endangered, sensitive, rare): Includes both plant and animal species that are proposed for listing, officially listed as threatened or endangered, or are candidates for listing as threatened or endangered under the provisions of the Endangered Species Act; those listed by a state in a category such as threatened or endangered, implying potential endangerment or extinction; and those designated by each BLM State Director as sensitive.

Spring: The point at which the water table meets Earth's surface, causing water to flow from the ground.

State Historic Preservation Officer (SHPO): The State officer charged with the identification and protection of prehistoric and historic resources in accordance with the National Historic Preservation Act.

Steam turbine-generator (STG): A device that uses high-pressure steam, produced in a boiler, to drive the blades of a turbine to produce mechanical energy that can then be used to produce electricity by causing rotation of the central shaft of a mechanically connected generator.

STG: *See* Steam turbine generator.

Stirling engine: Named after its inventor, a reciprocating engine that converts heat into useable mechanical energy (shaftwork) by the heating (expanding) and cooling (contracting) of a captive gas (a working fluid) such as helium or hydrogen. As a solar energy technology, the Stirling engine uses sunlight reflected off a parabolic surface to heat hydrogen to drive the engine that in turn drives a mechanically connected generator to produce electricity.

Surface water: Water on the Earth's surface that is directly exposed to the atmosphere, as distinguished from water in the ground (groundwater).

Texture: The visual manifestations of light and shadow created by the variations in the surface of an object or landscape.

Texture contrasts: Visual contrasts between different objects or landscapes resulting from different visual manifestations of the interplay of light and shadow created by the variations in the surfaces of the objects or landscapes.

Thermal energy: The use of heat as a source of energy. Thermal energy can be used directly or can be transformed into mechanical energy (using a steam engine), which can then be transformed into electrical energy. Thermal energy is usually measured in British thermal units (Btu).

Total dissolved solids (TDS): The dry weight of dissolved material, organic and inorganic, contained in water. The term is used to reflect salinity.

Transmission corridor: An electric or pipeline transmission corridor is a route approved on public lands, in a BLM or other federal agency land use plan, as a location that may be suitable for the siting of electric or pipeline transmission systems.

Utility scale facilities: Facilities that generate large amounts of electricity that is delivered to many users through transmission and distribution systems.

Visual contrast: Opposition or unlikeness of different forms, lines, colors, or textures in a landscape.

Volatile organic compound (VOC): Any organic compound that participates in atmospheric photochemical reactions except those designated by the EPA as having negligible photochemical reactivity. Sources include certain solvents, degreasers (benzene), and fuels. Volatile organic compounds react with other substances (primarily nitrogen oxides) to form ozone, which contributes significantly to photochemical smog production and certain health problems.

Wash: A normally dry stream bed that occasionally fills with water.

Wet cooling system: *See* Closed-cycle cooling system.

Wetlands: Areas that are soaked or flooded by surface or groundwater frequently enough or long enough to support plants, birds, animals, and aquatic life. Wetlands generally include swamps, marshes, bogs, estuaries, and other inland and coastal areas and are federally protected.

Environmental Science Division
Argonne National Laboratory
9700 South Cass Avenue, Bldg. 240
Argonne, IL 60439-4847

www.anl.gov

U.S. DEPARTMENT OF ENERGY

Argonne National Laboratory is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC