4 AFFECTED ENVIRONMENT

4.1 INTRODUCTION

Chapter 4 presents a general description of the existing conditions and trends of resources and resource uses in the six-state study area that may be affected by implementing BLM's and DOE's proposed alternatives. While the description in general covers the six-state area, with respect to certain resources the discussion of the affected environment on BLM-administered lands receives additional focus. For instance, ecological resources are varied in their distribution, and some that occur in the six-state area are not present on BLM-administered lands. The description of the affected environment in this chapter provides the basis for identifying potential impacts and is of sufficient detail to support the programmatic nature of the Solar PEIS. Detailed descriptions are provided for individual proposed solar energy zones (SEZs) in Chapters 8 through 13 of the PEIS. Factors such as climate change that may have an influence on the current conditions and potential trends of individual resources and resource uses have been incorporated as appropriate under individual resource sections that follow.

The U.S. Department of the Interior (DOI) Bureau of Land Management (BLM) manages large acreages of diverse public lands within the six-state study area, with topography ranging from low deserts to high mountains. The land uses are as varied as the terrain and include livestock grazing; fish and wildlife habitat; oil, gas, and mineral exploration and development; right-of-way (ROW) authorizations; a wide range of outdoor recreation activities; and timber production. These uses are managed within a framework of numerous public land laws, the most comprehensive of which is the Federal Land Policy and Management Act of 1976 (FLPMA). The FLPMA establishes several fundamental policies regarding the management of public lands (Section 102(a)), including the policy directing that lands be managed "...on the basis of multiple use and sustained yield unless otherwise specified by law." "Multiple use" means management so that "public lands and their various resource values … are utilized in the combination that will best meet the present and future needs of the American people" (Section 103(c) of FLPMA). "Sustained yield" means the achievement and maintenance in perpetuity of a high level or regular periodic output of the variable renewable resources of the public lands consistent with multiple use (Section 103(h) of FLPMA).

The uses to which public lands are dedicated and the allocation of those uses are identified in BLM land use plans called Resource Management Plans (RMPs). RMPs are periodically prepared and revised through an open process that encourages input from public land users and other interested individuals and groups regarding the mix of potential uses of the public lands. About 90 land use plans cover the lands within the six-state study area that are being analyzed in this programmatic environmental impact statement (PEIS) and that could be affected by decisions related to activities evaluated in the PEIS.

The status of public lands in the six-state study area is constantly changing with the approval of new ROWs, land exchanges, withdrawals, and the implementation of land use plan and management decisions. Some of these changes could be very large including the proposed 29 Palms Marine Base Expansion; the proposed legislation to preserve additional lands between the Mojave National Preserve, Joshua Tree National Park, and the San Bernardino National Forest; and the ongoing consideration of applications for solar energy development on BLM-administered lands.

Figures 2.2-1 through 2.2-6 in Section 2 show the BLM-administered lands proposed as being available for application for solar energy development in this PEIS. This chapter provides much of the basic land use and resource information that will be used in shaping the decisions regarding potential development of utility-scale solar energy production on the public lands within the six-state study area.

4.2 LANDS AND REALTY

The BLM administers approximately 245 million acres (more than 1 million km^2) of land in 11 western states and Alaska. These lands, which are generally known as "public lands," are often intermingled with other federal, state, or private lands. The BLM also administers about 700 million acres (2.83 million km^2) of subsurface mineral estate; some of these mineral estates underlie the BLM-managed lands mentioned above, some underlie lands administered by other federal agencies, and some underlie state or private lands.[1] Within the six-state PEIS study area, the BLM manages almost 120 million acres (486,000 km^2) of public lands. Table 4.2-1 lists the total surface acreage of the six-state study area as of FY 2007, as well as the acreages of all federal lands and BLM-administered lands. The acreage data used in the table were current at the time of assembly and are still generally representative.

The public lands included in the PEIS study area experience some of the highest levels of solar insolation in the United States. The existence of blocks of public land that could physically accommodate utility-scale solar development naturally has drawn attention to these areas; however, there also are large blocks of both private and state lands in the same areas with the same solar energy potential that could support utility-scale solar development.

ROWs are authorized under FLPMA. Section 103(l) FLPMA identifies ROWs as one of the principal or major uses of the public lands. A ROW conveys a legal right to occupy, use, or traverse public lands. The BLM grants or renews ROWs on public lands for a variety of uses, including reservoirs; pipelines; electrical generation, transmission, and distribution systems; and roads (BLM 2005a, 2006). Once granted, a ROW conveys a right to occupy public lands and, depending on the specific ROW grant, provides a priority for use of the public land for the specified term of the ROW. ROWs are typically issued for 20 to 30 years, but some may be granted in perpetuity. Through the land use planning process, the BLM may identify areas that are available for application for various types of ROWs and, in some areas, may identify where ROWs are either to be avoided or excluded. Through its land use planning process, the BLM has identified and continues to identify transmission corridors that are intended to provide locations on federal lands for future electrical and pipeline construction. These corridors would be available to provide for transmission facilities to support renewable energy developments. The

[1] Unless specifically noted otherwise, references in this PEIS to lands administered are for surface only and do not include mineral estates.

TABLE 4.2-1 Acreage and Percentage of BLM-Administered Public Lands in the Six-State Study Area

State	Total State Acreage (million acres[a])	Federal Surface Land Acreage (million acres[a])	BLM-Administered Public Lands (million acres[a])	% BLM Lands (of total state acreage)
Arizona	72.7	33.0	12.2	16.8
California	100.2	45.0	15.2	15.2
Colorado	66.5	24.1	8.3	12.5
Nevada	70.3	58.4	47.8	68.0
New Mexico	77.8	26.5	13.3	17.1
Utah	52.7	34.0	22.8	43.3
Total	440.2	221.0	119.6	27.2

[a] To convert acres to km^2, multiply by 0.004047.

Sources: BLM (2007c); percentages calculated.

PEIS entitled *Energy Corridors on Federal Land in the 11 Western States* (DOE and DOI 2008) (see Section 1.6.2.1), is an example of the ongoing nature of the transmission corridor planning and designation process.

Applications for utility-scale solar and transmission facilities would be processed as ROW authorizations under Title V of FLPMA and Title 43, Part 2804 of the *Code of Federal Regulations* (43 CFR Part 2804).

4.3 SPECIALLY DESIGNATED AREAS AND LANDS WITH WILDERNESS CHARACTERISTICS

Specially designated areas include a variety of types of areas that have received recognition or designation because they possess unique or important resource values. While these areas would not be available for development of solar energy resources, they could be located near solar development areas and could be affected by solar development.

Examples of BLM-administered specially designated areas include components of the BLM National Landscape Conservation System (NLCS), areas of critical environmental concern (ACECs), special recreation management areas (SRMAs), and areas with wilderness characteristics.[2] These areas may have been designated by Executive Order, an Act of Congress, or by the BLM through its land use planning process. The majority of specially designated areas

[2] Such an area is a category of land that has been recognized by the BLM as possessing wilderness characteristics but that has not been identified as a Wilderness Study Area (WSA). If the BLM has made a decision in a RMP to manage lands to protect these wilderness characteristics, they are not open to application for solar energy development.

discussed in this PEIS are located on BLM-administered public lands; however, some specially designated areas managed by the U.S. Forest Service (USFS), U.S. Fish and Wildlife Service (USFWS), and National Park Service (NPS), as well as areas designated by states and localities, also are included in the analysis when they could be affected by solar development on public lands. The specially designated areas on public lands are shown in the individual state maps in Figures 4.3-1 through 4.3-7.

In Fiscal Year (FY) 2007, about 42.7 million acres (173,000 km^2) of BLM-administered lands in the six-state study area were managed as part of the NLCS. NLCS lands include National Monuments and National Conservation Areas, Designated Wilderness, Wilderness Study Areas (WSAs), Wild and Scenic Rivers (WSRs) and national historic and scenic trails (Table 4.3-1).[3] Other conservation designations within the NLCS are Instant Study Areas[4] (ISAs), Forest Reserves, National Recreation Areas, Research Natural Areas, and Outstanding Natural Areas.

BLM land use plans within the six-state study area identify 528 areas, incorporating about 9.3 million acres (37,665 km^2), as Areas of Critical Environmental Concern (ACECs) (BLM 2007c).These areas are managed to protect the relevant and important resource values for which the areas were designated. Resource values protected can be quite varied; examples include important wildlife and plant habitat, scenic resources, recreation areas, cultural resources, and areas with natural hazards.

4.4 RANGELAND RESOURCES

4.4.1 Livestock Grazing

Livestock grazing is a major and widespread use of public lands. About 105 million acres (424,920 km^2) (Pack 2009) are included within grazing allotments located on public lands being considered in this PEIS. Grazing that occurs on public lands is authorized either through a grazing permit or lease. BLM grazing regulations governing such use of public lands are contained in 43 CFR 4100. In FY 2007, the BLM issued 6,439 grazing permits and leases in the six-state study area.

4.4.2 Wild Horses and Burros

Wild horses and burros occur on public lands within the six-state study area. The Wild Free-Roaming Horses and Burros Act (*United States Code*, Title 16, Section 1331 et seq.

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[3] The NLCS acreage cited includes substantial “double counting.“ For example, areas of wilderness are included within National Monuments and National Conservation Areas.

[4] Section 603(a) of FLPMA requires that areas identified as natural or primitive areas at the time of FLPMA’s passage in 1976 be studied for suitability for wilderness designation. These areas became known as Instant Study Areas (ISAs), and are managed as WSAs.

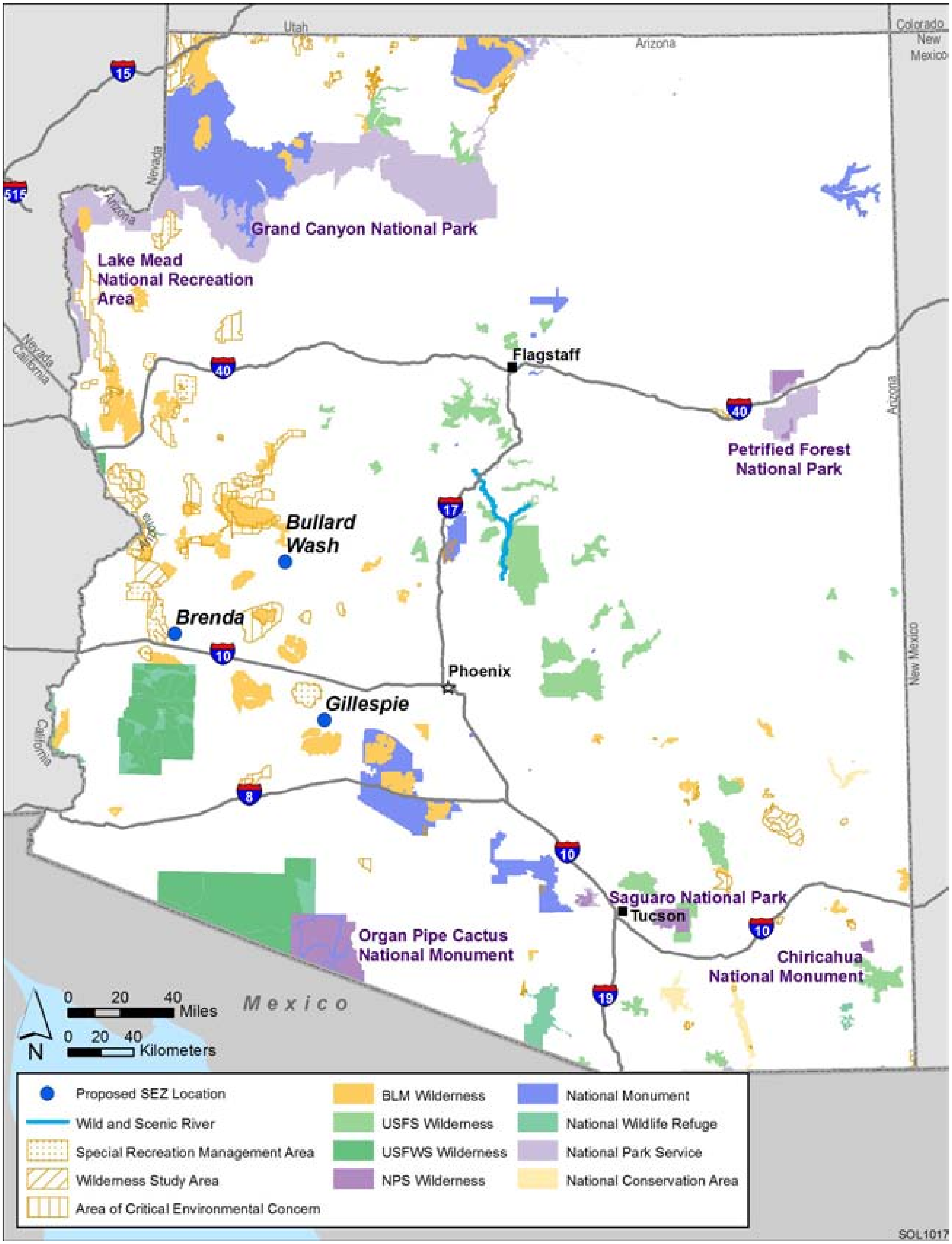

FIGURE 4.3-1 Specially Designated Areas on Public Lands in Arizona

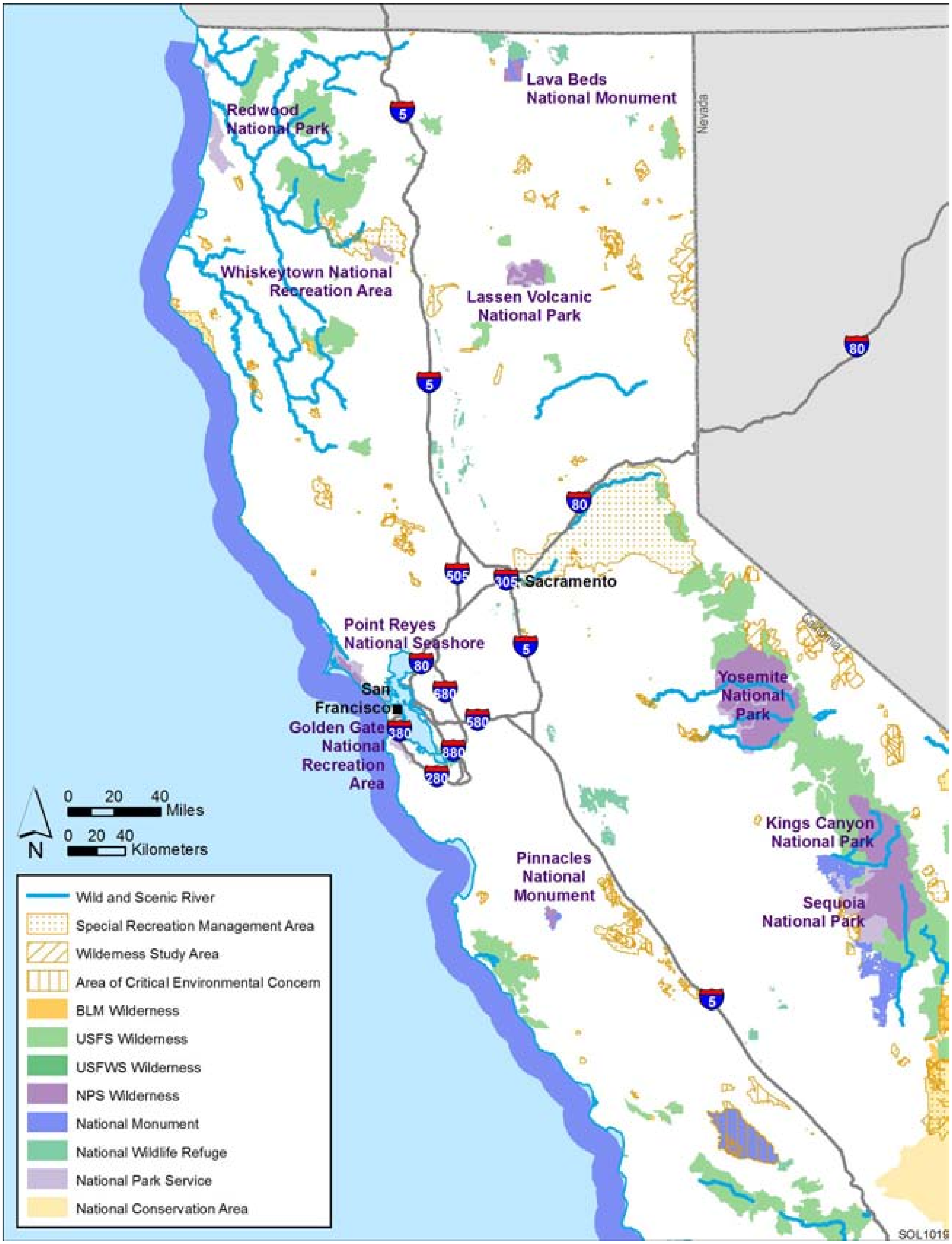

FIGURE 4.3-2 Specially Designated Areas on Public Lands in Northern and Central California

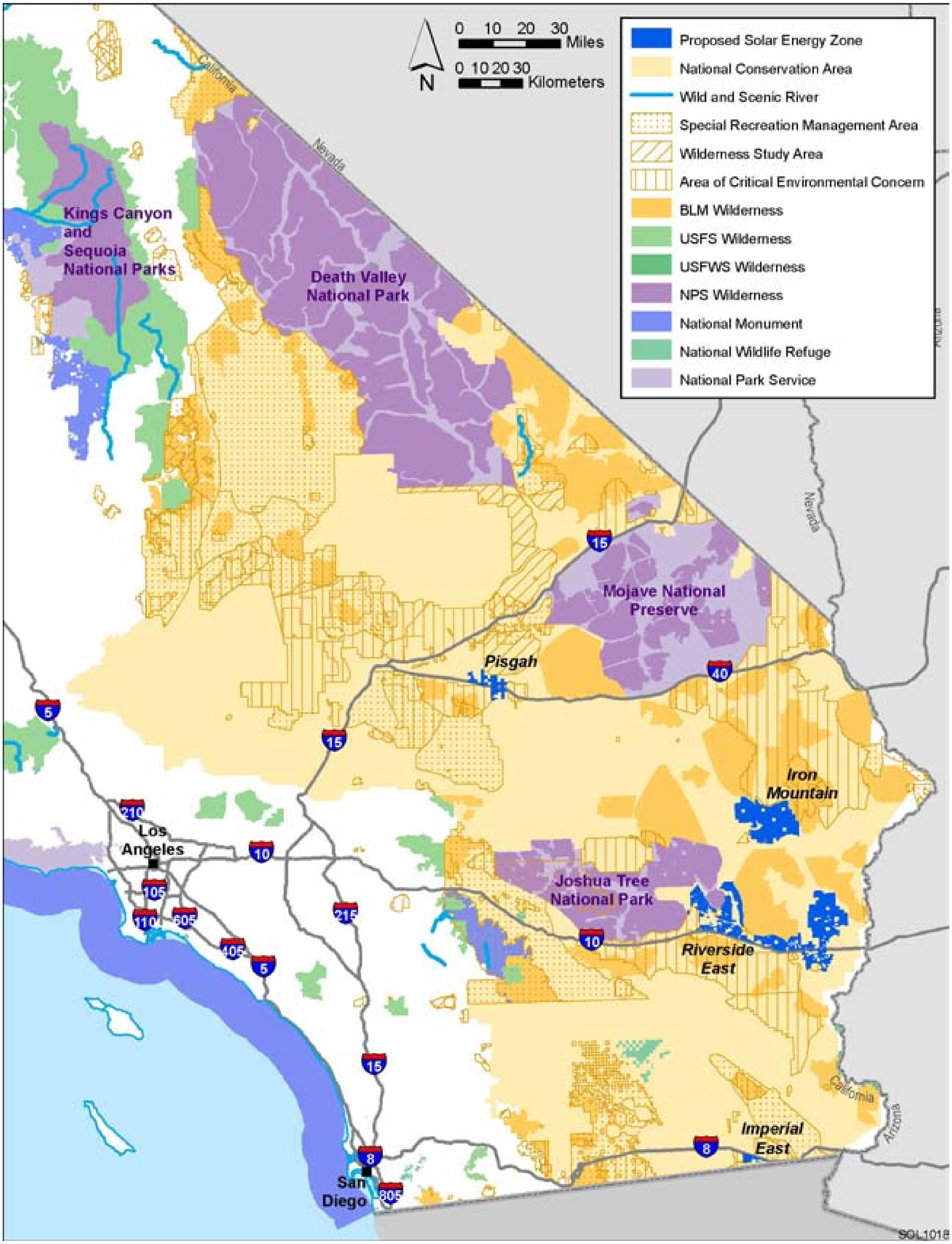

FIGURE 4.3-3 Specially Designated Areas on Public Lands in Southern California

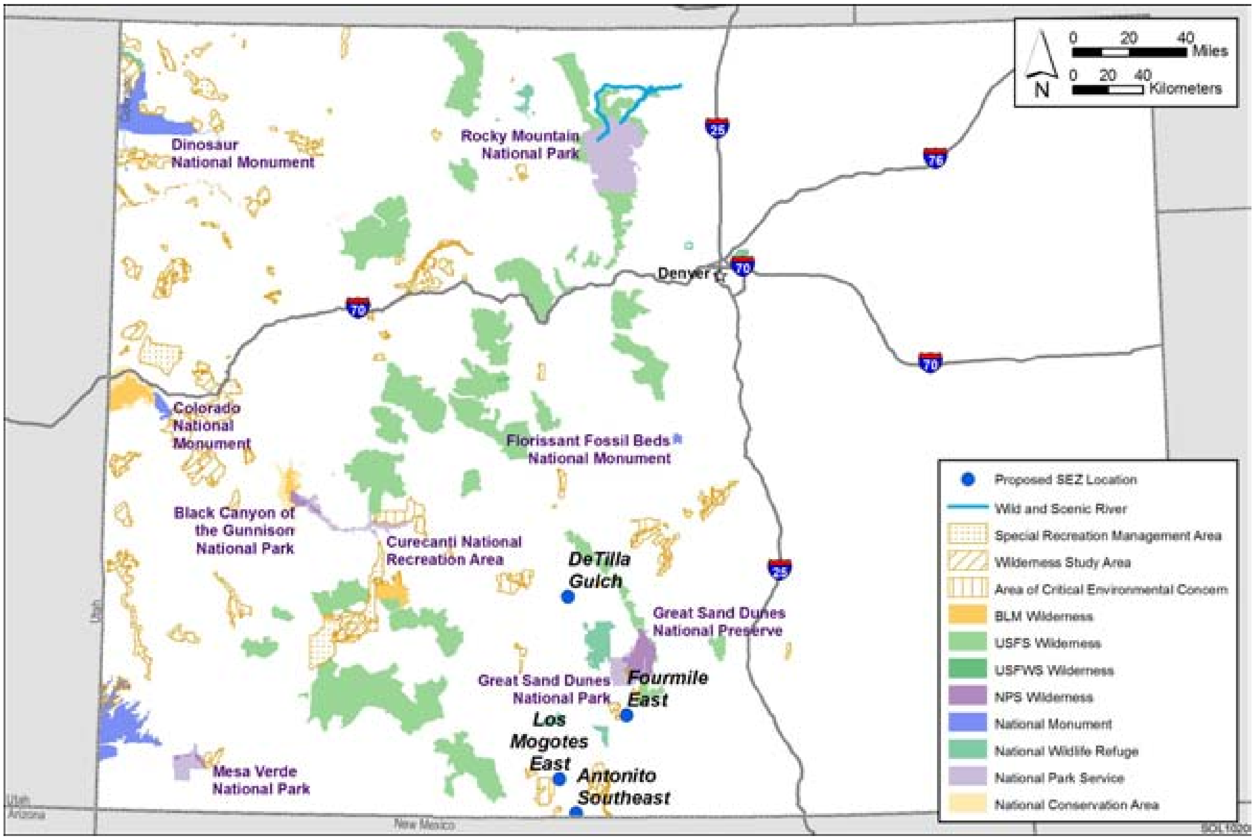

FIGURE 4.3-4 Specially Designated Areas on Public Lands in Colorado

[16 USC 1331 et seq.]) of 1971 (the Act) gave the BLM and other federal land management agencies the responsibility to protect, manage, and control wild horses and burros. The general management objectives for wild horses and burros are to (1) protect, maintain, and control viable, healthy herds with diverse age structures while retaining their free-roaming nature; (2) provide adequate habitat through the principles of multiple use and environmental protection; (3) maintain a thriving natural ecological balance with other resources; (4) provide opportunities for the public to view wild horses and burros; and (5) protect wild horses and burros from unauthorized capture, branding, harassment, or death.

Wild horses and burros are managed within herd management areas (HMAs) with the goal of maintaining the natural ecological balance of public lands as well as the ability to support multiple herds (BLM 2008a). HMAs are usually subsets of an area known as a herd area (HA), which is an area that at the time of the passage of the Act was wild horse or burro habitat but has not been designated for long-term management of wild horses or burros. The exterior boundaries of both HAs and HMAs can include private or state lands, but BLM has management authority only over public lands. Herd population management is important for balancing herd numbers with forage resources and with other uses of the public and adjacent private lands.

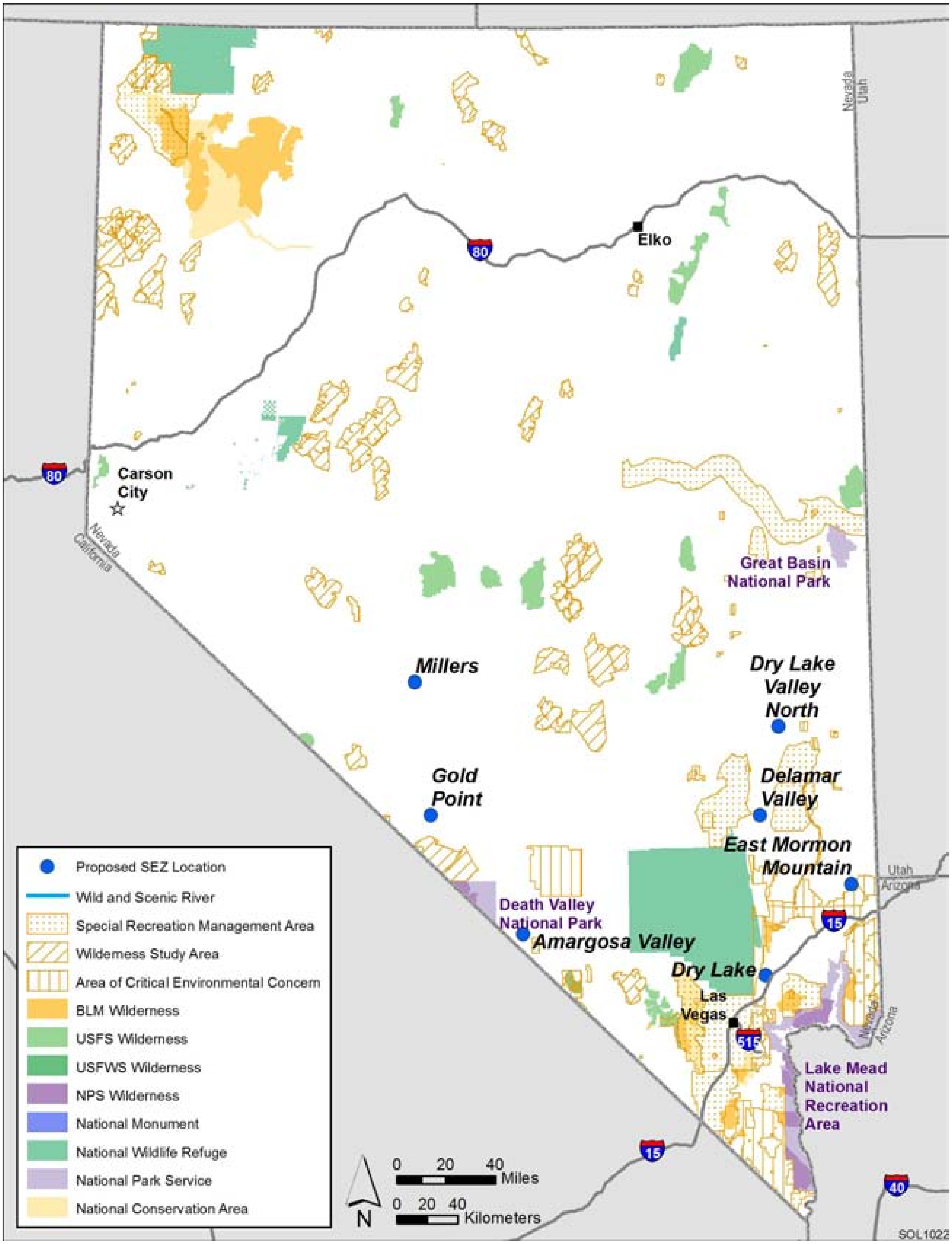

FIGURE 4.3-5 Specially Designated Areas on Public Lands in Nevada

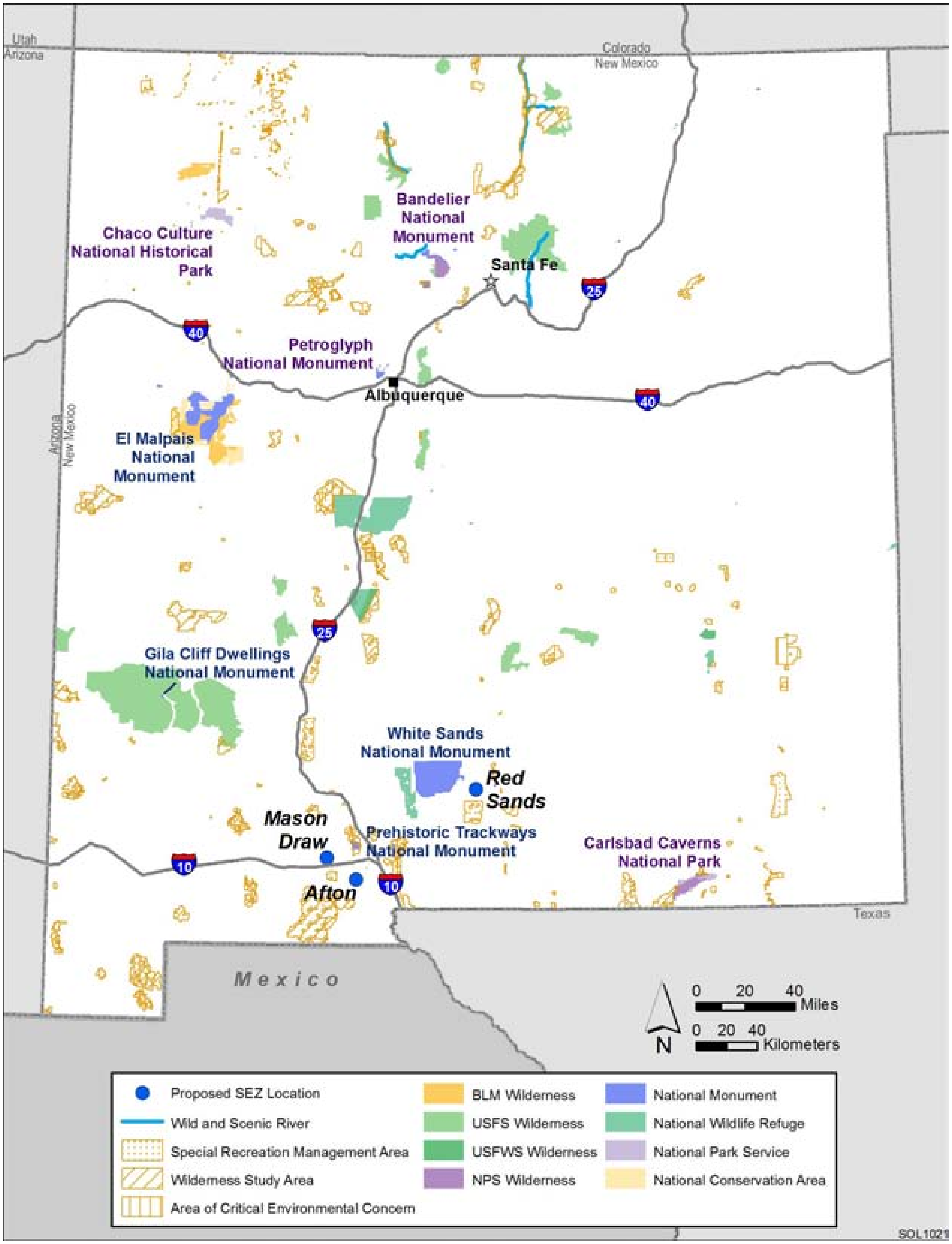

FIGURE 4.3-6 Specially Designated Areas on Public Lands in New Mexico

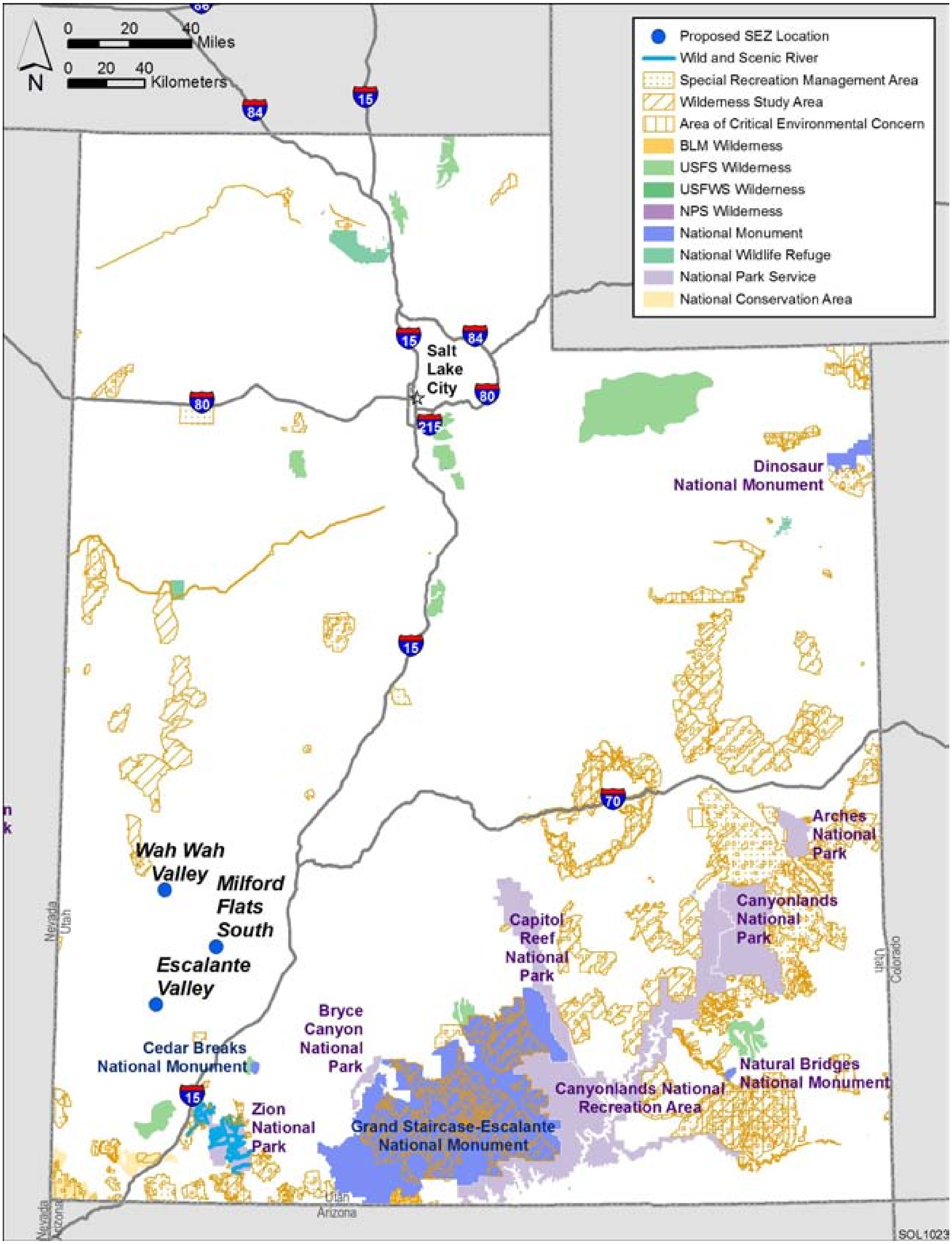

FIGURE 4.3-7 Specially Designated Areas on Public Lands in Utah

TABLE 4.3-1 BLM National Landscape Conservation System (NLCS) Units in the Six-State Study Area[a]

State	National Monuments (acres)	National Conservation Areas (acres)	Wilderness Areas (acres)	Wilderness Study Areas (acres)	National Wild, Scenic, and Recreational Rivers[b] (acres)	Other[c] (acres)	National Historic and Scenic Trails (mi)[d]	Totals[e] (acres)
Arizona	1,774,213	119,234	1,396,466	63,930	–[f]	–	990	3,354,833
California	291,390	10,729,231	3,659,800	880,175	19,360	7,472	1,716	15,589,144
Colorado	163,892	185,773[g]	139,524	621,737	–	–	389	1,111,315
Nevada	–	1,045,668[h]	2,056,545	2,552,457	–	–	596	5,655,266
New Mexico	4,124	227,100	151,190	953,087	22,720	–	60	1,358,281
Utah	1,870,800	–	129,120	3,207,364	–	–	–	5,207,284
Total	4,104,419	12,307,006	7,532,645	8,278,750	42,080	7,472	3,751	32,276,123

a To convert acres to km^2, multiply by 0.00405. To convert mi to km, multiply by 1.609.

b The congressionally authorized wild and scenic study rivers are not included. See Section 4.9.1.2 for details on this classification.

c Headwaters Forest Preserve (California).

d Values presented are in units of linear miles and therefore are not included in the total acreages for each state. Historic and scenic trails cross many states; values are assigned to the first state listed for each trail in Table 5-7 of the source document (BLM 2007c).

e Totals include double counted areas (e.g., some wilderness areas are included within a National Monument or National Conservation Area). As a result, the sum total of conservation acres listed is greater than the actual number of acres managed.

f A dash indicates no acreage.

g Acreage includes land in Utah.

h Acreage includes land in California.

Source: BLM (2007c).

As shown in Table 4.4-1, in FY 2009 the six states had a total of 28,293wild horses and burros, although the appropriate management level (i.e., the maximum number of animals sustainable on a year-long basis) is 19,416 animals (BLM 2010).

4.4.3 Wildland Fire

The six states in the PEIS study area have a wide range of climates and fuel types, and wildland fire is a factor to be considered as part of the site-specific planning for solar energy facilities. As a general rule the areas of highest interest for solar development (the southern portions of California, Nevada, and Arizona) support vegetation that while flammable, usually is not sufficiently dense to represent a large fire danger. Exceptions to this are precipitation related and occur when above-average amounts of rainfall spur the growth of annual plants, including invasive species, that provide a ready fuel source once a fire starts. The causes of fires can be either lightning (natural) or man-made, with lightning fires being more common in the states of Colorado, Nevada, and Utah while human caused fires are ubiquitous. Fire management and protection may be provided by BLM or cooperator organizations that could include private, state, or other federal agency fire organizations.

4.5 RECREATION

The vast majority of the American public's interaction with BLM-administered lands is through outdoor recreation activities. In FY 2007, more than 57 million visitors participated in such activities as rafting, hiking, biking, back-country driving, hunting, fishing, and camping in the six- state study area. Other activities include visits to heritage sites, national monuments, wild and scenic rivers, wilderness areas, national trails, and national conservation areas (BLM 2005a, 2007c). BLM manages 469 recreation sites within the six-state study area (Recreation.gov 2008).

Many BLM offices have also completed Transportation Management Plans that classify public lands as either closed, limited, or open for motorized vehicle use. The "limited" category is further broken down as being limited either "to existing roads and trails" or "to designated roads and trails." Many of these plans also address whether, and under what conditions, commercial or competitive vehicle events are allowed.

Recent BLM RMPs identify areas with high-value recreation resources as special recreation management areas (SRMAs). A SRMA is a unit of public land identified for the purpose of directing available recreation funding and personnel to fulfill commitments made to provide specific, structured recreation opportunities. Both RMP decisions and subsequent implementing actions for recreation in each SRMA are geared to one of three identified primary user markets: destination, community, or undeveloped recreation-tourism market (BLM 2005c). About 264 SRMAs are located within the six-state study area.

TABLE 4.4-1 Wild Horse and Burro Statistics for the Six-State Study Area, FY 2009

	Herd Area[a,b]			Herd Management Area[b,c]				Populations			
State	BLM Acres	Other Acres[d]	Total Acres	No. of HMAs	BLM Acres	Other Acres	Total Acres	Horses	Burros	Total	Total AML[e]
Arizona	2,019,932	1,617,998	3,637,930	7	1,756,086	1,327,777	3,083,863	390	1,967	2,357	1,676
California	4,810,248	1,813,228	6,623,476	22	1,946,590	471,855	2,418,445	4,057	895	4,952	2,201
Colorado	658,119	76,572	734,691	4	366,098	38,656	404,754	772	0	772	812
Nevada	19,076,183	3,073,205	22,149,388	85	13,580,401	1,688,864	15,249,265	16,642	819	17,461	12,688
New Mexico	88,653	37,874	126,527	2	24,505	4,107	28,612	114	0	114	83
Utah	3,150,220	676,855	3,827,075	19	2,174,850	310,747	2,485,597	2,495	142	2,637	1,956
Total	29,803,355	7,295,732	37,099,087	139	19,848,530	3,842,006	23,690,536	24,470	3,823	28,293	19,416

[a] Herd area is the geographic area identified as having been used by wild horse or burro herds as their habitat in 1971.

[b] To convert acres to km^2, multiply by 0.00405.

[c] Herd management area is the herd area or portion of the herd area that has been designated for special management, emphasizing the maintenance of an established wild horse or burro herd.

[d] Other acres include other federally administered lands (e.g., USFS, U.S. Department of Defense [DoD], NPS) and private lands.

[e] AML = appropriate management level. Number listed is the maximum number of animals sustainable on a year-long basis.

Source: BLM (2010).

4.6 MILITARY AND CIVILIAN AVIATION

Many military training routes (MTRs) and special use airspace (SUA) are used by the military and other agencies in the six-state study area. Their specific locations and operational needs must be considered when siting utility-scale solar energy facilities and related transmission facilities. Rather than just being individual routes or training areas, this military airspace forms a complex system that supports the training of military flight crews from all parts of the western United States. This interconnected system represents an important national defense asset.

The U.S. military uses airspace for its training operations, some of which occur at low altitudes (from 1,000 ft [305 m] to as low as ground surface). The National Aeronautics and Space Administration (NASA) uses military airspace near Edwards Air Force Base to support its space shuttle operations, and civilian military aircraft contractors also use military airspace to support their test programs. Airspace restrictions for MTRs and SUAs (SUAs also include military operating areas) cover about 37% of the public land in the western states. Public lands overlain by MTRs and SUAs are found throughout the six-state study area, with New Mexico and California having the largest amount of coverage. Figure 4.6-1 shows the extent of military airspace restrictions at altitudes of 1,000 ft (305 m) or less within the six-state study area. Solar development in proximity to these training areas would require consultation with the U.S. Department of Defense (DoD) during project planning to ensure that solar projects do not conflict with DoD training activities.

The presence of civilian airports and their operational airspaces also must be considered when siting utility-scale solar energy facilities and related transmission facilities. About 577 public airports are located in the six-state study area: Arizona, 81; California, 261; Colorado, 77; Nevada, 52; New Mexico, 59; and Utah, 47 (AirNav.com 2006). The numerous private and military airports in these states are not included in these numbers.

The Federal Aviation Administration (FAA) has jurisdiction over air traffic and must be contacted for any proposed construction or alteration of objects within navigable airspace under the following categories (FAA 2000):

- Proposed objects more than 200 ft (61 m) above ground level (AGL) at the structure's proposed location;

- Within 20,000 ft (6,100 m) of an airport or seaplane base that has at least one runway longer than 3,200 ft (975 m), and the proposed object would exceed a slope of 100:1 horizontally from the closest point of the nearest runway;

- Within 10,000 ft (3,048 m) of an airport or seaplane base that does not have a runway more than 3,200 ft (975 m) in length, and the proposed object would exceed a 50:1 horizontal slope from the closest point of the nearest runway; and/or

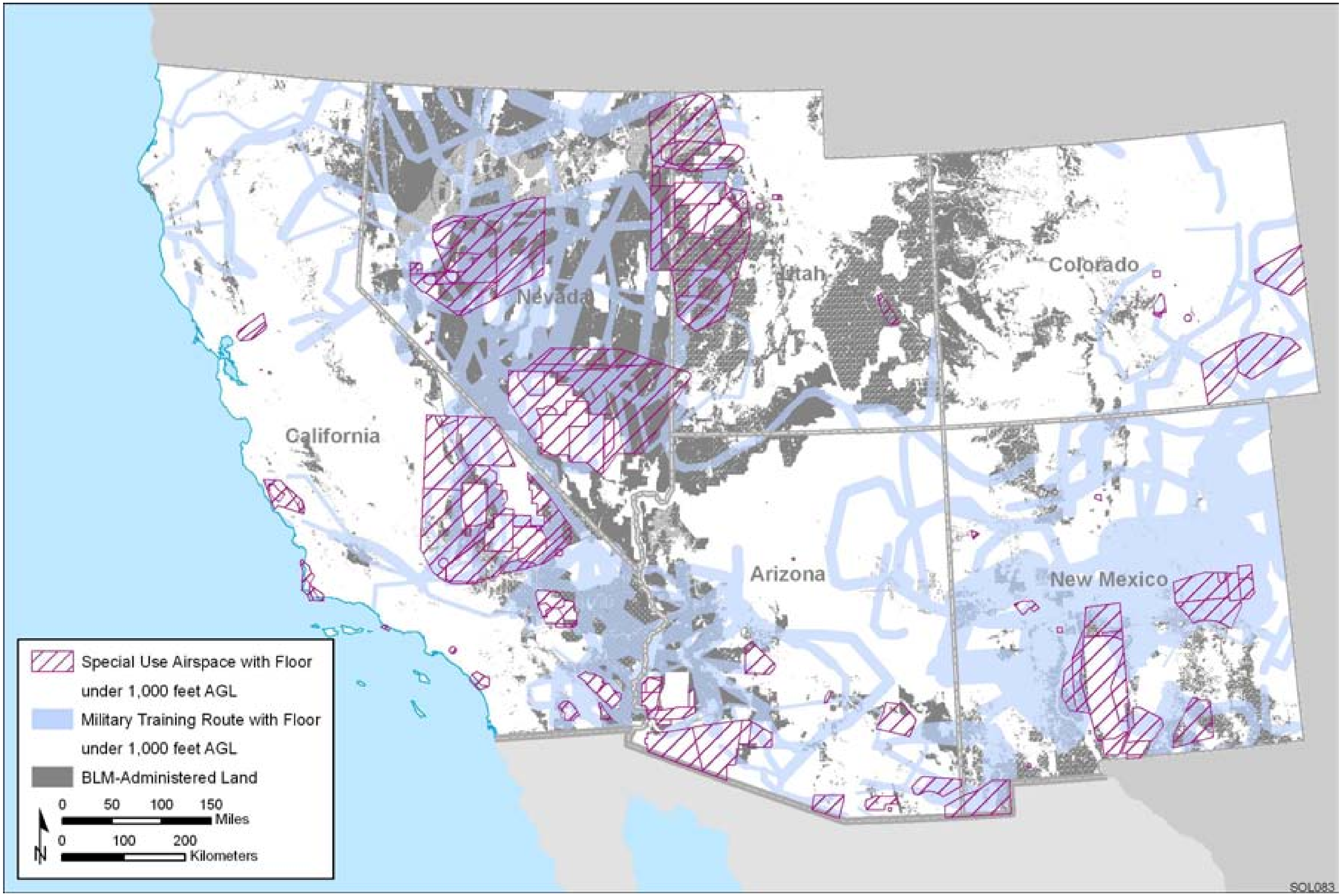

FIGURE 4.6-1 Locations of Restricted Military Airspace (including MTRs and SUAs) over the Six-State Study Area

- Within 5,000 ft (1,524 m) of a heliport, and the proposed object would exceed a 25:1 horizontal slope from the nearest landing and takeoff area of that heliport.

The FAA could recommend marking and/or lighting a structure that does not exceed 200 ft (61 m) AGL or that is not within the distances from airports or heliports mentioned above, because of its particular location (FAA 2000).

4.7 GEOLOGIC SETTING AND SOIL RESOURCES

4.7.1 Geologic Setting

The six-state study area encompasses several physiographic provinces, which are areas with similar terrain, rock types, and geologic structure and history (Burchfiel et al. 1992). From west to east (Figure 4.7-1), the physiographic provinces are (1) the Pacific Border and the Lower California provinces; (2) the Cascade–Sierra Mountains province; (3) the Basin and Range province; (4) the Columbia–Snake River Plateau (mostly in Oregon and Idaho, but with a small portion overlapping northern Nevada); (5) the Colorado Plateau; (6) the Middle and Southern Rocky Mountains provinces; (7) the Wyoming Basin; and (8) the Great Plains province, covering eastern Colorado and New Mexico. The characteristics of these physiographic provinces are summarized in Table 4.7-1.

4.7.2 Geologic Hazards

4.7.2.1 Seismicity

Seismic activity and related hazards, such as surface rupture, ground-shaking, and liquefaction, pose a moderate to high risk to solar energy development in some portions of the six-state study area. The following sections describe these hazards in terms of their probability and location in the study area. It is important to note that the scales of the accompanying maps are small because their purpose is to show the general locations of hazardous areas (not individual faults or landslides) and how they correlate to the physiography described in Table 4.7-1. The risks of local seismic hazards are discussed in later chapters of this report (under individual SEZs) and will be assessed more thoroughly during the site characterization phase of specific solar energy projects.

4.7.2.1.1 Quaternary Faults and Earthquake Activity. Quaternary faults (i.e., preexisting faults with evidence of movement or deformation within the past 1.6 million years) are thought to be the probable sources of past, current, and future earthquakes with magnitudes greater than 6.0. The U.S. Geological Survey's (USGS's) Quaternary fault and fold database contains information on these faults and fault-related folds, such as geologic setting,

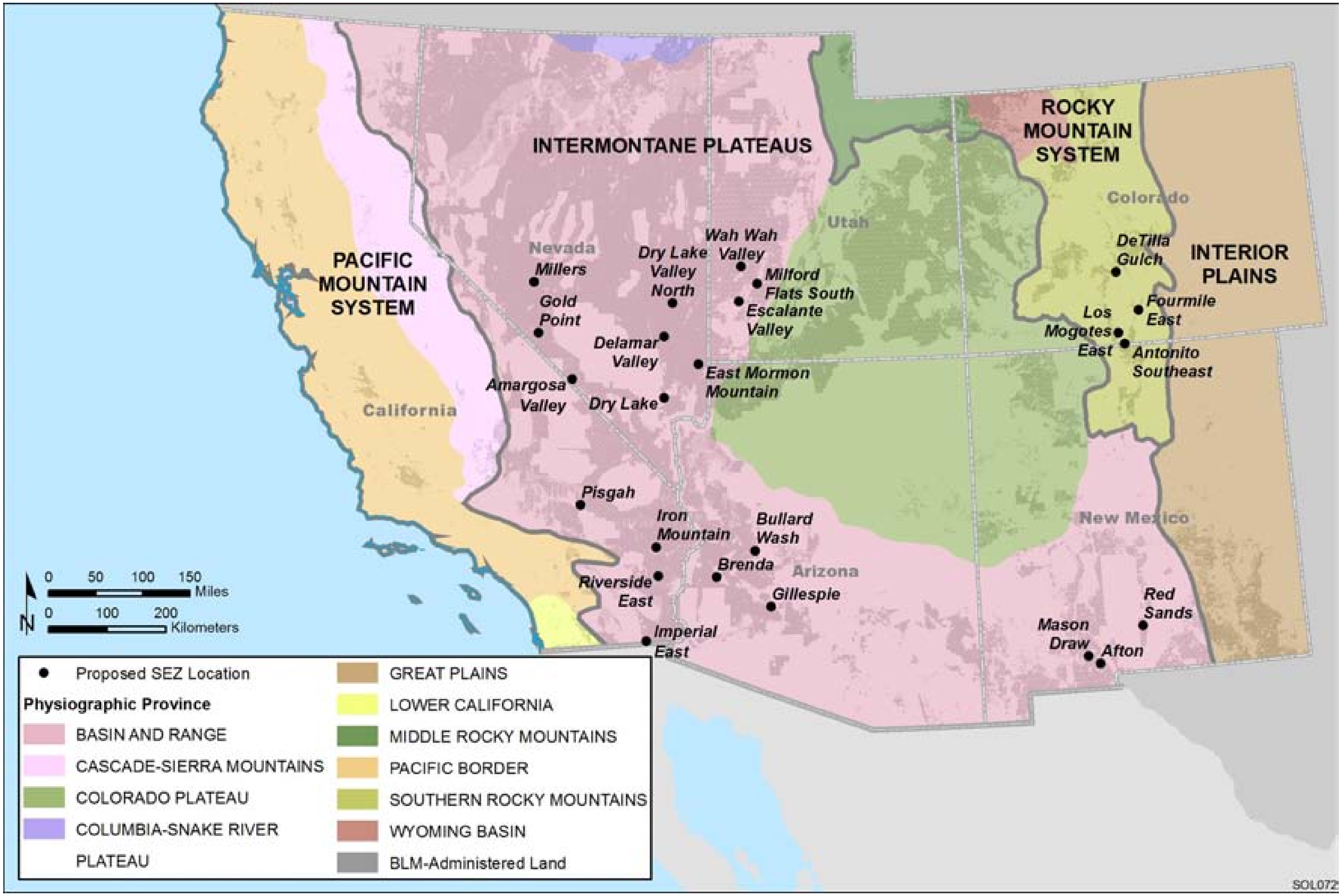

FIGURE 4.7-1 Physiographic Provinces of the Six-State Study Area (Sources: Modified from USGS 2004; National Atlas 2006)

TABLE 4.7-1 Physiographic Provinces in the Six-State Study Area

Physiographic Province	Section	Geographic Location	General Terrain	Rock Types
Pacific Border	California Coast Ranges	California, running parallel to the coast.	A series of ridges and valleys with a northwest trend. One of the main faults controlling the Coast Ranges is the San Andreas Fault. Elevations range from sea level to more than 11,483 ft (3,500 m). Earth flows and complex landslides are active in mountainous areas.	Folded and faulted formations of sedimentary, igneous, and metamorphic bedrock are common.
	Transverse Ranges	California, between the Coast Ranges to the north and the Lower California Province to the south.	Consists of ranges and basins trending nearly east and transverse to the southeasterly trend of adjoining areas (e.g., the Sierra Nevada, the Great Valley, and the Coast Ranges at the north, and the Lower California province at the south). Highest ranges reach elevations greater than 10,000 ft (3,048 m).	Mountains consist of marine formations; those to the east consist mostly of older rocks, including granite, and metamorphosed sedimentary and volcanic rocks. Basins are filled with thick terrestrial deposits buried under marine fill.
	Klamath Mountains	Situated between the Coast Ranges of California and Oregon.	Similar rock structures as the Sierra Nevada (see below).	Deformed and metamorphosed sediments intruded by granite.
	Great Valley of California	Situated between the Sierra Nevada and the Coast Ranges (and south of the Klamath Mountains) in central California.	A flat geological trough with elevations ranging from below sea level to more than 1,000 ft (305 m). Alluvial fans slope westward along the foot of the Sierra.	Thick sequence of sedimentary deposits derived from erosion of the Sierra Nevada.
Lower California		Situated between the Salton Trough and the coast on the northern end of Baja California.	The province is a westward-dipping plateau. Elevations range from 11,000 ft (3,353 m) at San Jacinto Peak on the north end to below sea level at the Salton Sea trough. Terraces along the coast are as high as 1,300 ft (396 m) above sea level.	Granitic batholith forms the plateau.

1

TABLE 4.7-1 (Cont.)

Physiographic Province	Section	Geographic Location	General Terrain	Rock Types
Cascade–Sierra Mountains[a]	High Cascade Mountains	Southern Washington, Oregon, and northern California.	Best known for their high, snow-capped volcanoes. The mountains are part of the circum-Pacific volcanic belt characterized by younger, active volcanoes (such as Mount St. Helens, Mount Rainer, and Glacier Peak). Overlooks the Columbia–Snake River Plateau.	Volcanic, sedimentary, and metamorphic rocks.
	Sierra Nevada Mountains	Eastern California, east of California's Great Central Valley.	Uplifted by faulting along the east, tilting westward exposing granitic and metamorphosed sedimentary formations. About 350 mi (563 km) long and 60 mi (97 km) wide with a maximum elevation of about 9,000 ft (2,743 m) along the east fault scarp and overall maximum elevation of 14,505 ft (4,421 m) at Mount Whitney. Lava flows.	Primarily granitic rocks with some older metamorphic rock; volcanic rocks along the eastern scarp.
Basin and Range		South of the Columbia Plateau, extending from southern Idaho and Oregon through most of Nevada and parts of western Utah, eastern California, western and southern Arizona, and southwestern New Mexico.	Consists of more than 400 evenly spaced, nearly parallel block-faulted mountain ranges and intervening basins. Jagged crests are generally abrupt, steeply sloping, and deeply dissected with elevations from 3,000 to 5,000 ft (914 to 1,524 m) above the intermountain basins. Basins are typically broad, gently sloping, and largely undissected with elevations ranging from below sea level to about 5,000 ft (1,524 m). Basins in the north are internally drained.	Mountain ranges composed of complexly deformed Precambrian and Paleozoic rocks. Mesozoic granitic rocks are found in the western province. Cenozoicvolcanic rocks are widespread. Intermontane basins filled with Tertiary rocks overlain by Quaternary sediments (e.g., alluvium, dune sand, and playa deposits).
Columbia–Snake River Plateau	Snake River Plain	Southern Idaho, extending into northern Nevada.	A flat and geomorphically featureless area surrounded by mountains and highlands.	The eastern part of the plateau is characterized by rhyolitic volcanic rocks covered by basaltic lava; the western plateau is a basin filled with sedimentary deposits over a thick slab of basalt.

TABLE 4.7-1 (Cont.)

Physiographic Province	Section	Geographic Location	General Terrain	Rock Types
Colorado Plateau		At the intersection of Colorado, Utah, Arizona, and New Mexico, covering 130,000 mi^2 (336,698 km^2) between the Rocky Mountain and Basin and Range provinces.	The plateau is an uplifted surface greater than 5,000 ft (1,524 m) in elevation, with peaks reaching to 11,000 ft (3,353 m). Extensive areas of horizontal sedimentary formations with structural upwarps and igneous structures (e.g., volcanoes, cinder cones and volcanic necks, lava-capped plateaus and mesas, and dome mountains caused by intrusion of stocks and laccoliths).	Mostly sedimentary rocks. Volcanic rocks and volcanic plugs are common in some areas.
Middle and Southern Rockies		Northwestern Wyoming and Colorado.	Before the Laramide mountain-building period, the Middle and Southern Rockies were part of a stable platform composed of Precambrian crystalline rocks. The platform received sediments that were transformed into sedimentary rocks, which were then uplifted and eroded during the mountain-building period. Later, volcanic activities produced mountains and high plateaus in many places. Separated from the Middle Rockies by the Wyoming Basin in Wyoming, the Southern Rockies have summits between 10,827 and 14,436 ft (3,300 and 4,400 m).	Sedimentary, metamorphic, and volcanic rocks.
Wyoming Basin		Located in northwestern Colorado, the basin provides a connection between the Colorado Plateau and the Great Plains (through a “break” in the Rocky Mountain range).	Consists of elevated semiarid basins and isolated low mountains with elevations ranging from 6,000 to 8,000 ft (1,829 to 2,438 m). Basins have a bowl-like structure with sedimentary deposits resting unconformably on older sedimentary formations. Cuestas and hogbacks formed around the rims of basins create topographic relief in those areas.	Sedimentary formations, with volcanic and intrusive rocks.

1

TABLE 4.7-1 (Cont.)

Physiographic Province	Section	Geographic Location	General Terrain	Rock Types
Great Plains		Located east of the Rocky Mountains and the Basin and Range province in the eastern parts of Montana, Wyoming, Colorado, and New Mexico.	A large region of generally low relief, sloping eastward from about 5,500 ft (1,676 m) at the foot of the Rocky Mountains to about 2,000 ft (610 m) at the eastern boundary of the province.	Marine sediments covered with more recent sedimentary deposits derived from the Rocky Mountains.

[a] The Cascade–Sierra Mountains province consists of the north-trending Cascade Mountains (in Oregon and Washington), the High Cascade Mountains, and the Sierra Nevada. However, only the sections falling within California are described here.

Sources: Burchfiel et al. (1992); Dohrenwend (1987); Madole et al. (1987); Wayne et al. (1991).

fault orientation, fault type and sense of movement, slip rate, recurrence interval, and the time of the most recent movement. The database is the USGS's primary source for seismic hazards information on Quaternary faults in the United States (Machete et al. 2004).

In the six-state study area, Quaternary faults occur predominantly in fault zones associated with the San Andreas Fault system (western California), the Eastern California Shear Zone (eastern California), the Central Nevada Seismic Zone (west-central Nevada), the block fault systems throughout the Basin and Range province (Nevada), the Intermountain Seismic Belt (northern Arizona and Utah), and the Rio Grande Rift system (New Mexico and Colorado) (Figure 4.7-2). Historically, the most active seismic regions have been along the San Andreas Fault system and within the Eastern California Shear Zone and the Nevada Seismic Zone. Earthquake-prone areas are subject to various hazards, including surface rupture, ground shaking, liquefaction, and landslides, that may cause severe damage to buildings and infrastructure.

4.7.2.1.2 Ground-Shaking. Seismic waves during an earthquake cause ground shaking that radiates outward from the rupturing fault. Shaking intensity is mainly a function of an earthquake's magnitude and the distance from the fault, but can be amplified by other factors, such as the softness of the ground (soft rocks and sediments versus hard rock) and the total thickness of sediments below the area. Shaking tends to be stronger in soft rocks and sediments and increases with increasing thickness of underlying sediments. Other factors affecting the pattern of shaking include the orientation of the fault, irregularities of the rupturing fault surface, and the scattering of waves as they intercept underground structures (Field et al. 2001).

The USGS's National Seismic Hazard Map series provide estimates of likely shaking for regions throughout the United States and are used as a basis for the seismic design provisions of building codes, insurance rate structures, earthquake loss studies, retrofit priorities, and land-use planning (USGS 2008b). On these maps, ground-shaking is expressed as a percentage of acceleration of a falling object due to the force of gravity (g)[5]. Figure 4.7-3 presents the peak horizontal acceleration in the six-state area as a percentage of g that has a 10% probability of being exceeded over a 50-year period. The peak horizontal acceleration ranges from 0 g (insignificant ground-shaking) to 1 g (strong ground-shaking). The highest ground-shaking hazard in the study area occurs in parts of California, with the highest probable peak acceleration (greater than 0.40 g or 40% of g) occurring along the trace of the San Andreas Fault system. In the Basin and Range, Colorado Plateau, and Great Plains provinces to the east, the probable peak acceleration is low, in the range of 0 g to 0.1 g (equal to or less than 10% of g), since seismically active areas are at some distance away. Table 4.7-2 provides a scale that relates peak horizontal acceleration to perceived shaking and potential damage to structures on the ground.

[5] Gravity (g) is a common value of acceleration equal to 9.8 m/s^2 (the acceleration due to gravity at the earth's surface).

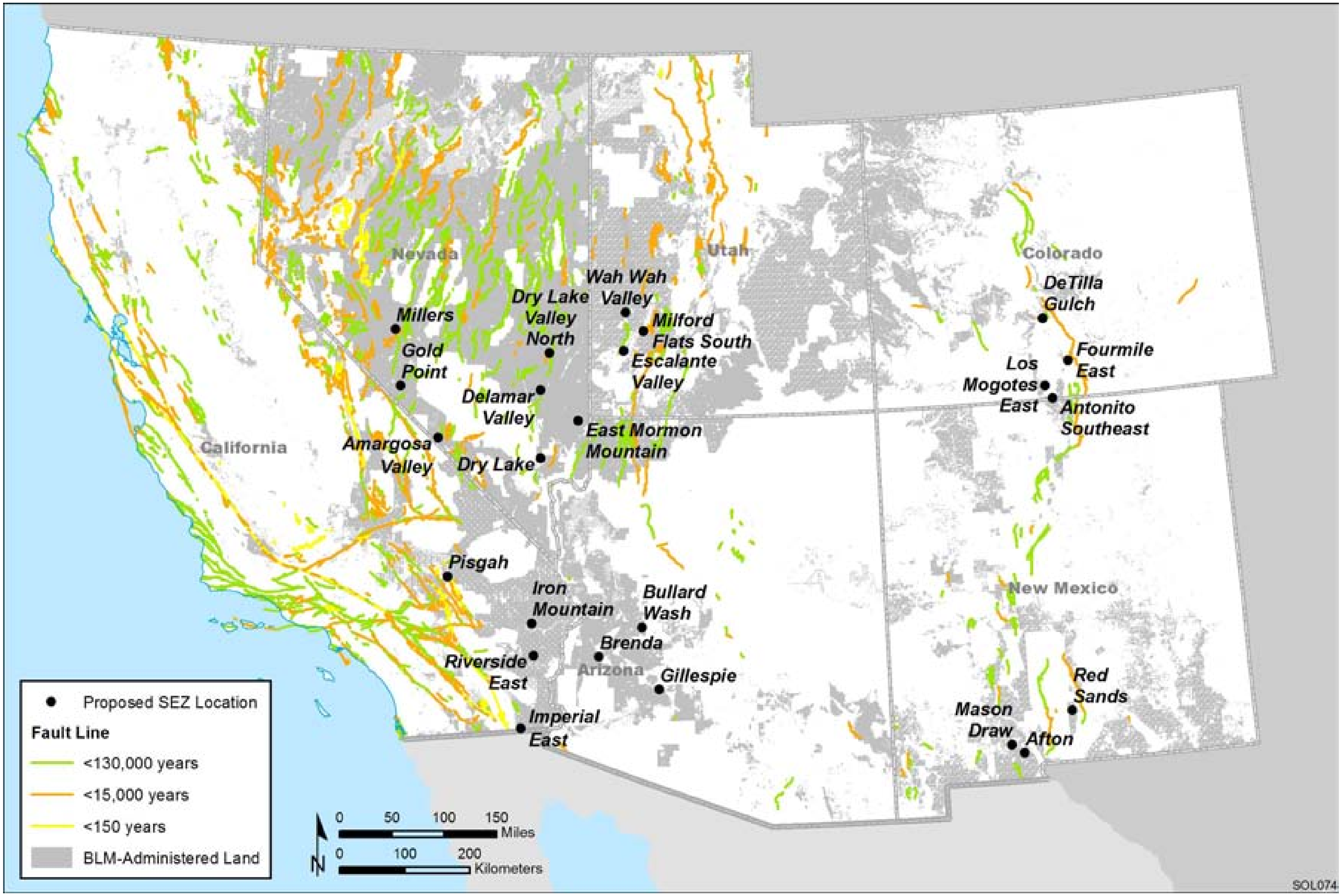

FIGURE 4.7-2 Quaternary Faults in the Six-State Study Area (Source: USGS 2010c)

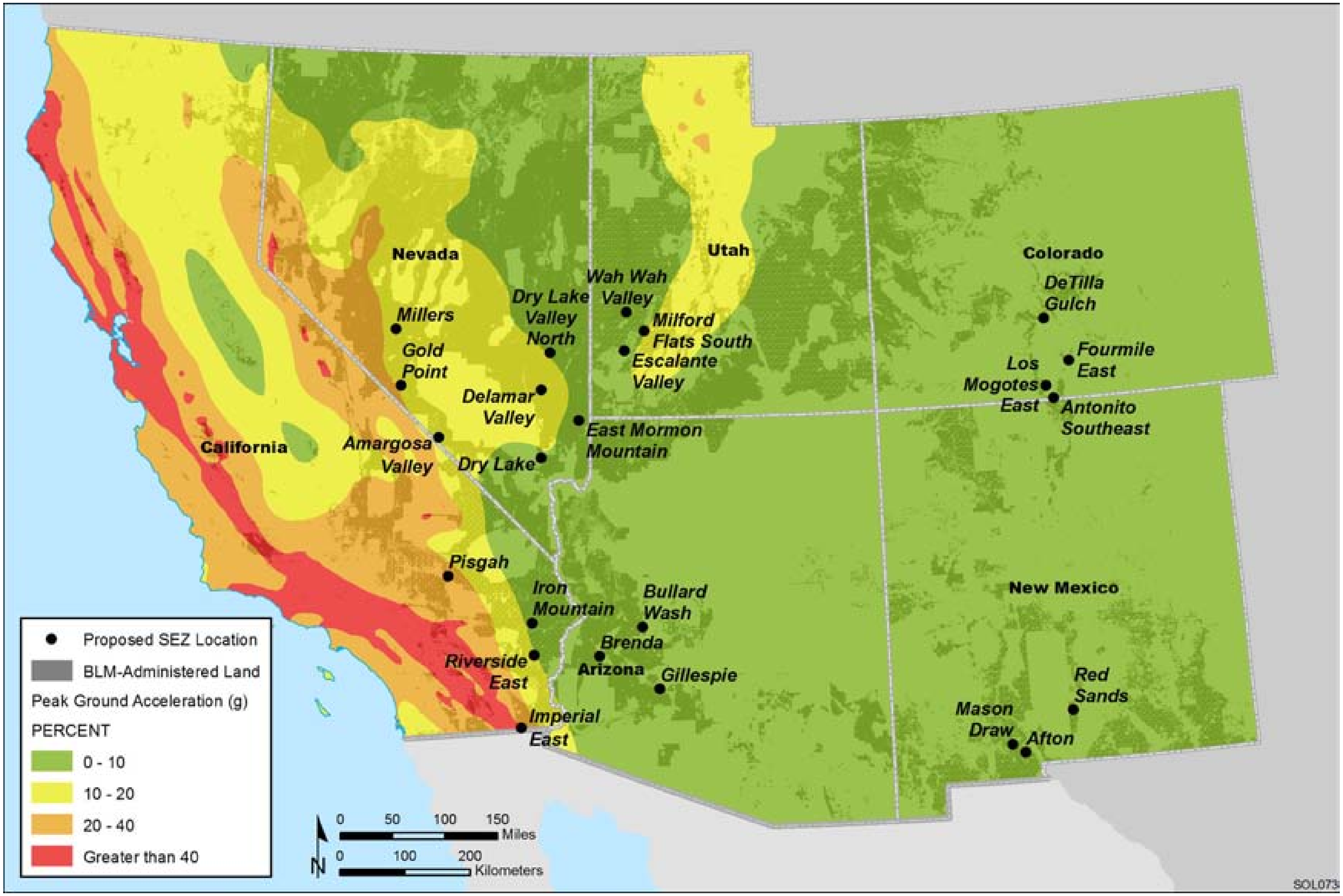

FIGURE 4.7-3 Peak Horizontal Ground Acceleration within the Six-State Study Area with a 10% Probability of Exceedance in 50 Years (Source: USGS 2008c)

TABLE 4.7-2 Relationship between Peak Horizontal Acceleration, Perceived Shaking, and Potential Structural Damage

Peak Horizontal Acceleration (%g)	Perceived Shaking	Potential Damage
<0.17	Not felt	None
0.17 to 1.4	Weak	None
1.4 to 3.9	Light	None
3.9 to 9.2	Moderate	Very light
9.2 to 18	Strong	Light
18 to 34	Very strong	Moderate
34 to 65	Severe	Moderate to heavy
65 to 124	Violent	Heavy
>124	Extreme	Very heavy

Source: Wald (2000).

4.7.2.1.3 Liquefaction and Landslide Susceptibility. Liquefaction refers to a sudden loss of strength and stability in loose, saturated soils, causing them to behave like a fluid. Liquefaction of soils results in ground failure of various types, including lateral spreads (landslides), flow failures, ground oscillation, and loss of bearing strength. Sand blows or boils (small eruptions) commonly accompany these types of ground failure, forming sand dikes in subsurface sediment layers and sand volcanoes at the ground surface. Liquefaction hazards occur during or immediately following large earthquakes and are associated with sandy and silty soils with low plasticity (i.e., low clay content); therefore, the potential to liquefy tends to be higher in recent deposits of fluvial, lacustrine, or eolian origin than in glacial till and older deposits. Saturated soils are more susceptible to liquefaction, and the hazards of liquefaction are most severe in near-surface soils (less than 50 ft [15 m] below the ground surface) and on slopes (SCEC 1999; Matti and Carlson 1991). Given the relatively low incidence of historic seismicity in most of the six-state study area, liquefaction is not a hazard of great concern. However, some earthquake-prone areas in parts of California (e.g., parts of the San Francisco Bay area) and along various inland water bodies (e.g., the shoreline of the Great Salt Lake) are highly susceptible to liquefaction.

Steeply sloping areas underlain by loose sediment or soft rocks are most susceptible to earthquake-induced landslides.

4.7.2.2 Volcanic Activity

Major volcanoes or volcanic fields in the six-state study area occur primarily in California along the Cascade-Sierra Nevada Mountains (Figure 4.7-4). In California, more than 75 volcanic vents have been active during the last 10,000 years. More than 10 have erupted during the past 600 years; these include Medicine Lake, Mount Shasta, and Lassen Peak, and

FIGURE 4.7-4 Active Volcanoes and Areas of Unrest Potentially Affecting the Six-State Study Area

Mono-Inyo volcanic chain near the Long Valley Caldera. The tectonic settings of California's volcanic centers include those related to subduction in the Cascade-Sierra Nevada Mountains (Mount Shasta and Lassen Peak), crustal thinning along the Sierra Nevada escarpment (Mono-Inyo volcanic chain and Long Valley Caldera), and active crustal spreading in the Salton Sea Trough (Salton Buttes rhyolite domes) (Miller 1989). Other potentially active volcanoes in the study area occur within the Southern Colorado Plateau (Uinkaret, Arizona), the Southern Rocky Mountains (Jemez Mountains, New Mexico), and the Basin and Range (Lavic Lake, California) provinces (USGS 2010a).

Active volcanoes and areas of unrest located outside of the study area with the potential to affect developments within the six-state region include those of the Cascade Range in Oregon and Washington and the Yellowstone volcanic field in Wyoming. Earthquake swarms and/or ground deformation (uplift or subsidence) have been reported for Mount Hood and South Sister (both located in Oregon) as recently as 2002 and 2004, respectively (Diefenbach et al. 2009). Mount St. Helens is the most frequently active volcano in the Cascade Range and has erupted as recently as 2008 (Diefenbach et al. 2009). Given its distance from the six-state study area, however, the only potential hazard from a large eruption from Mount St. Helens would result from tephra falls. Hazard zonation maps show that the probability of tephra accumulation of 4 in. (10 cm) or more would be less than 1% beyond a distance of about 400 mi (650 km) south and southeast of the volcano's center (Wolfe and Pierson 1995); all of the SEZs lie beyond this distance.

The volcanic-hydrothermal system of the Yellowstone region is very active and considered one of the largest in the world. It has produced at least three eruptions that deposited sheets of ash over most of the western and central parts of the United States, including all but northern California in the six-state study area (Christiansen et al. 2007). Earthquake swarms, ground deformation, and changes in hydrothermal activity have been ongoing at Yellowstone since 1980 (Diefenbach et al. 2009). No eruptions of lava or ash have occurred for thousands of years, but future eruptions are likely (though not predicted) (Lowenstern et al. 2005).

The types of hazards associated with volcanism relate to the composition of material erupted and the style of eruption; therefore, the classification of volcanoes is an important part of understanding the nature of future eruptions and their potential hazards. Large, silicic central-vent volcanoes like Mount Shasta and Lassen Peak are expected to erupt more frequently and explosively in the future because they are located above large, shallow chambers of viscous, gas-rich magma. Mafic magma arises from greater depths (i.e., not from large chambers in the crust). Vents within mafic volcanic fields therefore tend to erupt less frequently and are less likely to occur repeatedly from the same vent. Because mafic magma is less viscous, gas is able to escape nonexplosively (Miller 1989).

Volcanic hazards include flowage phenomena, such as directed blasts, pyroclastic flows and surges, lava flows and domes, landslides and debris flows (lahars), and floods; eruption of tephra, consisting of solidified lava, pumice, ash, and rock fragments ejected high into the air that fall back to earth on and downwind from the source vent; emissions of volcanic gases, consisting mainly of steam but also carbon dioxide, and compounds of sulfur and chlorine distributed by wind (Miller 1989; USGS 2010b).

4.7.2.3 Mass Wasting

4.7.2.3.1 Landslide-Prone Areas. Landslide-prone areas are generally closely related to high, steep, rugged terrain and a high level of precipitation. In the six-state study area, high landslide incidence and susceptibility are found primarily along the coast of California and in western Colorado and New Mexico (Figure 4.7-5). Moderate landslide susceptibility and incidence occur adjacent to the areas of high landslide susceptibility and incidence. It is important to note that many alluvial fans near mountain ranges also have high landslide susceptibility but are not shown on the map in Figure 4.7-5 because of the map's small scale. Fan deposits are common in the alluvial basins throughout the study area.

4.7.2.3.2 Debris Flows. A debris flow is a fast-moving mass of water with high sediment (from clay to boulder size) and debris (trees and brush) content capable of causing extensive damage to structures in its path with little or no warning. Debris flows are associated with younger (active) alluvial fans, which are cone- to fan-shaped landforms that commonly occur along the range fronts bordering alluvial basins. The behavior and path of a debris flow will depend on its sediment content and speed and on characteristics of the alluvial fan, such as soil and vegetation cover, slope, and fan type and degree of development. Debris flow hazards are greatest during heavy or sustained rainfall events and on steep fan slopes with available sediments and rocks (due to minimal vegetation cover). They also may be accompanied by flash floods (Larsen et al. 2001; National Research Council 1996; Meyer and Berger 1992; FEMA 1989).

Although rare, debris flows present significant hazards. These hazards include abrasion of objects and structures in the flow path, burial of objects and structures where debris is deposited, and erosion that occurs along the flow path—all with significant changes to the landscape (Katzer and Schroer 1986). The paths of future debris flows are not easy to predict since flows are subject to sudden relocation, even during a single event (FEMA 1989); however, geomorphological mapping of alluvial surfaces using the distribution patterns of soil development, desert pavement, and rock varnish to delineate active (and transient) parts of alluvial fans holds promise for flood-hazard assessment (Field 1997; Bedford and Miller 2010). Mitigation strategies to protect land from the hazards of debris flows involve building large structural controls (e.g., check dams) and avoiding construction on active alluvial fan surfaces (Larsen et al. 2001).

4.7.2.4 Land Subsidence

Land subsidence is a form of ground failure that occurs as the gradual settling or sudden collapse of the ground surface due to loss of subsurface support. Its cause is attributable to various human activities and natural processes, including withdrawal of underground fluids (groundwater, petroleum, and geothermal fluids), dewatering of organic soils, underground mining, wetting of dry, low-density sediments (hydrocompaction), natural compaction, dissolution of soluble sedimentary rocks (sinkholes), liquefaction, crustal deformation, and

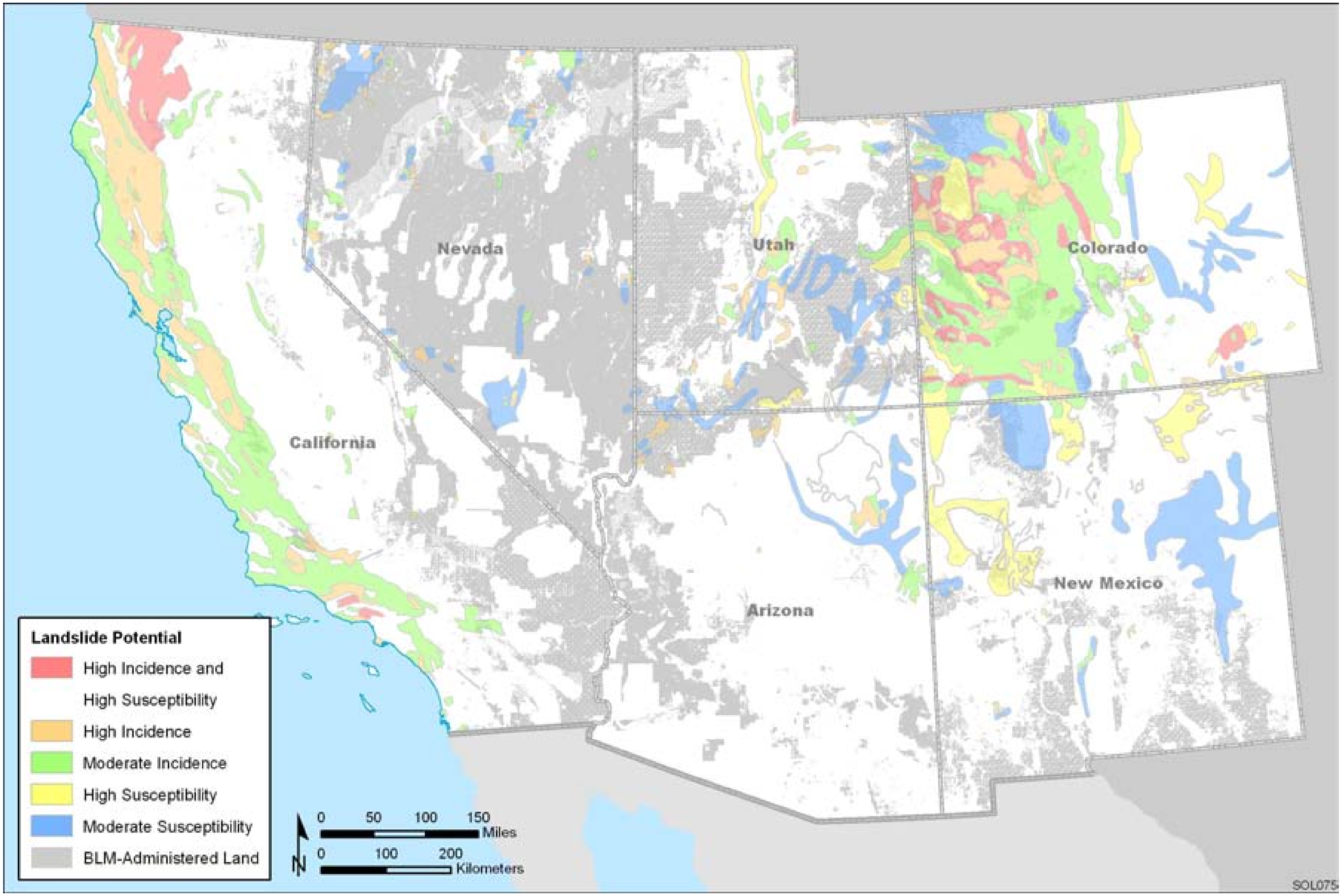

FIGURE 4.7-5 Landslide Hazard Potential Map of the Six-State Study Area (Source: National Atlas 2006)

thawing permafrost (Galloway et al. 1999; National Research Council 1991). In the six-state study area (especially in the alluvial basins where the SEZs are located), the most likely cause of subsidence is aquifer compaction as a result of groundwater withdrawal.

Alluvial basins are important sources of groundwater, especially for agricultural irrigation. When groundwater is over-pumped, water levels in the underlying aquifer decline, causing a decrease in the fluid pressures that normally support the weight of overburden. If the aquifer material is compressible, loss of pore volume (or compaction) occurs over a wide region, causing a permanent reduction in the total storage capacity of the aquifer system and land subsidence (National Research Council; Galloway et al. 1999). In the six-state study area, subsidence has been reported in numerous basins in California, Nevada, Arizona, and New Mexico (Table 4.7-3).

The types of hazards associated with land subsidence caused by groundwater withdrawal include flooding (due to reductions in ground elevation in flood-prone areas; e.g., Centennial Wash near Wendon, Arizona); earth fissures (Harquahala Plain, Arizona); differential vertical subsidence (due to variations in thickness of underlying compressible deposits; e.g., Las Vegas Valley); and horizontal displacement (Burbey 2002).

TABLE 4.7-3 Areas of Subsidence in California, Nevada, Arizona, and New Mexico due to Groundwater Withdrawal

California	
Antelope Valley	Salinas Valley
Coachella Valley	San Benito Valley
Elsinore Valley	San Bernardino area
La Verne area	San Gabriel Valley
Lucerne Valley	San Jacinto Valley
Mojave River Basin	San Luis Obispo area
Oxnard Plain	Santa Clara Valley
Pomona Basin	Temecula Valley
Sacramento Valley	Wolf Valley
Nevada	
Las Vegas Valley	
Arizona	
Avra Valley	San Simon Valley
East Salt River Valley	Stanfield Basin
Eloy Basin	Tucson Basin
Gila Bend area	West Salt River Valley
Harquahala Plain	Wilcox Basin
New Mexico	
Albuquerque Basin	
Mimbres Basin	

Source: Galloway et al. (1999).

4.7.3 Soil Resources

4.7.3.1 Soil Taxonomy

Soil formation results from the complex interactions between parent (geologic) material, climate, topography, vegetation, organisms, and time. The classification of soils is based on their degree of development into distinct layers or horizons and their dominant physical and chemical properties. For the purpose of this report, soils in the six-state study area are described according to their soil order, the highest category of soil taxonomy used by the Natural Resources Conservation Service (NRCS 1999). The eight soil orders within the study area, their distribution, and general characteristics are described in Table 4.7-4 in order of decreasing predominance. Most of the 24 SEZs are located in alluvial basins on soils that are predominantly Aridisols.

4.7.3.2 Biological Soil Crusts

Biological soil crusts, also known as cryptogamic, cryptobiotic, microbiotic, or microphytic soil crusts, are composed of complex communities of cyanobacteria, green algae, bryophytes, lichens, mosses, microfungi, and other bacteria. The filaments produced by these organisms weave through the top few millimeters of soil, forming a matrix that stabilizes and protects soil surfaces from wind and water erosion and retains soil moisture. They also contribute carbon to the underlying soils and increase the bioavailability of nutrients such as nitrogen and phosphorus (Belnap 2001; BLM 2007a; Rosentreter et al. 2007).

Biological soil crusts are commonly found in semiarid and arid environments, such as those throughout the six-state study area. They occur on all types of soils, especially in areas where vegetation is widely spaced. Their composition varies with soil pH and salinity; for example, green algae favor acidic soils with low salt content, while cyanobacteria favor alkaline soils with high salt content. The cover of lichens and mosses is greater in soils with high clay and silt content (except on clay soils with high shrink-swell potential) and in moist habitats (Rosentreter et al. 2007).

Biological soil crusts are highly susceptible to disturbance, especially in sandy soils. Disturbance can affect their composition (e.g., intense disturbance favors the growth of cyanobacteria but not lichens) and may reduce the number of crust organisms found on the surface. In areas where biological soil crusts are abundant, these changes may increase the rate of soil loss due to surface runoff or wind erosion (Belnap 2001; BLM 2007a). More information on biological soil crusts, including photographs and a complete reference list, is available on a USGS Web site: www.soilcrust.org.

TABLE 4.7-4 Soil Orders in the Six-State Study Area in Order of Decreasing Predominance

Soil Order	Geographic Extent	Characteristics
Aridisols	Arizona, southern California, Colorado, Nevada, New Mexico, and Utah	Light in color and low in organic material. Exhibit extreme water deficiency. Subsurface accumulations of soluble materials like calcium carbonate, silica, gypsum, soluble salts, and exchangeable sodium result in hardpans that impede water infiltration. Support desert rangeland; generally not productive without irrigation.
Mollisols	Arizona, California, Colorado, Nevada, New Mexico, and Utah	Commonly dark-colored, organic-rich, mineral soils. Base-rich throughout and highly fertile. Typically develop under grasslands, although some have formed under a forest ecosystem, in subhumid to subarid climates having a moderate to pronounced seasonal moisture deficit. Support cropland and pasture or rangeland.
Entisols	Arizona, California, Colorado, Nevada, New Mexico, and Utah	Common in lower elevation arid and semiarid environments. Young, weakly developed mineral soils showing little or no horizon development. Include recent alluvium, sands, soils on steep slopes, and shallow soils. Also formed in recently deposited sediments on floodplains, dunes, fans, and deltas along rivers and small streams. Support wildlife habitat and pasture or rangeland, but can support trees in areas of high precipitation.
Alfisols	Arizona, California, Colorado, New Mexico, and Utah	Occur in semiarid to moist areas. Characterized by subsurface clay accumulations leached from surface layer and nutrient-rich subsoils. Formed under forest or mixed vegetation cover. Can support cropland and commercial timberland.
Inceptisols	Arizona, northern California, Colorado, Nevada, New Mexico, and Utah	Occur in a wide range of climates, from semiarid to humid. Generally young mineral soils showing only moderate degrees of soil development and weathering (more than entisols). Develop where the native vegetation is grass, but some support trees. Can support pasture or cropland, rangeland, forest, or wildlife habitat.
Andisols	Limited areas in northern California	Common in cool areas with moderate to high precipitation. Formed from weathering processes that result in minerals with little orderly crystalline structure, including soils with a high percentage of volcanic glass. Highly productive soils.

TABLE 4.7-4 (Cont.)

Soil Order	Geographic Extent	Characteristics
Vertisols	Scattered in Arizona, California, and New Mexico	High content of expanding clay that swells when wet. Because of their swelling capacity, they transmit water very slowly and have undergone little leaching. Support natural vegetation that is predominantly forest, grass, or savannah. High in natural fertility. Used mainly as cropland, rangeland, or forest, although they present a drainage problem for croplands because of their low hydraulic conductivity when wet.
Ultisols	Scattered in northern California	Occur in humid environments. Strongly acid mineral soils, low in nutrients. Show intensive leaching of clay minerals and other constituents, resulting in a clay-enriched subsoil dominated by quartz, kaolinite, and iron oxides. Formed under forest vegetation.

Sources: BLM (2007a); NRCS (1999, 2010).

4.7.3.3 Desert Pavement

Desert pavement is a type of surface armor that forms on the ground in hot desert environments, such as those covering the southern portion of the six-state study area. Desert pavements consist of a thin layer of closely packed, angular to sub-rounded coarse rock fragments and are associated with alluvial fans and other unsorted alluvial deposits (Ritter 1986). They typically occur on surfaces with very little relief and lie above a gravel-free layer of well-developed soil; their exposed surface is often characterized by a dark and shiny coating or varnish of minerals (e.g., iron oxide) and organic carbon (McFadden et al. 1987). The abundance of coarse particles on desert pavements is thought to be the result of deflation, a process whereby fine sediments are eroded from alluvium by wind or water and/or the upward movement of larger clasts through the alluvial matrix (by cycles of shrinking and swelling and/or freezing and thawing) until they reach the surface (Ritter 1986). Other investigators have observed well-developed desert pavements in volcanic terrains where eolian silt and fine sand have filled the voids between clasts of basaltic colluvium (e.g., Cima volcanic field) and scoria (e.g., Amargosa Desert) (McFadden et al. 1987; Valentine and Harrington 2005).

Desert pavements are less susceptible to disturbance than biological soil crusts, but once they are disturbed, desert pavements lose their armoring function, increasing the likelihood of soil loss due to surface runoff or wind erosion.

4.7.3.4 Wind Erosion of Soils

The soils of desert environments within the six-state study area are highly vulnerable to erosion by wind. Airborne dust is generated when wind forces exceed the ability of stabilizing factors to hold the fine-grained components of soil in place. Factors that function to stabilize soils include vegetation cover, biological soil crust cover, rock cover, high salt or calcium carbonate content, high clay and silt content, physical crusts (e.g., gypsite or playa efflorescent crusts), and desert pavement. When these factors are compromised by the compressional and shear forces created by vehicles and the trampling effects of livestock and humans, the loss of soil fines reduces the soil's productivity. This reduction of productivity occurs because most plant-essential nutrients are bound to fine particles near the surface and because the loss of the fine particles also reduces the soil's often already low water-holding capacity. Once airborne (as fugitive dust), soil fines are a nonpoint source of air pollution with potentially significant health effects. Deposition of soil fines may also be problematic because it reduces the fertility of plants and biological crusts (by burial of photosynthetic components) and contributes to sedimentation in surface water bodies (Belnap 2001; Belnap et al. 2007).

Because soil formation by weathering of parent rock is a slow process, often taking thousands of years, and dust deposition is low in most regions (except in areas near large dust sources), the replacement of lost soil is also very slow (Belnap et al. 2007). Therefore, the best mitigation to reduce soil loss by wind erosion is to follow practices that avoid soil disturbance and control dust emissions to the maximum extent possible.

Table 4.7-5 provides a summary of soil textures and their vulnerability to wind erosion, as expressed by the U.S. Department of Agriculture's (USDA's) wind erodibility index. The wind erodibility index is a measure of soil (in tons) eroded by wind from an acre (4,000 m^2) of exposed land over a one-year period based on the amount of fines in the soil. The largest erodible aggregate (soil particle) size is about 84 mm (0.033 in.) in diameter. Soils with a small percentage of dry aggregates greater than 84 mm (0.033 in.) contain more fines and have a high erodibility index (high vulnerability to wind erosion) relative to soils with a large percentage of dry aggregates greater than 84 mm (0.033 in.) (Countess Environmental 2006; USDA 2010).

The soil texture class most vulnerable to wind erosion is sand (very fine sand, fine sand, sand, or coarse sand), a common constituent of exposed sediments in the alluvial basins throughout the study area. The soil sections in later chapters provide wind erodibility ratings and the wind erosion group designations for the soils within and adjacent to the individual SEZs.

4.8 MINERALS (FLUIDS, SOLIDS, AND GEOTHERMAL RESOURCES)

Energy and mineral resources have the highest economic values among commercial uses for surface lands and subsurface estates administered by the BLM in the six-state study area (Table 4.8-1). These economic values derive from the production of locatable, leasable, and salable mineral resources. Locatable minerals, defined in the General Mining Law of 1872, can be obtained by locating a mining claim; they include both metallic (e.g., gold, silver, lead) and nonmetallic (e.g., gemstones, fluorspar, mica) materials. Leasable minerals are subject to the

TABLE 4.7-5 Wind Erodibility of Soils by Soil Texture

Soil Texture	Dry Aggregates greater than 0.84 mm (wt.%)	Wind Erodibility Index (tons/ac/yr)	Wind Erodibility Group
Very fine sand, fine sand, sand or coarse sand	1 2 3 5 7	310 250 220 (average) 180 160	1 (High)[a]
Loamy very fine sand, loamy fine sand, loamy sand, and loamy course sand; very fine sandy loam and silt loam with ≤5% clay and ≤25% very fine sand; and sapric material	10	134	2 (High)
Very fine sandy loam, fine sandy loam, sandy loam, and coarse sandy loam; noncalcareous silt loam with ≥20% to <50% very fine sand and ≥5 to <12% clay	25	86	3 (Moderate)
Clay, silty clay, noncalcareous clay loam with >35% clay and noncalcareous silty clay loam with >35% clay	25	86	4 (Moderate)
Calcareous loam, calcareous silt loam, calcareous silt, calcareous sandy clay, calcareous sandy clay loam, calcareous clay loam, and calcareous silty clay loam	25	86	4L (Moderate)
Noncalcareous loam with <20% clay; noncalcareous silt loam with ≥5 to <20% clay; noncalcareous sandy clay loam; noncalcareous sandy clay; and hemic soil materials	40	56	5 (Moderate)
Noncalcareous loam and silt loam with ≥20% clay; noncalcareous clay loam and noncalcareous silty clay loam with ≤35% clay; silt loam with high iron oxide content	45	48	6 (Moderate)
Noncalcareous silt; noncalcareous silty clay, noncalcareous silty clay loam, and noncalcareous clay with high iron oxide content	50	38	7 (Low)
Soils not susceptible to wind erosion due to rock and pararock fragments at the surface and/or wetness	NA	0	8 (Low)

[a] Designations of high, moderate, or low are for purposes of this report only.

Sources: USDA (2010); Countess Environmental (2006).

TABLE 4.8-1 Subsurface Mineral Lands under BLM-Administered Surface Lands within the Six-State Study Area[a]

State	Subsurface Mineral Estates Underlying Federal Surface Lands[b] (millions of acres)
Arizona	33.0
California	47.0
Colorado	27.1
Nevada	56.1
New Mexico	36.0
Utah	33.9
Total	233.1

[a] Data from FY 2002 (BLM 2003a-f).

[b] To convert acres to km^2, multiply by 0.004047.

Mineral Leasing Act of 1920 and include energy (e.g., coal, oil, gas, geothermal) and nonenergy (e.g., sodium, phosphate) resources. Leases for these resources are obtained through a competitive bidding process.

Salable minerals include basic natural resources, such as sand, gravel, and building stone; the BLM sells them at fair market value. The BLM may also grant free-use leases to states, counties, or other government entities for public projects (BLM 2005b). Through the land use planning process, the BLM may identify specific terms and conditions applicable to developing mineral resources in specific areas or in some instances may recommend that the mineral estate not be available for development because of the presence of other important resource values.

4.9 WATER RESOURCES

4.9.1 Surface Water Resources

4.9.1.1 Hydrologic Regions

Nine major hydrologic regions have been identified in the six-state study area based on the USGS's classification system (Figure 4.9-1): (1) Pacific Northwest, (2) California, (3) Upper Colorado, (4) Lower Colorado, (5) Rio Grande, (6) Missouri, (7) Great Basin,

FIGURE 4.9-1 Hydrologic Regions in the Six-State Study Area (Source: USGS 2008a)

(8) Arkansas–White-Red, and (9) Texas–Gulf. Each hydrologic region encompasses either the drainage area of a major river or the combined drainage areas of a series of rivers (USGS 2008a). Table 4.9-1 lists the hydrologic regions in the six-state study area and their major river systems and provides a brief description of precipitation patterns and principal uses of surface water within each region.

Stream discharge in the six-state study area is affected by precipitation (which varies with season) and the regional topography. For example, moist air masses from the Pacific Ocean rise and cool as they approach the various mountain ranges in the western states. This condition causes increased precipitation with elevation on the western slopes of the ranges, thereby stripping moisture from the air masses as they move eastward and reducing the moisture available for precipitation on the eastern slopes of the ranges (creating a rainshadow effect). Seasonally, spring snowmelts cause high streamflows during the spring months. High streamflows also occur during summer thunderstorms. Many streams, especially those in basins, rely on groundwater discharge for their flow. Decrease of natural streamflow may occur due to consumptive use of surface water and/or groundwater in a basin, such as use for irrigation and public drinking water supply. Many rivers in the six-state study area are regulated by dams and other flow control structures, so stream discharge is also controlled by release schedules from reservoirs.

The quality of surface water varies by stream segment and is related to the volume of streamflow, the nature of local bedrock and soils, and human activities (e.g. mining, wastewater discharges, and agriculture). Generally, the quality of surface water in mountainous areas is considered good. However, as the water flows downstream to arid and semiarid valleys, the quality is reduced as tributaries pick up dissolved solids and sediments from bedrock and soils. Evaporation also increases the dissolved solids content of waters. During the spring, meltwater may dilute these constituents, but by summer the dilution effect disappears. The quality of groundwater discharge also contributes to the quality of surface water. The return base flows from agricultural irrigation commonly carry elevated levels of nutrients, salts, and metals leached from the soils. As base flows eventually return to surface water bodies, they could degrade the quality of surface water.

4.9.1.2 Wild and Scenic Rivers

Surface waters that are classified as Wild and Scenic Rivers (WSRs) are of particular concern with regard to impacts. The Wild and Scenic Rivers Act (Public Law [P.L.] 90−542 as amended; 16 USC 1271−1287), enacted in October 1968, provides a national policy and program to preserve and protect selected rivers, or segments of rivers, in their free-flowing condition. The Act states that certain selected rivers of the nation, along with their immediate environments, possessing outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition, and that they shall be protected for the benefit of present and future generations. The Act also states that each component of the National Wild and Scenic Rivers System (NWSRS) shall be administered in such a manner as to protect and enhance its values, without limiting other uses, water rights, or

TABLE 4.9-1 Hydrologic Regions and Surface Water Conditions in the Six-State Study Area

Hydrologic Region	Geographic Area	Major River Systems	Precipitation	General Surface Water Quality
Pacific Northwest	A small region in northern Nevada and northern Utah	Snake	Precipitation decreases east of the Cascades, and stream flow is driven primarily by snowmelt or groundwater discharge.	Agricultural areas degraded by nutrients (nitrates and phosphates) and pesticides from agricultural and grazing practices.
California	Most of California and a very small portion of western Nevada	Sacramento, San Joaquin	Precipitation occurs primarily in winter, with prolonged summer periods of little rainfall. Streamflow derived primarily from spring snowmelt.	Elevated TDS[a] levels from high salinity because of irrigation practices and arid climate. Agricultural practices in central California have resulted in elevated nutrients and pesticides.
Upper Colorado	Colorado Plateau in western Colorado, eastern Utah, northern Arizona, and New Mexico	Upper Colorado	Precipitation varies with elevation and includes winter snow storms and heavy fall rainstorms, with most streamflow dominated by snowmelt in the mountains.	Generally good water quality except in historic mining areas and in agricultural areas. Areas of sedimentary rock may have high levels of TDS, radon, uranium, and other metals.
Lower Colorado	Most of Arizona and portions of western New Mexico, southern Nevada, and southeastern California	Lower Colorado	This region is arid, with precipitation limited to winter months and periods of heavy storms. Streamflow is largely absent except in winter or after major storms. High erosion rates common in areas with grazing livestock.	Elevated TDS in areas with agriculture and grazing, and metals in mining areas.

TABLE 4.9-1 (Cont.)

Hydrologic Region	Geographic Area	Major River Systems	Precipitation	General Surface Water Quality
Rio Grande	Central New Mexico and south central Colorado	Rio Grande, Pecos	An arid region with precipitation limited to winter months and periods of heavy storms. Streamflow derived from spring snowmelt and summer thunderstorms.	Elevated TDS and nutrient and pesticide contamination in agriculture areas. Upper reaches of the Rio Grande have elevated levels of metals in mining areas attributed to the Creede mining district of southern Colorado.
Missouri	Northeastern Colorado	Platte	Precipitation generally sparse in summer and fall, with streamflow derived from snowmelt in mountainous areas, and in summer and fall from groundwater discharge.	Good water quality in high Rocky Mountains. Quality degrades as streams enter plains and valleys, where agricultural practices and urban runoff impact water quality. Mining and oil extraction cause locally increased TDS and metals concentrations, while grazing contributes sediments and nutrients.
Great Basin	Central and northern Nevada and western Utah, and a very small portion of northeastern California	Humbolt, Truckee	Arid region located in rain shadow of the Sierra Nevada Mountains. Surface water flow in basins derived from rain and snow falling in mountain areas.	Poor water quality in areas near urban centers; elevated metal concentrations in historic mining areas. Near-surface rocks naturally contribute arsenic, uranium, and radon to surface waters.
Arkansas–White-Red	Southeastern Colorado and northeastern New Mexico	Arkansas, Canadian, Red	Precipitation sparse in summer and fall. Streamflow derived from snowmelt in the mountainous areas.	Surface water quality is typically moderate in this region except poor in areas with extensive agricultural or livestock production.

TABLE 4.9-1 (Cont.)

Hydrologic Region	Geographic Area	Major River Systems	Precipitation	General Surface Water Quality
Texas-Gulf	A small region in eastern New Mexico	Running Water Draw, Black Water Draw, Yellow House Draw, Lost Draw, Sulphur Springs Draw, Mustang Draw, Monument-Seminole Draw[b]	An arid region with precipitation limited to winter months and periods of heavy storms. Streamflow derived from spring snowmelt and summer thunderstorms.	Not known.[c]

[a] TDS = total dissolved solids; a measurement of water quality.

[b] Source: New Mexico State University (2008).

[c] Data for the Texas-Gulf hydrologic region are incomplete (Jantzen 2005).

development projects that do not substantially interfere with public use and enjoyment of these values.

4.9.1.2.1 Designated Rivers. The NWSRS consists of selected rivers or segments of rivers that Congress authorizes for inclusion (designation by Congress) or that are designated as wild, scenic, or recreational rivers by the legislatures of the states through which they flow and are approved by the Secretary of the Interior (Section 2(a)(ii) of the Act). The former are assigned for administration either to the Secretary of the Interior or the Secretary of Agriculture through their agencies (e.g., BLM), while the latter are administered by the state. If a river or a segment of river is included in the system, it must be classified, designated, and administered as a wild, scenic, or a recreational river area. Additionally, a comprehensive management plan must be created and implemented for each WSR to protect its outstanding remarkable values.

Figure 4.9-2 is a map of WSR segments within the six-state study area. These rivers and segments are listed in Table 4.9-2, which identifies the specific classification (wild, scenic, or recreational) and administrative authority for each designated segment.

4.9.1.2.2 Congressionally Authorized Wild and Scenic Study Rivers. In addition to the directly designated rivers, the Secretary of the Interior, the Secretary of Agriculture, or the two Secretaries jointly could submit to the President names of additional rivers suitable for inclusion in the NWSRS. The President must make recommendations and proposals to Congress for potential additional rivers. Among the potential additions, those authorized by Congress for studies would be provided statutory protection. Congressionally authorized study rivers are afforded statutory protection under Section 7(b) of the Wild and Scenic Rivers Act for a 3-year period after the report is submitted to Congress (NWSRS 1999). Analogous to designated rivers, this provision protects the congressionally authorized study rivers from the harmful effects of water resources projects (for any part of a project proposed for construction within a study river bed or its banks).

4.9.1.2.3 Federal Agency Protected Rivers. Section 5(d)(1) of the Wild and Scenic Rivers Act directs each federal agency to identify potential additions to the NWSRS through agency planning processes. However, such rivers are not provided statutory protection. Each federal agency provides protection to the study river’s free-flowing condition, outstandingly remarkable values, and classification through guidance in its respective policy and through other authorities. For example, BLM policy for identifying and managing wild and scenic rivers can be found in BLM WSR Manual 8351 (BLM 1993). The NPS maintains a list of river segments that potentially qualify as WSR areas in the Nationwide Rivers Inventory (NRI). A presidential directive requires that each federal agency avoid or mitigate adverse impacts on rivers listed in the NRI (NPS 2010).

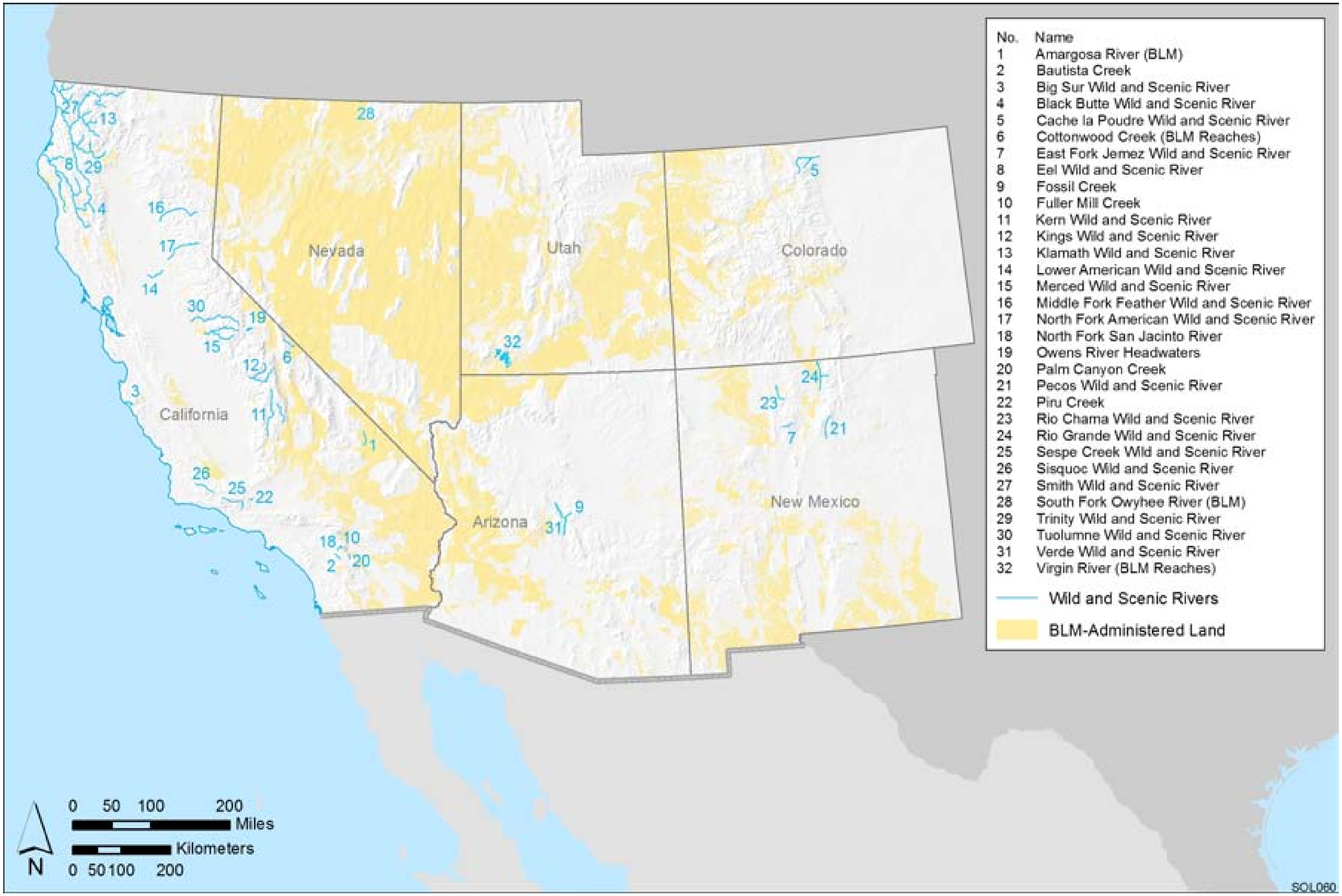

FIGURE 4.9-2 Wild and Scenic River Segments within the Six-State Study Area

TABLE 4.9-2 Designation Classification and Administrative Authority for Wild and Scenic Rivers in the Six-State Study Area

State	Wild and Scenic River	Administrative Authority[a]	Designation Classification and Length (mi)[b]			Total Designated Miles[b]	Designated Location and Length[b]
			Wild	Scenic	Recreational		
Arizona	Verde	USFS	22.2	18.3	– [c]	40.5	The northern boundary of the Scenic River Area from the section line between Sections 26 and 27, the Gila-Salt River meridian, to the southern boundary, the Mazatzal Wilderness. The northern boundary of the Wild River Area from the boundary of the Mazatzal Wilderness to the southern boundary at the confluence of Red Creek with the Verde River.
California	American (Lower)	State of California	–	–	23.0	23.0	From the confluence with the Sacramento River to the Nimbus Dam.
	American (North Fork)	USFS BLM	26.3 12.0	– –	– –	26.3 12.0	From a point 0.3 mi above Health Springs downstream to a point 1,000 ft upstream of Colfax-Iona Hill Bridge.
	Big Sur	USFS	19.5	–	–	19.5	From the confluence of the South and North Forks downstream to the boundary of the Ventana Wilderness. The South Fork and the North Fork from their headwaters to their confluence.
	Eel	State of California USFS BLM Round Valley Reservation	36.0 35.0 21.0 5.0	22.5 – 4.5 1.0	250.5 – 6.5 16.0	309.0 35.0 32.0 22.0	From the mouth of the river to 100 yd below Van Ardsdale Dam. The Middle Fork from its confluence with the main stem to the southern boundary of the Yolla Bolly Wilderness Area. The South Fork from its confluence with the main stem to the Section Four Creek confluence. The North Fork from its confluence with the main stem to Old Gilman Ranch. The Van Duzen River from its confluence with the Eel River to Dinsmure Bridge.
	Feather	USFS	32.9	9.7	35.0	77.6	The entire Middle Fork downstream from the confluence of its tributary streams 1 km south of Beckwourth, California.
	Kern	USFS NPS	96.1 27.0	20.9 –	7.0 –	124.0 27.0	The North Fork from the Tulare-Kern County line to its headwaters in Sequoia National Park. The South Fork from its headwaters in the Inyo National Forest to the southern boundary of the Domelands Wilderness in the Sequoia National Forest.

TABLE 4.9-2 (Cont.)

State	Wild and Scenic River	Administrative Authority[a]	Designation Classification and Length (mi)[b] Wild	Scenic	Recreational	Total Designated Miles[b]	Designated Location and Length[b]
California *(Cont.)*	Kings	USFS NPS	16.5 49.0	– –	9.0 6.5	25.5 55.5	From the confluence of the Middle Fork and the South Fork to the point at elevation 1,595 ft above mean sea level. The Middle Fork from its headwaters at Lake Helen to its confluence with the main stem. The South Fork from its headwaters at Lake 11599 to its confluence with the main stem.
	Klamath	State of California USFS BLM Hoopa Valley Reservation NPS	– 12.0 – – –	3.0 21.0 – – –	41.0 177.5 1.5 29.0 1.0	44.0 210.5 1.5 29.0 1.0	From the mouth to 3,600 ft below Iron Gate Dam. The Salmon River from its confluence with the Klamath to the confluence of the North and South Forks of the Salmon River. The North Fork of the Salmon River from the Salmon River confluence to the southern boundary of the Marble Mountain Wilderness Area. The South Fork of the Salmon River from the Salmon River confluence to the Cecilville Bridge. The Scott River from its confluence with the Klamath to its confluence with Schackleford Creek. All of Wooley Creek.
	Merced	USFS NPS BLM	15.0 53.0 3.0	2.0 14.0 –	12.5 14.0 9.0	29.5 81.0 12.0	From its source (including Red Peak Fork, Merced Peak Fork, Triple Peak Fork, and Lyle Fork) in Yosemite National Park to a point 300 ft upstream of the confluence with Bear Creek. The South Fork from its source in Yosemite National Park to the confluence with the main stem.
	Sespe Creek	USFS	27.5	4.0	–	31.5	The main stem from its confluence with Rock Creek and Howard Creek downstream to where it leaves Section 26, T5N, R20W.
	Sisquoc	USFS	33.0	–	–	33.0	From its origin downstream to the Los Padres National Forest boundary.

TABLE 4.9-2 (Cont.)

State	Wild and Scenic River	Administrative Authority[a]	Designation Classification and Length (mi)[b] Wild	Scenic	Recreational	Total Designated Miles[b]	Designated Location and Length[b]
California *(Cont.)*	Smith	State of California	–	0.5	28.5	29.0	The segment from the confluence of the Middle Fork Smith River and the North Fork Smith River to its mouth at the Pacific Ocean. The Middle Fork from its headwaters to its confluence with the North Fork Smith River, including Myrtle Creek, Shelly Creek, Kelly Creek, Packsaddle Creek, the East Fork of Patrick Creek, the West Fork of Patrick Creek, Little Jones Creek, Griffin Creek, Knopki Creek, Monkey Creek, Patrick Creek, and Hardscrabble Creek. The Siskiyou from its headwaters to its confluence with the Middle Fork, including the South Siskyou Fork of the Smith River. The South Fork from its headwaters to its confluence with the main stem, including Williams Creek, Eightmile Creek, Harrington Creek, Prescott Fork, Quartz Creek, Jones Creek, Hurdygurdy Creek, Gordon Creek, Coon Creek, Craigs Creek, Goose Creek, the East Fork of Goose Creek, Buch Creek, Muzzleloader Creek, Canthook Creek, Rock Creek, and Blackhawk Creek. The North Fork from the California-Oregon border to its confluence with the Middle Fork of the Smith River, including Diamond Creek, Bear Creek, Still Creek, the North Fork of Diamond Creek, High Plateau Creek, Stony Creek, and Peridotite Creek.
		USFS	78.0	30.5	187.9	296.4	
	Trinity	State of California	2.0	11.0	24.0	37.0	From the confluence with the Klamath River to 100 yd below Lewiston Dam. The North Fork from the Trinity River confluence to the southern boundary of the Salmon-Trinity Primitive Area. The South Fork from the Trinity River confluence to the California State Highway 36 bridge crossing. The New River from the Trinity River confluence to the Salmon-Trinity Primitive Area.
		USFS	42.0	22.0	71.0	135.0	
		BLM	–	–	17.0	17.0	
		Hoopa Valley Reservation	–	6.0	8.0	14.0	
	Tuolomne	USFS	7.0	6.0	13.0	26.0	The main stem from its source to the Don Pedro Reservoir.
		NPS	37.0	17.0	–	54.0	
		BLM	3.0	–	–	3.0	

TABLE 4.9-2 (Cont.)

State	Wild and Scenic River	Administrative Authority[a]	Designation Classification and Length (mi)[b] Wild	Scenic	Recreational	Total Designated Miles[b]	Designated Location and Length[b]
Colorado	Cache La Poudre	USFS NPS	18.0 12.0	– –	46.0 –	64.0 12.0	From Poudre Lake downstream to where the river intersects the easterly north-south line of the west half of the southwest quarter of Section 1, T8N, R71W of the sixth principal meridian. The South Fork from its source to Section 1, T7N, R73W of the sixth principal meridian, from its intersection with the easterly section line of Section 30 of the sixth principal meridian to the confluence with the main stem.
Nevada	No WSR						
New Mexico	Jemez (East Fork)	USFS	4.0	5.0	2.0	11.0	From the Santa Fe National Forest boundary to its confluence with the Rio San Antonio.
	Pecos	USFS	13.5	–	7.0	20.5	From its headwaters to the town of Terrerro.
	Rio Chama	USFS and BLM	19.8	4.9	–	24.7	From El Vado Ranch launch site (immediately south of El Vado Dam) downstream for 24.7 mi.
	Rio Grande	USFS and BLM	53.2	–	2.5	55.7	The segment extending from the Colorado state line downstream approximately 68 mi to the west section line of Section 15, T23N, R10E. The lower 4 mi of the Red River.
Utah	No WSR						

[a] BLM = Bureau of Land Management; USFS = U.S. Forest Service; NPS = National Park Service.

[b] To convert mi to km, multiply by 1.609; to convert ft to m, multiply by 0.3048; to convert yd to m, multiply by 0.9144.

[c] A dash indicates zero mileage.

Sources: NPS (2006); USFWS (2008a).

4.9.1.3 Floodplains, Ephemeral Streams, and Wetlands

Surface water resources of the affected environment include lakes and rivers, as well as numerous floodplains, ephemeral streams (i.e., streams that carry water only briefly in direct response to precipitation), and wetlands. The Clean Water Act (33 USC §1251–1387) is the primary law protecting water quality in surface waters by means of regulatory and nonregulatory methods to limit pollution discharges by point and non-point sources. Additional protections to floodplains, ephemeral streams, and wetlands are provided by Executive Orders 11988 and 11990 ("Floodplain Management" [*Federal Register*, Volume 42, page 26951, May 24, 1977] and "Protection of Wetlands" [*Federal Register*, Volume 42, page 26961, May 24, 1977]). Appendix H provides further information on laws and regulations governing surface waters at the state and local levels for the six-state study region.

Floodplain maps are usually prepared for populated areas that could experience flooding. These maps are generally prepared by the Federal Emergency Management Agency (FEMA) for floods that statistically have a 1% chance of occurring each year (i.e., 100-year flood events). Such maps are used for property insurance purposes (FEMA 2008). Because the six-state study area has large areas that have not been evaluated for 100-year flood potential, affected environments and future project-specific impacts would need to be addressed during site-specific project planning.

Stream channels for ephemeral and intermittent streams are often incorporated in the National Hydrography Dataset from the USGS, but drainages and washes often are not. Again, for site-specific project work, planners would need to identify these drainages during assessment of affected environments and future project-specific impacts (e.g., using aerial photographs, field surveys). The six-state study region contains many mountain valley regions with low-relief alluvial fans. Surface water flows over alluvial fans and drainages can be significant during large storm events, resulting in localized flooding and severe erosion.

Wetlands in the six-state study area are often associated with perennial water sources such as springs, streams, lakes, or ponds. Given the arid climate of the Southwest, wetlands in this region are often inundated from seasonal to intermittent portions of the year. However, even when wetlands are not inundated, shallow groundwater depths are typical, which often supports vegetation important to ecological habitats (see Section 4.10.1 for further discussion of wetlands).

4.9.1.4 Water Management: Interstate Compacts and International Treaties

Several international compacts pertain to the governing of water rights in the southwestern United States for both surface waters and groundwater. The International Boundary and Water Commission (IBWC) was established in 1889 to implement water treaties between the United States and Mexico (IBWC 2010a). The commission has sections representing each country that consist of an engineer-commissioner, a team of engineers, and legal staff. The main goals of the IBWC relate to boundary preservation, water conveyance, water quality, and resource management of water bodies shared along the United States–Mexico border (IBWC

2010b). Two major river systems cross several western states and Mexico—the Colorado River and the Rio Grande River—along with several smaller water bodies. There are also groundwater aquifers that underlie the border between the United States and Mexico. In 2006, the United States and Mexico signed the Transboundary Assessment Aquifer Act (P.L. 109-448), which promotes sustainability of the aquifer systems that are shared across the United States–Mexico border. The Transboundary Aquifer Assessment Act allocates funds to study aquifers that underlie the United States–Mexican border with the states of Arizona, New Mexico, and Texas. The program aims to better understand the properties of groundwater aquifers along the border and has identified several priority aquifers that will be studied through 2016. The Act does not impact water rights, laws, or international treaties.

4.9.1.4.1 Colorado River. The Colorado River Basin covers an area of 156 million acres (632,000 km^2) across seven states: Colorado, Wyoming, Utah, New Mexico, Nevada, Arizona, and California). The Colorado River headwaters are located in the Colorado Rocky Mountains, and the river historically flowed 1,440 mi (2,300 km) to Mexico's Gulf of California, but currently its waters are consumed before reaching the Gulf. The Colorado River is managed by an assemblage of compacts, federal laws, court decrees, and contracts that form the "Law of the River." In the Consolidated Decree (2006) the Supreme Court directed the Secretary of the Interior to determine and manage flow of the Colorado River, acting as a water master. The major components of the Law of the River are described in Table 4.9-3.

Most of the components of the Law of the River pertain to allocation of Colorado River water, but the Colorado River Basin Salinity Control Act of 1974 addresses water quality. Salinity has long been recognized as one of the major problems of the Colorado River (CRBSCF 2005). The river carries an average salt load of about 4.4 million tons (4.0 million metric tons) annually past Lees Ferry, Arizona. It is estimated that the BLM-administered lands in the Upper Colorado River Basin contribute about 700,000 tons (635,000 metric tons) of salt per year from surface runoff. The remaining 3.7 million tons (3.4 million metric tons) are contributed primarily by groundwater inflow and saline springs, as well as runoff from other federal, Tribal, state, and private lands (DOI 2005). The sources of salinity in the Colorado River Basin were estimated to be 47% from natural sources, 37% from irrigation, 12% from reservoir leaching, and 4% from municipal and industrial activities. In 2004, the salinity control programs of the Bureau of Reclamation (BOR), USDA, and the BLM prevented a total of 1,072,000 tons (972,300 metric tons) of salts from entering the river. A goal has been set to prevent an additional 728,000 tons/yr (660,000 metric tons/yr) from entering the river basinwide by 2025 (DOI 2005).

4.9.1.4.2 Rio Grande. The Rio Grande originates in the San Juan Mountains in southern Colorado and flows 1,865 mi (3,000 km) south through New Mexico before forming the border between Texas and Mexico in route to the Gulf of Mexico. Debates over Rio Grande water resources have led to three major water compacts—the 1905 Rio Grande Project (RGP) compact between Texas and New Mexico; the 1906 United States–Mexico treaty; and the 1938 Rio Grande Compact between Colorado, Texas, and New Mexico (Littlefield 1999). These treaties

TABLE 4.9-3 Summary of Components to the Law of the River

Year	Agreement	Components
1922	Colorado River Compact	Defined Upper Colorado River Basin and Lower Colorado River Basin and allotted to each 7.5 million ac-ft/yr (9.3 billion m^3/yr) of water for beneficial use.
1928	Boulder Canyon Project Act	Ratified the 1922 compact. Authorized the construction of Hoover Dam and related facilities. Apportioned the Lower Colorado River Basin's 7.5 million ac-ft/yr (9.3 billion m^3/yr) to Arizona (2.8 million ac-ft/yr [3.5 billion m^3/yr]), California (4.4 million ac-ft/yr [5.4 billion m^3/yr]), and Nevada (0.3 million ac-ft/yr [370 million m^3/yr]). Authorized the Secretary of the Interior to manage all water uses in Lower Colorado River Basin.
1931	California Seven Party Agreement	Prioritized California's allotment among local water management entities–Palo Verde Irrigation District, Yuma Project, Imperial Irrigation District, Coachella Valley Irrigation District, Metropolitan Water District, and the City and County of San Diego.
1944	Mexican Water Treaty	Committed 1.5 million ac-ft/yr (1.9 billion m^3/yr) of Colorado River water to Mexico
1948	Upper Colorado River Basin Compact	The Upper Colorado River Commission was created and apportioned the Upper Colorado River Basin's 7.5 million ac-ft/yr (9.3 billion m^3/yr) to Colorado (51.75%), New Mexico (11.25%), Utah (23%), and Wyoming (14%). The northern portion of Arizona located within the Upper Colorado River Basin was granted 50,000 ac-ft/yr (62 million m^3/yr).
1956	Colorado River Storage Project Act	Provided comprehensive water resources development plan for the Upper Colorado River Basin and authorized the construction of the Glen Canyon, Flaming Gorge, Navajo, and Curecanti Dams, as well as several irrigation projects.
1964	Arizona v. California U.S. Supreme Court Decision	Settled dispute between Arizona and California regarding each state's allotment of Colorado River water. Directed the Secretary of the Interior to account for consumptive use of Colorado River water.
	Supplemental Decree (1979)	Addressed the current status of perfected water rights outlined in the Colorado River Compact and the Boulder Canyon Project Act.
	Consolidated Decree (2006)	Provided a single reference to the 1964 U.S. Supreme Court Decision and provisions. Also incorporated provisions for Tribal water rights for the Fort Yuma Indian Reservation.

TABLE 4.9-3 (Cont.)

Year	Agreement	Components
1968	Colorado River Basin Project Act	Authorized the construction of several water development projects, including the Central Arizona Project. Directed the Secretary of the Interior to develop long-range operating criteria for the Colorado River reservoir system.
1970	Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs	Provided the coordination of Colorado River reservoirs between the upper and lower basins and set conditions for water releases from Lake Powell and Lake Mead.
1973	Minute 242 of the U.S.-Mexico International Boundary and Water Commission	Required the United States to take action in reducing salinity in Colorado River water released from Morelos Dam into Mexico.
1974	Colorado River Basin Salinity Control Act	Authorized desalinization projects, including the Yuma desalting plant, to improve water quality.

Source: BOR (2010b).

are overseen and enforced cooperatively by the New Mexico Office of the State Engineer (NMOSE), New Mexico's Elephant Butte Irrigation District, Texas' El Paso County Water Improvement District No. 1, and the BOR. The Rio Grande Compact establishes appropriations of Rio Grande water between Colorado, New Mexico, and Texas by setting downstream delivery schedules for each state based on the natural supply. The Mexican Water Treaty of 1944 allocated water to Mexico, including 1.5 million ac-ft/yr (1.9 billion m^3/yr) of Colorado River water (Table 4.9-3) and two-thirds of the flows that originate from tributaries originating in Mexico, which averages to 350,000 ac-ft/yr (432 million m^3/yr) over a 5-year period (CRS 2005).

4.9.2 Groundwater Resources

Fourteen major aquifer systems occur in the six-state study area (Figure 4.9-3). Groundwater occurs primarily in basin-filled sediments, volcanic rocks, and carbonate bedrock. The most widely distributed systems are the basin-fill aquifers of the Basin and Range Region in Nevada, southeastern California, and western Utah, and the aquifers within the Colorado Plateau that occupy western Colorado, eastern Utah, northeastern Arizona, and northwestern New Mexico. Other major aquifer systems include the Central Valley aquifer system in California, the Rio Grande aquifer system in New Mexico, and the High Plains aquifer system east of the Rocky Mountains (Planert and Williams 1995; Robson and Banta 1995).

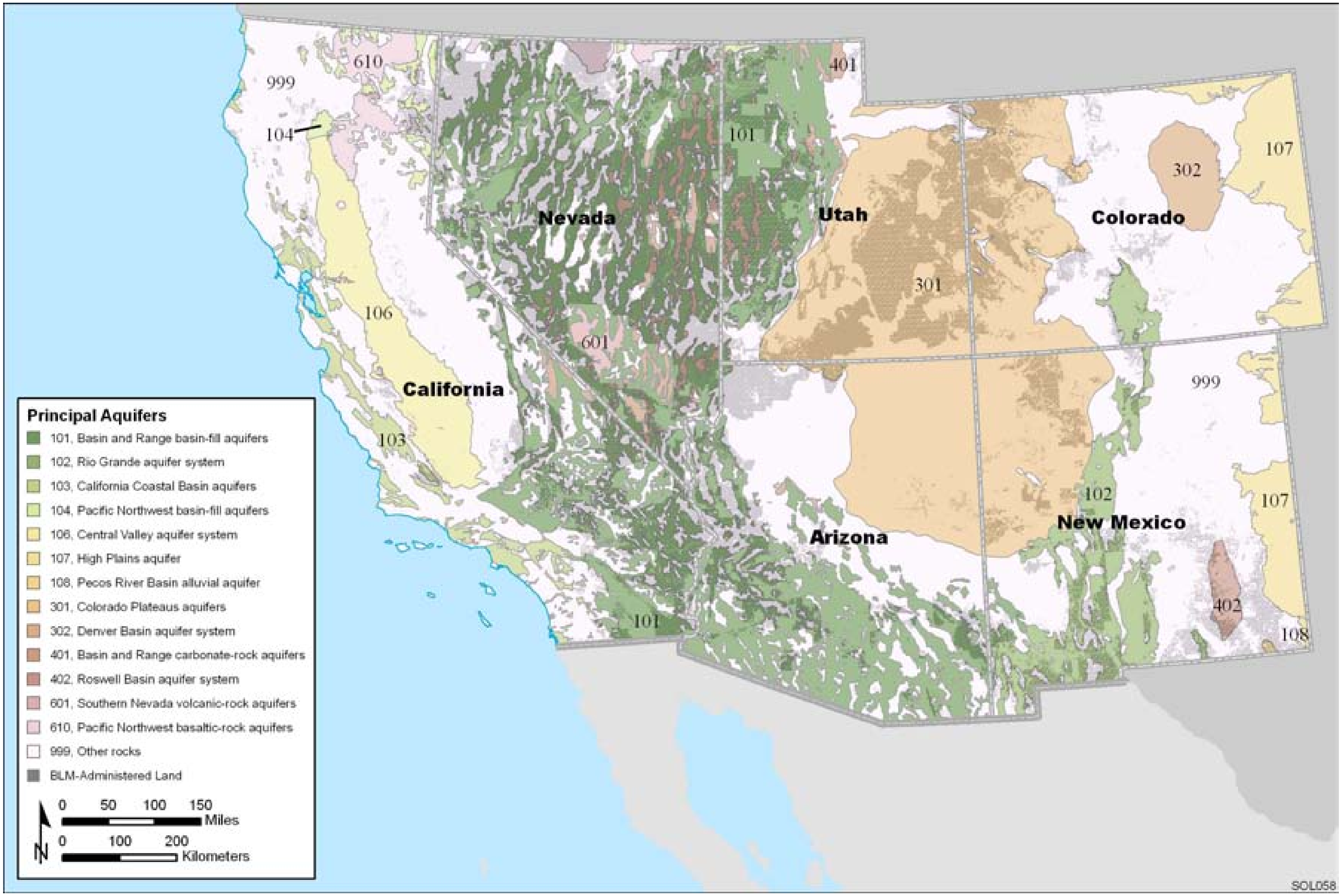

FIGURE 4.9-3 Major Aquifer Systems in the Six-State Study Area (USGS 2003)

Shallow groundwater is typically found near the surface in the vicinity of large surface water bodies (i.e., lakes and streams) and near the areas with lowest elevation in a basin. Deeper groundwater may occur at great depths in bedrock aquifers. Recharge of these aquifer systems occurs mainly through precipitation, especially in mountainous areas where snow precipitation is significant and evaporation is relatively low. Groundwater discharges to local streams and rivers and to springs in valleys of low-lying areas and in alluvial fans. During the summer, groundwater discharges contribute significantly to streamflows in low-lying arid and semiarid regions. Groundwater quality is significantly affected by the host bedrock. Recharge of aquifers can be of critical importance to the appropriate management of groundwater resources. Overdraft conditions occur when more water is discharged from an aquifer than is recharged to the aquifer. Overdraft conditions can lead to permanent damage to the storage capacity of an aquifer. Subsidence and surface fissures may occur due to severe overdraft. Determining the water budget of a specific local basin is an important tool for proper management of groundwater use. Table 4.9-4 lists the potentially affected aquifer systems within the nine hydrologic regions covered by the six-state study area and summarizes their principal uses and general water quality.

A few aquifers provide the major water supply for local communities and are federally designated as sole source aquifers (Table 4.9-5). The U.S. Environmental Protection Agency (EPA) defines a sole source (or principal source) aquifer as one that supplies at least 50% of the drinking water consumed in the area overlying the aquifer. The EPA's criteria for sole source aquifer designation also require that the area have no alternative drinking water sources that could physically, legally, and economically supply all those who depend upon the aquifer for drinking water (EPA 2008a).

The EPA's Sole Source Aquifer Protection Program is authorized by Section 1424(e) of the U.S. Safe Drinking Water Act (SDWA). Proposed federally funded projects that have the potential to contaminate a designated sole source aquifer are subject to EPA review. In many cases, Memoranda of Understanding (MOUs) have been developed by the EPA with federal funding agencies (e.g., the Federal Highway Administration and the Department of Housing and Urban Development) to establish a review of responsibilities under the Sole Source Aquifer Protection Program and to list categories of projects that should or should not be referred to the EPA for review. MOUs help ensure that projects that pose serious threats to groundwater quality are referred to the EPA (EPA 2008a).

Most projects referred to the EPA for review meet all federal, state, and local groundwater protection standards and are approved without imposing additional conditions. Occasionally, site- or project-specific concerns for groundwater quality protection lead to specific recommendations or additional pollution prevention requirements as a condition of funding. In rare cases, federal funding has been denied when the applicant either has been unwilling or unable to modify the project (EPA 2008a).

TABLE 4.9-4 Characteristics of Major Aquifer Systems in the Six-State Study Area

Hydrologic Region	Geographic Area	Major Aquifer Systems	Aquifer Types	Principal Water Uses	General Groundwater Quality
Pacific Northwest	A small region in northern Nevada	Pacific Northwest basaltic-rock aquifers	Bedrock	Irrigation	Generally good water quality.
California	Most of California and a very small portion of western Nevada	Pacific Northwest basin-fill aquifers, Pacific Northwest basaltic-rock aquifers, Basin and Range carbonate-rock aquifers, Basin and Range basin-fill aquifers, California Coastal Basin aquifers, and Central Valley aquifer system	Sedimentary rocks (including carbonate rock) and basin sediments	Main source of water for public supply, domestic consumption, and agricultural irrigation	Elevated TDS levels from evaporative beds in southern California. Agricultural practices in central California combined with a high evaporation rate have resulted in elevated nitrates and pesticides in shallow groundwater systems and substantial declines in shallow groundwater tables.
Upper Colorado	Colorado Plateau in western Colorado, eastern Utah, northern Arizona, and New Mexico	Colorado Plateau aquifers	Sedimentary rocks	Major source of water for municipal and domestic uses	Groundwater quality is influenced by the nature of the bedrock. Elevated levels of TDS in areas of sedimentary rock. Mining may cause metal contamination in local groundwater.
Lower Colorado	Most of Arizona and portions of western New Mexico, southern Nevada, and southeastern California	Southern Nevada volcanic-rock aquifers, Rio Grande aquifer system, Basin and Range basin-fill aquifers, and the Colorado Plateau aquifers	Basin sediments and bedrock	Main source of water for domestic consumption and agricultural irrigation	Groundwater quality is influenced by the nature of the bedrock. Elevated TDS and salinity in alluvium or in areas with Late Tertiary sedimentary bedrock. Elevated metals in groundwater in mining areas. Good water quality in deep, carbonate aquifers. Irrigation and mine dewatering lowered the water levels in shallow groundwater in Arizona.

TABLE 4.9-4 (Cont.)

Hydrologic Region	Geographic Area	Major Aquifer Systems	Aquifer Types	Principal Water Uses	General Groundwater Quality
Rio Grande	Central New Mexico and south central Colorado	Rio Grande aquifer system, Colorado Plateau aquifers, Roswell Basin aquifer system, and the High Plains aquifer	Basin sediments	Irrigation, livestock watering, and domestic uses	Elevated nitrate in agricultural areas such as the San Luis and Rincon Valleys. Pesticides detected in agricultural and urban areas.
Missouri	Northeastern Colorado	Denver Basin aquifer system and the High Plains aquifer	Basin sediments	Primarily for irrigation. Other uses include municipal and domestic water supplies	Generally good water quality. Elevated levels of sulfate and metals in local groundwater near mining areas. Elevated concentrations of nutrients and pesticides in shallow alluvial groundwater near agricultural areas.
Great Basin	Central and northern Nevada and western Utah	Basin and Range basin-fill and carbonate-rock aquifers and the southern Nevada volcanic-rock aquifers	Basin sediments and bedrock	Domestic consumption, public water supply, irrigation, and power plant cooling	Groundwater quality is influenced by the nature of the bedrock. Good water quality in carbonate rock and sandstone aquifers. Elevated levels of salts and TDS in the central parts of basins, elevated metal concentrations in historic mining areas, and elevated nitrate and pesticide concentrations in shallow groundwater in agricultural areas.
Arkansas-White-Red	Southeastern Colorado and northeastern New Mexico	High Plains	Basin sediments	Irrigation	Generally good quality. Dissolved solid concentrations less than 250 mg/L are found in northeastern Colorado and are the result of relatively large recharge rates in areas of sandy soil that contains few soluble minerals.

TABLE 4.9-4 (Cont.)

Hydrologic Region	Geographic Area	Major Aquifer Systems	Aquifer Types	Principal Water Uses	General Groundwater Quality
Texas-Gulf	A small region in eastern New Mexico	High Plains	Basin sediments	Irrigation	Not known.[a]

[a] Data for the Texas-Gulf hydrologic region is incomplete (Jantzen 2005).

Sources: BLM (2007a); Hutson et al. (2004).

TABLE 4.9-5 Sole Source Aquifers in the Six-State Study Area

Sole Source Aquifer	Location
Upper Santa Cruz and Avra Basin Aquifer	Arizona
Bisbee-Naco Aquifer	Arizona
Fresno County Aquifer	California
Santa Margarita Aquifer, Scotts Valley	California
Campo/Cottonwood Creek	California
Ocotillo-Coyote Wells Aquifer	California
Española Basin Aquifer System	New Mexico
Glen Canyon Aquifer	Utah
Castle Valley Aquifer	Utah
Western Unita Arch Paleozoic Aquifer System	Utah

Sources: EPA (2008b-d).

Special agency stipulations may apply to lands that have been designated with sole source aquifers. For example, no surface-disturbing activities would be allowed within sole source aquifer designated areas on BLM lands, unless an exception was granted for activities for which it can be demonstrated that the proposed action would not result in a negative impact on the aquifer.

4.9.3 Water Rights, Supply, and Use

The arid climate and scarcity of water resources of the Southwest make water rights and management of extreme importance in achieving beneficial uses of water resources while maintaining healthy aquatic ecosystems. Water rights and management activity varies by state, and in addition, surface water and groundwater can be managed together or separately. Beneficial uses of water resources vary by state, but typically include irrigation, domestic, recreational, and industrial uses. Balancing beneficial uses with scarce water resources, in combination with complex water rights and management practices, can make obtaining water supplies for solar energy development difficult. A significant component to any solar energy development plan will be an analysis to determine the ability to meet the necessary water requirements. Regulation of water resources can be imposed by state and local agencies, legislation, Native American water rights, court decisions, and international compacts. The myriad of applicable laws and agencies regulating water resources in any one location is complex and often needs to be assessed on a case-by-case basis. There are varying water management doctrines and approaches among the states, and sometimes surface water resources are managed differently than groundwater resources. Variation of management among the states stems from quantity and types of available resources, the climate and terrain of a state, and historical development. Water management strategies must accommodate many water needs and uses (human and ecological), while maintaining the sustainability of those resources. The following sections provide descriptions of general water management concepts and of the various agencies involved in water management and water rights issues, and a summary of state-by-state water management.

For the rest of this section, the general supply and uses of water resources in the six-state study area are described. The description uses the long-term water supply as a baseline. Several constraints in using this baseline should be recognized. Drought conditions, which have occurred in the six states since early 2000, may reduce the water supply substantially from time to time, thus affecting the pattern of water use. Water use may also be legally restricted because of water right issues and various interstate compacts. As water rights can be transferred or traded, the use of water among various sectors could also change with time. Such transfer of water rights is affected by national and local economies. Regional population growth and weather patterns related to climate change may also contribute to the variation of water supply and use. Finally, conservation measures implemented in different states change water use behaviors. All in all, water supply and use are dynamic and interdependent in nature. The information on water supply and use described below provides a general picture of existing conditions by state. Whether the supply is able to meet the demand varies among different hydrologic basins and water management areas, districts, or hydrologic regions within each state. Therefore, local hydrologic conditions and water rights and management must be considered when impacts are evaluated at the project level.

Water Rights Doctrines. Two main water rights doctrines are used as the basis of water laws in the United States: the riparian doctrine and the doctrine of prior appropriation. The right to use water that is present or passes through a piece of property is termed a riparian water right. The riparian doctrine of water rights is based on the principle of "reasonable use." A property owner is allowed to divert or consume water that physically touches their property, but it must not be unreasonably detained or diverted. The definition of reasonable use of riparian water is variable among states, and the definition is subject to change. Riparian water rights are tied to the land adjacent to the water body and are generally not transferrable to non-riparian areas. Most of the eastern United States follows the riparian doctrine. Within the six-state study area analyzed for this PEIS, California is the only state that uses aspects of the riparian doctrine for land that borders a surface water body. California also uses aspects of the doctrine of prior appropriation, but the riparian rights are considered the most senior rights in a system.

The doctrine of prior appropriation says that the first person (or entity) to divert water from a source has a priority to that water right, and so on. Owners of water rights do not need to be adjacent to the water body, as in the riparian doctrine, but can divert water for use where it is needed. Most of the western states use the prior appropriation doctrine to manage water resources. Under the system of prior appropriation, water rights that are junior are not allowed to prevent senior water rights holders from obtaining their allocation of water. Thus, in times of drought, a junior water rights holder may not be entitled to their share of the resource. However, even senior water rights holders are not allowed to change the time of use, place of use, purpose of use, or point of diversion of the right if it would injure other water rights holders within a basin. Some areas allow transfer of water rights away from the land the water is tied to, but other areas forbid such transfers. Additionally, some states specify that if a water right is not used for a certain period of time, that water right is forfeited. In Arizona, if a water right is not used for five consecutive years, the water right is considered forfeited and the water becomes available for appropriation again (BLM 2001).

Beneficial Use of Water Resources. In some states, the priority of a water right can be based solely upon the first date of use, and in others the priority can also depend on the specific use of the water. Priority "beneficial uses" of water can be specified, including for example: municipal, irrigation, industrial, or habitat uses. Each state has its own system for defining priorities regarding beneficial uses of water, from different sources and in different basins. For example, water rights in Utah are based on the concept of beneficial use, and any water right granted in the state has a specified beneficial use associated with it (BLM 2001).

Water that supports wildlife within a stream system can be defined as a beneficial use and is sometimes termed "instream flow." Some states, or basins within states, define instream flow, and accompanying support of wildlife, a beneficial use of that water. This use can be given a priority in times of drought to support wildlife by maintaining a minimum amount of water that has been demonstrated to support wildlife. In Utah, instream flows were defined as a beneficial use in 1986 through passage of legislation. The instream flow water rights in Utah can only be held by the Utah Division of Wildlife Resources or the Division of Parks and Recreation and can only be obtained through legislative approval. New Mexico has no state laws governing instream flows, and they are not recognized as a beneficial use in the state. However, ongoing litigation in New Mexico is working toward defining instream flows as a beneficial use (BLM 2001).

Federal, Native American, and Pueblo Water Rights. While most water rights are determined by the states, the United States has implied reserved water rights, termed federal reserved water rights, for Indian reservations and for most federal lands. The federal reserved water rights are only to include water needed to maintain the "primary purpose" for which the land was established. Determining the amount needed to satisfy the "primary purpose" of the land is subject to court ruling by the states (BLM 2001). In addition, there are federal water rights that apply to Indian Tribes and their reservations. The U.S. Supreme Court has typically sided with tribal governments over the management of federal Indian water rights (Williams 1997). Pueblo water rights apply to lands that were recognized by Spanish law as Spanish or Mexican pueblos (cities) and have been designated in California and New Mexico. A pueblo water right specifies that water flowing through or contained within the original pueblo can be used for municipal purposes within the modern city limits.

Federal, State, and Local Legislation and Adjudications. Water use is primarily governed through state and/or local regulations, but there are a few federal laws that play an important role in water use in the Southwest. As discussed above, the United States has federal reserved water rights that apply to most federal lands and to Indian reservations, and for the most part, these rights are independent of state laws. Wilderness designations can secure a minimum amount of water for wildlife that is dependent upon such water, as set forth in the Wilderness Act of 1964. Also, designation of a Wild and Scenic River under the Wild and Scenic Rivers Act of 1968 is accompanied by a minimum flow requirement to maintain the character of the river as defined in the designation. Additionally, no diversions are allowed on the reach of the river that has been designated as Wild and Scenic (NPS 1998).

Some aquifers provide the major water supply for local communities and are federally designated as sole source aquifers. The EPA defines a sole source (or principal source) aquifer as one that supplies at least 50% of the drinking water consumed in the area overlying the aquifer. The EPA's criteria for sole source aquifer designation also require that the area have no alternative drinking water source(s) that could physically, legally, and economically supply all those who depend upon the aquifer for drinking water (EPA 2008a). Proposed federally funded projects that have the potential to contaminate a designated sole source aquifer are subject to EPA review.

All of the states in the six-state study area have passed legislation concerning the use and supply of water. For example, California has a suite of water laws that fall under the *California Code of Regulations,* Title 23. Colorado also has enacted statewide water laws in the *Colorado Revised Statutes.* Additionally, Colorado has a system of water courts that handle all water rights applications. Many of the states also provide specific regulations on standards for the reuse or recharge of municipal wastewater. The state water laws establish the rules and agencies/parties responsible for enforcing those rules. Additionally, some counties in the southwestern United States have additional laws or ordinances that govern the water supplies within that county. For example, 27 county-level ordinances have been established in California to manage groundwater resources. Local and municipal ordinances relating to water use or regulations within an irrigation district may also apply to certain areas in the Southwest.

Court determinations, termed adjudications, can also be used to determine the priority of, and settle disputes over, water rights in a basin. Adjudications have been necessary in many states to resolve complex water rights claims, including those claimed under the federal reserved rights doctrine (including tribal rights) that had previously not been included in a state's accounting of water rights for a basin (Gerlak and Thorson 2006). The McCarran Amendment of 1952 assigned the state court systems responsibility for determining the federal and tribal water rights for a basin (Hobbs 2006). The adjudications involve all water users in a basin, so the process can be long and complex. In New Mexico, the adjudication of the Pecos River basin began in 1956 and is still ongoing (NMOSE 2010b). Each state handles water rights adjudications in different ways. In New Mexico, Nevada, and Utah, the State Engineer initiates the adjudications. In California, the State Water Board has only initiated 2 out of 20 adjudications, the rest are conducted by the state or federal court system or by the court system with the State Water Board as a referee (CADWR 2010a). The results of adjudications are often a complex set of new rules and regulations for a basin that are enforced by state or regional water officials (Gerlak and Thorson 2006; Hobbs 2006). The water rights decisions can sometimes include a settlement of both money and water (Gerlak and Thorson 2006).

Federal, State, and Local Agencies and Water Resources Managed. A myriad of agencies are involved with water management. At the federal level, the EPA and the U.S. Army Corps of Engineers (USACE) enforce many programs to protect water bodies from, for example, contamination or physical alteration. The EPA also has set standards and regulations for the reuse of wastewater treatment plant effluent. The National Park Service (NPS), the U.S. Fish and Wildlife Service (USFWS), the BLM, and other federal agencies are responsible for securing federal reserved water rights that accompany the land holdings of these agencies. Often, these agencies are interested in preserving instream flows or maintaining groundwater-fed springs to protect wildlife habitat. The BOR and the USACE are responsible for managing hydropower and other types of dams; however, the flows from these dams are often regulated by state laws or international treaties. The U.S. Section of the IBWC is the agency responsible for managing the water at the United States–Mexico border.

Water management at the state level is typically performed by a division of water resources or an office of the state engineer, and a combination of agencies is responsible for water management in some cases. In Utah, there are two agencies: the Division of Water Resources, responsible for planning within the surface water basins, and the Division of Water Rights, responsible for appropriating available water resources within basins. In California, the State Water Resources Control Board holds the primary responsibility for issuing and regulating surface water rights, while groundwater resources are typically managed at a local level. The California Department of Water Resources is responsible for planning for the future of California's water resources and is a repository of information on those resources. For example, all wells drilled in the state must be registered with the Department of Water Resources, and water levels for 35,000 wells are available from their Web site (CADWR 2010b). Additionally, each state has a department of environmental quality or equivalent agency that regulates the quality of water and maintains drinking water standards within the state.

At a regional, county, or local level, there is often another layer of management. In New Mexico, the Office of the State Engineer has identified priority regions within the state, each of which has an appointed "water master" to help track water use and enforce water law within that region. New Mexico also has a system of acequias, or community ditches, that have been in existence since the Spanish colonized the area starting in the seventeenth century (NMOSE 2010c). Acequia associations are in charge of distributing surface water in certain areas of New Mexico. In California, water masters are often appointed to enforce an adjudication of a basin. Colorado water rights are established through seven regional water court systems throughout the state and enforced by regional water commissioners. Before a water right is approved, it must be approved by both the water court system and the local Division Engineer Office (CDWR 2008). Additionally, in many regions of the southwestern United States, water conservation agencies and irrigation districts are responsible for the local management of water resources, and can also act as the water master for adjudicated basins (e.g. Imperial Irrigation District, Mojave Water Agency, Palo Verde Irrigation District, and Metropolitan Water Agency, operating in California).

There are many different approaches to managing water resources. In some states surface water and groundwater are managed differently, and in others all water resources are managed conjunctively. Also, in some regions, the beneficial uses of water within a basin are stipulated by water management agencies. For example, in Nevada the groundwater in some basins is designated as having preferred beneficial uses, and all other uses are not allowed within the basin. As is the case with many basins in Nevada, agricultural irrigation is not allowed as a groundwater use in the Las Vegas Valley basin. Other uses are specified as preferred within the basin. Various beneficial uses are recognized in the six southwestern states. Arizona recognizes the following beneficial uses: domestic, municipal, irrigation, stock watering, power, mining, recreation, wildlife and fish, and groundwater recharge. California recognizes several more beneficial uses, including aquaculture, fire protection, frost protection, heat control, industrial use, and water quality control (BLM 2001).

To obtain water rights in most states, users must submit to the appropriate state (or local) agency an application that, in most cases, must identify the source of the water, the location of the proposed diversion (or well), the proposed place of use, the beneficial use, and the proposed quantity of use. Surface water is almost universally acquired using a process similar to that described here, but the process of obtaining groundwater varies from state to state. Permits to withdraw groundwater are not required to be obtained through a state agency in California, but may be required through a county or local agency. In Arizona, permits to withdraw groundwater are only required in certain areas. In Nevada, the exact same process must be followed for obtaining rights to surface water or groundwater.

Many groundwater basins in the six southwestern states have been over-appropriated and are experiencing groundwater overdraft. The basins in overdraft have been experiencing groundwater level declines because the outputs from the basins (including withdrawals from wells) have far exceeded the inputs to the basins. The declining water levels have the potential to cause land subsidence. Many of the over-appropriated basins are closed to new applications for groundwater use, and any future groundwater use within the basins must be transferred from other uses. Each state handles these groundwater overdrafts differently. Many states (including Arizona, California, and Nevada) have started artificially recharging some overdrawn aquifers by either diverting surface waters to infiltration basins and allowing water to percolate from the surface into an aquifer or by pumping the water down wells to replenish an aquifer. In most cases, excess surface water during wet periods is diverted for these artificial recharge activities. Usually, the water is considered available for use later, during times of water shortage. Special permits may be required to use artificially recharged water.

Another strategy for optimizing water use has been the rise of the reuse of wastewater treatment plant effluent for irrigation, energy production, artificial recharge, industrial purposes, or other uses. Most western states are encouraging the reuse of treated water to optimize water use, especially within heavily populated areas. In Arizona, 80,000 ac-ft/yr (99 million m^3/yr) of effluent from the Phoenix metro area is allocated to the Palo Verde Nuclear Generating Station for cooling, allowing the existence of the only nuclear power plant not located on a major body of water (Azcentral 2010).

Many states have a process for designating basins or regions as special management areas to impose additional regulation of water resources. The Nevada Department of Water Resources (NDWR) designates groundwater basins when they are deemed to be in a state of overdraft. As of 2005, the New Mexico Office of the State Engineer (NMOSE) had “declared” every basin within the state as being in need of management (NMOSE 2010e). Prior to that time, basins that had not been declared were not subject to regulation by the NMOSE. Additionally, New Mexico has instituted a program called Active Water Resource Management that is currently being employed in the seven “priority” basins within New Mexico (NMOSE 2004). This initiative is developing tools to perform detailed accounting of water use, implementing new or existing regulations, creating water districts for management, and assigning water masters to those districts (NMOSE 2004).

Most states allow interbasin transfers of water if water is available in one place but needed in another. States handle these interbasin transfers in different ways. In Nevada, there is a formal process by which the NDWR approves interbasin transfers, but in Utah, for example, interbasin transfers are allowed, but there is no formal process for evaluating and approving them in the state. In Colorado, interbasin transfers are necessary to support the half of the population that lives on the eastern side of the state that only receives 20% of the precipitation (CLCS 2009). Twenty-five of the 39 interbasin transfers in Colorado originate from the Colorado River Basin (CLCS 2009).

In addition to managing surface water and groundwater resources, water managers also need to consider the health of springs and seeps, the quality of water, and instream flow needs for wildlife. Water supports life, and clean, flowing water is needed in many areas to support wildlife, some of which is threatened or endangered. The need to support wildlife can often lead to court cases to establish the amount of water deemed sustainable to withdrawal from a stream or aquifer in order to maintain ecosystems in a basin.

4.9.3.1 Arizona

Arizona water law is based on the doctrine of prior appropriation. However, water laws in Arizona are based on a bifurcated system in which surface water and groundwater rights are administered and assessed separately. Arizona has four main sources of water: (1) Colorado River water, (2) surface water separate from the Colorado River, (3) groundwater, and (4) treated effluent. Rights for these four sources are assessed and administered separately. Colorado River water is regulated under the Law of the River; surface water is based on prior appropriation; and groundwater rights are handled on a region by region basis (BLM 2001). Effluent is not available for use until it takes on the characteristics of surface water through treatment (ADWR 2010f). The Arizona Department of Water Resources (ADWR) is the agency responsible for the conservation and distribution of water in the state. It is also responsible for the administering and assessment of novel and transfer of existing water rights and applications. The agency's broad goal is the security of long-term dependable water supplies for the state, which is the main factor in the assessment of water right applications (ADWR 2010a).

Upon completion of an application for water rights, the ADWR assesses it with three main criteria: (1) whether the proposed water right will conflict with more senior water rights, (2) whether the proposed right is a threat to public safety, and (4) whether the proposed right will be detrimental to the interests and welfare of the general public (BLM 2001). Generally, surface water rights are assessed solely upon these four criteria, but they may also be subject to certain management plans in specific areas put into effect by the ADWR. Unlike the majority of groundwater rights that are bound to the land they occupy, users of surface water rights have the option to change location of the water right but not the beneficial use (a change of beneficial use application would need to be submitted). In order to change a surface water right's location, a "sever and transfer" permit needs to be approved by the ADWR and the governing body of the irrigation district or water users council of the proposed new location of the surface water right. Evaluations of "sever and transfer" permits follow the same general evaluation guidelines as new surface water rights, and the proposed new location of the right after the transfer is treated as a new surface water right. The new surface water right must not exceed the old one in annual water use (ADWR 2010f).

Because of historic groundwater overdraft, where groundwater recharge is exceeded by discharge (in some places groundwater overdraft is in excess of 700,000 ac-ft/yr [863 million m^3/yr]), the Ground Water Management Code (the Code) was put into effect in 1980 (ADWR 1999, 2010d). The Code describes three main goals for the state regarding the management of groundwater: (1) controlling severe overdraft, (2) allocation of the limited water resources of the state, and (3) enhancement of the state's groundwater resources using water supply development (BLM 2001). Arizona's groundwater management laws are separated using a three tier system based on the Code. In that system, proposed applications are evaluated with an increasing level of scrutiny. The lowest level of management includes provisions that apply statewide, Irrigation Non-Expansion Areas (INAs) have an intermediate level of management, and Active Management Areas (AMAs) have the highest level of management with the most restrictions and provisions. There are currently five AMAs and three INAs in the state, each of which has its own specific rules and regulations regarding the appropriation of groundwater (ADWR 2010b).

Recently, the ADWR has created guidelines regarding the appropriation of water for solar generating facilities, specifically detailing what information needs to be submitted for permit evaluation (ADWR 2010e). The information required includes the proposed method of power generation, the proposed amount of water to be consumed, the point of diversion, and to what or whom the power is to be distributed (ADWR 2010f). To secure water rights for a solar facility to be located within an AMA, the applicant must demonstrate that there is an "assured water supply" for the life of the project (ADWR 2010e). The ADWR then makes a decision based on whether the proposed water right will be detrimental to public welfare and general conservation of water (ADWR 2010f).

Arizona has rights to 2.8 million ac-ft (3.5 billion m^3) of Colorado River water annually, which is further sub-divided into allocations for both general Colorado River water users and Central Arizona Project (CAP) users (ADWR 2010c). CAP is a system of water delivery canals, aqueducts, and pumping stations that deliver 1.5 million ac-ft/yr (1.9 billion m^3/yr) of Colorado River water from Lake Havasu to Pima, Pinal, and Maricopa Counties annually (CAP 2010). The flows of the Colorado River are variable, and thus the water resource actually available varies from year to year.

In addition to the Colorado River, the Salt, Verde, and Gila Rivers provide essential supplies for water users in central Arizona. In other parts of Arizona, local surface water supplies, such as Little Colorado River, San Pedro River, Verde River, and other rivers and streams, as well as captured runoff in reservoirs and springs, are used by municipal, industrial, and agricultural users.

The Arizona State Legislature created the Underground Water Storage and Recovery Program in 1986 and enacted the Underground Water Storage, Savings, and Replenishment Act in 1994 to make use of excess water that may otherwise be lost in times of surplus water supply (AWBA 2010). The Underground Water Storage, Savings, and Replenishment Act created the Arizona Water Banking Authority, which has two programs: (1) Underground Storage Facilities, which use excess CAP water, other surface water, or effluent to artificially recharge a groundwater aquifer, and (2) Groundwater Savings Facilities, which provide water supplies (CAP water, other surface water or effluent) in lieu of using groundwater, allowing the groundwater to stay in storage and become "savings" (ADWR 2010e; AWBA 2010). The ADWR is in charge of the distribution of the program's waters as well as the evaluation of permits to store and recover their waters (ADWR 2010e). To put this water to use, the ADWR must first award a recovery well permit (ADWR 2010e). If a recovery well permit is submitted for use inside an AMA, a "hydrologic impact analysis" report may also need to be submitted (ADWR 2010f).

Table 4.9-6 lists the water withdrawal in Arizona in 2003. The table shows that the state relies on both groundwater and surface water for its water use. Among the various water uses, agricultural and municipal uses are the biggest consumers, accounting for 5.4 million and 1.6 million ac-ft (6.7 billion and 1.9 billion m^3), respectively. With population growth, the effluent water from sewage treatment plants increases. This effluent and the effluent from the Palo Verde nuclear power plant also provide 190,000 ac-ft (230 million m^3) of water, primarily for irrigation and recharges. The total amount of water used in 2003 was about 7.8 million ac-ft (9.6 billion m^3).

4.9.3.2 California

California uses a "plural" system to manage water resources that consists of a mixture of riparian and prior appropriation doctrines for surface waters, a separate doctrine for groundwater, and pueblo rights (BLM 2001). Several agencies are involved with the management of California's water resources, including federal, state, local, and water/irrigation districts. For example, water rights and water quality are managed by the State Water Control Board, while the Department of Water Resources manages water conveyance, infrastructure, and flood management (CADWR 2010c). Surface water appropriations for nonriparian rights begin with a permit application to the State Water Control Board and a review process that examines the application's beneficial use, pollution potential, and water quantity availability. The permitting, review, and licensing procedure should not take more than 6 months to complete unless the application is protested (BLM 2001).

The California Department of Water Resources divides the state into 10 hydrologic regions for managing its water resources: (1) North Coast, (2) San Francisco Bay, (3) Central Coast, (4) South Coast, (5) Sacramento River, (6) San Joaquin River, (7) Tulare Lake, (8) North Lahontan, (9) South Lahontan, and (10) Colorado River. In addition to these 10 regions, 2 special districts (the Mountain Counties and the Sacramento-San Joaquin Delta area) are delineated. The special districts overlay parts of the other hydrologic regions.

TABLE 4.9-6 Water Withdrawal (thousand ac-ft[a]) in Arizona by Sector, 2003

Use Sector	Surface Water	Groundwater	CAP[b]	Effluent	Others	Subtotal
Municipal	418	633	422	94.0		1,567
Agricultural	2,298	2,484	585	69.4		5,436
Industrial	6.7	312	1.8	21.2	600	403
Tribal	130	145	140	5.2		421
Subtotal	2,913	3,575	1,149	189.8	600	7,827
Total						7,827

[a] To convert ac-ft to m^3, multiply by 1,234.

[b] CAP = Central Arizona Project; includes direct use and recharge credit recovery in the CAP, in which water from the Colorado River is transferred to central Arizona.

Source: ADWR (2006).

Groundwater management in California is primarily implemented at the local level of government through local agencies or ordinances and can also be subject to court adjudications. State statute provides authority and revenue mechanisms to several types of local agencies to provide water for beneficial uses, as well as to manage withdrawals in order to prevent overdraft of the aquifers. Local ordinances (typically at the county level) can also be used to manage groundwater resources and have been adopted in 27 California counties. Many of these local groundwater ordinances are focused on controlling water exports out of the basin through permitting processes. Court adjudications are the strongest form of groundwater management used in California and often result in the creation of a court-appointed water master agency to manage withdrawals for all users to ensure that the court-determined safe yield is achieved (CADWR 2003).

Reuse of effluent in California is governed under Title 22 of the *California Code of Regulations.* California has long been a leader in recycled water use and technology (Davis 2000). Artificial recharge is also widely practiced throughout the state for various purposes, but there is no state law that governs this practice. California is divided into regions, and each regional water quality control board has different regulations that must be complied with in that region that determine the management strategy of the artificial recharge activities (Mills et al. 2009).

The water supplies of California are based on precipitation in the state as well as imports from neighboring states, such as Arizona (the Colorado River) and Oregon, and from Mexico. For water management purposes, the surface water supplies are provided in different storage and delivery systems and are divided as follows: Local Deliveries, Local Imported Deliveries, Colorado River Deliveries, Central Valley Project (CVP) Base and Project Deliveries, Other

Federal Deliveries, State Water Project (SWP) Deliveries, and Required Environmental Instream Flow. Groundwater is also used extensively in California.

The water supply in California varies from year to year. Table 4.9-7 summarizes the water supply for 1998, 2000, and 2001. These three years represent a wet year, a normal year, and a slightly dry year, respectively. As indicated in the table, yearly water usage is dictated by the precipitation of that year. During a wet year (such as 1998), surface water is the primary source. However, that source is substituted by groundwater during a dry year (such as 2001). The reuse/recycle water is also reduced in a dry year.

California receives water from the Colorado River. Under the Colorado River Compact of 1922, California is apportioned with 4.4 million ac-ft/yr (5.4 billion m^3/yr) of the river water. In 2001, inflow from the Colorado River was 5.2 million ac-ft (6.4 billion m^3) (CDWR 2005). The state is going to reduce the inflow in the future to meet the Compact's requirement, thus reducing its supply from the Colorado River.

Table 4.9-8 gives the water consumption of different water users. Water use fluctuates among different sectors with hydrologic conditions, such as a wet (1998), normal (2000), or dry year (2001), especially for environmental use, which ranges from 14.5million to 44.7 million ac-ft (17.9 billion to 55.1 billion m^3) in depletion from 1998 to 2001. Agricultural use of water is more than three times the urban use, regardless of the hydrologic conditions. The agricultural depletion ranges from 20.4 million ac-ft (25.2 billion m^3) (1998 wet year) to 26 million ac-ft (32 billion m^3) (2001 dry year) and was not affected much by hydrologic conditions. Urban use ranged from 6.3 million to 7.2 million ac-ft (7.8 billion to 8.9 billion m^3) in the same period.

TABLE 4.9-7 Water Supplies (thousand ac-ft[a]) for Applied Water[b] in California, 1998, 2000, and 2001

Year	Surface Water	Groundwater	Deep Percolation of Surface water and Groundwater	Reuse/Recycle	Subtotal
1998	68,900	4,400	5,600	15,400	94,500
2000	55,700	7,800	7,000	11,800	82,500
2001	38,200	11,000	6,700	8,800	64,800

[a] To convert ac-ft to m^3, multiply by 1,234.

[b] Applied water refers to the total amount of water that is diverted from any source to meet the demands of water users, without adjusting for water that is used up, returned to the developed supply, or irrecoverable.

Source: CDWR (2005).

TABLE 4.9-8 Water Use in California (thousand ac-ft[a]) by Sector, 1998, 2000, and 2001

Sector	1998 Applied Water Use[b]	1998 Depletion[c]	2000 Applied Water Use[b]	2000 Depletion[c]	2001 Applied Water Use[b]	2001 Depletion[c]
Urban[d]	7,800	6,300	8,900	7,200	8,600	7,000
Agricultural[e]	27,300	20,400	34,200	25,600	33,700	26,000
Environmental[f]	59,400	44,700	39,400	28,500	22,500	14,500

[a] To convert ac-ft to m^3, multiply by 1,234.

[b] Applied water refers to the total amount of water that is diverted from any source to meet the demands of water users, without adjusting for water that is used up, returned to the developed supply, or irrecoverable.

[c] Depletion is the water consumed in the system, irrecoverable water, and outflow minus water that can be later recovered, such as deep percolation and return flow to developed supply.

[d] Urban water use includes large landscape, commercial, industrial, energy production, residential, evapotranspiration of applied water, deep percolation to salt sink, outflow, any conveyance water, groundwater recharge applied water, groundwater recharge evaporation, and evapotranspiration.

[e] Agricultural water use includes on-farm applied water, evapotranspiration of applied water, deep percolation to salt sink, outflow, any conveyance water, groundwater recharge applied water, groundwater recharge evaporation, and evapotranspiration.

[f] Environmental water use includes instream flow, WSR, required delta outflow, and managed wetlands flows.

Source: CDWR (2005).

4.9.3.3 Colorado

Colorado administers its water rights using the doctrine of prior appropriation as its cornerstone, with water rights being granted by a water court system and administered by the Colorado Division of Water Resources (CDWR) (BLM 2001). Surface waters in much of Colorado were over-appropriated before the turn of the twentieth century, groundwater was not actively managed until mid 1960, and the Water Rights Determination and Administration Act of 1969 (C.R.S. §§37-92-101 through §§37-92-602) required that surface waters and groundwater be managed together (CDWR 2010a).

The state has seven regional division engineer offices, corresponding with the state's seven major river basins. These division offices are authorized by the CDWR to review and administer water rights within the basin boundaries. The process of obtaining both surface and groundwater rights in Colorado differs from those of other western states. In Colorado, water rights are established through regional water court systems throughout the state and enforced by regional water commissioners. Before a water right is granted, it must be approved by both the water court system and the local division engineer office. Proposed water rights are assessed based on whether the proposed right will have available, unappropriated water and if it will impair existing water rights (CDWR 2008). A water right's date of establishment is determined by when the water was first put to beneficial use, and this date determines the priority of the water right in the basin. Water rights are considered real property in Colorado and can be bought and sold as such, but transfer of rights requires approval of a change application by the CDWR (BLM 2001).

Groundwater in Colorado is governed by the Groundwater Management Act of 1965. Under this act, all Colorado groundwater is governed under the doctrine of prior appropriation and is typically considered part of a surface water body. If a potential groundwater user can prove that the proposed groundwater right will not deplete a surface water body by a tenth of one percent of the proposed amount of groundwater withdrawn for 100 years, the groundwater will be deemed as "non-tributary" groundwater, and thus deemed not connected to a surface water body (BLM 2001).

If the primary source of water within a basin has been groundwater for a period of 15 years, the basin may be deemed "designated" by the State Engineer (CDWR 2008). Within designated basins, water courts have no water right authority. Authority to distribute, administer and review novel and transfer of existing water rights within designated basins is held solely by the Colorado Ground Water Commission (the Commission) (CDWR 2010b). The Commission's overall goals are working toward water conservation and protecting existing senior water rights. To fulfill those goals, pumping levels and rates of discharge are established and assessed on a basin-by-basin basis (BLM 2001; CDWR 2008). Within designated basins of the state, groundwater management districts (GWMD) may be formed; however, GWMDs do not have any permit approval authority. Once a proposed application is approved by the Commission, GWMDs have authority to administer groundwater and adopt new regulations to help conservation goals within their basin (CDWR 2008). Colorado's 8 designated basins and 13 GWMDs are all located in the eastern portion of the state.

In 2002, Colorado experienced one of the worst droughts of the century, which sparked development of improved water resource planning and reuse facilities that capture effluent water to be recycled. Prior to the 2002 drought, the primary use of recycled water was irrigation and golf course watering (CDM 2007). There are now 18 water reuse facilities statewide that distribute treated effluent to a wide variety of water users, including municipal and industrial users (CDM 2007). Along with water recycling programs, Colorado also has an extensive artificial recharge program. Artificially recharged water is designed to be used in times of shortage and to reduce falling groundwater levels in areas where natural recharge may not offset discharge of the aquifer (CWCB 2007).

In response to increasing water demands in the state, the Colorado Legislature enacted the *Colorado Water for the 21st Century Act* in 2005, which created the Interbasin Compact Committee (IBCC) along with nine basin roundtables (CLCS 2009; Houston 2007). The nine roundtables are composed of water rights owners, water suppliers, and representatives of all water interests of the basin (agricultural, industrial, municipal, recreational, etc). These roundtables meet periodically to discuss statewide and basin-specific water management issues and possible solutions (CWCB 2010a; CWCB 2010d).The IBCC consists of 27 members—some appointed by the governor or legislature and others appointed by the basin roundtables. The

IBCC is responsible for facilitating negotiations between the basin roundtables and assessing and approving any project, compact proposal, or proposed interbasin transfer between each of the basins involved (CWCB 2010c; Houston 2007). Each roundtable is also responsible for developing a basin-specific report that focuses on current and projected unmet demands and future plans of conservation to meet demands (CWCB 2010b).

Colorado's water supply comes from precipitation in the form of rain or snow. No major rivers flow into Colorado. Instead, several major river basins originate in the Colorado Rockies and flow out of the state, thus providing water to neighboring states (McKee et al. 2000). On average, some 16.0 million ac-ft (19.7 billion m^3) of precipitation finds its way into Colorado's creeks and rivers annually. As a headwater state, under various interstate compacts Colorado is legally obligated to provide two-thirds of the surface water it receives from precipitation to downstream users (Fey 2007). Each year, a total of about 10.2 million ac-ft (12.6 billion $m^{3)}$ of water flows to Utah, Nevada, California, New Mexico, Arizona, Nebraska, Kansas, Wyoming, and Mexico. This leaves about 6.0 million ac-ft (7.4 billion m^3) of water for the state in the form of surface water and groundwater (Fey 2007). The precipitation as well as the water supply for Colorado fluctuates with time. In all parts of Colorado, no consistent long-term trends in annual precipitation have been detected in the last 100 years (Ray et al. 2008). Annual precipitation ranges from roughly half to double the long-term average.

Water withdrawals in Colorado in 2000 by water use category are shown in Table 4.9-9. The statewide water use for municipal and self-supplied industries was estimated to be 1.1 million ac-ft (1.4 billion m^3) in 2000. Agricultural irrigation used about 12.8 million ac-ft (15.8 billion m^3), accounting for about 90% of water withdrawals in 2000. Historically, 80 to 85% of the water in Colorado was used for agricultural irrigation (CAWA 2008).

Groundwater use is widespread and constitutes almost 20% of total water use in Colorado. In 2000, groundwater withdrawals for irrigation accounted for 93% of the groundwater used (and about 17% of the total water withdrawals). Other major uses of groundwater were for the public water supply (2.3% of groundwater use) and self-supplied domestic use (2.9% of groundwater use). The remainder of the groundwater withdrawals (about 1.7%) were for industrial and thermoelectric uses.

The Northern and Southern High Plains Designated Basins are two important groundwater resources. The recoverable groundwater was estimated to be 12 million ac-ft (14.8 billion m^3) in the Southern High Plains and 48 million ac-ft (59.2 billion m^3) in the Northern High Plains. The current withdrawal rate in the Southern High Plains Basin is about 220,000 ac-ft/yr (270 million m^3/yr). Groundwater levels have been declining at an average rate of about 5.4 ft/yr (1.6 m/yr) over the past 10 years. The pumping rate in the Northern High Plains Basin was unclear. However, pumping from large wells for irrigation results in drawdown in water levels of more than 10 ft/yr (3 m/yr) in large areas of several counties.

The recoverable groundwater in the Denver Basin bedrock aquifers was estimated to be 206 million to 295 million ac-ft (254 billion to 364 billion m^3), depending on the assumed values of the aquifer storage coefficient. Pumping of the Denver Basin bedrock aquifers results in significant large drawdown in water levels, as much as 30 ft/yr (9.1 m/yr) in some locations

TABLE 4.9-9 Water Withdrawals (thousand ac-ft[a,b]) in Colorado by Water Use Category, 2000

Use Category	Surface Water	Groundwater	Total	Percentage of Total Withdrawal
Public water supply	948	60.2	1,008	7.1
Self-supplied domestic	0	74.9	74.9	0.53
Irrigation	10,400	2,420	12,820	90
Livestock	NC[c]	NC[c]	NC[c]	0
Aquaculture	NC[c]	NC[c]	NC[c]	0
Industrial self-supplied[a]	108	26.4	134.4	0.95
Mining[a]	NC[c]	NC[c]	NC[c]	0
Thermoelectric power[a]	137	18.0	155	1.1
Subtotal	11,593	2,600	14,193	

[a] Values converted from million gallons/day.

[b] To convert from ac-ft to m^3, multiply by 1,234.

[c] NC = data not collected.

Source: Hutson et al. (2004).

(CWCB 2004). The sustainable yield of the aquifer is much less than that of recoverable groundwater.

4.9.3.4 Nevada

All waters in Nevada are the property of the public in the state and are subject to the laws described in *Nevada Revised Statutes,* Chapters 532 through 538 (available at http://leg.state.nv.us/nrs/). The Nevada Division of Water Resources (NDWR), lead by the State Engineer, is the agency responsible for managing both the surface water and groundwater resources. This responsibility includes overseeing water right applications, appropriations, and interbasin transfers (NDWR 2010a). The two principal ideas behind water rights in Nevada are the prior appropriations doctrine and the concept of beneficial use. A water right establishes an appropriation amount and date such that more senior water rights have priority over newer water rights. Additionally, water rights are treated as both real and personal property, such that water rights can be transferred without affecting the land ownership (NDWR 2010a). Water rights applications (new or transfer of existing) are approved if the water is available to be appropriated, if existing water rights will not be affected, and if the proposed use is not deemed to be harmful to the public interest. If these conditions are satisfied according to the State Engineer, a proof of beneficial use of the approved water must be provided within a certain time period, and following that a certificate of appropriation is issued (BLM 2001).

Surface water use makes up 70% of all water uses in the state, and all surface water resources are considered fully appropriated; however, transfer of rights is possible (NDWR 1999). Averaging only 9 in. of annual precipitation, Nevada is the most arid state in the nation. This makes surface water resources highly variable, causing higher rates of groundwater use during periods of growth and shortage (NDWR 1999).

Nevada has 14 hydrographic regions, which are further divided into 232 sub-basins. Groundwater use in the state makes up 30% of total water use during periods of average surface water flow and 40% during periods of surface water shortage (NDWR 1999). Considering the fact that surface water rights in the state are fully appropriated, the potential for development in the state relies almost solely upon the use of groundwater (NDWR 1999). In 1999, it was estimated that 60% of Nevada's basins might have room for additional appropriations; however, some basins were already over-appropriated by over four times above the estimated perennial basin yield, often causing groundwater overdraft (NDWR 1999). Following the realization of a basin's being in a state of overdraft, the NDWR may deem the basin "designated" (NDWR 2010b). Of Nevada's 232 sub-basins, 116 are deemed "designated" (NDWR 2010b). In these basins, unlike surface water rights, the doctrine of prior appropriation may not be the only basis on which groundwater rights are managed. The NDWR, in the interest of the public welfare, has the authority to prioritize preferred uses of groundwater (e.g., municipal or industrial), as well as groundwater extraction quantities (NDWR 2010b).

Artificial recharge in Nevada is mostly through geothermal energy production plants, but it is also associated with mining operations and groundwater replenishment in the Las Vegas Valley (SNWA 2010; Lopes and Evetts 2004).

The estimated average annual yield from Nevada's surface water bodies is about 3.2 million ac-ft (3.9 billion m^3). The annual surface runoff from watersheds within the state is about 1.9 million ac-ft (2.3 billion m^3), while the annual inflow from other states is 1.3 million ac-ft (1.6 billion m^3). Nevada is one of the lower basin states of the Colorado River Basin. It is entitled to 300,000 ac-ft/yr (370 million m^3/yr) of water under the Colorado River Compact of 1922. The perennial yield of the groundwater, defined as the amount of usable water that can be economically withdrawn from a groundwater aquifer and consumed each year without depleting the source, is estimated to be 2.1 million ac-ft/yr (2.6 billion m^3/yr) (NDWP 1999a).

Surface water provides 60% to 70% of the total water supply used in Nevada and has been fully appropriated and used for many years (NDWP 1999a). The rest of the water supply is from groundwater. In some areas, groundwater provides the entire supply.

The total water withdrawal in Nevada was 4.0 million ac-ft (5.0 billion m^3) in 1995 (Table 4.9-10). Agricultural withdrawals accounted for 3.1 million ac-ft (3.8 billion m^3), or 77% of the total water withdrawals in 1995. Public water supply was the second biggest water withdrawal, about 525,000 ac-ft (648 million m^3) (about 13% of the total withdrawal). The mining and self-supplied uses were 274,000 ac-ft (338 million m^3) (6% to 7%) and 122,000 ac-ft (150 million m^3) (3% to 4%), respectively (NDWP 1999b).

TABLE 4.9-10 Water Withdrawals (ac-ft[a]) in Nevada by Sector, 1995

Sector	Surface Water	Groundwater	Total	Percentage of Total Withdrawal
Irrigation	1,975,401	1,138,184	3,113,585	77
Public supply	392,903	131,958	524,861	13
Self-supplied domestic	321	17,783	18,104	0.45
Self-supplied commercial	15,559	7,919	23,478	0.58
Self-supplied industrial	8,446	8,322	16,768	0.41
Thermoelectric	23,176	40,650	63,826	1.6
Livestock	5,210	1,119	6,329	0.16
Mining	3,909	270,524	274,433	6.8
Subtotal	2,424,925	1,616,459	4,041,384	

[a] To convert ac-ft to m^3, multiply by 1,234.

Source: NDWP (1999b).

4.9.3.5 New Mexico

Water law in New Mexico is governed under the doctrine of prior appropriation. All waters (both groundwater and surface water) are public and subject to appropriation by a legal entity with plans of beneficial use (BLM 2001). A water right in New Mexico is a legal entity's right to appropriate water for a specific beneficial use and is defined by seven major elements: owner, point of diversion, place of use, purpose of use, priority date, amount of water, and periods of use. Water rights in New Mexico are administered through the Water Resources Allocation Program (WRAP) under the New Mexico Office of the State Engineer (NMOSE 2010d).

Under the WRAP, the NMOSE is responsible for both surface and groundwater appropriations (both novel and transfer of existing water rights). The extent of the NMOSE's authority to regulate groundwater applies only to those groundwater basins that are "declared" as underground water basins. As of 2005, all groundwater basins within the state have been declared. An application for appropriation must be filed with declared basins. When assessing water right applications, the WRAP considers the following factors: the existence of unappropriated waters within the basin, the possibility of impairing existing water rights, whether granting the application would be contrary to the conservation of water within the state, and if the application will be detrimental to public welfare (BLM 2001).

In most regions of the state, groundwater and surface water appropriation application procedures are handled the same; however, the criteria for which they are evaluated and administered may vary by region or case (NMOSE 2005, 2006). Within select basins, in addition to the routine evaluations described above, groundwater and surface water rights applications may be subject to water management plans to ensure that the proposed junior water rights will not be detrimental to more senior water rights or impair efforts of water conservation in the specific region (NMOSE 2004). The WRAP has created the Active Water Resource Management (AWRM) initiative, which is responsible for administering the water management plans in specific basins/regions (NMOSE 2010a). The AWRM is also responsible for the prioritization of basins that are in need of conservation and water management plans. In basins deemed "priority," policies are set in place that mandate junior water rights be temporarily curtailed in favor of more senior water rights in times of drought or shortage. These priority basins are generally more restrictive in terms of rewarding novel and transfer of existing water rights (NMOSE 2004). Specific tools that are to be used in the AWRM initiative are (1) detailed accounting for water use, (2) implementing new or existing regulations, (3) creating water districts for management purposes, and (4) assigning water masters to those districts (NMOSE 2004). The water masters are tasked with prioritizing water rights, which is necessary to accurately establish which rights will be curtailed and which will not in a time of water shortage.

The New Mexico Interstate Stream Commission was created in 1935 by the New Mexico State Legislature to "investigate, protect, conserve and develop New Mexico's waters including both interstate and intrastate stream systems" (BOR 2010a). The responsibilities of the commission include evaluating of the conditions of the eight interstate river basins and ensuring compliance with interstate compacts for those basins. In 1987, the New Mexico Legislature created a regional water planning program for the state, which is overseen by the Interstate Stream Commission (NMOSE 2010f). The Interstate Stream Commission has divided the state into 16 regions and has funded the creation of unique regional water plans corresponding to each of the regions (NMOSE 2010f). The regional water plans examine water resource availability issues at smaller scales and highlight the diverse availability of water resources throughout the state. The plans present data on water supply, water demand, and projected demands for each region. Using these datasets, conclusions are drawn as to where water shortage areas are and where they may soon appear based on historical water consumption records, historical population data, and projected population increases. This information enables the regions to construct plans for times of shortage to ensure senior water rights are protected (NMOSE 2010f).

The water supply in New Mexico is difficult to quantify (OSE/ISC 2003) because of high natural variability in the surface water supply; data limitations of groundwater; variation in yearly obligations of in-state and interstate delivery; the interrelationship between groundwater and streamflows; and the complication caused by groundwater quality, economic constraints, local land use regulations, and land ownership. Nevertheless, the Office of the State Engineer and Interstate Stream Commission of New Mexico in the 2003 State Water Plan concluded that the water supply barely accommodates and has sometimes fallen short of existing demand, even during the unusually wet years of the 1980s and 1990s. During times of average water supply, the demand for water exceeds the supply.

The Office of the State Engineer's Water Use and Conservation Bureau of New Mexico conducts statewide water use inventories every 5 years. The latest report was published in 2008 for water use in 2005 (Longworth et al. 2008). The water uses were listed by river basins as well as by counties and could be used to estimate the water resource demand in the state. In general, groundwater withdrawals (or uses) in 2005 accounted for 46.5% (or 1.8 million ac-ft

[2.3 billion m^3]) of the total withdrawals (3.9 million ac-ft [4.8 billion m^3]), while surface water withdrawals accounted for the remainder (2.1 million ac-ft [2.6 billion m^3]). Total withdrawals from streams and aquifers in 2000 were more than 4.2 million ac-ft (5.2 billion m^3).

Table 4.9-11 gives water use in New Mexico in 2005. Water for agricultural irrigation accounted for the largest water usage, at about 78% of the total water withdrawal that year. Public water supply and reservoir evaporation were the second and third largest use categories, with about 8% and 7% of the total water withdrawal, respectively. More than 90% of New Mexico's population depends on groundwater for drinking, and it is the only source of potable water in many areas of the state (OSE/ISC 2003). Groundwater contributed about 87% of the public water supply in 2005.

4.9.3.6 Utah

Utah water law is governed under the doctrine of prior appropriation (BLM 2001). The agency responsible for the regulation, appropriation, and distribution of the state's water is the Utah Division of Water Rights, headed by the State Engineer (Utah Division of Water Rights 2010a). Water rights are assessed regionally in one of the seven regional offices of the Utah Division of Water Rights (Reid et al. 2008). The Utah Division of Water Rights assesses proposed water right applications based on whether the proposed right will have available unappropriated water, whether the right will impair existing rights, and whether granting the proposed right will be detrimental to the public welfare (BLM 2001). The means to acquire both

TABLE 4.9-11 Water Withdrawals (thousand ac-ft[a]) in New Mexico by Water Use Category, 2005

Use Category	Surface Water	Groundwater	Total	Percentage of Total Withdrawal
Public water supply	42	278	320	8.1
Self-supplied domestic	0	35.8	35.8	0.91
Irrigated agriculture	1,731	1,344	3,075	78
Self-supplied livestock	3.3	53.7	57.0	1.4
Self-supplied commercial	1.5	39.1	40.6	1.0
Industrial	2.0	16.3	18.3	0.46
Mining	1.4	58.8	60.2	1.5
Power	51.6	12.0	63.6	1.6
Reservoir evaporation	279		279	7.1
Subtotal	2,112	1,838	3,950	

[a] To convert ac-ft to m^3, multiply by 1,234.

Source: Longworth et al. (2008).

surface and groundwater rights (novel and transfer of existing rights) are identical; however, the policy on which they are assessed varies. Surface water applications are assessed solely upon the criteria previously stated, while groundwater rights applications are assessed on a regional basis (BLM 2001). About one third of the state's groundwater basins are closed to new appropriations, so the only means of appropriating water within those basins would be the transfer of existing rights (Utah Department of Water Resources 2005). Interbasin transfers of water are considered legal in Utah; however, unlike other states that allow them (e.g., Colorado and Nevada), Utah has no formal process for dealing with interbasin transfers (Houston 2007). Water rights in Utah are considered property and may be bought, sold, and transferred as such, but a change application must be approved by the Utah Division of Water Rights (BLM 2001).

There are 11 primary river basins in Utah, each with variable supplies of water on a yearly basis. A basin plan has been written by the Utah Division of Water Resources for each of the 11 basins describing the basin's current and projected water use and detailing methods of meeting future projected water demands (Utah Department of Water Resources 2010). Transfer of existing surface rights is possible but must be approved by the Utah Division of Water Rights (BLM 2001).

About one third of the groundwater basins in Utah are closed to new appropriations of water rights and another third are "restricted," implying that the assessment of proposed water rights by Utah Division of Water Rights is conditional on a number of factors. The remaining third of the state is open to new water right appropriation applications, which are assessed on a regional basis. Of the 36 defined groundwater basins, 12 have experienced water level drops of up to 110 ft (33.5 m) since 1950. All 12 of these areas are closed to new appropriations and have basin-specific water plans that outline conservation guidelines and goals for the future. Some of these plans include strict guidelines involving water right transfers (Utah Department of Water Resources 2005). It has been suggested that additional groundwater may be available outside of the 36 primary basins,; however, issues concerning depth to water table, water quality, and overdraft may prove detrimental to the approval of new water rights (Utah Department of Water Resources 2001).

In Utah, there are six effluent reuse programs throughout the state, with five more planned for future use. The effluent is used primarily for irrigation or watering of residential and golf course grass. The appropriation and use of effluent requires a water right that must be granted by the Utah Division of Water Rights, and the main criterion of assessment is whether the proposed right will be reduce the water quantity for use by downstream users who may depend on the effluent to satisfy their water rights (Utah Department of Water Resources 2001).

The Utah Division of Water Rights manages and oversees the state's aquifer storage and recovery (ASR) facilities, where artificial recharge of aquifers occurs (Utah Division of Water Rights 2010b). To date, there are six ASR facilities statewide, and recovery of ASR facility water requires the approval of a recovery permit by the Utah Division of Water Rights (2010d-f). Recovery permits give the water user the right to use the recovered water "in the manner in which the water was permitted to be used or exchanged before the water was artificially recharged, unless a change or exchange application is filed and approved" (Utah Division of Water Rights 2010g). The main factor in assessing potential recovery permits is whether the proposed application will be detrimental to current water rights, so permit approval varies by region (Utah Division of Water Rights 2010c).

Between 1961 and 1990, the long-term water supply in Utah was estimated to be 7.3 million ac-ft (9.0 billion m^3) annually (UDNR 2001). The estimate was derived from total precipitation in the state and interstate inflows minus the amount of evapotranspiration and the export due to interstate compacts, and accounts for both the surface water and groundwater resources.

The groundwater resources in Utah are well delineated. Thirty-six areas have significant groundwater development, most of them in central Utah (UDNR 2001). The average annual yields of these areas range from less than 3,000 to 133,000 ac-ft (3.7 million to 164 million m^3), based on data collected from 1989 to 1998. The total amount of groundwater developed was 851,000 ac-ft/yr (1.0 billion m^3/yr) during that period.

Water withdrawals in Utah (in 2000) by water use category are shown in Table 4.9-12. Agricultural irrigation was the largest water use category, accounting for 4.3 million ac-ft/yr (5.3 billion m^3/yr), about 78% of Utah's water withdrawals in 2000. Municipal and industrial usage was about 769,000 ac-ft/yr (949 million m^3/yr) (about 14% of the water withdrawal in 2000). Great Salt Lake evaporation, wetland and riparian evaporation and evapotranspiration, and reservoir evaporation combined to deplete another 4.0 million ac-ft/yr (4.9 billion m^3/yr) (UDNR 2001).

TABLE 4.9-12 Water Withdrawals (thousand ac-ft)[a,b] in Utah by Water Use Category, 2000

Use Category	Surface Water	Groundwater	Total	Percentage of Total Withdrawal
Public water supply	307	408	715	13
Self-supplied domestic	0	18.0	18.0	0.32
Irrigation	3,800	526	4,326	78
Livestock	NC[c]	NC[c]	NC[c]	0
Aquaculture	0	130	130	2.3
Industrial self-supplied[a]	9.39	44.1	53.5	0.96
Mining[a]	217	33.7	251	4.5
Thermoelectric power[a]	55.1	14.7	69.8	1.3
Subtotal	4,388	1,175	5,563	

[a] Values converted from million gallons/day.

[b] To convert ac-ft to m^3, multiply by 1,234.

[c] NC = data not collected.

Source: Hutson et al. (2004).

4.10 ECOLOGICAL RESOURCES

4.10.1 Vegetation

Plant communities occurring within the six-state study area span a great variety of ecosystems, from arid deserts to coastal coniferous forests. Each plant community is unique in species composition, richness, diversity, and structure. Several environmental factors, including climate, elevation, aspect (i.e., compass direction of slope), precipitation, and soil type, influence the presence and development of various types of plant communities throughout the study region.

Because of the great variety and complexity of the plant communities occurring within the six states, the area is best represented by description at the "ecoregion" level. The concept of ecoregions is intended to provide a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components (EPA 2007a). An ecoregion is an area having a general similarity in ecosystems and is characterized by the spatial patterning and composition of biotic and abiotic features, including vegetation, wildlife, geology, physiography (patterns of terrain or land forms), climate, soils, land use, and hydrology, such that within an ecoregion, there is a similarity in the type, quality, and quantity of environmental resources present (EPA 2007b). Ecoregions of North America have been mapped in a hierarchy of four levels, with Level I being the broadest classification. Each level consists of subdivisions of the previous (next highest) level. Level IV ecoregions have not been developed for all of the six states of the study area. Therefore, the ecoregion discussions presented in this PEIS follow the Level III ecoregion classification, with 22 ecoregions covering the six-state area (see Figure I.1, Appendix I). These ecoregions are based on Omernik (1987) and refined through collaborations among EPA regional offices, state resource management agencies, and other federal agencies (EPA 2007b). Ecoregion descriptions and maps that overlay solar energy resources with the ecoregions in each state are presented in Appendix I.

The 22 ecoregions in the six states include a wide variety of upland plant community types, such as coniferous forest, coniferous and deciduous woodland, shrub communities, shrub steppe, and grassland. Mountain ranges often support coniferous forest and woodlands, such as the ponderosa pine (*Pinus ponderosa*) habitats and pinyon-juniper (*Pinus* sp.-*Juniperus* sp.) woodlands found in many of the ecoregions, or mixed habitats such as the oak-juniper (*Quercus* sp.-*Juniperus* sp.) woodlands of the Chihuahuan Deserts and Madrean Archipelago ecoregions. Numerous basins occur in the study area and often support shrublands, such as Great Basin sagebrush (*Artemisia* sp.), saltbush-greasewood (*Atriplex* sp.-*Sarcobatus vermiculatus*), creosotebush (*Larrea tridentata*), or palo verde (*Cercidium* sp.) -cactus shrublands. Basins in the region are typically arid and include the Chihuahuan, Mojave, and Sonoran Deserts. Habitats on plateaus may include woodland, shrubland, or grassland. The Arizona/New Mexico Plateau ecoregion, for example, supports shrublands of big sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus* sp.), winterfat (*Ceratoides lanata*), shadscale saltbush (*Atriplex confertifolia*), and greasewood, and grasslands of blue grama (*Bouteloua gracilis*), western wheatgrass (*Agropyron smithii*), green needlegrass (*Stipa viridula*), and needle-and-thread grass (*Stipa comata*). Shrublands and pinyon-juniper woodlands are common in the Colorado Plateaus ecoregion. The basins and plateaus of the study area include the predominance of those areas where solar energy development is most likely to occur.

TABLE 4.10-1 Wetland Areas in the Six-State Study Area, 1980s Estimates

State	Wetland Area (acres[a])	Percentage of Surface Area of State
Arizona	600,000	0.8
California	454,000	0.4
Colorado	1,000,000	1.5
Nevada	236,350	0.3
New Mexico	481,900	0.6
Utah	558,000	1.0

[a] To convert from acres to km^2, multiply by 0.004047.

Source: Dahl (1990).

Wetlands occurring within these ecoregions are extremely varied and include such wetland types as marshes, bogs, vernal pools, and forested wetlands. Wetland areas are typically inundated or have saturated soils for a portion of the growing season and support plant communities that are adapted to saturated soil conditions. Streambeds, mudflats, gravel beaches, and rocky shores are wetland areas that may not be vegetated (Cowardin et al. 1979). While surface flows provide the water source for some wetlands, others, such as springs and seeps, are supported by groundwater discharge. Wetlands are often associated with perennial water sources, such as springs, perennial segments of streams, or lakes and ponds. However, some wetlands, such as vernal pools, have seasonal or intermittent sources of water. The total wetland areas present within each of the six states, based on estimates from the 1980s, range from about 236,350 acres (956 km^2) in Nevada to 1,000,000 acres (4,047 km^2) in Colorado (Table 4.10-1). These estimates represent 1.5% or less of the total surface area of each of the six states and less than 1% of the total state surface area for four of the states. Annual wetland losses have since decreased nationally compared with pre-1980s levels (Dahl 2006). While freshwater wetlands showed a slight overall gain in total area in recent years, vegetated freshwater wetlands continued to show losses (Dahl 2006).

Riparian vegetation communities occur along rivers, perennial and intermittent streams, lakes, and reservoirs, and at springs. These communities generally form a vegetation zone along the margin that is distinct from the adjacent upland area in species composition and density and may be emergent marsh, scrub-shrub, or forest communities. Riparian communities are dependent on streamflows or reservoir levels and are strongly influenced by the hydrologic regime, which affects the frequency, depth, and duration of flooding or soil saturation. Riparian communities may include wetlands; however, the upper margins of riparian zones may be only infrequently inundated. Riparian areas and wetlands are valued because of the important services they provide within the landscape, such as providing fish and wildlife habitats and maintaining water quality and flood control.

4.10.2 Wildlife

The various ecoregions encompassed by the six-state study area (Section 4.10.1) include a wide range of habitats that support a high diversity of terrestrial wildlife species Table 4.10-2 lists the number of wildlife species that occur within the six-state study area. Many of these

TABLE 4.10-2 Number of Wildlife Species in the Six-State Study Area[a]

State	Amphibians	Reptiles	Birds	Mammals
Arizona	29	113	544	162
California	68	90	640	180
Colorado	18	56	490	129
Nevada	15	54	483	128
New Mexico	25	96	523	154
Utah	17	57	432	134

[a] Excludes marine mammal species, native species that have been extirpated and not subsequently reintroduced into the wild, and feral domestic species.

Sources: AZGFD (2008); American Society of Mammalogists (1999); CDFG (2006); CDOW (2008); Colorado Herpetological Society (2006); Hole (2007); Lepage (2008); NNHP (2002); UDWR (2008).

species may be expected to occur within or near a solar energy facility or associated ancillary facilities (e.g., transmission lines and access roads), depending upon the plant communities and habitats present within the project area.

The BLM and other federal agencies that administer public lands have active wildlife management programs. These programs are aimed largely at habitat protection and improvement. The general objectives of wildlife management are to (1) maintain, improve, or enhance wildlife species diversity while ensuring healthy ecosystems; (2) restore disturbed or altered habitat with the objective of obtaining desired native plant communities while providing for wildlife needs and soil stability; and (3) protect and maintain wildlife and associated wildlife habitat by addressing and mitigating impacts from authorized and unauthorized uses of BLM-administered lands. Federal agencies such as the BLM are primarily responsible for managing habitats, while state agencies (e.g., Colorado Department of Natural Resources and Utah Department of Wildlife Resources) are responsible for managing the big game, small game, and nongame wildlife species in cooperation with the BLM. The USFWS has responsibility for oversight of migratory bird species and most federal threatened, endangered, proposed, or candidate species. Management of threatened and endangered species is discussed in Section 4.10.4.

The following discussions present general descriptions of the wildlife species that may occur on BLM and other federally administered lands where solar energy development could occur.

4.10.2.1 Amphibians and Reptiles

The six-state study area supports a variety of amphibians and reptiles, many of which may occur at or in the vicinity of an individual solar facility. The number of amphibian species reported from these states ranges from 15 species in Nevada to 68 species in California. The number of reptile species reported from these states ranges from 54 species in Nevada to 113 species in Arizona (Table 4.10-2). The amphibians include frogs, toads, and salamanders that occupy a variety of habitats that include forested headwater streams in mountain regions, marshes, and wetlands, and xeric habitats in the desert areas of the Southwest. The reptile species include a variety of turtles, snakes, and lizards.

4.10.2.2 Birds

Several hundred species of birds have been reported from the six-state study area (Table 4.10-2), ranging from 432 in Utah to 640 in California. The bird species in coastal areas of California include oceanic species such as boobies, gannets, frigatebirds, fulmars, and albatrosses that would not be expected in areas where solar energy development may occur.

A number of Important Bird Areas (IBAs) have been identified by the National Audubon Society within the six-state study area. IBAs are locations that provide essential habitats for breeding, wintering, or migrating birds. While these sites can vary in size, they are discrete areas that stand out from the surrounding landscapes. IBAs must support one or more of the following:

- Species of conservation concern (e.g., threatened or endangered species);
- Species with restricted ranges;
- Species that are vulnerable because their populations are concentrated into one general habitat type or ecosystem; or
- Species or groups of similar species (e.g., waterfowl or shorebirds) that are vulnerable because they congregate in high densities.

The IBA program has become a key component of many bird conservation efforts (National Audubon Society 2008). Information on the IBA program and a list of IBAs for each state can be found at http://www.audubon.org/bird/iba.

4.10.2.2.1 Migratory Routes. Many of the bird species occurring in the six-state study area are seasonal residents within individual states and exhibit seasonal migrations. These birds include waterfowl, shorebirds, raptors, and neotropical songbirds. The six-state study area falls within two of the four major North American migration flyways (Lincoln et al. 1998)—the Central Flyway and the Pacific Flyway (Figure 4.10-1). These pathways are used in spring by birds migrating north from wintering areas to breeding areas and in fall by birds migrating south to wintering areas.

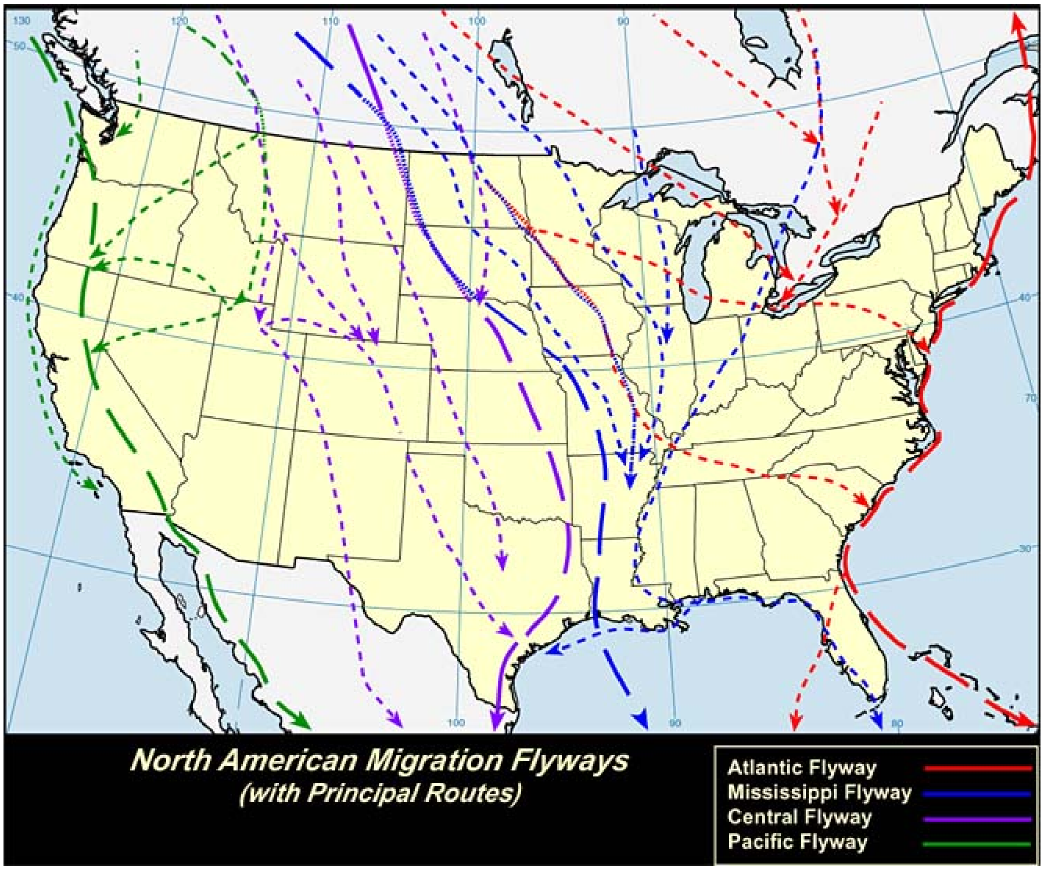

FIGURE 4.10-1 North American Migration Flyways (Source: Birdnature.com 2006, used with permission)

The Central Flyway includes the Great Plains–Rocky Mountain routes (Lincoln et al. 1998). These routes extend from the northwest arctic coast south between the Mississippi River and the Rocky Mountains. Within the six-state study area, this flyway encompasses all or most of Colorado, a large portion of New Mexico, and a portion of Utah. This flyway is relatively simple, with the majority of birds making relatively direct north and south migrations.

The Pacific Flyway includes the Pacific Coast Route, which occurs between the Rocky Mountains and the Pacific coast of the United States. In the six-state study area, this flyway encompasses the states of California and Nevada. Birds migrating from the Alaskan Peninsula follow the coastline to near the mouth of the Columbia River, then travel inland to the Willamette River Valley before continuing south through interior California (Lincoln et al. 1998). Birds migrating south from Canada pass through portions of Montana and Idaho and then migrate either east to enter the Central Flyway, or turn southwest along the Snake and Columbia River Valleys and then continue south across central Oregon and the interior valleys of California (Birdnature.com 2006). This route is not as heavily used as some of the other migratory routes in North America (Lincoln et al. 1998).

4.10.2.2.2 Waterfowl, Wading Birds, and Shorebirds. Waterfowl (ducks, geese, and swans), wading birds (herons and cranes), and shorebirds (plovers, sandpipers, and similar birds) are among the more abundant groups of birds in the six-state study area. Many of these species exhibit extensive migrations from breeding areas in Alaska and Canada to wintering grounds in Mexico and southward (Lincoln et al. 1998). While many of these species nest in Canada and Alaska, a number, such as the American avocet (*Recurvirostra americana*), willet (*Catoptrophorus semipalmatus*), spotted sandpiper (*Actitis macularia*), gadwall (*Anas strepera*), and blue-winged teal (*A. discors*), also nest in suitable habitats in many of the western states (National Geographic Society 1999). Most are ground-level nesters, and many sometimes forage in relatively large flocks on the ground or water. Within the region, migration routes for these birds are often associated with riparian corridors and wetland or lake stopover areas.

Major waterfowl species hunted in the six-state study area include the mallard (*Anas platyrhynchos*) and Canada goose (*Branta canadensis*). Other species commonly hunted include gadwall, American widgeon (*A. americana*), teal (*A.* spp.), northern pintail (*A. acuta*), northern shoveler (*A. clypeata*), and snow goose (*Chen caerulescens*) (USFWS 2005). Hunting for sandhill cranes (*Grus canadensis*) also occurs in Arizona, Colorado, New Mexico, and Utah (Sharp et al. 2005). Various conservation and management plans exist for waterfowl, shorebirds, and waterbirds.

4.10.2.2.3 Neotropical Migrants. Songbirds of the order Passeriformes represent the most diverse category of birds, with the warblers and sparrows representing the two most diverse groups of passerines. The passerines exhibit a wide range of seasonal movements, with some species remaining as year-round residents in some areas and migratory in others, and still other species undergoing migrations of hundreds of miles or more (Lincoln et al. 1998). Nesting occurs in vegetation from near ground level to the upper canopy of trees. Some species, such as the thrushes and chickadees, are relatively solitary throughout the year, while others, such as swallows and blackbirds, may occur in small to large flocks at various times of year. Foraging may occur in flight (e.g., swallows and swifts) or on vegetation or the ground (e.g., warblers, finches, and thrushes). Various conservation and management plans exist for neotropical migrants (and other landbirds), including the Partners in Flight North American Landbird Conservation Plan (Rich et al. 2004) and numerous physiographic area and state plans. These plans can be accessed from the Partners in Flight Web site (http://www.partnersinflight.org).

The regulatory framework organized to protect the neotropical migrants includes:

- *Migratory Bird Treaty Act.* The Migratory Bird Treaty Act implements a variety of treaties and conventions among the United States, Canada, Mexico, Japan, and Russia. This treaty makes it unlawful to take, kill, or possess migratory birds, as well as their eggs or nests. Most of the bird species reported from the six-state study area are classified as migratory under this act.

- *Executive Order 13186:* "Responsibilities of Federal Agencies to Protect Migratory Birds" (*Federal Register,* Volume 66, page 3853, January 17, 2001). Under this Executive Order, each federal agency that is taking an action that could have, or is likely to have, negative impacts on migratory bird populations must work with the USFWS to develop a memorandum of understanding (MOU) to conserve those birds. The MOUs developed by this consultation are intended to guide future agency regulatory actions and policy decisions.

In addition to the federal regulatory framework, the individual states have regulations that apply to the general protection of avian species. While the BLM is not bound by those state regulations, they are an important consideration in that they apply to private projects or actions that take place on BLM-administered lands.

4.10.2.2.4 Birds of Prey. The birds of prey include the raptors (hawks, falcons, eagles, kites, and osprey), owls, and vultures. These species represent the top avian predators in many ecosystems. Common raptor and owl species include the red-tailed hawk (*Buteo jamaicensis*), sharp-shinned hawk (*Accipiter striatus*), northern harrier (*Circus cyaneus*), Swainson's hawk (*B. swainsoni*), American kestrel (*Falco sparverius*), golden eagle (*Aquila chrysaetos*), great horned owl (*Bubo virginianus*), short-eared owl (*Asio flammeus*), and burrowing owl (*Athene cunicularia*). The raptors and owls vary considerably among species with regard to their seasonal migrations, with some species being nonmigratory (year-round residents), others being migratory in the northern portions of their ranges and nonmigratory in the southern portions of their ranges, and still other species being migratory throughout their ranges.

Raptors forage on a variety of prey, including small mammals, reptiles, other birds, fish, invertebrates, and, at times, carrion. They typically perch on trees, utility support structures, highway signs, and other high structures that provide a broad view of the surrounding topography, and they may soar for extended periods at relatively high altitudes. The raptors forage from either a perch or on the wing (depending on the species), and all forage during the day. The owls also perch on elevated structures and forage on a variety of prey, including mammals, birds, and insects. Forest-dwelling species typically forage by diving on a prey item from a perch, while open-country species hunt on the wing while flying low over the ground. While generally nocturnal, some owl species are also active during the day.

The vultures are represented by three species: the turkey vulture (*Cathartes aura*), which occurs in each of the six western states; the black vulture (*Coragyps atratus*), which is reported from Arizona, California, and New Mexico; and the endangered California condor (*Gymnogyps californianus*), reported from Arizona and California. These birds are large, soaring scavengers that feed on carrion.

The bald eagle (*Haliaeetus leucocephalus*) and golden eagle are protected under the Bald and Golden Eagle Protection Act (16 USC 668–668d, 54 Statute 250, as amended), which prohibits the taking or possession of, or commerce in, bald and golden eagles, with limited exceptions for permitted scientific research and Native American religious purposes. The Secretary of the Interior can authorize the taking of eagle nests that interfere with resource development or recovery operations (USFWS 2008b). The BLM field offices also have specific management guidelines for raptors, including eagles. States also have regulations regarding the protection of raptors that would be applicable to private projects or actions conducted on BLM-administered lands.

4.10.2.2.5 Upland Game Birds. Upland game birds that are native to the six-state study area include dusky grouse (*Dendragapus obscurus*), ruffed grouse (*Bonasa umbellus*), greater sage-grouse (*Centrocercus urophasianus*), Gunnison sage-grouse (*C. minimus*), lesser prairie chicken (*Tympanuchus pallidicinctus*), Gambel's quail (*Callipepla gambelii*), California quail (*C. californica*), scaled quail (*C. squamata*), mountain quail (*Oreortyx pictus*), mourning dove (*Zenaida macroura*), and white-winged dove (*Z. asiatica*). Introduced species include ring-necked pheasant (*Phasianus colchicus*), chukar (*Alectoris chukar*), and gray partridge (*Perdix perdix*). The wild turkey (*Meleagris gallopavo*) is native to Arizona, Colorado, and New Mexico and has been introduced to the three other states. All of the upland game bird species are year-round residents.

Most concerns about upland game birds in the six-state study area have focused on the potential impacts on the greater sage-grouse and the Gunnison sage-grouse because of the reduction, fragmentation, and modification of grassland and shrubland habitats. Within the six-state study area, the Gunnison sage-grouse is restricted to southwestern Colorado and southeastern Utah, while the greater sage-grouse occurs in all of the states except Arizona and New Mexico, where they are extirpated (Bird and Schenk 2005; NatureServe 2010). The life history and habitat requirements of both species are similar (Bird and Schenk 2005); therefore, the following discussion emphasizes the more widely distributed greater sage-grouse.

The decline in greater sage-grouse populations over the past half century is believed to be the result of many factors, including oil and gas wells and their associated infrastructure, traffic, power lines, urbanization, recreation, predators, and a decline in the quality and quantity of sagebrush habitat (due to alteration of historical fire regimes, water developments, drought, use of herbicides and pesticides, livestock and wild horse grazing, and establishment of invasive species) (see Connelly et al. 2000; Lyon and Anderson 2003; Crawford et al. 2004; Holloran 2005; Holloran et al. 2005; Rowland 2004; Schroeder et al. 2004; Bird and Schenk 2005; Braun 2006; Aldridge and Boyce 2007; Walker et al. 2007; Colorado Greater Sage-grouse Steering Committee 2008; Doherty et al. 2008 and references cited therein). West Nile virus is also a significant stressor of greater sage-grouse (Naugle et al. 2004).

The BLM manages more habitats for greater sage-grouse than does any other entity; therefore, it has developed a National Sage-Grouse Habitat Conservation Strategy for BLM-administered public lands that is intended to maintain, enhance, and restore greater sage-grouse habitat while providing for multiple uses of BLM-administered public lands (BLM 2004). In addition, the Western Association of Fish and Wildlife Agencies has produced two documents that together constitute a conservation assessment for greater sage-grouse (Connelly et al. 2004; Stiver et al. 2006). A rangewide conservation plan has been prepared for the Gunnison sage-grouse (Gunnison Sage-grouse Rangewide Steering Committee 2005). Also, state and/or regional recovery, management, or conservation plans have been prepared for grouse species that occur throughout the western states. The recommendations in these documents would be considered for solar energy developments.

4.10.2.3 Mammals

The number of mammal species reported from the six-state study area ranges from 128 species in Nevada to 180 species in California (Table 4.10-2). The following discussion emphasizes big game and small mammal species that (1) have key habitats within or near the areas in which solar energy development may occur, (2) are important to humans (e.g., big and small game and furbearer species), and/or (3) are representative of other species that share important habitats.

The primary big game species within the six-state study area include elk (*Cervis canadensis*), mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), pronghorn (*Antilocapra americana*), bighorn sheep (*Ovis canadensis*), American black bear (*Ursus americanus*), and cougar (*Puma concolor*). Several other big game species occur within a few states. These include the moose (*Alces americanus*) in Colorado and Utah; American bison (*Bos bison*) in Arizona, California, New Mexico, and Utah; African oryx (*Oryx gazella*), ibex (*Capra ibex*), and Barbary sheep (*Ammotragus lervia*) in New Mexico; javelina (*Pecari tajacu*) in Arizona and New Mexico; and the wild pig (*Sus scrofa*) in California. The African oryx, ibex, and Barbary sheep are non-native species that were introduced for hunting.

A number of the big game species make migrations when seasonal changes reduce food availability, when movement within an area becomes difficult (e.g., due to snow pack), or when local conditions are not suitable for calving or fawning. Established migration corridors for these species provide an important transition habitat between seasonal ranges and provide food for the animals during migration (Feeney et al. 2004). Maintaining genetic interchange through landscape linkages among subpopulations is also essential for long-term survival of species. Maintaining migration corridors and landscape linkages, especially when seasonal ranges or subpopulations are far removed from each other, can be difficult because of the various land ownership mixes that often need to be traversed (Sawyer et al. 2005).

The following paragraphs present a generalized overview of the primary big game species. Table 4.10-3 presents the conservation status for the primary big game species within the six-state study area.

4.10.2.3.1 Elk. Elk are generally migratory between their summer and winter ranges, although some herds remain within the same area year-round (UDWR 2005). Their summer range occurs at higher elevations. Aspen and conifer woodlands provide security and thermal cover, while upland meadows, sagebrush/mixed grass, and mountain shrub habitats are used for forage. Their winter range occurs at mid to lower elevations, where they forage in sagebrush/ mixed grass, big sagebrush/rabbitbrush, and mountain shrub habitats. They are highly mobile within both summer and winter ranges in order to find the best forage conditions. In winter, they congregate into large herds of 50 to more than 200 individuals. The crucial winter range

TABLE 4.10-3 State Conservation Status Ranks for Big Game Species in the Six-State Study Area

	State Conservation Status Rank[a]					
Species	AZ	CA	CO	NM	NV	UT
Elk (*Cervis canadensis*)	U	AS	S	V	S	AS
Mule deer (*Odocoileus hemionus*)	S	S	S	S	S	S
White-tailed deer (*Odocoileus virginianus*)	S	–	S	AS	–	CI
Pronghorn (*Antilocapra americana*)	S	AS	AS	S	S	AS
Bighorn sheep (*Ovis canadensis*)[b]	AS	V	AS	CI	V	V
American black bear (*Ursus americanus*)	S	S	S	AS	AS	V
Cougar (*Puma concolor*)	AS	S	AS	V	S	AS

[a] – = the state is not within the species' range; AS = apparently secure (uncommon but not rare, some cause for long-term concern due to declines or other factors); CI = critically imperiled (critically imperiled because of extreme rarity [often 5 or fewer occurrences] or because some factors such as very steep declines make it especially vulnerable to extirpation); S = secure (common, widespread, and abundant); U = unranked (conservation status not yet assessed); V = vulnerable (vulnerable due to a restricted range, relatively few populations [often 80 or fewer], recent or widespread declines, or other factors making it vulnerable to extirpation).

[b] The peninsular bighorn sheep (*Ovis Canadensis nelsoni*) and the Sierra Nevada bighorn sheep (*Ovis Canadensis sierrae*) in California are federally endangered.

Source: NatureServe (2010).

is considered to be the part of the local elk range where about 90% of the local population is located during an average of 5 winters out of 10 from the first heavy snowfall to spring. Elk calving generally occurs in aspen-sagebrush parkland vegetation and habitat zones during late spring and early summer. Calving areas are mostly located where cover, forage, and water are nearby. They may migrate up to 60 mi (97 km) annually (NatureServe 2010). Elk are susceptible to chronic wasting disease.

4.10.2.3.2 Mule Deer. Mule deer occur within most ecosystems in the six-state study area but attain their highest densities in shrublands characterized by rough, broken terrain with abundant browse and cover. The size of home ranges can vary from 74 to 593 acres (0.3 to 2.4 km^2) or more, depending on the availability of food, water, and cover (NatureServe 2008). Some populations of mule deer are resident (particularly those that inhabit plains), but those in mountainous areas are generally migratory between their summer and winter ranges (NatureServe 2010). In arid regions, they may migrate in response to rainfall patterns (NatureServe 2010). In mountainous regions, they may migrate more than 62 mi (100 km) between high summer and lower winter ranges (NatureServe 2010). Their summer range occurs at higher elevations that contain aspen and conifers and mountain browse vegetation. Fawning occurs during the spring while the mule deer are migrating to their summer range. This normally occurs in aspen-mountain browse intermixed vegetation.

Mule deer have a high fidelity to specific winter ranges where they congregate within a small area at a high density. Their winter range occurs at lower elevations within sagebrush and pinyon-juniper vegetation. Winter forage is primarily sagebrush, but Colorado birchleaf mountain-mahogany (*Cercocarpus montanus*), fourwing saltbush (*Atriplex canescens*), and antelope bitterbrush (*Purshia tridentata*) are also important. Pinyon-juniper provides emergency forage during severe winters. Overall, mule deer habitat is characterized by areas of thick brush or trees (used for cover) interspersed with small openings (for forage and feeding areas); mule deer do best in habitats that are in the early stage of succession (UDWR 2003). Prolonged drought and other factors can limit mule deer populations. Several years of drought can limit forage production, which can substantially reduce animal condition and fawn production and survival. Severe drought conditions were responsible for declines in the population of mule deer in the 1980s and early 1990s. In arid regions, they are seldom found more than 1.0 to 1.5 mi (1.6 to 2.4 km) from water. Mule deer are also susceptible to chronic wasting disease. When the disease is present, up to 3% of a herd's population can be affected. Some deer herds in Colorado have experienced significant outbreaks of chronic wasting disease.

4.10.2.3.3 White-Tailed Deer. White-tailed deer inhabit a variety of habitats but are often associated with woodlands and agricultural lands (CDOW 2008). Within arid areas, they are mostly associated with riparian zones and montane woodlands that have more mesic conditions. They can also occur within suburban areas. Urban areas and very rugged mountain terrain are unsuitable habitats (NatureServe 2010).

White-tailed deer occur in two social groups: (1) adult females and young and (2) adult and occasionally yearling males, although adult males are generally solitary during the breeding season except when with females (NatureServe 2010). The annual home range of sedentary populations can average as much as 1,285 acres (5 km^2), while some populations can undergo annual migrations of up to 31 mi (50 km). In some areas, the density of white-tailed deer may exceed 129/mi^2 (50/km^2) (NatureServe 2010). Snow accumulation can have a major controlling effect on populations (NatureServe 2010). White-tailed deer feed mostly on agricultural crops, browse, grasses, and forbs but also consume mushrooms, acorns, fruits, and nuts (CDOW 2008; UDWR 2008). They often cause damage when browsing on ornamental plants around homes (NatureServe 2010).

4.10.2.3.4 Pronghorn. Pronghorn inhabit nonforested areas such as desert, grassland, and sagebrush habitats. Herd size can commonly exceed 100 individuals, especially during winter. Pronghorn consume a variety of forbs, shrubs, and grasses, with shrubs being most important in winter. Some pronghorn are year-long residents and do not have seasonal ranges. Fawning occurs throughout the species range. However, some seasonal movement within their range occurs in response to factors such as extreme winter conditions and water or forage availability. Other pronghorn are migratory. Most herds range within an area 5 mi (8 km) or more in diameter, although the separation between summer and winter ranges has been reported to be as much as 99 mi (159 km) or more (NatureServe 2010). Pronghorn populations have been adversely affected in some areas by historic range degradation and habitat loss and by periodic drought conditions.

4.10.2.3.5 Bighorn Sheep. The bighorn sheep is considered to be a year-long resident; it does not make seasonal migrations as do elk and mule deer. However, it does make vertical migrations in response to an increasing abundance of vegetative growth at higher elevations in the spring and summer and when snow accumulation occurs in high-elevation summer ranges (NatureServe 2010). Also, ewes move to reliable watercourses or water sources during the lambing season, with lambing occurring on steep talus slopes within 1 to 2 mi (1.6 to 3.2 km) of water. Bighorn sheep prefer open vegetation such as low shrub, grassland, and other treeless areas with steep talus and rubble slopes. Unsuitable habitats include open water, wetlands, dense forests, and other areas without grass understory (NatureServe 2010).

The diet of the bighorn sheep consists of shrubs, forbs, and grasses. In the early 1900s, bighorn sheep experienced significant declines due to disease, habitat degradation, and hunting. Threats to bighorn sheep include habitat changes resulting from fire suppression, interactions with feral and domestic animals, and human encroachment (NatureServe 2010). Bighorn sheep are very vulnerable to viral and bacterial diseases carried by livestock, particularly domestic sheep. Therefore, the BLM has adopted specific guidelines regarding domestic sheep grazing in or near bighorn sheep habitat. In appropriate locations, reintroduction efforts, coupled with water and vegetation improvements, have been conducted to restore bighorn sheep to their native habitat.

4.10.2.3.6 American Black Bear. American black bears are found mostly within forested or brushy mountain environments and woody riparian corridors (UDWR 2008). They are omnivorous. Depending upon seasonal availability, they will feed on forbs and grasses, fruits and acorns, insects, small vertebrates, and carrion (CDOW 2008). Breeding occurs in June or July, with young born in January or February (UDWR 2008). American black bears are generally nocturnal and have a period of winter dormancy (UDWR 2008). They are locally threatened by habitat loss and disturbance by humans (NatureServe 2010). The home range size of American black bears varies depending on area and gender and has been reported to be from about 1,250 to nearly 32,200 acres (5 to 53 km^2) (NatureServe 2010).

4.10.2.3.7 Cougar. Cougars (also known as mountain lions or puma) inhabit most ecosystems in the six-state study area but are most common in the rough, broken terrain of foothills and canyons, often in association with montane forests, shrublands, and pinyon-juniper woodlands (CDOW 2008). They mostly occur in remote and inaccessible areas (NatureServe 2010). Their annual home range can be more than 560 mi^2 (1,450 km^2), while densities are usually not more than 10 adults/100 mi^2 (10 adults/259 km^2) (NatureServe 2010). The cougar is generally found where its prey species (especially mule deer) are located. In addition to preying on deer, cougars prey upon most other mammals (which sometimes include domestic livestock) and some insects, birds, fishes, and berries (CDOW 2008). They are active year-round. Their peak periods of activity are within 2 hours of sunset and sunrise, although their activity peaks after sunset when they are near humans (NatureServe 2010; UDWR 2008). In some states, they are hunted on a limited and closely monitored basis (NatureServe 2010).

4.10.2.3.8 Small Mammals. Small mammals include small game, furbearers, and nongame species. Small game species that occur within the six-state study area include black-tailed jackrabbit (*Lepus californicus*), white-tailed jackrabbit (*L. townsendii*), desert cottontail (*Sylvilagus audubonii*), mountain cottontail (*S. nuttallii*), squirrels (*Sciurus* spp.), snowshoe hare (*L. americanus*), and yellow-bellied marmot (*Marmota flaviventris*). Common furbearers include American badger (*Taxidea taxus*), American marten (*Martes americana*), American beaver (*Castor canadensis*), bobcat (*Lynx rufus*), common muskrat (*Ondatra zibethicus*), coyote (*Canis latrans*), red fox (*Vulpes vulpes*), gray fox (*Urocyon cinereoargenteus*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and long-tailed weasel (*Mustela frenata*). Nongame species include bats, shrews, mice, voles, chipmunks, and many other rodent species. Bats may be of particular importance because of their function in vector control and the fact that bat populations have declined in many parts of North America.

4.10.3 Aquatic Biota

Within the six-state study area, the BLM administers lands containing a variety of freshwater aquatic habitats, which in turn support a wide diversity of aquatic biota. The area considered contains a variety of freshwater aquatic habitats, which in turn support a wide diversity of aquatic biota. Aquatic habitats on these lands range from isolated desert springs in the southwestern portion that support unique and endemic fish species such as pupfish (family Cyprinodontidae); cold- and coolwater portions of the Colorado, Green, and Snake Rivers that support trout fisheries; and coastal rivers of northern California that support anadromous salmon. Sport fish throughout the six-state study area include trout and salmon (family Salmonidae), catfish (family Ictaluridae), sunfish and black basses (family Centrarchidae), suckers (family Catostomidae), perch and walleye (family Percidae), and pike (family Esocidae). Nonsport fish include numerous species of minnows and other species. In addition to fish, aquatic habitats also support a large variety of aquatic invertebrates, including mollusks, crustaceans, and insects.

The following sections provide a general description of freshwater aquatic organisms and habitats grouped according to the major USGS water resource regions that coincide with the six-state study area.

4.10.3.1 Pacific Northwest Hydrologic Region

Only a small portion (in northern Nevada and northern Utah) of the Pacific Northwest hydrologic region falls within the six-state study area; the remainder of this hydrologic region encompasses the states of Washington, Oregon, Idaho, and portions of Montana (Figure 4.9-1). It is considered unlikely that utility-scale solar energy projects would be considered on most lands within this region, but the region is discussed here for completeness. In terms of ecological, cultural, and commercial importance, fishes in the family Salmonidae make up the most important group of native fishes found in this hydrologic region (ODFW 2005a,b). This group, which includes salmon, trout, grayling, and whitefish, requires relatively clear and cold freshwater habitats during part or all of their life cycles, and as such, depend greatly on the conditions of surrounding forests and rangelands to ensure their survival.

Some species of salmonids within this hydrologic region are anadromous (i.e., they spawn in freshwater but spend part of their life cycle at sea). These species require large stream and river systems with direct ocean access. In the Pacific Northwest, streams that support important stocks of anadromous salmon within public lands include those within the Columbia and Snake River Basins. Because of the need for these salmon to migrate between ocean and freshwater environments in order to reproduce and to become adults, one of the major factors that has affected the distribution and survival of salmon stocks in recent decades is the construction of obstacles to migration (e.g., dams) in streams and rivers used by these species (ODFW 2005a,b).

Various fish species have been introduced into aquatic systems throughout the Pacific Northwest. Most of these non-native species have been introduced to promote sportfishing opportunities. Introduced salmonids (such as brook, brown, lake, and rainbow trout), sunfishes, basses, and walleye now support much, if not most, of the non-native sport fishing opportunities within the region (Moyle and Marchetti 2006; Moyle and Davis 2001).

A variety of aquatic invertebrates occur in aquatic habitats of the Pacific Northwest. The diversity of aquatic insects is generally lower in glacier-fed streams; whereas streams flowing through conifer forests typically support a more diverse aquatic invertebrate fauna, including many types of mayflies, stoneflies, and caddisflies. Freshwater mollusks, including mussels (Nedeau et al. undated) and snails, are also important components of the invertebrate fauna in some aquatic ecosystems.

4.10.3.2 Lower Colorado, Rio Grande, and Great Basin Hydrologic Regions

As described in Section 4.9.1 (Surface Water Resources), the Lower Colorado, Rio Grande, and Great Basin hydrologic regions include arid areas in Arizona, Nevada, New Mexico, southwestern Utah, and south-central Colorado (Figure 4.9-1). The natural hydrology of southwestern desert rivers and streams in these hydrologic regions is highly variable and episodic, with hydrologic inputs typically occurring in pulses of short duration. Springs and seeps also occur throughout the desert ecosystem within these hydrologic regions, ranging from quiet pools or trickles to small headwater streams. Many of the larger springs discharge warm water, with temperatures that are greater than the mean annual air temperature. Water conditions in springs can range from freshwater to highly mineralized, and some of these springs contain very low dissolved oxygen levels.

Although relatively few fish and invertebrate species may occur within some desert streams, springs, and pools, the native species that do occur are often specially adapted to the conditions in these systems, and 82% of desert fish are endemic (i.e., native to only a single locality) (Rinne and Minckley 1991; USGS 2005; Mueller and Marsh 2002; Desert Fish Habitat Partnership Workgroup 2008). Natural flow regimes play an important role in sustaining the existing native fish populations and maintaining the ecological integrity of the aquatic ecosystems in these arid regions (e.g., Poff et al. 1997; Propst et al. 2008; Eby et al. 2003; Lytle and Poff 2004). Numerous fish species have been introduced, either intentionally or accidentally, into some watersheds within these hydrologic regions. Overall, non-native fish species in these hydrologic regions now outnumber natives in terms of numbers of species, population densities, and, often, biomass at many localities (Mueller and Marsh 2002; Olden and Poff 2005; Rinne and Minckley 1991). Common non-native fishes include sunfishes and black basses, trout, several species of catfishes (family Ictaluridae), and temperate basses (family Percithyidae) (Mueller and Marsh 2002).

The native fish community within the lower Colorado River hydrologic region is dominated by fishes within the minnow and sucker families. The Lower Colorado River itself was historically a warm, turbid, and swift river (Schmidt 1993). Construction of dams within the region, such as the Glen Canyon and Hoover Dams on the main-stem Colorado River, has now altered habitat conditions and changed flow regimes in some of the major river systems by creating a series of cold, clear impoundments. These changes, along with the introduction of non-native fishes and a variety of other anthropogenic influences, have resulted in declines in native fish populations throughout much of the lower Colorado River Basin (Mueller and Marsh 2002; Olden and Poff 2005; Propst et al. 2008). A variety of protected native fish species occur within the basin, including the endangered Gila trout, spikedace, headwater chub, and razorback sucker (Section 4.10.4).

The Rio Grande originates in the Rocky Mountains of southwestern Colorado and meanders about 1,900 mi (3,058 km) across Colorado, New Mexico, and Texas before terminating at the Gulf of Mexico. Public lands within the Rio Grande region are primarily limited to the upper and middle reaches of this drainage. Most precipitation in the basin falls as snow near its headwaters or as rain near its mouth, while little water is contributed to the system along the middle reaches of this river (Langman and Nolan 2005). Prior to the construction of dams such as the Cochiti Dam, the Rio Grande had characteristics similar to the Colorado River, with warm water and a high sediment load. Dams, and the resulting reservoirs, have resulted in slower, clearer, and colder water. The Rio Grande contains more than 16 families of fishes in the non-tidal portions of the river, including a diverse minnow assemblage. Benthic invertebrate sampling in portions of the Rio Grande in New Mexico revealed caddisflies, mayflies, black flies, and chironomids were dominant (Dahm et al 2005). Pupfish can be found in desert springs. Modification of stream habitat within the Rio Grande Basin due to impoundments, water diversion for agriculture, stream channelization, and the introduction of non-native fishes has affected the abundance and distribution of the Rio Grande silvery minnow, a species that was once widely distributed in the Pecos River and Rio Grande, but that is now federally listed as endangered. Currently, 157 mi (253 km) of the Rio Grande has been designated as critical habitat for this species (Section 4.10.4) (USFWS 2007).

The Great Basin hydrologic region covers an arid expanse of approximately 190,000 mi^2 (492,000 km^2) and is the area of internal drainage between the Wasatch Mountains of Utah and the Sierra Nevada Range in California and Nevada (Figure 4.9-1). Streams in this area never reach the ocean, but instead drain toward the interior of the basin, resulting in terminal lakes such as Mono Lake and the Great Salt Lake, marshes, or similar hydrologic sinks that are warm and saline (Sigler and Sigler 1987). Some fish species that inhabit the Great Basin hydrologic region are adapted to extreme conditions (Sigler and Sigler 1987). Trout are found in lakes and streams at higher elevations within the basin. Bonneville cutthroat trout have persisted in the isolated, cool mountain streams of the eastern portion of the Great Basin hydrologic region, while Lahontan cutthroat trout populations occupy small, isolated habitats throughout the basin. These trout species are unusually tolerant of both high temperatures (greater than 80°F [27°C]) and large daily fluctuations in temperature (up to 35F° [19C°]). They are also quite tolerant of the higher alkalinity present in some of the aquatic habitats within this hydrologic region (USFWS 1995). Water diversions, subsistence harvest, and stocking of non-native fish have caused the extirpation of the Bonneville cutthroat trout from most of its range within the Great Basin hydrologic region. Lahontan cutthroat trout, which were once common in desert lakes and in large rivers, such as the Humboldt, Truckee, and Walker Rivers, have declined in numbers overall and have disappeared in many areas (USFWS 1995).

Various native and non-native minnows are common throughout streams and lakes of the Great Basin hydrologic region (Sigler and Sigler 1987). Native pupfish species, which are tolerant of high temperature ranges compared with many other fish species, occur in some of the thermal artesian springs and in some streams in portions of Nevada (Sigler and Sigler 1987). Because the isolation of these pupfish populations makes them more prone to extinction, most of them, such as the Devils Hole pupfish, are currently listed as endangered or threatened under the Endangered Species Act (ESA) or are considered species of special concern by the states where they occur (Section 4.10.4). Several species of springsnails (*Pyrgulopsis* spp. and *Tryonia* spp) are also protected or proposed for protection under the ESA.

4.10.3.3 California Hydrologic Region

Primarily composed of areas within the state of California, the California hydrologic region (Figure 4.9-1) can be broadly divided into northern and southern freshwater fish habitat regions (although finer-scale zoogeographic regions can also be delineated [Moyle and Marchetti 2006]). The northern region extends from the Oregon border south to Sacramento (the southernmost extent of anadromous salmon distribution in North America). This region includes rain-fed coastal streams, snow-fed streams of the western Sierra Nevada, and the Central and San Joaquin Valleys. Habitat characteristics and the associated fish assemblages are relatively similar to those in the western portion of the Pacific Northwest hydrologic region (as described previously).

Freshwater fish habitats within the southern portion of the California hydrologic region are located predominantly within the arid southeastern portion of the state. As described above for the Lower Colorado and Great Basin regions, native fish communities containing taxa such as pupfish and minnows occur in the lower elevations, and cutthroat trout populations occur in the mountainous regions.

Approximately 125 species of freshwater, anadromous, and euryhaline (saline-tolerant) fish occur in the inland waters of California (Moyle and Davis 2001). About 67 of these are native resident or anadromous species, 53 are non-native species, and 5 are marine species that occur in freshwater habitats (Moyle and Davis 2001). Most of the native fish species are endemic to California, a situation typical of fish faunas in regions with arid climates (Moyle and Marchetti 2006). New non-native fish species have become established in the state at the rate of about 1 species every 3 years since 1981 (Moyle and Davis 2001).

4.10.3.4 Upper Colorado River Hydrologic Region

The Colorado River Basin falls within two hydrologic regions: the Upper and Lower Colorado River hydrologic regions, with a dividing line near Lee's Ferry, Arizona. The Upper Colorado River hydrologic basin is predominantly within a subarid to arid region that includes portions of Wyoming, Colorado, Utah, Arizona, and New Mexico (Figure 4.9-1). Falling primarily between the Wasatch Mountains in Utah and the Rocky Mountains in Colorado, this hydrologic region is composed of three major subbasins: the Green River subbasin, the upper Colorado River subbasin, and the San Juan-Colorado River subbasin.

Coldwater assemblages in the Upper Colorado River hydrologic region typically include salmonids, such as mountain whitefish and trout. Conditions that support such species are usually found in ponds, lakes, or reservoirs at higher elevations and in the headwaters of selected rivers and streams where water temperatures are cooler. Because deepwater releases from dams at some large, deep reservoirs can introduce cold, clear waters into rivers, coldwater fish assemblages have also become established in historically warmwater sections of some rivers, such as the portions of the Green River immediately downstream (i.e., tailwaters) of Fontenelle and Flaming Gorge Dams. Warmwater assemblages typically occur at lower elevations, where waters tend to be warmer and more turbid. Warmwater fish communities within the Upper Colorado River Basin include species of minnows (including chubs), suckers, sunfishes, black basses, and catfishes.

Historically, only 12 species of fish were native to the Upper Colorado River Basin, including 5 minnow species, 4 sucker species, 2 salmonids, and the mottled sculpin (family Cottidae). Four of these native species (humpback chub, bonytail, Colorado pikeminnow, and razorback sucker) are now federally listed as endangered, and critical habitat for these species has been designated within the Upper Colorado River Basin (Section 4.10.4). In addition to native fish species, more than 25 non-native fish species are now present in the basin, often as a result of intentional introductions (e.g., for establishment of sport fisheries) (Muth et al. 2000; McAda 2003). While most of the trout species found within the Upper Colorado River Basin are introduced non-natives (e.g., rainbow, brown, and some strains of cutthroat trout), mountain whitefish and Colorado River cutthroat trout are native to the basin. Although it was once common within the upper Green River and upper Colorado River watersheds, the Colorado River cutthroat trout is now found only in isolated subdrainages in Colorado, Utah, and Wyoming and is a species of concern in those states (Hirsch et al. 2006).

4.10.3.5 Missouri River Basin Hydrologic Region

Portions of Colorado east of the Continental Divide fall within the Missouri River hydrologic region (Figure 4.9-1). Historically, the Missouri River carried a heavy silt load, which was collected from tributaries in the northern part of its drainage. Its wide and diverging channel created shifting sandy islands, spits, and pools, resulting in fish species suited to its turbid and dynamic conditions. Many of the fish communities within the upper reaches of the Missouri River are considered benthic fishes and include sturgeon (family Acipenseridae) and minnows. Streams flowing through the arid, desert plains of Colorado are characterized by low gradients, meandering or braided channels, and sand and gravel substrates. Riparian vegetation in this area is dominated by cottonwoods, willows, shrubs, and grasses. Native and non-native minnows and suckers dominate fish communities in these areas. Within the six-state area, the South Platte River in Colorado is the primary river draining into the Missouri River Basin. Fish within the upper reaches of the Platte River include native shiners, minnows (including chubs), and channel catfish. Examples of introduced species in the Missouri River drainage include smallmouth bass, walleye, and white crappie.

4.10.4 Special Status Species

Table 4.10-4 shows the species listed under the ESA that occur in the six-state study area. Species that are proposed for listing or candidates for listing under the ESA are also included in the table. The large area being considered under the proposed action and the large number of species that could be present in the vicinity of solar energy project areas preclude detailed species-specific evaluations. Project-specific assessments, which may include consultations with the USFWS or National Marine Fisheries Service (NMFS), would be conducted to comply with Section 7 of the ESA prior to approval of project development and subsequent ground-disturbing activities.

The following definitions are applicable to the species listing categories under the ESA:

- *Endangered:* any species that is in danger of extinction throughout all or a significant portion of its range.

- *Threatened*: any species that is likely to become endangered within the foreseeable future throughout all or a significant part of its range.

- *Proposed for listing*: species that have been formally proposed for listing by the USFWS or NMFS by notice in the *Federal Register*.[6]

[6] Within 1 year of a listing proposal, the USFWS or NMFS must take one of three possible courses of action: (1) finalize the listing rule (as proposed or revised); (2) withdraw the proposal if the biological information on hand does not support the listing; or (3) extend the proposal for up to an additional 6 months because, at the end of 1 year, there is substantial disagreement within the scientific community concerning the biological appropriateness of the listing. After the extension, the USFWS or NMFS must make a decision on whether to list the species on the basis of the best scientific information available.

TABLE 4.10-4 Species That Occur in the Six-State Study Area That Are Listed, Proposed for Listing, or Candidates for Listing under the ESA

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Plants					
Abronia alpina	Ramshaw Meadows sand verbena	C	CA	N	N
Acanthomintha ilicifolia	San Diego thornmint	T	CA	Y	N
Acanthomintha obovata duttonii	San Mateo thornmint	E	CA	N	Y
Allium munzii	Munz's onion	E	CA	Y	N
Alopecurus aequalis var. *sonomensis*	Sonoma alopecurus	E	CA	N	N
Ambrosia pumila	San Diego ambrosia	E	CA	N	N
Amsinckia grandiflora	Large-flowered fiddleneck	E	CA	Y	Y
Amsonia kearneyana	Kearney's blue-star	E	AZ	N	Y
Arabis mcdonaldiana	McDonald's rock-cress	E	CA	N	Y
Arctomecon humilis	Dwarf bear-poppy	E	UT	N	Y
Arctostaphylos glandulosa crassifolia	Del Mar manzanita	E	CA	N	N
Arctostaphylos hookeri var. *ravenii*	Presidio manzanita	E	CA	N	Y
Arctostaphylos morroensis	Morro manzanita	T	CA	N	Y
Arctostaphylos myrtifolia	Ione manzanita	T	CA	N	N
Arctostaphylos pallida	Pallid manzanita	T	CA	N	Y
Arenaria paludicola	Marsh sandwort	E	CA	N	Y
Arenaria ursina	Bear Valley sandwort	T	CA	Y	N
Argemone pleiacantha pinnatisecta	Sacramento prickly poppy	E	NM	N	Y
Asclepias welshii	Welsh's milkweed	T	AZ, UT	Y	Y
Astragalus albens	Cushenbury milk-vetch	E	CA	Y	Y
Astragalus ampullarioides	Shivwits milk-vetch	E	UT	Y	Y
Astragalus brauntonii	Braunton's milk-vetch	E	CA	Y	Y
Astragalus clarianus	Clara Hunt's milk-vetch	E	CA	N	N
Astragalus cremnophylax var. *cremnophylax*	Sentry milk-vetch	E	AZ	N	Y
Astragalus desereticus	Deseret milk-vetch	T	UT	N	N
Astragalus holmgreniorum	Holmgren milk-vetch	E	AZ, UT	Y	Y
Astragalus humillimus	Mancos milk-vetch	E	CO, NM	N	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Plants (Cont.)					
Astragalus jaegerianus	Lane Mountain milk-vetch	E	CA	Y	N
Astragalus lentiginosus var. *coachellae*	Coachella valley milk-vetch	E	CA	Y	N
Astragalus lentiginosus var. *piscinensis*	Fish Slough milk-vetch	T	CA	Y	Y
Astragalus magdalenae var. *peirsonii*	Peirson's milk-vetch	T	CA	Y	N
Astragalus osterhoutii	Osterhout milk-vetch	E	CO	N	Y
Astragalus montii	Heliotrope milk-vetch	T	UT	Y	Y
Astragalus phoenix	Ash Meadows milk-vetch	T	NV	Y	Y
Astragalus pycnostachyus var. *lanosissimus*	Ventura Marsh milk-vetch	E	CA	Y	N
Astragalus tener var. *titi*	Coastal dunes milk-vetch	E	CA	N	Y
Astragalus tortipes	Sleeping Ute milk-vetch	C	CO	N	N
Astragalus tricarinatus	Triple-ribbed milk-vetch	E	CA	N	N
Atriplex coronata var. *notatior*	San Jacinto Valley crownscale	E	CA	N	N
Baccharis vanessae	Encinitas baccharis	T	CA	N	N
Berberis nevinii	Nevin's barberry	E	CA	Y	N
Blennosperma bakeri	Sonoma sunshine	E	CA	N	N
Brodiaea filifolia	Thread-leaved brodiaea	T	CA	Y	Y
Brodiaea pallida	Chinese Camp brodiaea	T	CA	N	N
Calochortus persistens	Siskiyou mariposa lily	C	CA	N	N
Calochortus tiburonensis	Tiburon mariposa lily	T	CA	N	Y
Calyptridium pulchellum	Mariposa pussypaws	T	CA	N	N
Calystegia stebbinsii	Stebbins' morning-glory	E	CA	N	Y
Camissonia benitensis	San Benito evening-primrose	T	CA	N	Y
Carex albida	White sedge	E	CA	N	N
Carex specuicola	Navajo sedge	T	AZ, UT	Y	Y
Castilleja affinis neglecta	Tiburon paintbrush	E	CA	N	Y
Castilleja campestris succulenta	Fleshy owl's-clover	T	CA	Y	Y
Castilleja cinerea	Ash-grey paintbrush	T	CA	Y	N
Castilleja mollis	Soft-leaved paintbrush	E	CA	N	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Plants (Cont.)					
Caulanthus californicus	California jewelflower	E	CA	N	Y
Ceanothus ferrisae	Coyote ceanothus	E	CA	N	Y
Ceanothus ophiochilus	Vail Lake ceanothus	T	CA	Y	N
Ceanothus roderickii	Pine Hill ceanothus	E	CA	N	Y
Centaurium namophilum	Spring-loving centaury	T	CA, NV	Y	Y
Chamaesyce hooveri	Hoover's spurge	T	CA	Y	Y
Chlorogalum purpureum	Purple amole	T	CA	Y	N
Chorizanthe howellii	Howell's spineflower	E	CA	N	Y
Chorizanthe orcuttiana	Orcutt's spineflower	E	CA	N	N
Chorizanthe parryi var. *fernandina*	San Fernando Valley spineflower	C	CA	N	N
Chorizanthe pungens var. *hartwegiana*	Ben Lomond spineflower	E	CA	N	Y
Chorizanthe pungens var. *pungens*	Monterey spineflower	T	CA	Y	Y
Chorizanthe robusta	Robust spineflower	E	CA	Y	Y
Chorizanthe valida	Sonoma spineflower	E	CA	N	Y
Cirsium fontinale var. *fontinale*	Fountain thistle	E	CA	N	Y
Cirsium fontinale var. *obispoense*	Chorro Creek bog thistle	E	CA	N	Y
Cirsium hydrophilum var. *hydrophilum*	Suisun thistle	E	CA	Y	N
Cirsium loncholepis	La Graciosa thistle	E	CA	Y	N
Cirsium vinaceum	Sacramento Mountains thistle	T	NM	N	Y
Clarkia franciscana	Presidio clarkia	E	CA	N	Y
Clarkia imbricata	Vine Hill clarkia	E	CA	N	N
Clarkia speciosa immaculata	Pismo clarkia	E	CA	N	Y
Clarkia springvillensis	Springville clarkia	T	CA	N	N
Cordylanthus maritimus maritimus	Salt marsh bird's-beak	E	CA	N	Y
Cordylanthus mollis mollis	Soft bird's-beak	E	CA	Y	Y
Cordylanthus palmatus	Palmate-bracted bird's beak	E	CA	N	Y
Cordylanthus tenuis capillaris	Pennell's bird's-beak	E	CA	N	Y
Coryphantha robbinsorum	Cochise pincushion cactus	T	AZ	N	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Plants (Cont.)					
Coryphantha scheeri var. *robustispina*	Pima pineapple cactus	E	AZ	N	N
Coryphantha sneedii var. *leei*	Lee pincushion cactus	T	NM	N	Y
Coryphantha sneedii var. *sneedii*	Sneed pincushion cactus	E	NM	N	Y
Cupressus abramsiana	Santa Cruz cypress	E	CA	N	Y
Cupressus goveniana goveniana	Gowen cypress	T	CA	N	Y
Cycladenia jonesii	Jones cycladenia	T	AZ, UT	N	Y
Deinandra conjugens	Otay tarplant	T	CA	Y	Y
Deinandra increscens villosa	Gaviota tarplant	E	CA	Y	N
Delphinium bakeri	Baker’s larkspur	E	CA	Y	N
Delphinium luteum	Yellow larkspur	E	CA	Y	N
Dodecahema leptoceras	Slender-horned spineflower	E	CA	N	N
Dudleya abramsii parva	Conejo dudleya	T	CA	N	Y
Dudleya cymosa marcescens	Marcescent dudleya	T	CA	N	Y
Dudleya cymosa ovatifolia	Santa Monica Mountains dudleya	T	CA	N	Y
Dudleya setchellii	Santa Clara Valley dudleya	E	CA	N	Y
Dudleya stolonifera	Laguna Beach liveforever	T	CA	N	N
Dudleya verityi	Verity’s dudleya	T	CA	N	Y
Echinocactus horizonthalonius var. *nicholii*	Nichol’s Turk’s head cactus	E	AZ	N	Y
Echinocereus fendleri var. *kuenzleri*	Kuenzler hedgehog cactus	E	NM	N	Y
Echinocereus triglochidiatus var. *arizonicus*	Arizona hedgehog cactus	E	AZ	N	Y
Echinomastus erectocentrus var. *acunensis*	Acuna cactus	C	AZ	N	N
Enceliopsis nudicaulis var. *corrugata*	Ash Meadows sunray	T	NV	Y	Y
Eremalche kernensis	Kern mallow	E	CA	N	Y
Eriastrum densifolium sanctorum	Santa Ana river woolly-star	E	CA	N	N
Erigeron lemmonii	Lemmon fleabane	C	AZ	N	N
Erigeron maguirei	Maguire daisy	T, PDL	UT	N	Y
Erigeron parishii	Parish’s daisy	T	CA	Y	Y
Erigeron rhizomatus	Zuni fleabane	T	AZ, NM	N	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Plants (Cont.)					
Eriodictyon altissimum	Indian Knob Mountain balm	E	CA	N	Y
Eriodictyon capitatum	Lompoc yerba santa	E	CA	Y	N
Eriogonum apricum	Ione buckwheat	E	CA	N	N
Eriogonum diatomaceum	Churchill Narrows buckwheat	C	NV	N	N
Eriogonum gypsophilum	Gypsum wild-buckwheat	T	NM	Y	Y
Eriogonum kelloggii	Red Mountain buckwheat	C	CA	N	N
Eriogonum kennedyi var. *austromontanum*	Southern mountain wild-buckwheat	T	CA	Y	N
Eriogonum ovalifolium var. *vineum*	Cushenbury buckwheat	E	CA	Y	Y
Eriogonum ovalifolium var. *williamsiae*	Steamboat buckwheat	E	NV	N	Y
Eriogonum pelinophilum	Clay-loving wild-buckwheat	E	CO	Y	Y
Eriophyllum latilobum	San Mateo woolly sunflower	E	CA	N	Y
Eryngium aristulatum var. *parishii*	San Diego button-celery	E	CA	N	Y
Eryngium constancei	Loch Lomond coyote thistle	E	CA	N	Y
Erysimum capitatum var. *angustatum*	Contra Costa wallflower	E	CA	Y	Y
Erysimum menziesii	Menzies' wallflower	E	CA	N	Y
Erysimum teretifolium	Ben Lomond wallflower	E	CA	N	Y
Eutrema penlandii	Penland alpine fen mustard	T	CO	N	N
Fremontodendron californicum decumbens	Pine Hill flannelbush	E	CA	N	Y
Fremontodendron mexicanum	Mexican flannelbush	E	CA	Y	N
Galium californicum sierrae	El Dorado bedstraw	E	CA	N	Y
Gaura neomexicana var. *coloradensis*	Colorado butterfly plant	T	CO	Y	N
Gilia tenuiflora arenaria	Monterey gilia	E	CA	N	Y
Gilia tenuiflora hoffmannii	Hoffmann's slender-flowered gilia	E	CA	N	Y
Grindelia fraxino-pratensis	Ash Meadows gumplant	T	CA, NV	Y	Y
Hazardia orcuttii	Orcutt's hazardia	C	CA	N	N
Hedeoma todsenii	Todsen's pennyroyal	E	NM	Y	Y
Helianthus paradoxus	Pecos sunflower	T	NM	Y	Y
Hesperolinon congestum	Marin dwarf-flax	T	CA	N	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Plants (Cont.)					
Holocarpha macradenia	Santa Cruz tarplant	T	CA	Y	N
Howellia aquatilis	Water howellia	T	CA	N	Y
Ipomopsis polyantha	Pagosa skyrocket	C	CO	N	N
Ipomopsis sancti-spiritus	Holy Ghost ipomopsis	E	NM	N	Y
Ivesia kingii var. *eremica*	Ash Meadows ivesia	T	NV	Y	Y
Ivesia webberi	Webber ivesia	C	CA, NV	N	N
Lasthenia burkei	Burke's goldfields	E	CA	N	N
Lasthenia conjugens	Contra Costa goldfields	E	CA	Y	Y
Layia carnosa	Beach layia	E	CA	N	Y
Lepidium barnebyanum	Barneby ridge-cress	E	UT	N	Y
Lesquerella congesta	Dudley Bluffs bladderpod	T	CO	N	Y
Lesquerella kingii bernardina	San Bernardino Mountains bladderpod	E	CA	Y	Y
Lesquerella tumulosa	Kodachrome bladderpod	E	UT	N	Y
Lessingia germanorum	San Francisco lessingia	E	CA	N	Y
Lilaeopsis schaffneriana var. *recurva*	Huachuca water-umbel	E	AZ	Y	N
Lilium occidentale	Western lily	E	CA	N	Y
Lilium pardalinum pitkinense	Pitkin marsh lily	E	CA	N	Y
Limnanthes floccosa californica	Butte County meadowfoam	E	CA	Y	Y
Limnanthes vinculans	Sebastopol meadowfoam	E	CA	N	Y
Lupinus nipomensis	Nipomo Mesa lupine	E	CA	N	N
Lupinus tidestromii	Clover lupine	E	CA	N	Y
Mentzelia leucophylla	Ash Meadows blazingstar	T	NV	Y	Y
Monardella linoides viminea	Willowy monardella	E	CA	Y	N
Monolopia congdonii	San Joaquin wooly-threads	E	CA	N	Y
Navarretia fossalis	Spreading navarretia	T	CA	Y	Y
Navarretia leucocephala pauciflora	Few-flowered navarretia	E	CA	N	Y
Navarretia leucocephala plieantha	Many-flowered navarretia	E	CA	N	Y
Neostapfia colusana	Colusa grass	T	CA	Y	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Plants (Cont.)					
Nitrophila mohavensis	Amargosa niterwort	E	CA, NV	Y	Y
Oenothera avita eurekensis	Eureka Valley evening-primrose	E	CA	N	Y
Oenothera deltoides howellii	Antioch Dunes evening-primrose	E	CA	Y	Y
Opuntia treleasei	Bakersfield cactus	E	CA	N	Y
Orcuttia californica	California orcutt grass	E	CA	N	Y
Orcuttia inaequalis	San Joaquin orcutt grass	T	CA	Y	Y
Orcuttia pilosa	Hairy orcutt grass	E	CA	Y	Y
Orcuttia tenuis	Slender orcutt grass	T	CA	Y	Y
Orcuttia viscida	Sacramento orcutt grass	E	CA	Y	Y
Oxytheca parishii var. *goodmaniana*	Cushenbury oxytheca	E	CA	Y	Y
Parvisedum leiocarpum	Lake County stonecrop	E	CA	N	Y
Pediocactus bradyi	Brady pincushion cactus	E	AZ	N	Y
Pediocactus despainii	San Rafael cactus	E	UT	N	Y
Pediocactus knowltonii	Knowlton cactus	E	CO, NM	N	Y
Pediocactus peeblesianus peeblesianus	Peebles Navajo cactus	E	AZ	N	Y
Pediocactus peeblesianus fickeiseniae	Fickeisen plains cactus	C	AZ	N	N
Pediocactus sileri	Siler pincushion cactus	T	AZ, UT	N	Y
Pediocactus winkleri	Winkler cactus	T	UT	N	Y
Penstemon debilis	Parachute beardtongue	C	CO	N	N
Penstemon penlandii	Penland beardtongue	E	CO	N	Y
Penstemon scariosus albifluvis	White River beardtongue	C	CO, UT	N	N
Pentachaeta bellidiflora	White-rayed pentachaeta	E	CA	N	Y
Pentachaeta lyonii	Lyon's pentachaeta	E	CA	Y	Y
Phacelia argillacea	Clay phacelia	E	UT	N	Y
Phacelia formosula	North Park phacelia	E	CO	N	Y
Phacelia stellaris	Brand's phacelia	C	CA	N	N
Phacelia submutica	Debeque phacelia	C	CO	N	N
Phlox hirsuta	Yreka phlox	E	CA	N	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Plants (Cont.)					
Physaria obcordata	Dudley Bluffs twinpod	T	CO	N	Y
Piperia yadonii	Yadon's piperia	E	CA	Y	Y
Plagiobothrys strictus	Calistoga allocarya	E	CA	N	N
Poa atropurpurea	San Bernardino bluegrass	E	CA	Y	N
Poa napensis	Napa bluegrass	E	CA	N	N
Pogogyne abramsii	San Diego mesa-mint	E	CA	N	Y
Pogogyne nudiuscula	Otay mesa-mint	E	CA	N	Y
Polygonum hickmanii	Scotts Valley polygonum	E	CA	Y	N
Potentilla basaltica	Soldier Meadows cinquefoil	C	CA, NV	N	N
Potentilla hickmanii	Hickman's potentilla	E	CA	N	Y
Primula maguirei	Maguire primrose	T	UT	N	Y
Pseudobahia bahiifolia	Hartweg's golden sunburst	E	CA	N	N
Pseudobahia peirsonii	San Joaquin adobe sunburst	T	CA	N	N
Purshia subintegra	Arizona cliff-rose	E	AZ	N	Y
Ranunculus aestivalis	Autumn buttercup	E	UT	N	Y
Rorippa gambellii	Gambel's watercress	E	CA	N	Y
Rorippa subumbellata	Tahoe yellow cress	C	CA, NV	N	N
Schoenocrambe argillacea	Clay reed-mustard	T	UT	N	Y
Schoenocrambe barnebyi	Barneby reed-mustard	E	UT	N	Y
Schoenocrambe suffrutescens	Shrubby reed-mustard	E	UT	N	Y
Sclerocactus glaucus	Uinta Basin hookless cactus	T	CO, UT	N	Y
Sclerocactus mesae-verdae	Mesa Verde cactus	T	CO, NM	N	Y
Sclerocactus wrightiae	Wright fishhook cactus	E	UT	N	Y
Sedum eastwoodiae	Red Mountain stonecrop	C	CA	N	N
Senecio franciscanus	San Francisco Peaks groundsel	T	AZ	Y	Y
Senecio layneae	Layne's butterweed	T	CA	N	Y
Sidalcea keckii	Keck's checker-mallow	E	CA	Y	N
Sidalcea oregana valida	Kenwood marsh checker-mallow	E	CA	N	N

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Plants (Cont.)					
Sidalcea pedata	Pedate checker-mallow	E	CA	N	Y
Spiranthes delitescens	Canelo hills ladies'-tresses	E	AZ	N	N
Spiranthes diluvialis	Ute ladies'-tresses	T	CO, UT	N	Y
Streptanthus albidus albidus	Metcalf Canyon jewelflower	E	CA	N	Y
Streptanthus niger	Tiburon jewelflower	E	CA	N	Y
Suaeda californica	California seablite	E	CA	N	N
Swallenia alexandrae	Eureka dune grass	E	CA	N	Y
Taraxacum californicum	California taraxacum	E	CA	Y	N
Thelypodium stenopetalum	Slender-petaled mustard	E	CA	N	Y
Thlaspi californicum	Kneeland Prairie penny-cress	E	CA	Y	Y
Townsendia aprica	Last chance townsendia	T	UT	N	Y
Trichostema austromontanum compactum	Hidden Lake bluecurls	T	CA	N	N
Trifolium amoenum	Showy Indian clover	E	CA	N	N
Trifolium trichocalyx	Monterey clover	E	CA	N	Y
Tuctoria greenei	Greene's tuctoria	E	CA	Y	Y
Tuctoria mucronata	Solano grass	E	CA	Y	Y
Verbena californica	Red Hills vervain	T	CA	N	N
Verbesina dissita	Big-leaved crownbeard	T	CA	N	N
Mollusks					
Assiminea pecos	Pecos assiminea snail	E	NM	Y	N
Haliotis sorenseni	White abalone	E	CA	N	N
Helminthoglypta walkeriana	Morro shoulderband snail	E	CA	Y	Y
Juturnia kosteri	Koster's springsnail	E	NM	N	N
Oreohelix peripherica wasatchensis	Ogden mountainsnail	C	UT	N	N
Oxyloma haydeni kanabensis	Kanab ambersnail	E	AZ, UT	N	Y
Popenaias popei	Texas hornshell	C	NM	N	N
Pyrgulopsis chupaderae	Chupadera springsnail	C	NM	N	N

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Mollusks (Cont.)					
Pyrgulopsis gilae	Gila springsnail	C	NM	N	N
Pyrgulopsis morrisoni	Page springsnail	C	AZ	N	N
Pyrgulopsis neomexicana	Socorro springsnail	E	NM	N	Y
Pyrgulopsis roswellensis	Roswell springsnail	E	NM	N	N
Pyrgulopsis thermalis	New Mexico springsnail	C	NM	N	N
Pyrgulopsis thompsoni	Huachuca springsnail	C	AZ	N	N
Pyrgulopsis trivialis	Three Forks springsnail	C	AZ	N	N
Stagnicola bonnevillensis	Bonneville pondsnail	C	UT	N	N
Tryonia alamosae	Alamosa springsnail	E	NM	N	Y
Arthropods					
Ambrysus amargosus	Ash Meadows naucorid	T	NV	Y	Y
Ambrysus funebris	Nevares Spring naucorid bug	C	CA	N	N
Apodemia mormo langei	Lange's metalmark butterfly	E	CA	N	Y
Boloria acrocnema	Uncompahgre fritillary butterfly	E	CO	N	Y
Branchinecta conservatio	Conservancy fairy shrimp	E	CA	Y	Y
Branchinecta longiantenna	Longhorn fairy shrimp	E	CA	Y	Y
Branchinecta lynchi	Vernal pool fairy shrimp	T	CA	Y	Y
Branchinecta sandiegonensis	San Diego fairy shrimp	E	CA	Y	Y
Callophrys mossii bayensis	San Bruno elfin butterfly	E	CA	N	Y
Cicindela limbata albissima	Coral pink sand dunes tiger beetle	C	UT	N	N
Cicindela ohlone	Ohlone tiger beetle	E	CA	N	N
Desmocerus californicus dimorphus	Valley elderberry longhorn beetle	T	CA	Y	Y
Elaphrus viridis	Delta green ground beetle	T	CA	Y	Y
Euphilotes battoides allyni	El Segundo blue butterfly	E	CA	N	Y
Euphilotes enoptes smithi	Smith's blue butterfly	E	CA	N	Y
Euphydryas editha bayensis	Bay checkerspot butterfly	T	CA	Y	Y
Euphydryas editha quino	Quino checkerspot butterfly	E	CA	Y	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Arthropods (Cont.)					
Euproserpinus euterpe	Kern primrose sphinx moth	T	CA	N	Y
Gammarus desperatus	Noel's amphipod	E	NM	N	N
Glaucopsyche lygdamus palosverdesensis	Palos Verdes blue butterfly	E	CA	Y	Y
Hesperia leonardus montana	Pawnee montane skipper	T	CO	N	Y
Heterelmis stephani	Stephan's riffle beetle	C	AZ	N	N
Icaricia icarioides missionensis	Mission blue butterfly	E	CA	N	Y
Lepidurus packardi	Vernal pool tadpole shrimp	E	CA	Y	Y
Lycaeides argyrognomon lotis	Lotis blue butterfly	E	CA	N	Y
Pacifastacus fortis	Shasta crayfish	E	CA	N	Y
Polites mardon	Mardon skipper	C	CA	N	N
Polyphylla barbata	Mount Hermon june beetle	E	CA	N	Y
Pseudocopaeodes eunus obscurus	Carson wandering skipper	E	CA, NV	N	Y
Pyrgus ruralis lagunae	Laguna Mountains skipper	E	CA	Y	N
Rhaphiomidas terminatus abdominalis	Delhi sands flower-loving fly	E	CA	N	Y
Speyeria callippe callippe	Callippe silverspot butterfly	E	CA	N	N
Speyeria zerene behrensii	Behren's silverspot butterfly	E	CA	N	Y
Speyeria zerene hippolyta	Oregon silverspot butterfly	T	CA	Y	Y
Speyeria zerene myrtleae	Myrtle's silverspot butterfly	E	CA	N	Y
Streptocephalus woottoni	Riverside fairy shrimp	E	CA	Y	Y
Syncaris pacifica	California freshwater shrimp	E	CA	N	Y
Thermosphaeroma thermophilus	Socorro isopod	E	NM	N	Y
Trimerotropis infantilis	Zayante band-winged grasshopper	E	CA	Y	Y
Fishes					
Acipenser medirostris	North American Green Sturgeon	T	CA	N	N
Catostomus discobolus yarrowi	Zuni bluehead sucker	C	AZ, NM	N	N
Catostomus microps	Modoc sucker	E	CA	Y	Y
Catostomus santaanae	Santa Ana sucker	T	CA	Y	N

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Fishes (Cont.)					
Chasmistes brevirostris	Shortnose sucker	E	CA	N	Y
Chasmistes cujus	Cui-ui	E	NV	N	Y
Chasmistes liorus	June sucker	E	UT	Y	Y
Crenichthys baileyi baileyi	White River springfish	E	NV	Y	Y
Crenichthys baileyi grandis	Hiko White River springfish	E	NV	Y	Y
Crenichthys nevadae	Railroad Valley springfish	T	NV	Y	Y
Cyprinella formosa	Beautiful shiner	T	AZ, NM	Y	Y
Cyprinodon diabolis	Devils Hole pupfish	E	NV	N	Y
Cyprinodon macularius	Desert pupfish	E	AZ, CA	Y	Y
Cyprinodon nevadensis mionectes	Ash Meadows amargosa pupfish	E	NV	Y	Y
Cyprinodon nevadensis pectoralis	Warm Springs pupfish	E	NV	N	Y
Cyprinodon radiosus	Owens pupfish	E	CA	N	Y
Deltistes luxatus	Lost River sucker	E	CA	N	Y
Empetrichthys latos	Pahrump poolfish	E	NV	N	Y
Eremichthys acros	Desert dace	T	NV	Y	Y
Etheostoma cragini	Arkansas darter	C	CO	N	N
Eucyclogobius newberryi	Tidewater goby	E	CA	Y	Y
Gambusia nobilis	Pecos gambusia	E	NM	N	Y
Gasterosteus aculeatus williamsoni	Unarmored threespine stickleback	E	CA	N	Y
Gila bicolor mohavensis	Mohave tui chub	E	CA	N	Y
Gila bicolor snyderi	Owens tui chub	E	CA	Y	Y
Gila cypha	Humpback chub	E	AZ, CO, UT	Y	Y
Gila ditaenia	Sonora chub	T	AZ	Y	Y
Gila elegans	Bonytail chub	E	AZ, CA, CO, NV, UT	Y	Y
Gila intermedia	Gila chub	E	AZ, NM	Y	N
Gila nigra	Headwater chub	C	AZ, NM	N	N
Gila nigrescens	Chihuahua chub	T	NM	N	Y
Gila purpurea	Yaqui chub	E	AZ	Y	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Fishes (Cont.)					
Gila robusta jordani	Pahranagat roundtail chub	E	NV	N	Y
Gila seminuda	Virgin River chub	E	AZ, NV, UT	Y	Y
Hybognathus amarus	Rio Grande silvery minnow	E	NM	Y	Y
Hypomesus transpacificus	Delta smelt	T	CA	Y	Y
Ictalurus pricei	Yaqui catfish	T	AZ	Y	Y
Lepidomeda albivallis	White River spinedace	E	NV	Y	Y
Lepidomeda mollispinis pratensis	Big Spring spinedace	T	NV	Y	Y
Lepidomeda vittata	Little Colorado spinedace	T	AZ	Y	Y
Meda fulgida	Spikedace	T	AZ, NM	Y	Y
Moapa coriacea	Moapa dace	E	NV	Y	Y
Notropis girardi	Arkansas River shiner	T	NM	Y	N
Notropis simus pecosensis	Pecos bluntnose shiner	T	NM	Y	Y
Oncorhynchus aguabonita whitei	Little Kern golden trout	T	CA	Y	Y
Oncorhynchus apache	Apache trout	T	AZ	N	Y
Oncorhynchus clarkii henshawi	Lahontan cutthroat trout	T	CA, NV, UT	N	Y
Oncorhynchus clarkii seleniris	Paiute cutthroat trout	T	CA	N	Y
Oncorhynchus clarkii stomias	Greenback cutthroat trout	T	CO	N	Y
Oncorhynchus gilae	Gila trout	T	AZ, NM	N	Y
Oncorhynchus kisutch	Coho salmon[b]	T, E[c]	CA	Y	N
Oncorhynchus mykiss	Steelhead[b]	T, E[c]	CA	Y	N
Oncorhynchus tshawytscha	Chinook salmon[b]	T, E[c]	CA	Y	N
Plagopterus argentissimus	Woundfin	E	AZ, UT	Y	Y
Poeciliopsis occidentalis	Gila topminnow	E	AZ, NM	N	Y
Ptychocheilus lucius	Colorado pikeminnow	E	AZ, CA, CO, NM, NV, UT	Y	Y
Rhinichthys osculus lethoporus	Independence Valley speckled dace	E	NV	N	Y
Rhinichthys osculus nevadensis	Ash Meadows speckled dace	E	NV	Y	Y
Rhinichthys osculus oligoporus	Clover Valley speckled dace	E	NV	N	Y
Salvelinus confluentus	Bull trout	T	NV	Y	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Fishes (Cont.)					
Tiaroga cobitis	Loach minnow	T	AZ, NM	Y	Y
Xyrauchen texanus	Razorback sucker	E	AZ, CA, CO, NM, NV, UT	Y	Y
Amphibians					
Ambystoma californiense	California tiger salamander	T, E[c]	CA	Y	N
Ambystoma macrodactylum croceum	Santa Cruz Long-Toed Salamander	E	CA	N	Y
Ambystoma tigrinum stebbinsi	Sonora tiger salamander	E	AZ	N	Y
Batrachoseps aridus	Desert slender salamander	E	CA	N	Y
Bufo californicus	Arroyo toad	E	CA	Y	Y
Bufo canorus	Yosemite toad	C	CA	N	N
Rana aurora draytonii	California red-legged frog	T	CA	Y	Y
Rana chiricahuensis	Chiricahua leopard frog	T	AZ, NM	N	Y
Rana luteiventris	Columbia spotted frog	C	NV	N	N
Rana muscosa	Mountain yellow-legged frog	E, C[c]	CA, NV	Y	N
Rana onca	Relict leopard frog	C	AZ, NV, UT	N	N
Rana pretiosa	Oregon spotted frog	C	CA	N	N
Reptiles					
Crotalus willardi obscurus	New Mexican ridge-nosed rattlesnake	T	AZ, NM	Y	Y
Gambelia silus	Blunt-nosed leopard lizard	E	CA	N	Y
Gopherus agassizii	Desert tortoise	T	AZ, CA, NV, UT	Y	Y
Kinosternon sonoriense longifemorale	Sonoyta mud turtle	C	AZ, NM	N	N
Masticophis lateralis euryxanthus	Alameda whipsnake	T	CA	Y	Y
Sceloporus arenicolus	Sand dune lizard	C	NM	N	N
Thamnophis gigas	Giant garter snake	T	CA	N	Y
Thamnophis sirtalis tetrataenia	San Francisco garter snake	E	CA	N	Y
Uma inornata	Coachella Valley fringe-toed lizard	T	CA	Y	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Birds					
Brachyramphus marmoratus	Marbled murrelet	T	CA	Y	Y
Charadrius alexandrinus nivosus	Western snowy plover	T	CA	Y	Y
Charadrius melodus	Piping plover	T	CO	N	Y
Coccyzus americanus	Western yellow-billed cuckoo	C	AZ, CA, CO, NM, NV, UT	N	N
Colinus virginianus ridgwayi	Masked bobwhite	E	AZ	N	Y
Empidonax traillii extimus	Southwestern willow flycatcher	E	AZ, CA, CO, NM, NV, UT	Y	Y
Falco femoralis septentrionalis	Northern Aplomado falcon	E, XN	AZ, NM	N	Y
Grus americana	Whooping crane	E	CO	Y	Y
Gymnogyps californianus	California condor	E	AZ, CA, UT	Y	Y
Haliaeetus leucocephalus	Sonoran desert bald eagle	T	AZ	N	N
Pelecanus occidentalis	Brown pelican	E, PDL	CA	N	Y
Pipilo crissalis eremophilus	Inyo California towhee	T	CA	Y	Y
Polioptila californica californica	Coastal California gnatcatcher	T	CA	Y	N
Rallus longirostris levipes	Light-footed clapper rail	E	CA	N	Y
Rallus longirostris obsoletus	California clapper rail	E	CA	N	Y
Rallus longirostris yumanensis	Yuma clapper rail	E	AZ, CA, NV, UT	N	Y
Sterna antillarum	Interior least tern	E	CO, NM	N	Y
Sterna antillarum browni	California least tern	E	CA	N	Y
Strix occidentalis caurina	Northern spotted owl	T	CA	Y	Y
Strix occidentalis lucida	Mexican spotted owl	T	AZ, CO, NM, UT	Y	Y
Synthliboramphus hypoleucus	Xantus's murrelet	C	CA	N	N
Tympanuchus pallidicinctus	Lesser prairie-chicken	C	CO, NM	N	N
Vireo bellii pusillus	Least Bell's vireo	E	CA	Y	N
Mammals					
Antilocapra americana sonoriensis	Sonoran pronghorn	E	AZ	N	Y
Aplodontia rufa nigra	Point Arena mountain beaver	E	CA	N	N
Canis lupus	Gray wolf	E	AZ, CO, NM, NV, UT	Y	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Mammals (Cont.)					
Cynomys parvidens	Utah prairie dog	T	UT	N	Y
Dipodomys heermanni morroensis	Morro Bay kangaroo rat	E	CA	Y	Y
Dipodomys ingens	Giant kangaroo rat	E	CA	N	Y
Dipodomys merriami parvus	San Bernardino Merriam's kangaroo rat	E	CA	Y	N
Dipodomys nitratoides exilis	Fresno kangaroo rat	E	CA	Y	Y
Dipodomys nitratoides nitratoides	Tipton kangaroo rat	E	CA	N	Y
Dipodomys stephensi	Stephens' kangaroo rat	E	CA	N	Y
Eumetopias jubatus	Steller sea lion	T	CA	Y	N
Herpailurus yagouaroundi tolteca	Sinaloan jaguarundi	E	AZ	N	Y
Leopardus pardalis	Ocelot	E	AZ	N	Y
Leptonycteris curasoae yerbabuenae	Lesser long-nosed bat	E	AZ, NM	N	Y
Leptonycteris nivalis	Mexican long-nosed bat	E	NM	N	Y
Lynx canadensis	Canada lynx	T	CO, UT	N	N
Martes pennanti	West coast fisher	C	CA	N	Y
Microtus californicus scirpensis	Amargosa vole	E	CA	Y	Y
Microtus mexicanus hualpaiensis	Hualapai Mexican vole	E	AZ	N	Y
Mustela nigripes	Black-footed ferret	E	AZ, CO, UT	N	Y
Neotoma fuscipes riparia	Riparian woodrat	E	CA	N	Y
Ovis canadensis	Peninsular bighorn sheep	E	CA	Y	Y
Ovis canadensis sierrae	Sierra Nevada bighorn sheep	E	CA	Y	Y
Panthera onca	Jaguar	E	AZ, NM	N	Y
Perognathus longimembris pacificus	Pacific pocket mouse	E	CA	N	Y
Reithrodontomys raviventris	Salt marsh harvest mouse	E	CA	N	Y
Sorex ornatus relictus	Buena Vista Lake ornate shrew	E	CA	Y	Y
Spermophilus tereticaudus chlorus	Palm Springs round-tailed ground squirrel	C	CA	N	N
Sylvilagus bachmani riparius	Riparian brush rabbit	E	CA	N	Y
Tamiasciurus hudsonicus grahamensis	Mount Graham red squirrel	E	AZ	Y	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Mammals (Cont.)					
Vulpes macrotis mutica	San Joaquin kit fox	E	CA	N	Y
Zapus hudsonius preblei	Preble's meadow jumping mouse	T	CO	Y	N

[a] C = candidate for listing; E = listed as endangered; PDL = proposed for delisting; PT = proposed for listing as threatened; T = listed as threatened; XN = experimental population.

[b] Includes one or more "evolutionarily significant units" that spawn in different river basins or at different times of year and that have been assigned separate listing status.

[c] More than one listing category indicates that the species has different status in different states.

Source: USFWS (2010).

- *Candidate*: species for which the USFWS or NMFS has sufficient information on their biological status and threats to propose them as threatened or endangered under the ESA but for which development of a proposed listing regulation is precluded by other higher priority listing actions.

- *Critical habitat*: critical habitat for listed species consists of: (1) the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of Section 4 of the ESA, on which are found those physical or biological features (constituent elements) (a) essential to the conservation of the species and (b) which may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of Section 4 of the ESA, upon a determination by the Secretary of the Interior that such areas are essential for the conservation of the species. Designated critical habitats are described in 50 CFR 17 and 226.

In the six-state study area, 241 plant species and 190 animal species are federally listed as threatened or endangered, proposed for listing, or candidates for listing under the ESA. The animals are 17 species of mollusks, 39 species of arthropods, 62 species of fishes, 10 species of amphibians, 9 species of reptiles, 21 species of birds, and 32 species of mammals. California has the largest number of listed plant and animal species (257); whereas Colorado has the fewest (31). Critical habitat has been designated for 158 of these species, and recovery plans have been developed for 302 species (Table 4.10-4). These plans must be followed where federal projects might affect those species.

The BLM has established a policy, as specified in BLM Manual 6840, *Special Status Species Management* (BLM 2008b), whose purpose is "to provide policy and guidance for the conservation of BLM special status species and the ecosystems upon which they depend on BLM-administered lands." Objectives of the BLM special status species policy are to (1) conserve and/or recover ESA-listed species and the ecosystems on which they depend so that ESA protections are no longer needed for these species and (2) initiate proactive conservation measures that reduce or eliminate threats to BLM sensitive species to minimize the likelihood of and need for listing of these species under the ESA. BLM special status species are "(1) species listed or proposed for listing under the ESA, and (2) species requiring special management consideration to promote their conservation and reduce the likelihood and need for future listing under the ESA, which are designated as Bureau sensitive by the State Director(s). All Federal candidate species, proposed species, and delisted species in the 5 years following delisting will be conserved as Bureau sensitive species." Each BLM state director maintains a list of sensitive species, and impacts on these species would have to be considered in project-specific assessments developed before approval of any activity that would affect listed or proposed species or critical habitat.

In implementing this policy, the BLM has designated certain areas throughout the six-state study region to protect important resources, including populations of special status species. These areas are referred to as Areas of Critical Environmental Concern (ACECs) and typically have specific protection or management requirements associated with them, including surface occupancy restrictions, activity timing restrictions, and compatible uses depending on the resources contained in those areas.

Each of the six states in the study area has also identified species that are of concern in the state. Each state differs in the listing status designations it uses and in its regulations for protecting those species. Project-specific assessments would consider impacts on these state-listed species prior to project development. Many of these species are also listed as BLM sensitive species, and some are also listed under the ESA. In cooperation with the USFWS, the states are required to monitor, for no less than 5 years, the status of all species that have recovered to the point at which they are no longer listed as threatened or endangered (e.g., bald eagle).

4.11 AIR QUALITY AND CLIMATE

4.11.1 Meteorology

Climate varies substantially across the six-state study area and is influenced by variations in elevation, latitude, topographic features, moisture source, and proximity to water bodies. General meteorological conditions for each state, extracted from historic climatic information issued by the Western Regional Climate Center (WRCC 2008), are briefly described below, followed by a summary of temperature, precipitation, wind direction, and severe weather conditions across the six-state area.

4.11.1.1 Arizona

Arizona has three main topographic areas: (1) a mountainous region oriented southeast to northwest; (2) a high plateau in the northeast; and (3) lower mountain ranges and desert valleys in the southwest. A large portion of Arizona is classified as desert or semiarid. The air is generally dry and clear, with low relative humidity (annual averages ranging from 55% at Flagstaff to 33% at Yuma) and a high percentage of sunshine (annual averages ranging from 86 to 92%). Sometimes cold air masses from Canada penetrate into the state and bring temperatures well below zero (a lowest record of –35°F [–37°C]) in the high plateau and mountainous regions of central and northern Arizona. High temperatures are common throughout the summer months at the lower elevations, and the highest temperature of 125°F (52°C) was observed in the desert area. Great temperature extremes occur between day and night throughout Arizona with daily ranges as large as 50 to 60°F (10 to 16°C). The mountainous region averages 25 to 30 in. (64 to 76 cm) of precipitation per year, while the desert southwest averages as low as 3 or 4 in. (8 or 10 cm) per year. The plateau area receives about 10 in. (25 cm) of precipitation per year. Solar power resources are shown in Figures 4.11-1 and 4.11-2.

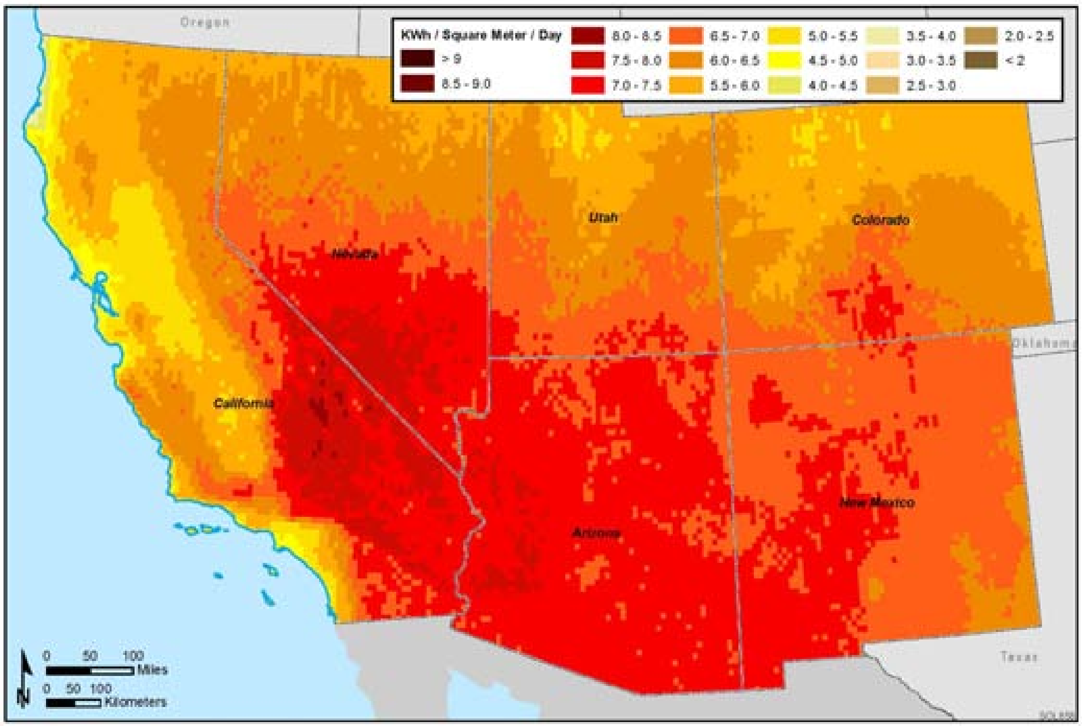

FIGURE 4.11-1 CSP Resources in Six Southwestern States (Source: NREL 2010)

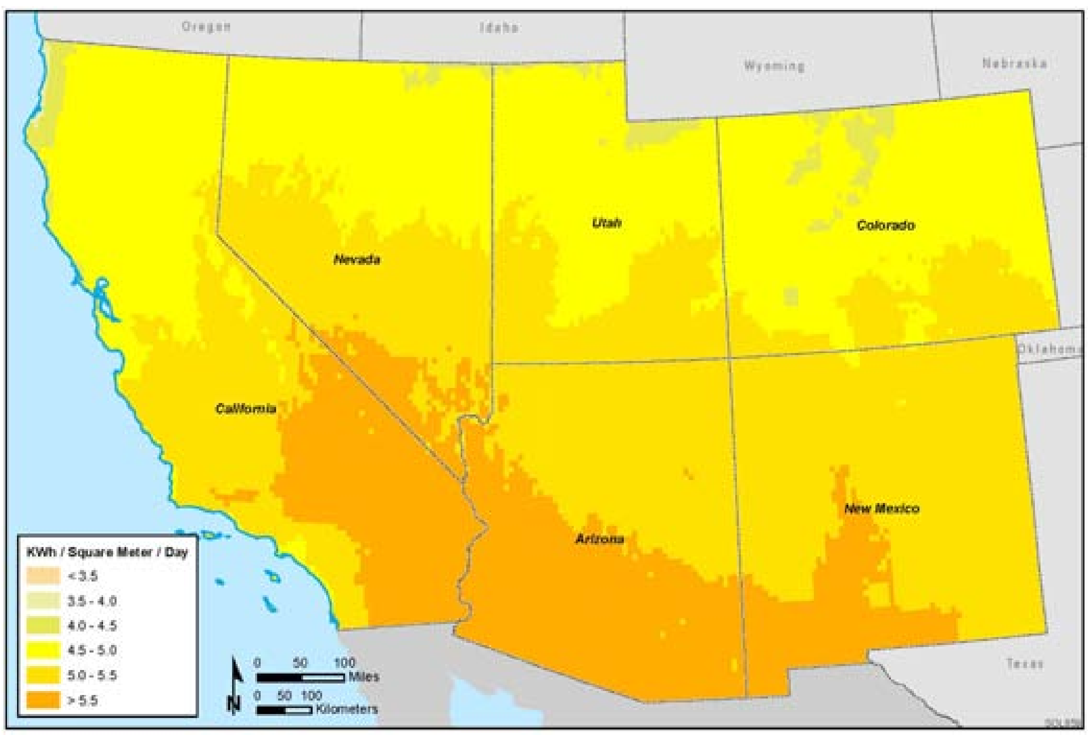

FIGURE 4.11-2 PV Solar Resources in Six Southwestern States (Source: NREL 2010)

4.11.1.2 California

> **Solar Power Resources**
>
> Two types of data are available. The direct normal solar values represent the resource available to concentrating systems that track the sun throughout the day using two-axis concentrators. Flat plate insolation values represent the resource available to a flat plate collector, such as a photovoltaic panel, oriented due south at an angle from horizontal to equal to the latitude of the collector location.

Because of the size of California, a latitude span of almost 10 degrees, and complex topography, substantial spatial and temporal variations in climate exist within the state. The easternmost mountain chains form a barrier that protects much of the state from the extremely cold air of the Great Basin in winter. The ranges of mountains to the west offer some protection to the interior from the strong flow of air off the Pacific Ocean. Thus, precipitation is heavy (in excess of 50 in. [130 cm] per year) on the coastal or western side of both the Coast Range and the Sierra Nevada and lighter on the eastern slopes (under 9 in. [20 cm] in some areas). Between the two mountain chains and over much of the desert area, hot summers and moderate to cold winters are the rule. Along the coast, the climate is subject to wide variations within short distances because of the influence of topography on the circulation of marine air. Depending to some extent upon the amount of marine influence experienced, temperature ranges become wider. On the coast, temperature ranges are small from day to night and from winter to summer. Higher elevations in the mountains experience large temperature variations. Extreme temperatures have been recorded as low as –45°F (–43°C) and as high as 134°F (57°C). Annual precipitation at one station has exceeded 161 in. (409 cm), while other points have gone for more than a year with no measurable rain. Solar power resources are shown in Figures 4.11-1 and 4.11-2.

4.11.1.3 Colorado

Colorado has an inland continental location in the middle latitudes, which is characterized by rugged mountain ranges in the west and level-to-rolling prairie in the east. Most of the state experiences a cool and invigorating mountain climate. In the western portion of the state, rugged topography causes large variations in climate within short distances and precludes climatic generalizations. The highest temperature can reach 90 to 95°F (32 to 35°C) in the summer, and temperatures on snow-covered mountain peaks and valleys can be as low as –50°F (–46°C). In the eastern plains, the climate is fairly uniform, with characteristic features of low relative humidity, abundant sunshine, light rainfall, moderate to high winds, and a large daily range in temperature. Summer daily maximum temperatures of 95 to 100°F (35 to 38°C) have been recorded, and the highest temperature, exceeding 115°F (46°C), occurred in the northeastern plains. Usual winter extremes are from 0 to –15°F (–18 to –26°C). For most of western Colorado, the greatest monthly precipitation occurs in the winter, while June is the driest month. In contrast, June is one of the wetter months in most of the eastern portions of the state. Solar power resources are shown in Figures 4.11-1 and 4.11-2.

4.11.1.4 Nevada

Nevada is predominantly a plateau and lies on the eastern side of the Sierra Nevada Range, a massive mountain barrier that causes air from the west to be warm and dry along with the prevailing westerlies. Prolonged cold weather is rare because mountains east and north of the state act as a barrier to prevent intrusions of extremely cold continental arctic air masses. Nevada has great climatic diversity, ranging from scorching lowland desert in the south to cool mountain forest in the north. Wide daily temperature ranges are caused by strong daytime surface heating and rapid nighttime cooling because of the dry air. The average range is about 30 to 35F° (17 to 19C°). Summer temperatures above 100°F (38°C) occur frequently in the south, and temperature extremes have ranged from –50 to 120°F (–46 to 49°C). Variation in precipitation is due primarily to differences in elevation and exposure to precipitation-bearing storms. Precipitation is lightest in the lower portions of the western plateau, opposite California's Death Valley and northward to Idaho. In valleys in this area, annual precipitation is less than 5 in. (13 cm), but reaches about 40 in. (102 cm) in the Sierra Nevadas. Solar power resources are shown in Figures 4.11-1 and 4.11-2.

4.11.1.5 New Mexico

New Mexico is divided into three major areas by mountain ranges and highlands, running generally in a north-south direction and merging in the north. It has a mild, arid or semiarid, continental climate characterized by light precipitation, abundant sunshine, low relative humidity, and relatively large annual and diurnal temperature ranges. During the summer, daytime temperatures often exceed 100°F (38°C) at elevations below 5,000 ft (1,500 m), but average monthly maximum temperatures range from the upper 70s°F (20s°C) at higher elevations to above 90°F (32°C) at lower elevations. During the winter, minimum temperatures below freezing are common throughout the state; subzero temperatures, however, are rare except in the mountains. The lowest recorded temperature was –50°F (–46°C) and the highest was 116°F (47°C). Average annual precipitation ranges from less than 10 in. (25 cm) over much of the southern desert and the Rio Grande and San Juan Valleys to more than 20 in. (51 cm) at higher elevations. Arid and semiarid climates are characterized by a wide variation in annual precipitation, as illustrated by annual extremes ranging from 3 to 34 in. (8 to 86 cm) at Carlsbad. From 75% to 80% of possible sunshine is received, with as much as 90% being received in November and some spring months. Relative humidity averages near 65% at sunrise and near 30% in mid-afternoon. It is often less than 20% and occasionally as low as 4% in the afternoon in warmer months. Solar power resources are shown in Figures 4.11-1 and 4.11-2.

4.11.1.6 Utah

The topography of Utah is extremely varied, with most of the state being mountainous. Along with prevailing westerly air masses, a large portion of the original moisture of the Pacific storms falls as precipitation while passing over the mountain ranges in the western United States, such as the Sierra Nevada and Cascade Ranges and the Rocky Mountains. Thus air masses reaching Utah are relatively dry, resulting in light precipitation over most of the state.

Temperatures vary with altitude and latitude. Temperatures below zero are uncommon in most of the state, and prolonged periods of extremely cold weather are rare. This is primarily because the mountains east and north of the state act as barriers to intensely cold continental arctic air masses. The lowest recorded temperature was –50°F (–46°C). Daily temperature ranges vary widely due to relatively strong daytime insolation and rapid nocturnal cooling. Precipitation varies greatly, from less than 5 in. (13 cm) over the Great Salt Lake Desert (west of Great Salt Lake) to more than 40 in. (102 cm) in some parts of the Wasatch Mountains, which run north-south in the middle of Utah. Solar power resources are shown in Figures 4.11-1 and 4.11-2.

4.11.1.7 Overview across the Study Area

Temperature and precipitation in the six-state study area vary widely with elevation, latitude, season, and time of day. Table 4.11-1 presents historical average temperatures and precipitation at selected locations throughout the six-state study area (WRCC 2008). Annual average temperatures range from mid-40s°F to mid-70s°F. Monthly temperature extremes range from a low of 10.8°F (–11.8°C) in Elko, Nevada, to a high of 105.6°F (40.9°C) in Phoenix, Arizona. Las Vegas, Nevada, averages only 4 in. (10 cm) of precipitation each year, compared with almost 3 ft (91 cm) in Redding, California. Many cities in Arizona and California, including Phoenix and Los Angeles, have no recorded snowfall, while Salt Lake City, Utah, and Denver, Colorado, have about 5 ft (152 cm) a year.

The predominant prevailing wind aloft is from the west, as in most of the United States. However, surface winds are greatly modified by local terrain and ground cover. The wind roses presented for selected locations in Figure 4.11-3 demonstrate the variation in surface winds over the six-state study area (NCDC 1997). As shown in the figure, the prevailing wind directions vary from site to site, and the distribution of wind frequencies between the various directions is also highly site dependent. The figure also shows substantial variation in wind speeds. Low wind speeds or calms are associated with conditions of poor atmospheric dispersion. Of the 10 stations shown, two—Sacramento and Phoenix—have calms more than 10% of the time. Grand Junction, Colorado, and Roswell, New Mexico, on the other hand, have calms less than 4% of the time.

Wind Rose

A *wind rose* summarizes wind speed and direction graphically as a series of bars pointing in different directions. The direction of each bar shows the direction *from* which the wind blows. Each bar is divided into segments, which represent wind speeds in a given range, for example, 1.1 to 4.7 mph (0.5 to 2.1 m/s). The length of a segment represents the percentage of the summarized hours that winds blew from the indicated direction with a speed in the given range.

TABLE 4.11-1 Temperature and Precipitation Summaries at Selected Meteorological Stations in the Six-State Study Area[a]

	Temperature (°F)[b]			Annual Precipitation (in.)[c]	
Station	Lowest Minimum[d]	Highest Maximum[d]	Mean[e]	Water Equivalent	Snowfall
Arizona					
Flagstaff	15.2	81.6	46.2	20.78	88.7
Phoenix	41.4	105.6	74.2	7.55	0.0
Tucson	38.6	99.6	68.7	11.59	1.1
California					
Bakersfield	38.4	98.6	65.0	6.17	0.1
Los Angeles	47.4	76.4	63.3	12.11	0.0
Redding	36.2	98.8	61.6	35.06	4.0
Sacramento	37.8	92.8	61.1	17.27	0.0
San Diego	48.0	76.3	64.4	10.17	0.0
San Francisco	42.4	73.3	57.3	20.17	0.0
Colorado					
Denver	16.9	88.2	50.1	15.47	59.6
Grand Junction	15.9	92.8	51.8	8.72	21.5
Pueblo	13.8	92.8	51.7	11.88	29.6
New Mexico					
Albuquerque	23.4	91.7	56.8	8.74	9.8
Farmington	19.3	91.1	52.1	8.62	11.1
Roswell	26.4	94.3	60.8	12.95	11.9
Nevada					
Elko	10.8	91.0	46.4	9.40	36.4
Las Vegas	34.3	104.5	68.1	4.19	0.9
Reno	20.6	91.5	51.3	7.29	22.9
Utah					
Moab	18.2	98.2	57.5	8.90	8.3
Salt Lake City	20.3	92.8	52.0	15.68	60.3
St. George	25.8	101.7	63.2	8.35	3.6

[a] Summary data presented in the table are based on a period of record from the inception of the meteorological station to December 31, 2007.

[b] To convert °F to °C use the following formula: °C = (°F – 32) × 5/9.

[c] To convert in. to cm, multiply by 2.54.

[d] "Lowest Minimum" denotes the lowest monthly average of the daily minimum during the period of record, which normally occurs in January. "Highest Maximum" denotes the highest monthly average of the daily maximum during the period of record, which normally occurs in July.

[e] National Climatic Data Center (NCDC) 1971 to 2000 monthly normals.

Source: WRCC (2008).

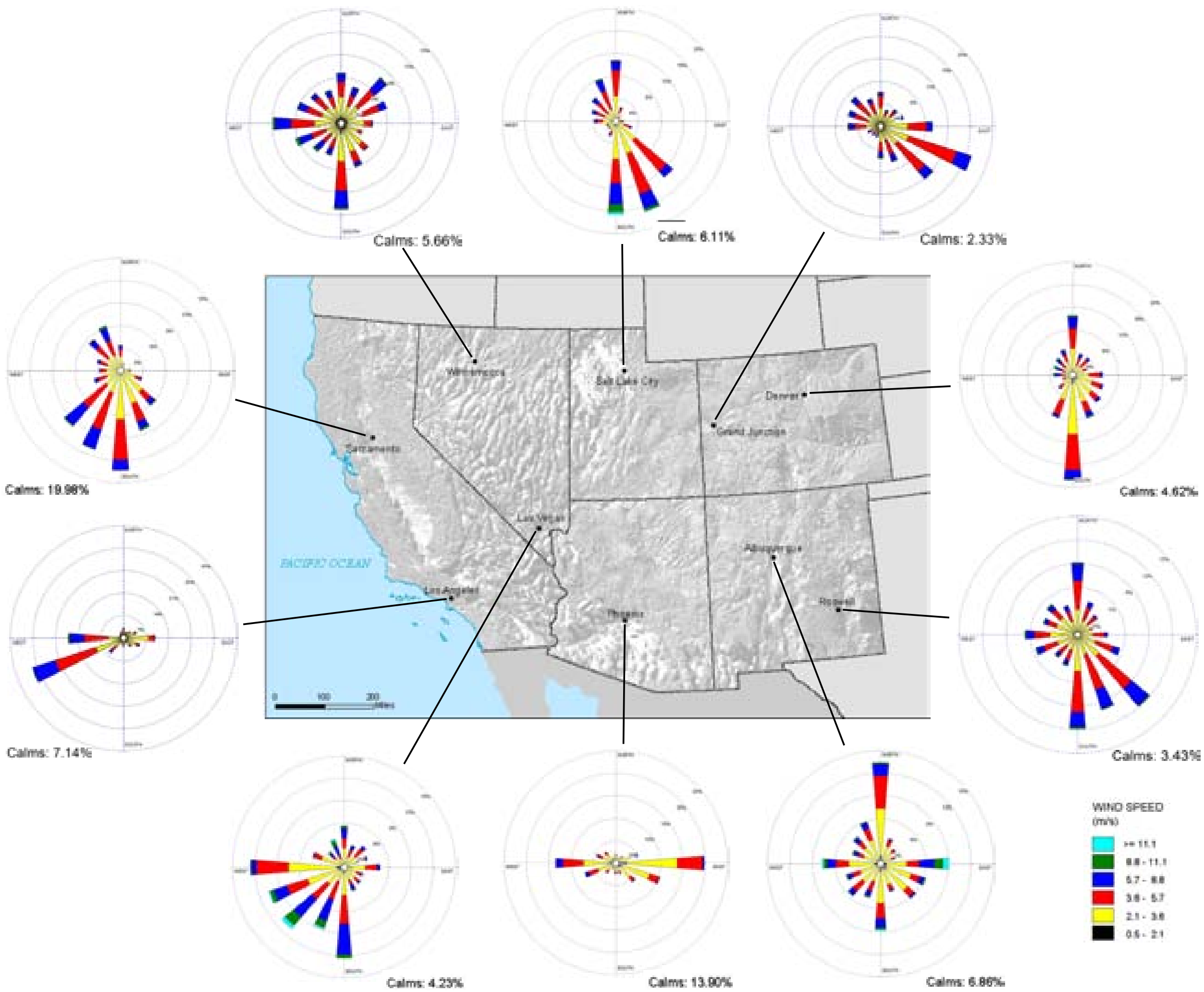

FIGURE 4.11-3 Wind Roses for Selected Meteorological Stations in the Six-State Study Area, 1990 to 1995 (Source: NCDC 1997)

Severe weather in the six-state study area includes thunderstorms, hail, dust storms, glaze, tornadoes, and hurricanes. Tornadoes and hurricanes are discussed collectively below.

Most of six-state study area has mountainous and rugged terrain, except for the easternmost low plains in Colorado and New Mexico, which are part of the tornado alley stretching from Texas to South Dakota. Complex terrain typically disrupts the mesocyclones associated with tornado-producing thunderstorms; thus tornadoes are less frequent and destructive in mountainous areas. Between January 1950 and June 2008, 2,984 tornadoes, with an annual average of 51, were reported in the six-state study area, as shown in Table 4.11-2 (NCDC 2008). The annual average number of tornadoes in the area was about 0.74 per 10,000 mi^2 (25,889 km^2), with the highest of 2.80 in Colorado and the lowest of 0.12 in Nevada. Most tornadoes that occurred in the area were relatively weak, mostly F0 to F2 on the Fujita

TABLE 4.11-2 Number of Tornadoes by Fujita Tornado Scale[a] in the Six-State Study Area for the Period of January 1, 1950 to June 30, 2008

	Number of Tornadoes by Fujita Tornado Scale								Number of Tornadoes per Year	
State	F[b]	F0	F1	F2	F3	F4	F5	Total	Mean	per 10,000 mi^2 [c]
Arizona	32	106	62	10	2	0	0	212	3.6	0.32
California	39	219	84	23	2	0	0	367	6.3	0.40
Colorado	55	1,006	508	111	18	1	0	1,699	29.0	2.80
Nevada	11	54	10	0	0	0	0	75	1.3	0.12
New Mexico	8	359	110	35	4	0	0	516	8.8	0.73
Utah	18	67	21	8	1	0	0	115	2.0	0.24
Total	163	1,811	795	187	27	1	0	2,984	51.0	0.74

[a] Fujita tornado scale is classified with the fastest 0.25-mi wind speeds:

F0 (gale):	40–72 mph (18–32 m/s)
1 (moderate):	73–112 mph (33–50 m/s)
2 (significant):	113–157 mph (51–70 m/s)
3 (severe):	158–206 mph (71–92 m/s)
4 (devastating):	207–260 mph (93–116 m/s)
5 (incredible):	261–318 mph (117–142 m/s).

[b] Not categorized by the Fujita tornado scale because damage level was not reported.

[c] To convert mi^2 to km^2, multiply by 2.590.

Source: NCDC (2008).

tornado scale. Twenty-seven "severe" F3 and one "devastating" F4 occurred, mostly on the eastern prairie of Colorado.

Hurricanes are a severe form of a tropical cyclone that can move inland from the Gulf of Mexico and the Pacific Ocean into the six-state study area. Because of the distance from the Gulf of Mexico and the Pacific Ocean and the rugged terrain, hurricanes seldom reach Colorado, Nevada, and Utah. On rare occasions, a tropical hurricane originating in the Gulf of Mexico may cause heavy rain in eastern and central New Mexico, but there is no record of serious wind damage from these storms (WRCC 2008). In the Pacific, hurricanes and tropical storms are formed off the coast of Central America and Mexico. Cold waters originating in the Arctic and moving south along the western coast will weaken any hurricane that moves toward the California coast. Accordingly, hurricanes generally dissipate before they reach California, although the state has infrequently been hit by the remnants of hurricanes and tropical storms. In addition, the general trend in hurricane motion is to the west-northwest because of the prevailing winds. Hurricanes that form in the Pacific follow this pattern, which directs hurricanes away from the West Coast of the United States. Historically, no hurricanes or tropical storms have hit the areas north of central California. Tropical storms hit southwestern Arizona next to the Gulf of California more than any other location in the six-state study area. Between 1851 and 2007, 14 storms (2 hurricanes and 12 tropical storms/depressions/lows) have passed within 100 mi (161 km) of southwestern Arizona (NOAA 2008).

4.11.2 Existing Emissions and Air Quality

This section provides general descriptions for existing emissions of criteria pollutants and volatile organic compounds (VOCs)[7] and the following federally based air quality programs likely to affect activities associated with solar energy development considered in this PEIS:

- National Ambient Air Quality Standards (NAAQS),
- Prevention of Significant Deterioration (PSD),
- Visibility Protection, and
- General Conformity.

4.11.2.1 Existing Emissions

Table 4.11-3 lists statewide criteria pollutant and VOC emissions for the six-state study area (WRAP 2006). The data upon which the table is based represent six source categories: point, area, onroad vehicles, nonroad vehicles, biogenic sources, and fire. Fire sources include wildfires, prescribed burning, and agricultural burning. Biogenic emissions are naturally occurring emissions from vegetation. Because of its large population and attendant industrial activities, California has the highest emissions of all criteria pollutants except sulfur dioxide (SO_2). Emissions from Arizona and Colorado are comparable for all criteria pollutants. Nevada generally has the lowest emissions among the six states. SO_2 emissions are the highest in Arizona, because of stationary "point" sources, primarily several coal-fired power plants.

4.11.2.2 National Ambient Air Quality Standards

The EPA has set National Ambient Air Quality Standards (NAAQS) for six criteria pollutants—SO_2, nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), PM (PM_{10} and $PM_{2.5}$),[8] and lead (Pb), as shown in Table 4.11-4. Primary NAAQS specify maximum ambient (outdoor air) concentration levels of the criteria pollutants with the aim of protecting public

[7] Volatile organic compounds (VOCs) are organic vapors in the air that can react with other substances, principally nitrogen oxides (NOx), to form ozone (O3) in the presence of sunlight.

[8] Particulate matter (PM) is dust, smoke, and other solid particles and liquid droplets in the air. The size of the particulate is important and is measured in micrometers (µm). A micrometer is 1 millionth of a meter (0.000039 in.). PM_{10} is particulate matter with an aerodynamic diameter less than or equal to 10 µm, and $PM_{2.5}$ is particulate matter with an aerodynamic diameter less than or equal to 2.5 µm.

TABLE 4.11-3 Statewide Criteria Pollutant and VOC Emissions for 2002 and Carbon Dioxide Emissions for 2005

	Statewide Emissions[a] (10^3 tons/yr)[b]						
State	SO_2	NO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	CO_2
Arizona	138	417	3,687	2,984	319	178	107,110
California	108	1,112	8,702	5,441	361	224	430,600
Colorado	118	412	3,474	1,619	349	173	103,990
Nevada	66	151	878	1,445	97	28	54,630
New Mexico	84	375	1,287	1,928	166	60	65,013
Utah	59	245	1,600	1,324	93	50	72,817
Total	573	2,712	19,628	14,741	1,385	773	834,160

a CO = carbon monoxide; CO_2 = carbon dioxide; NO_x = nitrogen oxides; $PM_{2.5}$ = particulate matter ≤ 2.5 μm; PM_{10} = particulate matter ≤ 10 μm; SO_2 = sulfur dioxide; VOC = volatile organic compound.

b To convert tons to metric tons, multiply by 0.907.

Sources: WRAP (2006); EPA (2008e).

health with an adequate margin of safety. Secondary NAAQS specify maximum concentration levels with the aim of protecting public welfare. The NAAQS specify different averaging times as well as maximum concentrations. Some of the NAAQS for averaging times of 24 hours or less allow the standard values to be exceeded a limited number of times per year, and others specify other procedures for determining compliance. States can have their own State Ambient Air Quality Standards (SAAQS), which must be at least as stringent as the NAAQS and they can include standards for additional pollutants (as is done in California, Nevada, and New Mexico). If a state has no standard corresponding to one of the NAAQS, the NAAQS apply.

An area where a criteria pollutant concentration exceeds NAAQS levels are is called a nonattainment area. Previous nonattainment areas where air quality has improved to meet the NAAQS are redesignated as maintenance areas and are subject to an air quality maintenance plan. Parts of the six-state study area have been in nonattainment for one or more of the NAAQS. Figure 4.11-4 shows these nonattainment areas for criteria pollutants, except for 1-hour O_3.[9] Currently, there are no nonattainment areas for NO_2 in the United States and no Pb NAAQS in the six-state study area. Eight-hour O_3 and PM_{10} account for more nonattainment areas than any other criteria pollutants and are in nonattainment over about half of California. Many counties in California have nonattainment areas for $PM_{2.5}$. Nonattainment areas for SO_2 and CO are limited to a few counties in the six-state study area.

9 Within the six-state study area, only the Denver area in Colorado was subject to the old 1-hour O_3 NAAQS, designated as the Subpart 1 Early Action Compact (EAC) area; however, it was redesignated nonattainment for 8-hour ozone, effective November 20, 2007 (EPA 2008f).

TABLE 4.11-4 National Ambient Air Quality Standards (NAAQS) and State Ambient Air Quality Standards (SAAQS) for Criteria Pollutants in the Six-State Study Area[a]

		NAAQS							
Pollutant[b]	Averaging Time	Value	Type[c]	Arizona[d]	California[e]	Colorado	Nevada[f]	New Mexico[g]	Utah[d]
SO_2	1-hour	75 ppb[h]	P	*	0.25 ppm (655 μg/m^3)	–[i]	–	–	*
	3-hour	0.50 ppm (1,300 μg/m^3)	S	*	–	700 μg/m^3 [j]	1,300 μg/m^3 (0.5 ppm)	–[k]	*
	24-hour	0.14 ppm (365 μg/m^3)	P	*	0.04 ppm (105 μg/m^3)	–[j]	365 μg/m^3 (0.14 ppm)	0.10 ppm[k]	*
	Annual	0.03 ppm (80 μg/m^3)	P	*	–	–[j]	80 μg/m^3 (0.03 ppm)	0.02 ppm[k]	*
NO_2	1-hour	100 ppb[l]	P	*	0.18 ppm (339 μg/m^3)	–	–	–	*
	24-hour	–	–	*	–	–	–	0.10 ppm	*
	Annual	0.053 ppm (100 μg/m^3)	P, S	*	0.030 ppm (57 μg/m^3)	100 μg/m^3	100 μg/m^3 (0.05 ppm)	0.05 ppm	*
CO	1-hour	35 ppm (40 mg/m^3)	P	*	20 ppm (23 mg/m^3)	40 mg/m^3	40,000 μg/m^3 (35 ppm)	13.1 ppm	*
	8-hour	9 ppm (10 mg/m^3)	P	*	9.0 ppm (10 mg/m^3) 6 ppm (7 mg/m^3)[m]	10 mg/m^3	10,000 μg/m^3 (9.0 ppm)[n] 6,670 μg/m^3 (6.0 ppm)[o]	8.7 ppm	*
O_3	1-hour	0.12 ppm [p]	P, S	*	0.09 ppm (180 μg/m^3)	235 μg/m^3	235 μg/m^3 (0.12 ppm) 195 μg/m^3 (0.10 ppm)[q]	–	*
	8-hour	0.075 ppm	P, S	*	0.070 ppm (137 μg/m^3)	–	–	–	*
PM_{10}	24-hour	150 μg/m^3	P, S	*	50 μg/m^3	150 μg/m^3	150 μg/m^3	–	*
	Annual	–	–		20 μg/m^3	50 μg/m^3	50 μg/m^3	–	*
$PM_{2.5}$	24-hour	35 μg/m^3	P, S	*	–	–	–	–	*
	Annual	15.0 μg/m^3	P, S	*	12 μg/m^3	–	–	–	*

TABLE 4.11-4 (Cont.)

		NAAQS							
Pollutant[b]	Averaging Time	Value	Type[c]	Arizona[d]	California[e]	Colorado	Nevada[f]	New Mexico[g]	Utah[d]
Pb	30-day	–	–	*	$1.5\ \mu g/m^3$	$1.5\ \mu g/m^3$	–	–	*
	calendar quarter	$1.5\ \mu g/m^3$	P, S	*	–	–	$1.5\ \mu g/m^3$	–	*
	rolling 3-month	$0.15\ \mu g/m^3$ [r]	P, S	*	–	–	-	–	*

[a] Detailed information on attainment determination criteria for NAAQS and reference method for monitoring is available in 40 CFR 50. Attainment determination criteria for each state are similar to those for the NAAQS.

[b] CO = carbon monoxide; NO_2 = nitrogen dioxide; O_3 = ozone; Pb = lead; $PM_{2.5}$ = particulate matter ≤ 2.5 μm; PM_{10} = particulate matter ≤ 10 μm; SO_2 = sulfur dioxide.

[c] P = Primary standard whose limits were set to protect public health; S = Secondary standard whose limits were set to protect public welfare.

[d] An asterisk indicates same as the NAAQS.

[e] The State of California has standards for additional pollutants such as visibility-reducing particles, sulfates, hydrogen sulfide, and vinyl chloride, which are not presented in this table; also refer to CARB (2008) for additional pollutants for California.

[f] The State of Nevada has standards for additional pollutants such as visibility and hydrogen sulfide, which are not presented in this table; also refer to NDEP (2008) for additional pollutants for Nevada.

[g] The State of New Mexico has standards for additional pollutants such as total suspended particulates, hydrogen sulfide, and total reduced sulfur, which are not presented in this table; also refer to NMED (2008) for additional pollutants for New Mexico.

[h] Effective August 23, 2010.

[i] A dash indicates that no standard exists.

[j] Colorado has also established increments limiting the allowable increase in ambient concentrations over an established baseline.

[k] Different standards apply within 3.5 mi (5.6 km) of the Chino Mines Company smelter furnace stack at Hurley (0.50 ppm 3-hour; 0.14 ppm 24-hour; 0.03 ppm annual).

[l] Effective April 12, 2010.

[m] Lake Tahoe.

[n] Below 5,000 ft (1,500 m) above mean sea level.

[o] Above 5,000 ft (1,500 m) above mean sea level.

[p] Applies only in limited areas. As of June 15, 2005, the EPA revoked the 1-hour O_3 standard in all areas except the 8-hour O_3 nonattainment Early Action Compact (EAC) Areas.

[q] Lake Tahoe Basin.

[r] Effective January 12, 2009.

Sources: ADEQ (2008); CARB (2008); CDPHE (2008); EPA (2010); NDEP (2008); NMED (2008); UDEQ (2008).

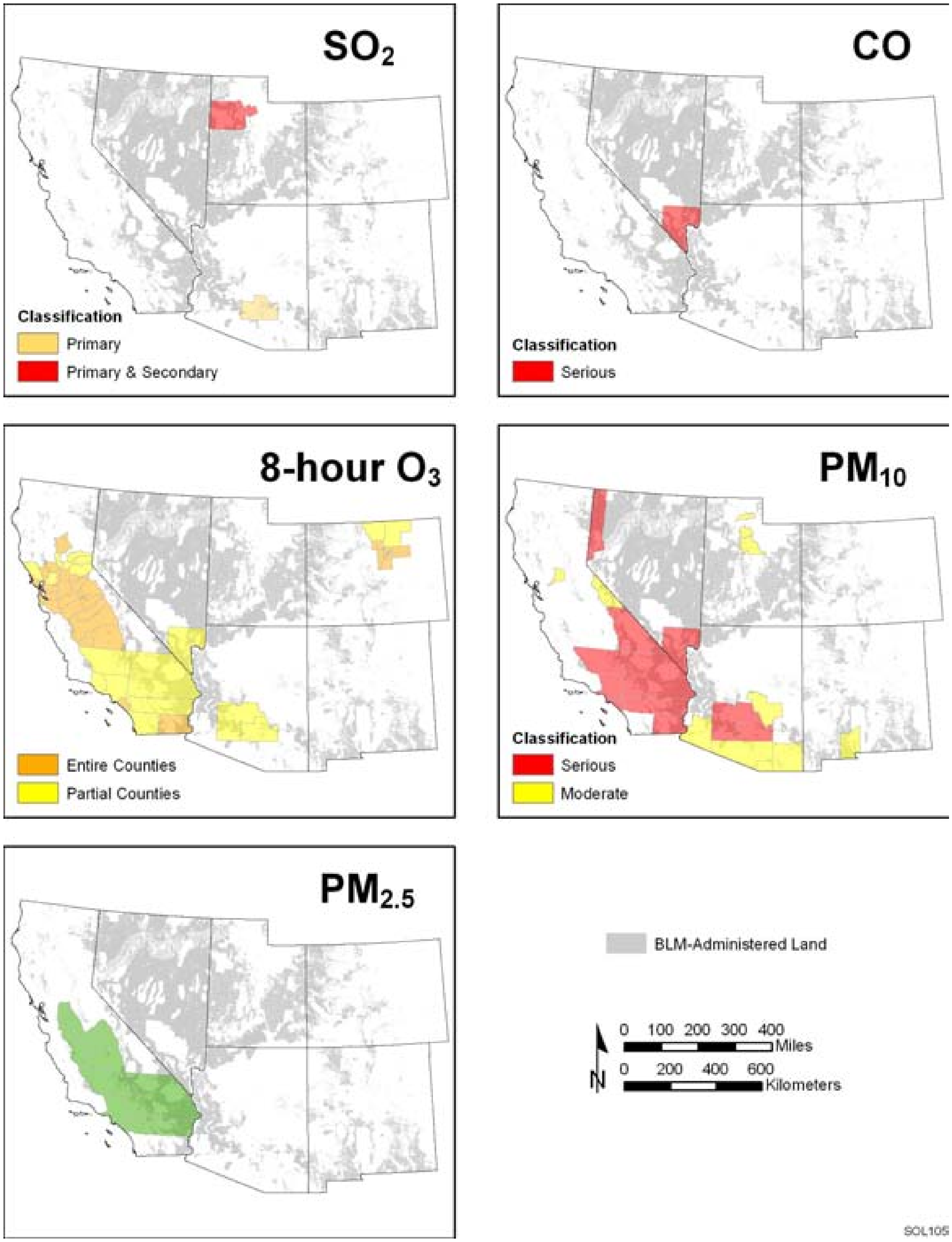

FIGURE 4.11-4 Nonattainment Areas for SO_2, CO, 8-hour O_3, PM_{10}, and $PM_{2.5}$ in the Six-State Study Area (For SO_2, CO, and PM_{10}, classification colors are shown for whole counties and denote the highest classification in that county. For O_3, partial counties, those with part of the county designated nonattainment and part attainment, are shown as full counties on the map. For $PM_{2.5}$, partial counties are shown as whole counties.) (Source: EPA 2008f)

4.11.2.3 Prevention of Significant Deterioration

While the NAAQS (and SAAQS) place upper limits on the levels of air pollution, Prevention of Significant Deterioration (PSD) regulations applying to attainment areas place limits on the total increase in ambient pollution levels above established baseline levels for SO_2, NO_2, and PM_{10}, thus preventing "polluting up to the standard" (see Table 4.11-5). These allowable increases are smallest in Class I areas, such as national parks and wilderness areas. The rest of the country is subject to larger Class II increments. States can choose a less stringent set of Class III increments, but they have not done so. Major (large) new and modified stationary sources must meet the requirements for the area in which they are locating and any areas they impact. Thus, a source locating in a Class II area near a Class I area would need to meet the more stringent Class I increment in the Class I area and the Class II increment elsewhere, as well as any other applicable requirements.

TABLE 4.11-5 Federal PSD Increments

Pollutant	Averaging Time	PSD Increment ($\mu g/m^3$) Class I	Class II
SO_2	3-hour	25	512
	24-hour	5	91
	Annual	2	20
NO_2	Annual	2.5	25
PM_{10}	24-hour	8	30
	Annual	4	17

Source: 40 CFR 52.21.

In addition to capping increases in criteria pollutant concentrations below the levels set by the NAAQS, the PSD program mandates stringent control technology requirements for new and modified major sources. In Class I areas, Federal Land Managers are responsible for protecting the air-quality-related values (AQRVs) of those areas, such as scenic, cultural, biological, and recreational resources. As stated in the Clean Air Act (CAA), the AQRV test requires the Federal Land Manager to evaluate whether the proposed project will have an adverse impact on the AQRVs, including visibility. As a matter of policy, EPA recommends that the permitting authority notify the Federal Land Managers when a proposed PSD source would locate within 62 mi (100 km) of a Class I area. If the source's emissions are considerably large (subjective), EPA recommends that sources beyond 100 km be brought to the attention of the Federal Land Manager. The Federal Land Manager then becomes responsible for demonstrating that the source's emissions could have an adverse effect on AQRVs.

Even if PSD increments are met, if the Federal Land Manager determines that there is an impact on an AQRV, the permit may not be issued. Figure 4.11-5 shows the locations of Class I PSD areas over the six-state study area. All BLM lands are currently designated as Class II areas, with few exceptions.[10]

[10] The BLM administers four mandatory federal PSD Class I areas: Domeland, San Gorgonio, and Yolla Bolly-Middle Eel in California, and Hells Canyon in Oregon. All of these areas represent congressional expansion of mandatory federal PSD Class I areas established in the August 7, 1977, amendments to the federal CAA. The original portions of these areas are administered by the USDA Forest Service (Archer 2010).

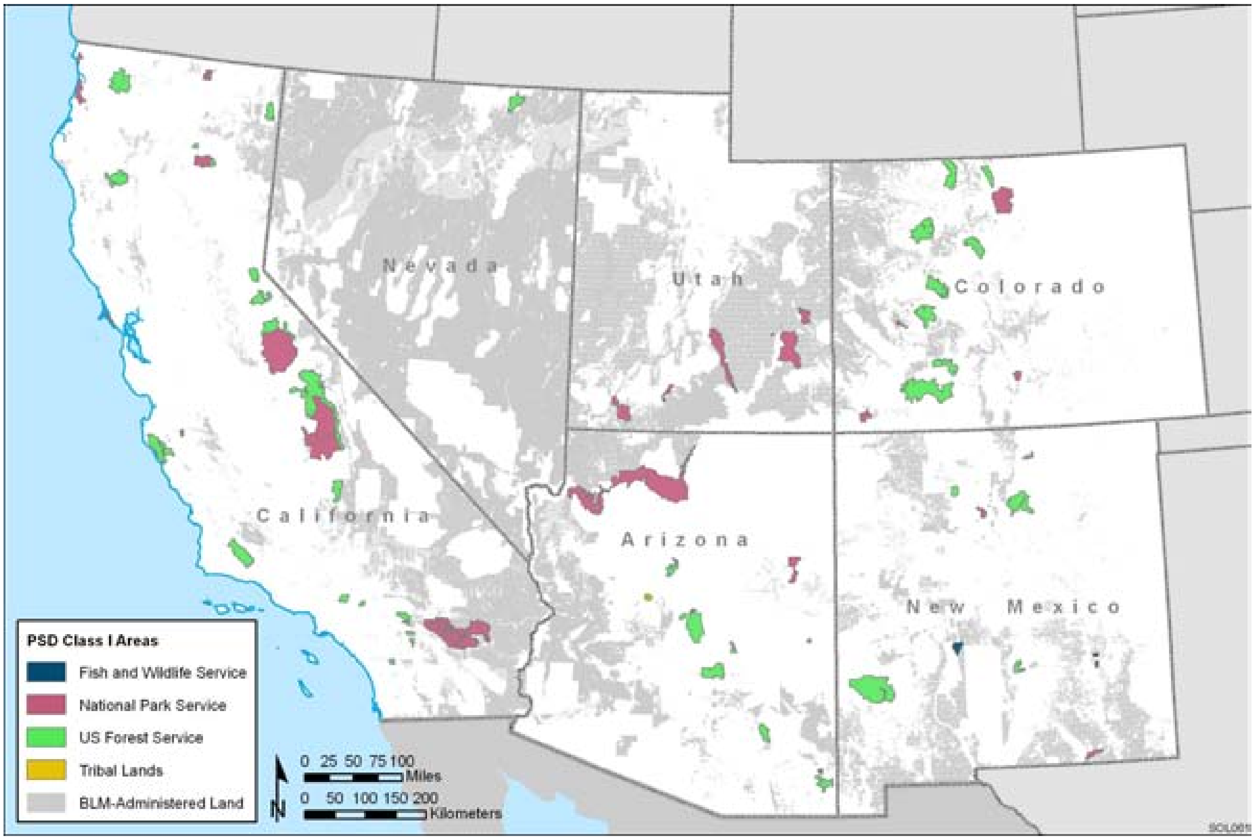

FIGURE 4.11-5 PSD Class I Areas in the Six-State Study Area (Source: EPA 2008g)

4.11.2.4 Visibility Protection

Visibility was singled out for particular emphasis in the Clean Air Act Amendments of 1977. Visibility in a Class I area is protected under two sections of the Act. Section 165 provides for the PSD program (described above) for new sources. Section 169(A), for older sources, describes requirements for both reasonably attributable single sources and regional haze that address multiple sources. Federal Land Managers have a particular responsibility to protect visibility in Class I areas. Even sources located outside a Class I area may need to obtain a permit that assures no adverse impact on visibility within the Class I area, and existing sources may need to retrofit controls. The EPA's 1999 Regional Haze Rule set goals of preventing future and remedying existing impairment to visibility in Class I areas. States had to revise their State Implementation Plans (SIPs) to establish emission-reduction strategies to meet a goal of natural conditions by 2064.

4.11.2.5 General Conformity

Federal departments and agencies are prohibited from taking actions in nonattainment and maintenance areas unless they first demonstrate that the actions would conform to the SIP as it applies to criteria pollutants. Transportation-related projects are subject to requirements for transportation conformity. General conformity requirements apply to stationary sources. Conformity addresses only those criteria pollutants for which the area is in nonattainment or maintenance (e.g., VOCs and NO_x for O_3). If annual source emissions are below specified threshold levels, no conformity determination is required. If the emissions exceed the threshold, a conformity determination must be undertaken to demonstrate how the action will conform to the SIP. The demonstration process includes public notification and response and may require extensive analysis.

The EPA proposed new general conformity regulations on January 8, 2008 (58 FR 1402); there will be changes to the applicable general conformity requirements upon promulgation.

4.11.3 Greenhouse Gas Emissions and Climate Change

The "greenhouse effect" is a natural phenomenon occurring when certain gases (greenhouse gases [GHGs]) absorb much of the long-wave thermal radiation emitted by the land and ocean and reradiate it back to earth, keeping the atmosphere warmer than it otherwise would be. Atmospheres, including water vapor and clouds, are also a major contributor to the greenhouse effect. Without the greenhouse effect, the earth would not be warm enough to support its existing biota. However, if the greenhouse effect becomes stronger, the earth's average temperature will rise, resulting in global warming. Even a slight increase in temperature may cause problems for humans, plants, and animals. Historic data indicate that the global surface temperature has increased 0.74 ± 0.18C° (1.33 ± 0.32F°) during the last 100 years, and that the rate of warming has accelerated over the last 50 years (IPCC 2007). Global warming has occurred in the distant past as a result of natural influences, but it is now occurring, especially since the Industrial Revolution, as a result of increased anthropogenic emissions of GHGs. For example, concentrations of CO_2, a primary GHG in the atmosphere, have continuously increased from approximately 280 ppm in preindustrial times to 379 ppm in 2005, a 35% increase (IPCC 2007).

Because the global warming phenomenon is not distributed evenly across the Earth's surface, it is increasingly referred to as "global climate change." Climate change is a more flexible term than global warming, reflecting the fact that changes in the climate due to warming are not universal across the globe—some regions will warm, others will cool. Some of the critical climate changes already observed in the United States are increased numbers of heat waves; changes in annual precipitation and drought, with significant regional variability; regional changes in snow cover; sea level rises along the Atlantic and Gulf coasts; and increases in the number and intensity of tropical storms and hurricanes.

The GHGs include water vapor (H_2O), ozone (O_3), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and trace amounts of fluorinated gases, such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Along with clouds, water vapor (the most abundant GHG) accounts for the largest percentage of the greenhouse effect. However, water vapor concentrations fluctuate regionally, and human activity does not directly affect water vapor concentrations except at a local scale, such as near irrigated fields. Typically, water vapor is not included in climate change analyses.

The contribution of a given gas to the greenhouse effect is affected by both its abundance and its characteristics, such as the efficiency of the molecule as a GHG and its atmospheric lifetime. Global warming potential (GWP) is a relative measure of how much a given mass of a GHG is estimated to contribute to climate change compared with that of the same mass of CO_2. A GWP is calculated over a specific time interval. For example, CH_4 has a relatively high GWP during its short lifetime, and thus has a large GWP of 72 over a 20-year period but a GWP of 25 over a 100-year period (IPCC 2007). Over the 100-year time horizon, N_2O has a GWP of 298. Some GWPs, such as fluorinated gases, are emitted in smaller quantities relative to CO_2, but have high GWPs; SF_6 has the highest GWP—22,800.

GHGs are emitted into the atmosphere through natural processes and human activities. CO_2 occurs naturally and also enters the atmosphere through the burning of fossil fuels, solid wastes, and trees and wood products, and also as a result of chemical reactions (EPA 2008e). CH_4 is emitted during the production and transport of fossil fuels and is also released to the environment as emissions from microbes, livestock, agricultural practices, and volcanoes. Natural emissions of N_2O primarily result from bacterial breakdown of nitrogen in soils and in the earth's oceans. N_2O is also emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste. Fluorinated gases are powerful GHGs that are emitted from various industrial activities.

In general, GHG emissions are inventoried for CO_2, CH_4, N_2O, and high-GWP gases in terms of "CO_2 equivalent," which is computed by multiplying the weight of the gas being measured (e.g., CH_4) by its estimated GWP (e.g., 25 for CH_4). CO_2 equivalent emissions for 2005 from fossil fuel combustion are available for the GHGs listed above by state and for the entire United States (EPA 2008e). Data on emissions of all GHGs by state also are available, but the most recent inventory years are 2000 or 2002, and the units used differ among states. Therefore, only CO_2 emissions by state for 2005 are presented in this analysis. For the 1996-2005 period, CO_2 emissions accounted for about 83% of the total GHG emissions in terms of CO_2 equivalent, followed by CH_4 with about 10% of the total. N_2O and high-GWP gases were minor contributors (about 5% and 2%, respectively) to total GHG emissions because of their relatively low concentrations. Accordingly, total GHG emissions would be about 20% more than CO_2 emissions discussed below, and thus should be interpreted in that context.

Because CO_2 is widely emitted worldwide, uniformly mixed throughout the troposphere, and stable, its climatic impact does not depend on the geographic location of sources; that is, the global total is the important factor with respect to climate change. Therefore, a comparison between United States and global emissions and the total emissions from the six-state study area is useful in understanding whether CO_2 emissions are significant with respect to climate change. As shown in Table 4.11-3, California is the largest contributor to CO_2 emissions among the six states (about 52% of the total six-state emissions) because of its population and attendant industrial and human activities (EPA 2008e). Existing total CO_2 emissions from the six-state study area would be about 12.7% of 2005 total U.S. CO_2 emissions. In 2005, CO_2 emissions in the United States were about 21% of worldwide emissions (EIA 2008); current emissions for the six-state study area were about 2.7% of global emissions.

The EPA issued a rule on the Mandatory Reporting of Greenhouse Gases (generally referred to as the Greenhouse Gas Reporting Rule) (40 CFR Parts 86, 87, 89, 90, 94, 98, 1033, 1039, 1042, 1045, 1048, 1051, 1054, 1065) on October 30, 2009. The rule became effective on December 29, 2009, and requires suppliers of fossil fuels or industrial greenhouse gases, manufacturers of vehicles and engines, and facilities that emit 25,000 metric tons or more per year of GHG emissions to submit annual emissions reports to EPA beginning in calendar year 2010. Requirements for additional sources and source categories are under development.

The California Global Warming Solutions Act of 2006 (Health and Safety Code, 38500 et seq.) requires the state to reduce its GHG emissions to 1990 levels by 2020–a reduction of approximately 25% (173 million tons [157 million metric tons] of carbon dioxide equivalent) under a business as usual case. The law covers the Kyoto Protocol GHGs: CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6 and empowers the California Air Resources Board to develop regulations and market mechanisms to achieve the emissions reductions. Nevada requires electrical generating power plants in the state that produce electricity for sale, have a maximum output design capacity of 5 megawatts or greater, and produce greenhouse gases to annually report their emissions of Kyoto Protocol GHGs to The Climate Registry. Renewable energy sources are specifically exempted from the reporting requirement. Utah announced a goal of reducing its GHG emissions to 2005 levels by 2020 through various policy mechanisms.

The physical effects of climate change in the western United States include warmer springs (with earlier snowmelt), melting glaciers, longer summer drought, and increased wildland fire activity (Westerling et al. 2006). All these factors contribute to detrimental changes to ecosystems (e.g., increases in insect and disease infestations, shifts in species distribution, and changes in the timing of natural events). Adverse impacts on human health, agriculture (crops and livestock), infrastructure, water supplies (reduced stream flow and rising stream temperatures), energy demand (due to increased intensity of extreme weather and reduced water for hydropower), and fishing, ranching, and other resource use activities are also predicted (GAO 2007; Backlund et al. 2008; National Science and Technology Council 2008).

4.12 VISUAL RESOURCES

4.12.1 Introduction

Visual resources refer to all objects (man-made and natural, moving and stationary) and features (e.g., landforms and water bodies) that are visible on a landscape. These resources add to or detract from the scenic quality (or visual appeal) of the landscape. A visual impact is the creation of an intrusion or perceptible contrast that affects the scenic quality of a landscape. A visual impact can be perceived by an individual or group as either positive or negative, depending on a variety of factors or conditions (e.g., personal experience, time of day, and weather/season).

The BLM's responsibility for managing visual (scenic) resources of public lands is established by law. The National Environmental Policy Act requires that measures be taken to "assure for all Americans…aesthetically pleasing surroundings," and FLPMA states that "public lands will be managed in a manner which will protect the quality of scenic values of these lands." Some states and local jurisdictions also have laws, ordinances, and regulations to manage and protect visual resources within their jurisdictions, and where applicable, solar energy development would be assessed for compliance with these laws, ordinances, and regulations.

Methods have been developed to assist federal agencies responsible for visual resource planning and assessing visual resource impacts. The BLM conducts visual inventories and analyses within the guidelines established in its Visual Resource Management (VRM) System (BLM 1986a,b). The BLM uses the VRM procedures and methods to support decision making for planning activities and reviews of proposed developments on BLM-administered lands. Since 1980, the BLM has used the system to evaluate thousands of projects on public lands while minimizing their visual impacts.

The VRM system includes systematic processes for inventorying scenic values on BLM-administered lands, establishing visual resource management objectives for those values through the Resource Management Plan (RMP) process, and evaluating proposed activities to determine whether they conform with the management objectives. The primary components of BLM's VRM system include visual resource inventory (VRI), VRM class designation, and visual contrast rating (see Section 5.12 of this PEIS for more information about VRM class designation and visual contrast ratings).

BLM's VRI process provides BLM managers with a means for determining visual values for a tract of land. The inventory includes the following three components: scenic quality evaluation, sensitivity level analysis, and delineation of distance zones. These inventory components provide systematic processes for rating the visual appeal of a tract of land, measuring public concern for scenic quality, and determining whether the tract of land is visible from travel routes or observation points. The text box below provides more detailed information about the VRI process.

On the basis of the evaluation results, BLM-administered lands are placed into one of four VRI classes. These inventory classes represent the relative value of the visual resources. The VRI class values may be affected by visual impacts associated with land management activities, such as utility-scale solar energy development. More information about VRI methodology is available in *Visual Resource Inventory*, BLM Manual Handbook 8410-1 (BLM 1986a).

The results of the VRI become an important component of BLM's RMP for the area. The RMP establishes how the public lands will be used and allocated for different purposes, and the VRI classes provide the basis for considering visual values in the RMP land use allocation process. When a land use allocation is made, the area's visual resources are then assigned to VRM classes with established management objectives, including the degree of contrast resulting from a project or management activity permissible for that VRM classification. BLM activities must conform to the VRM objectives that apply to the project area as established in the RMP process. Once visual resources are inventoried and visual management classes are delineated, the

BLM Visual Resource Inventory

Scenic Quality Evaluation. BLM inventory guidelines rate the apparent scenic quality of discrete areas of land as A, B, or C on the basis of their landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications (BLM 1986a). A-rated areas have outstanding or distinctive diversity or interest, B-rated areas have common or average diversity or interest, and C-rated areas have minimal diversity or interest.

Sensitivity Level Analysis. Sensitivity levels measure public concern for scenic quality. Areas are assigned a high, medium, or low sensitivity level by analyzing indicators of public concern: types of users, amount of use, public interest, adjacent land uses, special areas, and other factors that may be indicators of visual sensitivity. Special areas such as wilderness study areas, wild and scenic rivers, and scenic roads or trails require special consideration for protection of their scenic quality.

Distance Zone Delineation. The visual impact of a particular project will become less perceptible with increasing distance between the viewer and the project. The VRI uses three distance zones to account for this effect. It looks at locations (routes) such as highways, rivers, or other viewing locations from which a viewer could observe a particular site. The foreground-middleground zone includes areas at a distance of less than 3 to 5 mi (5 to 8 km) from the viewer. Viewed areas beyond the foreground-middleground zone but usually less than 15 mi (24 km) from the viewer are in the background zone. Areas hidden from view in the foreground-middleground zone or background zone are in the seldom-seen zone.

Visual Resource Inventory Classification. After the analyses is performed for scenic quality, sensitivity level, and distance zones, an overlay process is used to assign visual resource inventory classes for the areas of concern. Class I is assigned to those areas where a management decision has been made previously to maintain a natural landscape. This includes areas such as national wilderness areas, the wild section of national wild and scenic rivers, and other congressionally and administratively designated areas where decisions have been made to preserve a natural landscape. Classes II, III, and IV are assigned relative visual values based on a combination of scenic quality, sensitivity level, and distance zones. Class II is the highest rating for lands without special designation; Class III represents a moderate value; and Class IV represents the least relative value. Inventory classes are informational in nature and provide the basis for considering visual values in the RMP process. They do not establish management direction and are not intended to be used as a basis for constraining or limiting surface-disturbing activities.

potential impacts of a proposed project can be evaluated relative to management objectives for the affected area. The vulnerability of visual resources to impact-producing visual contrasts then determines the need for adjustments to or mitigation of the proposed development.

4.12.2 BLM Visual Resource Management in the Six-State Study Area

The six states analyzed in this PEIS encompass a great variety of landscape types, determined by geology, topography, climate, soil type, hydrology, and land use. This vast region, which encompasses nearly 694,000 mi^2 (1.8 million km^2), includes spectacular landscapes such as the Grand Canyon and Sequoia, Yosemite, and Zion National Parks, as well as relatively flat and visually monotonous landscapes such as the High Plains of eastern Colorado. Although much of the region is sparsely populated, human influences have altered much of the visual landscape, especially with respect to land use and land cover. In some places, intensive human activities, such as mineral extraction and energy development, have seriously degraded visual qualities. Large, fast-growing cities such as Las Vegas and Phoenix also contain heavily altered landscapes, with urban sprawl and associated visual blight spreading into what were recently relatively intact landscapes. Nonetheless, the various scenic attractions of the six-state study area help attract millions of tourists to the region each year and contribute to making tourism a major component of some regional and local economies.

Because scenic resources in a given area are largely determined by geology, topography, climate, soil type, and vegetation, such resources are generally homogenous within an ecoregion (an area that has a general similarity in ecosystems and is characterized by the spatial pattern and composition of biotic and abiotic features, including vegetation, wildlife, geology, physiography, climate, soils, land use, and hydrology [EPA 2007a]). Ecoregions of the United States as mapped and described by the EPA are presented in Appendix I of this PEIS as the basis for describing visual resources at a general level. The Level III ecoregion classification includes 22 ecoregions covering the six-state study area (Figure I.1, Appendix I). The ecoregion descriptions presented in Appendix I were primarily derived from EPA (2002), except where noted. Table 4.12-1 summarizes, by state, selected scenic resources (e.g., national parks, monuments, wilderness areas, historic trails, scenic highways) occurring within the six-state study area. Additional resource areas that may have important scenic qualities or sensitivities exist, such as ACECs designated for outstanding scenic values, Natural Heritage Areas, state and local parks, and others.

4.13 ACOUSTIC ENVIRONMENT

This section provides general descriptions of noise and vibration and the existing acoustic environment in the six-state study area. Potential impacts of noise and vibration on wildlife are discussed in Section 5.10.2.

4.13.1 Noise

Any pressure variation that the human ear can detect is considered sound; noise is unwanted sound. Sound is described in terms of amplitude (perceived as loudness) and frequency (perceived as pitch). Sound pressure levels are typically measured with the logarithmic decibel (dB) scale. To account for human sensitivity to frequencies of sound (i.e., less sensitivity to lower and higher frequencies, and most sensitivity to sounds between 1 and 5 kHz), A-weighting (denoted by dBA) is widely used and is correlated with a human's subjective reaction to sound (Acoustical Society of America 1983, 1985). To account for variations of sound with time, the equivalent continuous sound level (L_{eq}) is used. L_{eq} is the continuous sound level during a specific time period that would contain the same total energy as the actual time-varying sound. For example, L_{eq} (1-h) is the 1-hour equivalent continuous sound level. In addition, human responses to noise differ depending on the time of the day; humans experience more annoyance from noise during nighttime hours. The day-night average sound level (L_{dn} or DNL) is the average noise level over a 24-hour period, after the addition of 10 dB to sound levels from

TABLE 4.12-1 Summary of Selected Potentially Sensitive Visual Resource Areas within the Six-State Study Area[a]

Potentially Sensitive Visual Resource Areas	Arizona	California	Colorado	Nevada	New Mexico	Utah
National Parks[b]	3	8	4	2	2	5
National Monuments[c]	19	10	6	0	11	7
Wilderness Areas	87	130	38	70	25	32
Wilderness Study Areas	8	80	48	57	67	99
National Recreation Areas[d]	2	5	2	2	1	2
National Conservation Areas[e]	3	3	2	3	1	1
Other National Park Service Areas[f]	4	9	3	1	2	1
National Natural Landmarks	9	32	11	6	12	4
National Historic Landmarks	9	63	4	2	11	4
National Scenic Trails	0	1	1	0	1	0
National Historic Trails	2	4	3	3	2	4
National Scenic Highways[g]	5	7	10	3	8	7
National Scenic Areas	0	1	0	0	0	0
National Scenic Research Areas	0	0	0	0	0	1
National Wild and Scenic Rivers[h]	1	14	2	0	4	0
National Wildlife Refuges	9	35	7	8	7	4
State Totals	66	192	55	30	62	40

a Includes features wholly or partly within state boundaries.

b Does not include national historical parks.

c Includes national monuments managed by the NPS, USFS, BLM, and USFWS.

d Includes national recreation areas managed by the NPS and USFS.

e Includes Headwaters Forest Reserve.

f Includes national historical parks, national preserves, national reserves, national seashores, national historic sites, national battlefields, national memorials, national memorial parkways, and the San Francisco Presidio.

g Includes all-American roads and national scenic byways.

h The congressionally authorized wild and scenic study rivers are not included. See Section 4.9.1.2 for details on this classification.

10 p.m. to 7 a.m. to account for the greater sensitivity of most people to nighttime noise. The Community Noise Equivalent Level (CNEL) was introduced in the early 1970s by the State of California and gives 5-dB weighting to evening hours (7 to 10 pm), whereas L_{dn} has no weighting. As a practical matter, the CNEL and L_{dn} are almost equivalent, usually differing by less than 1 dB, and thus they can be used interchangeably.

People's responses to changes in sound levels generally exhibit the following characteristics (NWCC 2002). Except under laboratory conditions, a 1-dB change in sound level is not perceptible. Generally, a 3-dB change is considered a just-noticeable difference, and a

10-dB increase is subjectively perceived as a doubling in loudness and almost always causes an adverse community response.

Several important factors affect the propagation of sound in the outdoor environment (Anderson and Kurze 1992):

- *Source characteristics,* such as sound power, directivity, and configuration;

- *Geometric spreading* as the sound moves away from the source, which does not depend on frequency, and 6- and 3-dB reductions per doubling of distance for point (e.g., fixed equipment) and line (e.g., road traffic) sources, respectively;

- *Atmospheric absorption,* which depends strongly on frequency and relative humidity, somewhat on temperature, and slightly on pressure;

- *Ground effects,* which result from interferences of reflected sound by reflecting surfaces (e.g., ground surfaces) with direct sound;

- *Meteorological effects* due to turbulence and variations in vertical wind speed and temperature; and

- *Screening effects* by topography, structures, dense vegetation, and other natural or man-made barriers.

Among the factors listed above, meteorological effects due to vertical wind speed and temperature profiles are likely the most important in noise propagation over longer distances (say, beyond several hundred meters from the noise sources). Because of surface friction, wind speed typically increases with height, which will bend the path of sound downward to "focus" it on the downwind side and upward to make a "shadow"[11] on the upwind side of the source ("wind gradient effect"). Also, on a typical clear, sunny day, temperature tends to decrease with height due to solar heating on the ground, the condition known as "temperature lapse." Similar to the wind gradient effect, upward refraction of sound creates a "temperature gradient effect" shadow zone. Conversely, on a clear night with calm or low winds, temperature increases with height due to radiative cooling of surface air. This nocturnal temperature inversion is the strongest in winter months due to a longer nighttime period. Temperature inversions can cause downward refraction to create enhanced sound fields near a noise source, particularly because there would be little, if any, shadow zone within 1 or 2 mi (1.6 or 3.2 km) of the source in the presence of a strong temperature inversion (Beranek 1988). Temperature gradient effects are exerted omnidirectionally from the source, in contrast to wind gradient effects, which are limited to mostly upwind and downwind areas.

A refined noise analysis would employ a sound propagation model that integrates most of the sound attenuation mechanisms noted above along with detailed source-, receptor-, and

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[11] A shadow zone is defined as the region where direct sound does not penetrate because of upward diffraction.

site-specific data, such as land use and topography. However, in many screening applications, only geometric spreading or geometric spreading combined with ground effects is considered when predicting noise levels. This method assumes a simplified uniform (isothermal) atmosphere with no wind, which is unusual for typically changing atmospheric conditions. For a temperature lapse condition typical of daytime, sound levels would be about 5 dB lower than those for the uniform condition (Saurenman et al. 2005). For a temperature inversion condition typical of nighttime, sound levels would be about 5 to 10 dB higher than those for the uniform condition. Just before sunrise, when the temperature inversion is the strongest, sound levels would be about 10 to 15 dB higher (but noise-producing operations at solar facilities are not anticipated to occur at this time of day).

The Noise Control Act of 1972, along with its subsequent amendments (Quiet Communities Act of 1978, USC 42 4901–4918), delegates to the states the authority to regulate environmental noise and directs government agencies to comply with local community noise statutes and regulations.

Many local noise ordinances are qualitative, such as prohibiting excessive noise or noise that results in a public nuisance. Because of the subjective nature of such ordinances, they are often difficult to enforce. However, several states and counties have established quantitative noise-level regulations, which typically specify environmental noise limits based on the land use of the property receiving the noise. Table 4.13-1 lists the maximum permissible noise levels for Colorado by land use zone and by time of day. In California, noise is regulated at the state and local level. The state requires each municipality and county to have a Noise Element of the General Plan, a substantial noise database and blueprint for making land use decisions in that jurisdiction (CGOPR 2003). State land use compatibility criteria for the community noise environment presented in terms of L_{dn} or CNEL are used to identify the noise levels that are compatible with various types of land uses. The Noise Element of the General Plan contains goals and policies to support land use planning that will allow the jurisdiction to ensure that these criteria are met for various land uses.

TABLE 4.13-1 Colorado Limits on Maximum Permissible Noise Levels

	Maximum Permissible Noise Level (dBA)[a]	
Zone	7 am to 7 pm[b]	7 pm to 7 am
Residential	55	50
Commercial	60	55
Light industrial	70	65
Industrial	80	75

[a] At a distance of 25 ft or more from the property line. Periodic, impulsive, or shrill noises are considered a public nuisance at a level 5 dBA less than those tabulated.

[b] The tabulated noise levels may be exceeded by 10 dBA for a period not to exceed 15 minutes in any 1-hour period.

Source: Colorado Revised Statutes, Title 25 "Health: Environmental Control," Article 12 "Noise Abatement."

The EPA has a noise guideline that recommends an L_{dn} of 55 dBA, which is sufficient to protect the public from the effect of broadband environmental noise in typical outdoor and residential areas (EPA 1974). These levels are not regulatory goals but are "intentionally conservative to protect the most sensitive portion of the American population" with "an additional margin of safety." For protection against hearing loss in the general population from nonimpulsive noise, the EPA guideline recommends an L_{eq} of 70 dBA or less over a 40-year period.

Noise levels continuously vary with location and time. In general, noise levels are high around major transportation corridors (highways and railways), airports, industrial facilities, and construction activities. Countywide day-night sound levels (L_{dn} or DNL) were estimated based on population density (Miller 2002) and are presented in Figure 4.13-1. About 57% and 29% of counties in the six-state study area are less than 35 and 35 to 45 dBA, which corresponds to wilderness natural background and rural areas, respectively (Cavanaugh and Tocci 1998). As might be expected, higher sound levels occur in the counties with significant urban/suburban populations, such as Denver, Los Angeles, Salt Lake City, and San Francisco.

4.13.2 Vibration

Construction activities can result in varying degrees of ground vibration, depending on the equipment and methods employed. Construction activities that typically generate the most severe vibrations are blasting and impact pile-driving.

Three ground-borne vibration impacts are of general concern: (1) human annoyance, (2) interference with vibration-sensitive activities, and (3) damage to buildings. In evaluating ground-borne vibration, two descriptors are widely used:

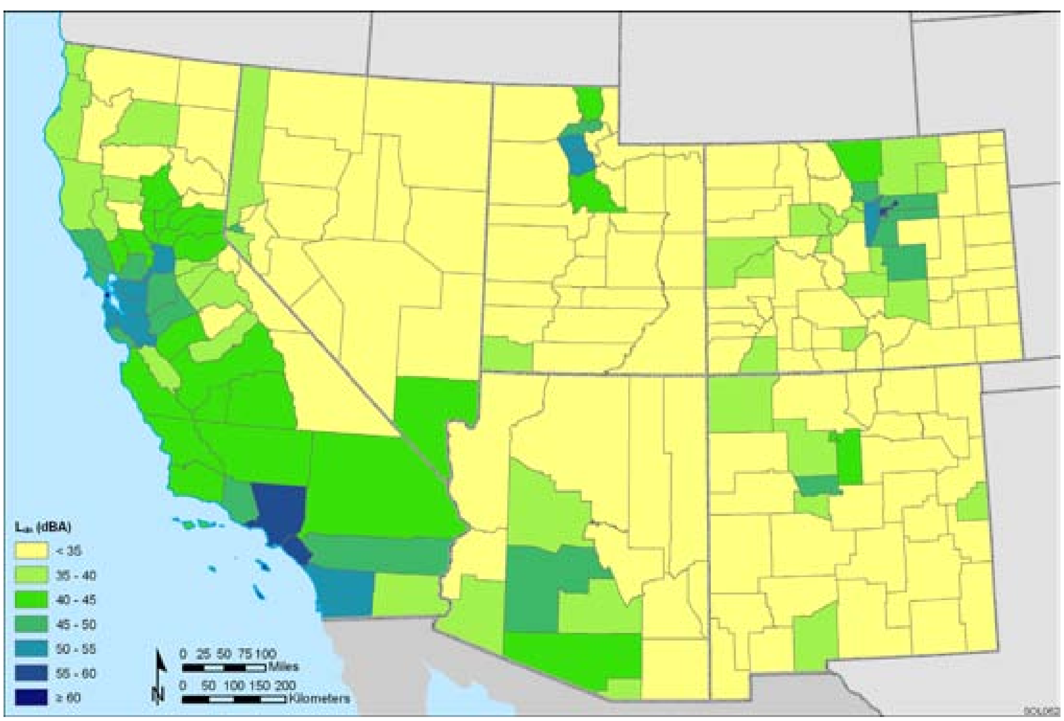

FIGURE 4.13-1 Day-Night Average Sound Level (L_{dn}) by County, Estimated on the Basis of Population Density (L_{dn} data based on the formula in Miller 2002)

- The peak particle velocity (PPV), measured as a distance per time (such as in./s), is the maximum peak velocity of the vibration and correlates with the stresses experienced by buildings.

- The vibration velocity level (L_V) represents a one-second average amplitude of the vibration velocity. It is typically expressed on a log scale in decibels (VdB) just as noise is measured in dB. This descriptor is suitable for evaluating human annoyance because the human body responds to average vibration amplitude.

In the United States, there are no widely adopted standards for acceptable levels of ground vibration generated by construction activities, although some jurisdictions elect to adopt vibration standards.

A background vibration velocity level in residential areas is usually 50 VdB or lower, well below the threshold of perception for humans, which is around 65 VdB (Hanson et al. 2006). However, vibration levels would typically be higher in the immediate vicinity of transportation corridors or construction/demolition sites. Human response is not usually significant unless the vibration exceeds 70 VdB. For evaluating interference with vibration-sensitive activities, the vibration impact criterion for general assessment is 65 VdB. For residential and institutional land use (primarily daytime use only, such as a school or church), the criteria range from 72 to 80 VdB and from 75 to 83 VdB, respective, depending on event frequency. For potential structural damage effects, guideline vibration damage criteria for various structural categories are provided in Hanson et al. (2006). Damage to buildings, however, would occur at much higher levels (0.12 in./s or higher, or about 90 VdB or higher) than human annoyance and interference with vibration-sensitive activities.

4.14 PALEONTOLOGICAL RESOURCES

Paleontological resources are fossilized remains, imprints, and traces of plants and animals preserved in rocks and sediments. Greater attention is often given to vertebrate fossils than to invertebrate and plant fossils because of their rarity; however, some plant and invertebrate fossils are also rare. The rarity of such specimens and fossil assemblages and the unique information that can be gleaned from these items emphasize their scientific value and the need to protect them. The area considered in this PEIS is extensive, including lands in six western states; therefore, there is a potential for paleontological resources (either individual specimens or larger assemblages of multiple fossils) to be present in sedimentary formations within these areas.

Various statutes, regulations, and policies govern the management of paleontological resources on public lands. Recently Congress passed a paleontology law, entitled *Paleontological Resources Preservation under the Omnibus Public Lands Act of 2009*. The law establishes three main points: (1) paleontological resources collected under a permit are U.S. property and must be available for scientific research and public education and preserved in an approved facility; (2) the nature and location of paleontological resources on public lands must be kept confidential to protect those resources from theft and vandalism; and (3) theft and vandalism of paleontological resources on public lands can result in civil and criminal penalties, including fines and/or imprisonment. The law also requires an expansion of public awareness and education regarding the importance of paleontological resources on public lands and the development of management plans for inventory, monitoring, and scientific and educational use of paleontological resources (BLM 2009).

Additional statutes for management and protection include the FLPMA (P.L. 94–579, codified at 43 USC 1701–1782) and Theft and Destruction of Government Property (18 USC 641), which penalizes the theft or degradation of property of the U.S. government. Other federal acts—the Federal Cave Resources Protection Act (P.L. 100–691, 102 Stat. 4546; codified at 16 USC 4301) and the Archaeological Resources Protection Act (16 USC 470(aa) et seq.)—protect fossils found in significant caves and/or in association with archeological resources.

The large number of productive fossil-bearing geological landforms found on federal land in the American West has encouraged the BLM to provide guidance on protecting this resource. Two instruction memoranda (IM) have been issued by the BLM to provide guidelines on implementing a Potential Fossil Yield Classification (PFYC) system for paleontological resources on public lands (IM 2008-009) (BLM 2007b) and for assessing potential impacts on paleontological resources (IM 2009-011) (BLM 2008c).[12] The PFYC system is described more fully below. The goal of the BLM program is to locate, evaluate, manage, and protect paleontological resources on public lands. Areas of critical environmental concern (ACECs) have been designated on BLM-administered lands containing exceptional paleontological resources, among other important resource values, such as scenic, ecological, and cultural resources (see Section 4.3). Those ACECs that are located near BLM-administered lands considered suitable for solar energy development and that have been designated specifically to protect paleontological resources are presented in Table 4.14-1.

Occurrences of paleontological resources are closely related to the geological units that contain them. Therefore, the potential for finding important paleontological resources can be predicted by the presence of the relevant geological units. The BLM recently adopted the PFYC system to provide baseline guidance for assessing the relative occurrence of important paleontological resources and the need for mitigation (BLM 2007b). Specifically, the system is used to classify geologic units at the formation or member level according to the probability of yielding paleontological resources of concern to land managers. Under the PFYC system, geologic units are classified from Class 1 to Class 5 on the basis of the relative abundance of

[12] Formerly, the 2000 report by the Secretary of the Interior on Fossils on Federal Land (DOI 2000) provided guidance on the treatment of paleontological resources. Further guidance was provided in the BLM Manual 8270, *Paleontological Resource Management* (BLM 1998). Procedures for managing these resources were identified in an attachment to BLM Manual 8270, the Paleontological Resources Handbook H-8270-1, *General Procedural Guidance for Paleontological Resource Management.* These guidance documents have been superseded in part by the expanded and clarified guidance available in BLM's Instruction Memoranda IM 2008-009 and IM 2009-011.

TABLE 4.14-1 ACECs Designated for Protection of Paleontological Resource Values That Are near BLM-Administered Lands Suitable for Solar Energy Development

ACEC	State	BLM Field Office	ACEC Values	Distance from Nearest Solar-Suitable Area
Carrow Stephens Ranches	Arizona	Kingman	Historic sites and paleontological resources	Adjacent
Bear Springs Badlands	Arizona	Safford	Paleontological resources; scenic	Adjacent
111 Ranch RNA	Arizona	Safford	Paleontological	Adjacent
Manix	California	Barstow	Paleontological and cultural	Adjacent
Mountain Pass Dinosaur Trackway	California	Barstow	Historic and paleontological values	Adjacent
Rainbow Basin/Owl Canyon	California	Barstow	Outstanding scenery; unique geology and paleontology; prehistoric archaeology	6 mi (10 km)
Marble Mountain Fossil Bed	California	Needles	Paleontological	Adjacent
Mountain Pass Dinosaur Trackway	California	Needles	Paleontological	Adjacent
Garden Park	Colorado	Royal Gorge	Paleontological; historical	7.5 mi (12 km)
Stewart Valley	Nevada[a]	Carson City	Paleontological	Adjacent
Arrow Canyon	Nevada[a]	Las Vegas	Paleontological; geological; cultural	Adjacent
Alamo Hueco Mountains	New Mexico	Las Cruces	Biological; scenic; cultural; paleontological; special status species	0.2 mi (0.3 km)
Robledo Mountains	New Mexico	Las Cruces	Paleontological, cultural, and scenic values; endangered plant species	Adjacent
Ball Ranch	New Mexico	Rio Puerco	Special status plant habitat; paleontological	Adjacent
Ojito	New Mexico	Rio Puerco	Geological; paleontological; cultural; wildlife; rare plant habitat; geologic hazard	Adjacent
Pronoun Cave	New Mexico	Rio Puerco	Paleontological; cultural	Adjacent
Torreon Fossil Fauna East	New Mexico	Rio Puerco	Paleontological; natural system	Adjacent
Torreon Fossil Fauna West	New Mexico	Rio Puerco	Paleontological; natural system	Adjacent
Fossil Mountain	Utah	Fillmore	Prehistoric life form	1 mi (1.6 km)

[a] No data available for Battle Mountain, Ely, or Winnemucca District Offices.

vertebrate fossils or uncommon invertebrate or plant fossils and their sensitivity to adverse impacts. A higher classification number indicates a higher fossil yield potential and greater sensitivity to adverse impacts (see text box).

Significant paleontological resources on public lands in the western United States are predominantly associated with geologic units (formations) from the Mesozoic and Cenozoic Eras (Table 4.14-2). Fossiliferous formations of the Mesozoic Era, particularly of the Jurassic and Cretaceous Periods (206 to 65 million years ago), are found in the Rocky Mountains and along canyons of the Colorado Plateau. The geologic units are of marine and nonmarine origin, representing alternating episodes of marine transgression and regression. They yield important vertebrate fossils, including fish, frogs, salamanders, turtles, crocodiles, pterosaurs, mammals, birds, and dinosaurs, and generally have a high PFYC ranking, which indicates a higher fossil yield potential and greater sensitivity to adverse impacts. Invertebrate fossils (e.g., ammonites) are more abundant.

Fossiliferous formations of the Cenozoic era, particularly from the Tertiary Period (65 to 1.8 million years ago), are found in the many sedimentary basins across the West. These formations contain important vertebrate fossils, including mammals, birds, reptiles, amphibians, and fish. Plants and invertebrates may also be important at some localities.

Although numerous localized paleontological resource projects have been completed, to date no comprehensive inventory of fossils and no systematic inventory of fossil-bearing areas on BLM-administered lands have been conducted. However, work is ongoing to prepare state-level PFYC maps. BLM paleontologists have completed PFYC mapping in Colorado, Utah, and New Mexico and will continue to refine those maps as more information is collected. The states of Arizona, California, and Nevada do not have completed PFYC maps at this time, although work has recently started in Nevada to complete this task. Most assessments and inventories of paleontological resources on public lands are conducted on a project-by-project basis. Some BLM field offices, along with various museums, geologic surveys, and other partners, maintain records of the paleontological finds made on the lands that they manage. Often this information is held by the primary state repository for fossil finds in that area. Site-specific information regarding paleontological resources would need to be collected to define the affected environment for an individual project.

4.15 CULTURAL RESOURCES

Cultural resources include archaeological sites and historic structures and features that are addressed under the National Historic Preservation Act (NHPA), as amended (P.L. 89-665). Cultural resources also include traditional cultural properties, that is, properties that are important to a community's practices and beliefs and that are necessary for maintaining the community's cultural identity. Cultural resources refer to both man-made and natural physical features associated with human activity and, in most cases, are finite, unique, fragile, and nonrenewable. Cultural resources that meet the eligibility criteria for listing in the *National*

Potential Fossil Yield Classification

Class 1: Geologic units that are not likely to contain recognizable fossil remains. This includes units that are igneous or metamorphic in origin (but excludes reworked volcanic ash units), as well as units that are Precambrian in age or older. Management concern for paleontological resources in Class 1 units is negligible or not applicable. No assessment or mitigation is needed except in very rare or isolated circumstances. The occurrence of significant fossils in Class 1 units is nonexistent or extremely rare. The probability for impacting any fossils is negligible, and assessment or mitigation of paleontological resources is usually unnecessary.

Class 2: Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically significant nonvertebrate fossils. This includes units in which vertebrate or significant invertebrate or plant fossils are not present or are very rare, units that are younger than 10,000 years before present, units that are of recent aeolian deposits, and sediments that exhibit significant diagenetic alteration (i.e., physical and chemical changes). The potential for impacting vertebrate fossils or uncommon invertebrate or plant fossils is low. Management concern for paleontological resources is low, and the assessment or mitigation of paleontological resources is not likely to be necessary. Localities containing important resources may exist but would be rare and would not influence the classification. These important localities would be managed on a case-by-case basis.

Class 3: Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence (Class 3a – Moderate Potential), or sedimentary units of unknown fossil potential (Class 3b – Unknown Potential). These units are often marine in origin with sporadic known occurrences of vertebrate fossils. Vertebrate fossils and scientifically significant invertebrate or plant fossils are known to occur inconsistently or intermittently, and predictability is known to be low. Class 3 includes units that are poorly studied and/or poorly documented, so that the potential yield cannot be assigned without ground reconnaissance. Management concern for paleontological resources in these units is moderate or cannot be determined from existing data. Management considerations cover a broad range of options that could include predisturbance surveys, monitoring, or avoidance. Surface-disturbing activities may require field assessment to determine a further course of action.

Class 4: Class 4 units are geologic units with a high occurrence of significant fossils that may vary in occurrence or predictability or have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation than Class 5 units. They include bedrock units with little or no soil or vegetative cover that are larger than 2 acres (0.008 km^2); bedrock units with extensive soil or vegetative cover; bedrock exposures that are limited or not expected to be impacted; units with areas of exposed outcrop that are smaller than two contiguous acres; units in which outcrops form cliffs of sufficient height and slope so that impacts are minimized by topographic effects; and units where other characteristics are present that lower the vulnerability of both known and unidentified fossil localities. Management concern for paleontological resources in Class 4 is moderate to high, depending on the proposed action, and mitigation considerations must include an assessment of the disturbance. A field survey by a qualified paleontologist is often needed to assess local conditions, and on-site monitoring or spot-checking may be necessary during construction activities. Management prescriptions for resource preservation and conservation through controlled access or special management designation should be considered.

Class 5: Highly fossiliferous geologic units that regularly and predictably produce vertebrate fossils or scientifically significant invertebrate or plant fossils and that are at risk of human-caused adverse impacts or natural degradation. These include units in which vertebrate fossils or uncommon invertebrate or plant fossils are known and documented to occur consistently, predictably, or abundantly. Class 5 pertains to highly sensitive units that are well exposed with little or no soil or vegetative cover, units in which outcrop areas are extensive, and exposed bedrock areas that are larger than two contiguous acres. Management concern for paleontological resources in Class 5 is high to very high. A field survey by a qualified paleontologist is usually necessary prior to surface-disturbing activities or land tenure adjustments. Mitigation will often be necessary before and/or during these actions. On-site monitoring may be necessary during construction activities. Official designation of areas of avoidance, special interest, and concern may be appropriate.

(Source: BLM 2007b, Attachment 1)

TABLE 4.14-2 Age of Geologic Units and Potential Fossil Yield

Era	Period (Ma)[a]	Epoch (Ma)[a]	Distinctive Fossils[b]	Examples of Geologic Units in the Study Area (PFYC Class[c])
Cenozoic	Quaternary (0–1.8)	Holocene (0–0.01)		Alluvium and colluvium (3) Dune sand (3) Eolian deposits (loess) (3) Lacustrine and playa deposits (3) Mud and salt flats (3) Terrace and flood gravels (3)
		Pleistocene (0.01–1.8)	Mammoths Bison and cows Horses Deer Squirrels and rabbits Invertebrates	Alluvium and colluvium (3) Dune sand (3) Eolian deposits (loess) (3) Glaciofluvial deposits (3) Lacustrine and playa deposits (3) Mud and salt flats (3) Terrace and flood gravels (3)
	Tertiary (1.8–65.0)	Pliocene (1.8–5.3)	Mammals Birds (eggs) Warm climate plankton (marine) Invertebrates	Ogallala Formation (4/5) CO, NM
		Miocene (5.3–23.8)	Mammals (rodents) Birds (eggs) Invertebrates	Browns Park Formation (4/5) UT Dry Union Formation (4/5) CO Muddy Creek Formation (3) AZ, CA, UT, NV Ogallala Formation (4/5) CO/NM Wagontongue Formation (4/5) CO
		Oligocene (23.8–33.7)	Mammals (early horses, primates, marsupials, carnivores) Crocodilians, alligators Lizards and turtles Amphibians and fish Invertebrates Birds (eggs) Plants and pollen	Bishop Conglomerate (3) CO Duchesne River Formation (4/5) CO, UT

TABLE 4.14-2 (Cont.)

Era	Period (Ma)[a]	Epoch (Ma)[a]	Distinctive Fossils[b]	Examples of Geologic Units in the Study Area (PFYC Class[c])
Cenozoic *(Cont.)*	Tertiary (1.8–65.0) *(Cont.)*	Eocene (33.7–54.8)	Mammals (early horses, primates, marsupials, carnivores, grazers) Crocodilians, alligators Lizards and turtles Amphibians and fish Invertebrates Birds (eggs) Plants and pollen	Bridger Formation (4/5) CO, UT Duchesne River Formation (4/5) CO, UT Green River Formation (4/5) CO, UT Uinta Formation (4/5) CO, UT Wasatch Formation (4/5) CO, UT
		Paleocene (54.8–65.0)	Small mammals Reptiles Amphibians and fish Birds (eggs) Insects Plants and pollen	Currant Creek Formation (4/5) UT Fort Union Formation (3) CO Nacimiento Formation (4/5) NM Ojo Alamo Formation (4/5) NM Wasatch Formation (4/5) CO, UT
Mesozoic	Cretaceous (65.0–144)		Terrestrial flora and fauna: – Dinosaurs – Birds – Early mammals – Diverse insects – Flowering plants – Freshwater fish and invertebrates Marine flora and fauna: – Plankton and diatoms – Cephalopods (ammonites, belemnites) – Marine reptiles – Fish – Sharks and rays	Burro Canyon Formation (4/5) AZ, CO, UT, NM Castlegate Formation (2) CO, UT Cliff House Sandstone (4/5) CO, NM Lewis Shale (4/5) CO, NM, UT Mowry Shale (3) CO, UT Niobrara Formation (4/5) CO Various volcanic units (1)

TABLE 4.14-2 (Cont.)

Era	Period (Ma)[a]	Epoch (Ma)[a]	Distinctive Fossils[b]	Examples of Geologic Units in the Study Area (PFYC Class[c])
Mesozoic (Cont.)	Jurassic (144–206)		Terrestrial flora and fauna: – Dinosaurs – Early mammals – Seed plants – Ferns Marine flora and fauna: – Plankton – Cephalopods (ammonites) – Marine reptiles – Fish – Sharks and rays	Kayenta Formation (4/5) AZ, CO, NV, UT Moenave Formation (4/5) AZ, NV, UT Morrison Formation (4/5) AZ, CO, NM, UT Navajo Sandstone (4/5) AZ, CO, NV, UT Summerville Formation (4/5) AZ, CO, NM, UT
	Triassic (206–248)		Terrestrial flora and fauna: – Dinosaurs – Early mammals – Seed plants – Conifers	Chinle Formation (4/5) AZ, CO, NV, NM, UT Chugwater Formation (3) CO Moenkopi Formation (3) AZ, CA, CO, NV, NM, UT Thaynes Limestone (2) UT Wingate Formation (4/5) AZ, CO, NM, UT
Paleozoic	Permian (248–290)		Terrestrial flora and fauna dominate: – Anapsids (turtles) – Diapsids – Archosaurs – Gymnosperms (conifers)	Coconino Sandstone (3) AZ, CA, NV, UT Kaibab Formation (2) AZ, CA, NV, UT San Andres Formation (4/5) NM Satanka Shale (2) CO Toroweap Formation (3) AZ, NV, UT

TABLE 4.14-2 (Cont.)

Era	Period (Ma)[a]		Epoch (Ma)[a]	Distinctive Fossils[b]	Examples of Geologic Units in the Study Area (PFYC Class[c])
Paleozoic *(Cont.)*	Carboniferous *(Cont.)*	Pennsylvanian (290–323)		Terrestrial flora and fauna dominate: – Freshwater clams – Seedless plants – Ferns – Winged insects (dragonflies) – Amniote species (lizards) – Diapsids (reptiles, snakes) – Archosaurs (crocodiles, dinosaurs, birds)	Belden Formation (2) CO Hermit Shale (2) AZ, CA, NV, UT Minturn Formation (2) CO Morgan Formation (2) CO, UT Oquirrh Formation (2) UT
		Mississippian (323–354)		Marine invertebrates (e.g., bryozoans and braciopods) dominate: – Foraminifera – Modern fish fauna	Brazer Formation (2) UT Deseret Limestone (2) UT Humbug Formation (2) CO, UT Madison Formation (3) CO, UT Redwall Limestone (2) AZ, CA, NM, UT
	Devonian (354–417)			Terrestrial plants (ferns, seed plants, trees) Terrestrial insects and spiders Diverse freshwater fish Marine vertebrates and invertebrates (see below)	Jefferson Limestone (2) UT, CO, NM Madison Formation (3) CO, UT Temple Butte Formation (2) AZ
	Silurian (417–443)			Coral reefs Marine invertebrates (see below) Marine fish Freshwater fish Terrestrial plants	

TABLE 4.14-2 (Cont.)

Era	Period (Ma)[a]	Epoch (Ma)[a]	Distinctive Fossils[b]	Examples of Geologic Units in the Study Area (PFYC Class[c])
Paleozoic *(Cont.)*	Ordovician (443–490)		Marine invertebrates: – Red and green algae – Bryozoans – Crinoids, blastoids – Corals – Graptolites – Trilobites – Brachiopods, snails, clams – Cephalopods – Archaeocyathids (sponges) Marine vertebrates: – Ostraderms (jawless, armored fish) Conodonts (early vertebrates) Terrestrial plants	Fishhaven Dolomite (2) UT Garden City Limestone (2) UT
	Cambrian (490–543)		Marine invertebrates: – Red and green algae – Trilobites – Brachiopods – Echinoderms – Archaeocyathids (sponges)	Bright Angel Shale (2) AZ, CA, NV, UT Tapeats Sandstone (2) AZ, CA, NV, UT
	Proterozoic (543–2,500)		Soft bodied fauna Carbon film Microbial mats (stromatolites)	Various igneous and metamorphic units (1)
	Archean (2,500–3,800?)		None	Various igneous and metamorphic units (1)

[a] Ma = millions of years before the present.

[b] Distinctive fossils are those characteristic of the geologic period listed and may or may not be present in the geologic units (formations) in the study area.

[c] The PFYC system ranks the highest potential fossil-yielding formations as Class 4 or Class 5, but assigns the lower rank (Class 4) to those formations for which potential impacts are reduced by the presence of a protective layer of soil or other mitigating circumstance. For this assessment, formations with the highest potential fossil yield were assigned to Class 4/5 since the presence of mitigating circumstances is unknown.

Sources: Adapted from Palmer and Geissman (1999); University of California Museum of Paleontology (2007).

Register of Historic Places (NRHP) are formally referred to as historic properties (see text box). Federal agencies must take into consideration the effects on historic properties of any undertakings under their direct or indirect jurisdiction before they approve expenditures or issue permits, ROWs, or other land use authorizations.

Federal agencies are also required to consider the effects of their actions on sites, areas, and other resources (e.g., plants) that are of religious significance to Native Americans[13] as established under the American Indian Religious Freedom Act (P.L. 95-341). Archaeological sites on public lands and Indian lands are protected by the Archaeological Resources Protection Act of 1979, as amended (P.L. 96–95), and Native American graves and burial grounds are protected by the Native American Graves Protection and Repatriation Act of 1990 (P.L. 101-601). Cultural resources on federal lands are protected by laws penalizing the theft or degradation of property of the U.S. government (Theft of Government Property [62 Stat. 764, 18 USC 1361] and FLPMA). A list of these and other regulatory requirements pertaining to cultural properties is presented in Table 4.15-1. These laws are applicable to any project undertaken on federal land or requiring federal permitting or funding.

National Register Criteria for Evaluation (36 CFR 60.4)[a]

The quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and

A. that are associated with events that have made a significant contribution to the broad patterns of our history; or

B. that are associated with the lives of persons significant in our past; or

C. that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

D. that have yielded or may be likely to yield, information important in prehistory or history.

[a] Additional *criteria considerations* are also provided in 36 CFR 60.4.

Cultural resources on BLM-administered land are managed primarily through the application of the laws identified in Table 4.15-1. As required by Section 106 of the NHPA, BLM offices work with land use applicants and interested consulting parties to inventory and evaluate cultural resources in areas that may be affected by proposed development. The BLM has established a cultural resource management program as identified in its 8100 series manuals and handbooks (see Table 4.15-2).

The goal of the program is to locate, evaluate, manage, and protect cultural resources on public lands. To achieve this goal, some significant cultural resources have been identified as ACECs (see Section 4.3). Those ACECs that are located near BLM-administered lands considered suitable for solar energy development and have been designated specifically to protect cultural resources are presented in Table 4.15-3. Guidance on how to apply the NRHP criteria to evaluate the eligibility of sites located on public lands is provided in numerous documents prepared by the NPS and in the BLM 8100 series manuals and handbooks. Further

[13] These acts refer specifically to Native Americans, Native Alaskans, and Native Hawaiians.

TABLE 4.15-1 Cultural Resource Laws and Regulations

Law or Order Name	Intent
Antiquities Act of 1906	This law makes it illegal to remove cultural resources from federal land without permission and establishes a permitting process for conducting archaeological fieldwork on federal land. It also allows the President to establish historical monuments and landmarks.
Bald and Golden Eagle Protection Act of 1940, as amended	Section 668a of this act allows the Secretary of the Interior to permit the taking, possession, and transportation of bald eagle or golden eagle specimens for the religious purposes of Indian tribes, as well as other scientific or exhibition purposes. Otherwise the act prohibits the take, possession, sale, purchase, or transportation of any bald eagle or golden eagle (alive or dead), or any part, nest, or egg thereof.
National Historic Preservation Act of 1966, as amended (NHPA)	The NHPA creates the framework within which cultural resources are managed in the United States. The law requires that each state appoint a State Historic Preservation Officer (SHPO) to direct and conduct a comprehensive statewide survey of historic properties and maintain an inventory of such properties, and it created the Advisory Council on Historic Preservation, which provides national oversight and dispute resolution. Section 106 of the NHPA defines the process for identifying and evaluating cultural resources and determining whether a project will result in an adverse effect on the resource. It also addresses the appropriate process for resolving (mitigating) adverse effects to historic properties. Section 110 of the NHPA directs the heads of all federal agencies to assume responsibility for the preservation of listed or eligible historic properties owned or controlled by their agency. Federal agencies are directed to locate, inventory, and nominate properties to the NRHP, to exercise caution to protect such properties, and to use such properties to the maximum extent feasible. Additional provisions of Section 110 include documentation of properties adversely affected by federal undertakings, the establishment of trained federal preservation officers in each agency, and the inclusion of the costs of preservation activities as eligible agency project costs. The NHPA also establishes the processes for consultation among interested parties, the lead agency, and the SHPO, and for government-to-government consultation between U.S. government agencies and Native American Tribal governments.
Executive Order (E.O.) 11593, *Protection and Enhancement of the Cultural Environment (Federal Register* 36:8921, May 13, 1971)	E.O. 11593 requires federal agencies to inventory their cultural resources and to record, to professional standards, any cultural resource that may be altered or destroyed.

TABLE 4.15-1 (Cont.)

Law or Order Name	Intent
Archaeological and Historic Preservation Act of 1974 (AHPA)	The AHPA directly addresses impacts on cultural resources resulting from federal activities that would significantly alter the landscape. The focus of the law is data recovery and salvage of scientific, prehistoric, historic, and archaeological resources that could be damaged during the creation of dams and the impacts resulting from flooding, worker housing, creation of access roads, etc.; however, its requirements are applicable to any federal action.
Federal Land and Policy Management Act of 1976 (FLPMA)	The FLPMA requires the BLM to manage its lands for multiple use and sustained yield in a manner that will protect the quality of its environmental values, such as cultural resources.
American Indian Religious Freedom Act of 1978 (AIRFA)	The AIRFA protects the right of Native Americans to have access to their sacred places. It requires consultation with Native American organizations if an agency action will affect a sacred site on federal lands.
Archaeological Resources Protection Act of 1979, as amended (ARPA)	The ARPA establishes civil and criminal penalties for the destruction or alteration of cultural resources and establishes professional standards for excavation.
Native American Graves Protection and Repatriation Act of 1990 (NAGPRA)	The NAGPRA requires federal agencies to consult with the appropriate Native American Tribes prior to the intentional excavation of human remains and funerary objects. It requires the repatriation of human remains found on the agencies' land.
E.O. 13006, *Locating Federal Facilities on Historic Properties in our Nation's Central Cities* (*Federal Register* 61:26071, May 21, 1996)	E.O. 13006 encourages the reuse of historic downtown areas by federal agencies.
E.O. 13007, *Indian Sacred Sites (Federal Register* 61:26771, May 24, 1996*)*	E.O. 13007 requires that an agency allow Native Americans to worship at sacred sites located on federal property.
E.O. 13175, *Consultation and Coordination with Indian Tribal Governments* (*Federal Register* 65:67249, Nov. 9, 2000)	E.O. 13175 requires federal agencies to ensure meaningful and timely input by tribal officials in the development of federal policies that have tribal implications.
E.O. 13287, *Preserve America* (*Federal Register* 68:10635, March 5, 2003)	E.O. 13287 encourages the promotion and improvement of historic structures and properties to encourage tourism.

TABLE 4.15-2 BLM Guidance Regarding Cultural Resource Management

BLM 8100 Series Manuals and Handbooks
8100 Manual: *The Foundations for Managing Cultural Resources*
8110 Manual: *Identifying and Evaluating Cultural Resources*
8120 Manual: *Tribal Consultation under Cultural Resource Authorities*
H-8120-1: *General Procedural Guidance for Native American Consultation*
8130 Manual: *Planning for Uses of Cultural Resources*
8140 Manual: *Protecting Cultural Resources*
8150 Manual: *Permitting Uses of Cultural Resources*
8170 Manual: *Interpreting Cultural Resources for the Public*

guidance on the application of cultural resource laws and regulations is provided through the 1997 BLM National Programmatic Agreement (PA) developed among the BLM, the National Council of State Historic Preservation Officers (SHPOs), and the Advisory Council on Historic Preservation, and implemented through state-specific protocols with each SHPO for the management of cultural resources programs and the review of projects pursuant to Section 106 of the NHPA. A National PA for addressing solar energy development on BLM-administered lands is currently under development among the BLM, each represented state SHPO (Arizona, California, Colorado, Nevada, New Mexico, and Utah), and the Advisory Council on Historic Preservation (see Appendix K).

Although site-specific information regarding cultural resources would need to be collected to define the affected environment of an individual project, the types of sites listed on or eligible for listing in the NRHP in the broad six-state study area for this PEIS include, but are not limited to, archaeological sites and features, historic buildings, bridges, trails, prehistoric dwellings, historic districts, water features (e.g., canals and ditches), traditional cultural properties, and cultural landscapes.

Traditional cultural properties and other areas of concern to various cultural groups, including Native Americans, can include a wide range of tangible and intangible resources (e.g., archaeological sites, funerary objects, places of religious ceremony, medicinal plants, and sacred landscapes). Government-to-government consultation, in addition to Section 106 consultation, provides a means of identifying the affected environment for a particular site-specific project for Native American governments. The public scoping and comment processes are avenues for other distinct cultural groups to make their concerns known regarding traditional cultural properties. It is difficult, if not impossible, to place hard boundaries on locations of traditional significance. Where boundaries might be defined, members of the cultural group may not be willing to disclose such information for a variety of reasons. Cultural sensitivity to the need to protect important places is required. Types of valued traditional resources may include, but are not limited to, archaeological sites, burial sites, religious sites, traditional harvest areas, trails, certain prominent geological features that may have spiritual significance (i.e., sacred landscapes), and viewsheds of sacred locations (including all of the above).

TABLE 4.15-3 ACECs Designated for Protection of Cultural Resource Values That Are near BLM-Administered Lands Suitable for Solar Energy Development

ACEC	State	BLM Field Office	ACEC Values	Distance[a] from Nearest Solar-Suitable Area
Johnson Spring	Arizona	Arizona Strip	Cultural resources, Siler pincushion cactus, scenic	Adjacent
Kanab Creek	Arizona	Arizona Strip	Cultural resources, endangered bird species, riparian, scenic	Adjacent
Little Black Mountains	Arizona	Arizona Strip	Cultural resources	Adjacent
Lost Spring Mountain	Arizona	Arizona Strip	Cultural resources, Siler pincushion cactus	Adjacent
Marble Canyon	Arizona	Arizona Strip	Cultural resources, Brady pincushion cactus, raptors, scenic	Adjacent
Moonshine Ridge	Arizona	Arizona Strip	Cultural resources, Siler pincushion cactus, scenic	Adjacent
Virgin River Corridor	Arizona	Arizona Strip	Cultural resources, endangered fish, riparian, scenic	Adjacent (0.1 mi [0.2 km])
Black Butte	Arizona	Hassayampa	Cultural resources, raptor habitat, scenic	Adjacent
Harquahala	Arizona	Hassayampa	Cultural resources, biological resources	Adjacent
Tule Creek	Arizona	Hassayampa	Cultural resources, Sonoran Desert riparian environment	1 mi (1.6 km)
Beale Slough	Arizona	Lake Havasu	Cultural resources, riparian habitat	Adjacent
Bullhead Bajada	Arizona	Lake Havasu	Cultural resources, desert tortoise	Adjacent
Crossman Peak	Arizona	Lake Havasu	Cultural resources, Traditional cultural properties, scenic, big horn sheep	Adjacent
Swansea Historic District	Arizona	Lake Havasu	Cultural resources	Adjacent
Black Mountains Ecosystem Management	Arizona	Kingman	Bighorn sheep and wild burro habitat, federal candidate plant species habitat, outstanding scenic values, open space near major population centers, rare and outstanding cultural resources, high locatable mineral potential	Adjacent
Burro Creek	Arizona	Kingman	Outstanding riparian resources, rare and outstanding cultural resources, important threatened and endangered species	Adjacent
Carrow Stephens Ranches	Arizona	Kingman	Historic site and paleontological resources	Adjacent
Joshua Tree Forest-Grand Wash Cliffs	Arizona	Kingman	Unique vegetation, outstanding scenic values, rare cultural resources, peregrine falcon aerie	Adjacent
Wright-Cottonwood Creeks	Arizona	Kingman	Rare and outstanding cultural resources, outstanding potential riparian resources	Adjacent

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TABLE 4.15-3 (Cont.)

ACEC	State	BLM Field Office	ACEC Values	Distance[a] from Nearest Solar-Suitable Area
San Pedro Riparian	Arizona	Phoenix/ Tucson	Riparian vegetation and wildlife, significant archaeological, historic and paleontological resources	Adjacent
White Canyon	Arizona	Phoenix/ Tucson	Outstanding scenic, wildlife and cultural resources	5 mi
Bowie Mountain Scenic	Arizona	Safford	Scenic backdrop to historic Fort Bowie	4 mi
Dos Cabezas Peaks	Arizona	Safford	Historic landmark, scenic	5 mi
Swamp Springs Hot Springs Watershed	Arizona	Safford	Riparian areas, threatened and endangered species, bighorn sheep, native fish, cultural resources	Adjacent
Big Marias	Arizona/ California	Yuma	Cultural resources, riparian habitat	Adjacent
Dripping Springs	Arizona	Yuma	Perennial spring, desert bighorn sheep, cultural resources	Adjacent
Sears Point (Gila River Cultural Area)	Arizona	Yuma	Cultural resources, historic and prehistoric trails, migratory birds, riparian habitat	Adjacent
Calico Early Man Site	California	Barstow	Prehistoric human occupation	2 mi
Clark Mountain	California	Barstow	Prehistoric and historic values; outstanding scenery; wildlife habitat	Adjacent
Cronese Basin	California	Barstow	Cultural resources; wildlife habitat	Adjacent
Dead Mountains	California	Barstow	Native American values	Adjacent
Manix	California	Barstow	Paleontological and Cultural	Adjacent
Mesquite Lake	California	Barstow	Prehistoric values	Adjacent
Mountain Pass Dinosaur Trackway	California	Barstow	Historic and paleontological values	Adjacent
Rainbow Basin/Owl Canyon	California	Barstow	Outstanding scenery; Unique geology and paleontology; Prehistoric archaeology	6 mi
Rodman Mountains Cultural Area	California	Barstow	Cultural	7 mi
Salt Creek Hills	California	Barstow	Wildlife; prehistoric and historic values	Adjacent
Bodie Bowl	California	Bishop	Historic resources; wildlife; mining deposits; livestock grazing	2 mi
Cerro Gordo	California	Bishop	Prehistoric and historic values; vegetation	5 mi
Travertine Springs	California	Bishop	Recreation use; cultural and Native American values; wildlife habitat; geologic features	3 mi
East Mesa	California	El Centro	Prehistoric values; wildlife habitat	Adjacent

TABLE 4.15-3 (Cont.)

ACEC	State	BLM Field Office	ACEC Values	Distance[a] from Nearest Solar-Suitable Area
Gold Basin/Rand Intaglios	California	El Centro	Prehistoric values	Adjacent
Indian Pass	California	El Centro	Prehistoric values	Adjacent
Lake Cahuilla A	California	El Centro	Prehistoric values	Adjacent
Lake Cahuilla B	California	El Centro	Prehistoric values	1 mi
Lake Cahuilla C	California	El Centro	Prehistoric values	Adjacent
Lake Cahuilla D	California	El Centro	Prehistoric values	Adjacent
Pilot Knob	California	El Centro	Prehistoric and Native American values	Adjacent
Plank Road	California	El Centro	Unique historic road	2 mi
San Sebastian Marsh/San Fellipe Creek	California	El Centro	Prehistoric; historic and Native American resources; riparian and wildlife values	1 mi
West Mesa	California	El Centro	Wildlife and cultural values	2 mi
Mesquite Hills/Crucero	California	Needles	Prehistoric values	Adjacent
Mopah Spring	California	Needles	Outstanding scenery; cultural resources	7 mi
Patton's Iron Mountain Division Camp	California	Needles	Historic military camp	Adjacent
Haloran Wash	California	Needles	Prehistoric values	2 mi
Whipple Mountains	California	Needles	Native American values	4 mi
Alligator Rock	California	Palm Springs/ South Coast	Archaeological resources	4 mi
Corn Springs	California	Palm Springs/ South Coast	Outstanding scenery; prehistoric/historic values; wildlife habitat; vegetation	5 mi
Mule Mountain	California	Palm Springs/ South Coast	Prehistoric values	Adjacent
Palen Dry Lake	California	Palm Springs/ South Coast	Prehistoric values	Adjacent
Cumbres & Toltec Railroad Corridor	Colorado	La Jara	Historic; scenic	Adjacent
Cucharas Canyon	Colorado	Royal Gorge	Scenic; cultural	2 mi
Garden Park	Colorado	Royal Gorge	Historic; paleontology	7.5 mi
Cane Man Hill	Nevada	Battle Mountain	Cultural	Adjacent[b]
Rhyolite	Nevada	Battle Mountain	Historic	Adjacent[b]

TABLE 4.15-3 (Cont.)

ACEC	State	BLM Field Office	ACEC Values	Distance[a] from Nearest Solar-Suitable Area
Tybo-McIntyre Charcoal Kilns	Nevada	Battle Mountain	Historic	3 mi[b]
Pah Rah High Basin Petroglyph	Nevada	Carson City	Cultural; scenic	Adjacent (0.1 mi)
Baker Archaeological Site	Nevada	Ely	Cultural	3 mi[b]
Honeymoon Hill/City of Rocks	Nevada	Ely	Cultural	Adjacent[b]
Mount Irish	Nevada	Ely	Cultural	1.5 mi[b]
Pahroc Rock Art	Nevada	Ely	Cultural	Adjacent[b]
Shooting Gallery	Nevada	Ely	Cultural	2.5 mi[b]
Snake Creek Indian Burial Cave	Nevada	Ely	Zooarchaeology; geology; archaeology	2 mi[b]
Swamp Cedar	Nevada	Ely	Special plant species; prehistoric sites; historic site	Adjacent[b]
Arden	Nevada	Las Vegas	Historic	Adjacent
Arrow Canyon	Nevada	Las Vegas	Paleontological; Geological; Cultural	Adjacent
Bird Springs	Nevada	Las Vegas	Cultural	0.5 mi
Crescent Townsite	Nevada	Las Vegas	Historic	1 mi
Gold Butte Part A	Nevada	Las Vegas	Cultural; scenic; wildlife habitat; sensitive species	Adjacent
Hidden Valley	Nevada	Las Vegas	Cultural	1 mi
Rainbow Gardens		Las Vegas	Geological; scientific; scenic; cultural; sensitive plants	Adjacent
Sloan Rock	Nevada	Las Vegas	Cultural	1.5 mi
Stump Springs	Nevada	Las Vegas	Cultural; historic	Adjacent
Virgin River	Nevada	Las Vegas	Threatened and Endangered species; riparian habitat; cultural resources	Adjacent
Pecos River/Canyons Complex	New Mexico	Carlsbad	Scenic; cultural; natural	7 mi
Adams Canyon	New Mexico	Farmington	Cultural	0.7 mi
Ah-shi-sle-pah Road	New Mexico	Farmington	Cultural	2 mi
Albert Mesa	New Mexico	Farmington	Cultural	6 mi
Andrews Ranch	New Mexico	Farmington	Cultural	0.7 mi
Ashii Nala'a' (Salt Point)	New Mexico	Farmington	Cultural	Adjacent
Bee Burrow	New Mexico	Farmington	Cultural	3 mi
Bis sa'ani	New Mexico	Farmington	Cultural	Adjacent
Bi Yaazh	New Mexico	Farmington	Cultural	Adjacent
Blanco Mesa	New Mexico	Farmington	Cultural	0.3 mi
Blanco Star Panel	New Mexico	Farmington	Cultural	2.5 mi

TABLE 4.15-3 (Cont.)

ACEC	State	BLM Field Office	ACEC Values	Distance[a] from Nearest Solar-Suitable Area
Cagle's Site	New Mexico	Farmington	Cultural	1 mi
Canyon View	New Mexico	Farmington	Cultural	Adjacent
Casa del Rio	New Mexico	Farmington	Cultural	4 mi
Cedar Hill	New Mexico	Farmington	Cultural	4 mi
Chacra Mesa	New Mexico	Farmington	Cultural	Adjacent
Cho'li'l (Gobernador Knob)	New Mexico	Farmington	Cultural	2 mi
Christmas Tree	New Mexico	Farmington	Cultural	5 mi
Church Rock Outlier	New Mexico	Farmington	Cultural	5 mi
Cottonwood Divide	New Mexico	Farmington	Cultural	1.5 mi
Crow Canyon	New Mexico	Farmington	Cultural	1 mi
Crown Point Steps and Herradura	New Mexico	Farmington	Cultural	2 mi
Deer House	New Mexico	Farmington	Cultural	0.5 mi
Delgadita/Pueblo Canyons	New Mexico	Farmington	Cultural	1 mi
Devils Spring Mesa	New Mexico	Farmington	Cultural	Adjacent
Dogie Canyon School	New Mexico	Farmington	Cultural	2.5 mi
Dzil'na'oodlii	New Mexico	Farmington	Cultural	Adjacent
East Rincon	New Mexico	Farmington	Cultural	4 mi
Encierro Canyon	New Mexico	Farmington	Cultural	0.3 mi
Encinada Mesa- Carrizo Canyon	New Mexico	Farmington	Cultural	1 mi
Farmer's Arroyo	New Mexico	Farmington	Cultural	2 mi
Four Ye'i	New Mexico	Farmington	Cultural	Adjacent (0.1 mi)
Frances Mesa	New Mexico	Farmington	Cultural	3 mi
Gonzales Canyon–Vigil Homestead	New Mexico	Farmington	Cultural	0.2 mi
Gould Pass Camp	New Mexico	Farmington	Cultural	4.5 mi
Halfway House	New Mexico	Farmington	Cultural	Adjacent
Haynes Trading Post	New Mexico	Farmington	Cultural	Adjacent
Holmes Group	New Mexico	Farmington	Cultural	0.7 mi
Hummingbird	New Mexico	Farmington	Cultural	Adjacent
Hummingbird Canyon	New Mexico	Farmington	Cultural	4 mi
Jacques Chacoan Community	New Mexico	Farmington	Cultural	0.8 mi

TABLE 4.15-3 (Cont.)

ACEC	State	BLM Field Office	ACEC Values	Distance[a] from Nearest Solar-Suitable Area
Kachina Mask	New Mexico	Farmington	Cultural	2 mi
Kin Nizhoni	New Mexico	Farmington	Cultural	0.5 mi
Kin Yazhi	New Mexico	Farmington	Cultural	Adjacent
Kiva	New Mexico	Farmington	Cultural	1.5 mi
Lake Valley	New Mexico	Farmington	Cultural	3.5 mi
Largo Canyon Star Ceiling	New Mexico	Farmington	Cultural	2.5 mi
Margarita Martinez Homestead	New Mexico	Farmington	Cultural	Adjacent
Martin Apodaco Homestead	New Mexico	Farmington	Cultural	0.7 mi
Martinez Canyon	New Mexico	Farmington	Cultural	2 mi
Morris 41	New Mexico	Farmington	Cultural	4 mi
Moss Trail	New Mexico	Farmington	Cultural	0.4 mi
Muñoz Canyon	New Mexico	Farmington	Cultural	0.4 mi
North Road	New Mexico	Farmington	Cultural	Adjacent
Pierre's Site	New Mexico	Farmington	Cultural	Adjacent
Pointed Butte	New Mexico	Farmington	Cultural	Adjacent
Pork Chop Pass	New Mexico	Farmington	Cultural	1.5 mi
Pregnant Basketmaker	New Mexico	Farmington	Cultural	2 mi
Pretty Woman	New Mexico	Farmington	Cultural	Adjacent
Rincon Largo District	New Mexico	Farmington	Cultural	Adjacent
Rincon Rockshelter	New Mexico	Farmington	Cultural	0.5 mi
Rock House- Nestor Martin Homestead	New Mexico	Farmington	Cultural	Adjacent
San Rafael Canyon	New Mexico	Farmington	Cultural	Adjacent
Santos Peak	New Mexico	Farmington	Cultural	2 mi
Shield Bearer	New Mexico	Farmington	Cultural	2 mi
Simon Canyon	New Mexico	Farmington	Natural; wildlife habitat; cultural; scenic	5 mi
Shield Bearer	New Mexico	Farmington	Cultural	2 mi
Star Rock	New Mexico	Farmington	Cultural	0.4 mi
Star Spring-Jesus Canyon	New Mexico	Farmington	Cultural	0.6 mi
String House	New Mexico	Farmington	Cultural	0.3 mi
Superior Mesa Community	New Mexico	Farmington	Cultural	Adjacent

TABLE 4.15-3 (Cont.)

ACEC	State	BLM Field Office	ACEC Values	Distance[a] from Nearest Solar-Suitable Area
Tapacito and Split Rock District	New Mexico	Farmington	Cultural	1.5 mi
Truby's Tower	New Mexico	Farmington	Cultural	Adjacent
Twin Angels	New Mexico	Farmington	Cultural	1 mi
Alamo Hueco Mountains	New Mexico	Las Cruces	Biological; scenic; cultural; paleontological; special status species	0.2 mi
Apache Box	New Mexico	Las Cruces	Biological; scenic; cultural; special status species; riparian	5.5 mi
Cooke's Range	New Mexico	Las Cruces	Biological; scenic; cultural; historic; recreation	Adjacent
Cornudas Mountain	New Mexico	Las Cruces	Visual; cultural; sensitive plants	4.5 mi
Dona Ana Mountains	New Mexico	Las Cruces	Scenic; recreation; biological; cultural	1.5 mi
Los Tules	New Mexico	Las Cruces	Cultural	Adjacent
Old Town	New Mexico	Las Cruces	Cultural; recreation	5 mi
Organ/Franklin Mountains	New Mexico	Las Cruces	Biological; scenic; cultural; special status species; riparian; recreation	Adjacent
Rincon	New Mexico	Las Cruces	Cultural	Adjacent
San Diego Mountain	New Mexico	Las Cruces	Cultural	0.4 mi
Three Rivers Petroglyph	New Mexico	Las Cruces	Cultural	Adjacent
Wind Mountain	New Mexico	Las Cruces	Visual; cultural; unique wildlife	6 mi
Cabezon Peak	New Mexico	Rio Puerco	Scenic; cultural; rare plant habitat; natural system geologic feature	1 mi
Casamero Community	New Mexico	Rio Puerco	Cultural	1 mi
Jones Canyon	New Mexico	Rio Puerco	Cultural; scenic; riparian	Adjacent
Ojito	New Mexico	Rio Puerco	Geological; paleontological; cultural; wildlife; rare plant habitat; geologic hazard	Adjacent
Mescalero Sands	New Mexico	Roswell	Biological; archaeological; scenic	7 mi
Agua Fria	New Mexico	Socorro	Biological; scenic; cultural; geological; recreation	Adjacent
Tinajas	New Mexico	Socorro	Cultural; recreation; scenic	Adjacent
Cottonwood Canyon	Utah	Kanab	Scenic; cultural; wildlife; natural processes; plant; geologic; Fredonia surface water watershed	Adjacent
Ten-Mile Wash	Utah	Moab	Cultural; wildlife	2 mi
Alkali Ridge	Utah	Monticello	Archaeological	Adjacent
Cedar Mesa	Utah	Monticello	Archaeological; scenic; primitive recreation	Adjacent

TABLE 4.15-3 (Cont.)

ACEC	State	BLM Field Office	ACEC Values	Distance[a] from Nearest Solar-Suitable Area
Hovenweep	Utah	Monticello	Archaeological; riparian	Adjacent
San Juan River	Utah	Monticello	Scenic; archaeological; wildlife	Adjacent
Shay Canyon	Utah	Monticello	Archaeological; riparian	1.5 mi
Dry Lake Archaeological District	Utah	Price	Archaeological; geologic	4 mi
Muddy Creek ACEC	Utah	Price	Scenic; mining; riparian	2.5 mi
Picotgraphs	Utah	Price	Archaeological	1 mi
Swasey Cabin	Utah	Price	Historic ranching	2 mi
Temple Mountain Historic District	Utah	Price	Mining; historic	1.5 mi)
Canaan Mountain	Utah	St. George	Scenic; cultural	0.5 m
Little Creek Mountain	Utah	St. George	Archaeological	Adjacent
Lower Virgin River	Utah	St. George	Endangered fish; archaeological	1.5 mi
Santa Clara Gunlock	Utah	St. George	Riparian; archaeological	3 mi

[a] To convert from mi to km, multiply by 1.609.

[b] Nevada ACEC distances to solar-suitable areas for Battle Mountain and Ely Field/District Offices are approximate; based on GIS data currently available at time of preparation.

4.15.1 Archaeological and Historic Resources

Through archaeology and ethnographic research, scientists have developed a historic framework for understanding how North America was settled and how Native American peoples lived on this continent prior to the arrival of Europeans. The history of Native Americans in the West is commonly approached by dividing the American West into culture areas (see Figure 4.15-1). These areas generally correspond to the major physiographic regions of the American West. The Native groups in a given culture area had to adapt to the regional climate and environment in order to survive. As a result, there are certain shared ways of life that characterize each region. Table 4.15-4 summarizes the major prehistoric periods and the types of cultural resources associated with each culture area. The cultural resource types presented in Table 4.15-4 represent the most common remains associated with each time period, not the total range of cultural resources associated with each time period.

Historic period cultural resources occur across the six-state study area. As with the prehistoric periods, Euro-American settlement and use of the West also can be understood through adaptation to the culture areas that loosely correspond to the major physiographic regions of the West. While considerable overlap exists in the general types of cultural resources that are found in the West, there also is considerable regional variability. Table 4.15-5 lists the culture areas and historic era cultural resource types by state. Again, this list of cultural resource types is not comprehensive; instead it is intended to provide the most common property types. Figure 4.15-1 also shows the locations of historic trails in addition to the culture areas.

Within BLM-administered lands, several cultural resource surveys have been conducted either for specific projects or for NHPA Section 110 requirements to inventory resources on federal lands. Each year the BLM is required to provide Congress with an annual reporting of their NHPA-related activities. Table 4.15-6 lists the number of acres surveyed on BLM-administered lands within the six-state study area and the number of cultural properties recorded since 1970.

4.15.2 *National Register of Historic Places* and Congressionally Designated Properties

As discussed above, cultural resources that meet the eligibility criteria for listing in the NRHP are formally referred to as historic properties. Many historic properties are located in the six-state region. The BLM has made eligibility determinations on many properties within their lands in accordance with Section 110 requirements of the NHPA. Table 4.15-7 lists the total numbers of BLM properties determined eligible since 1998 in their annual reporting requirements to Congress. Certain sites of significance have been given National Historic Landmark status by the Secretary of the Interior and are shown on Figure 4.15-1. The National Historic Landmarks within 25 mi (40 km) of solar suitable areas are included in Table 4.15-8. Congressionally designated National Historic Trails are listed in Table 4.15-9.

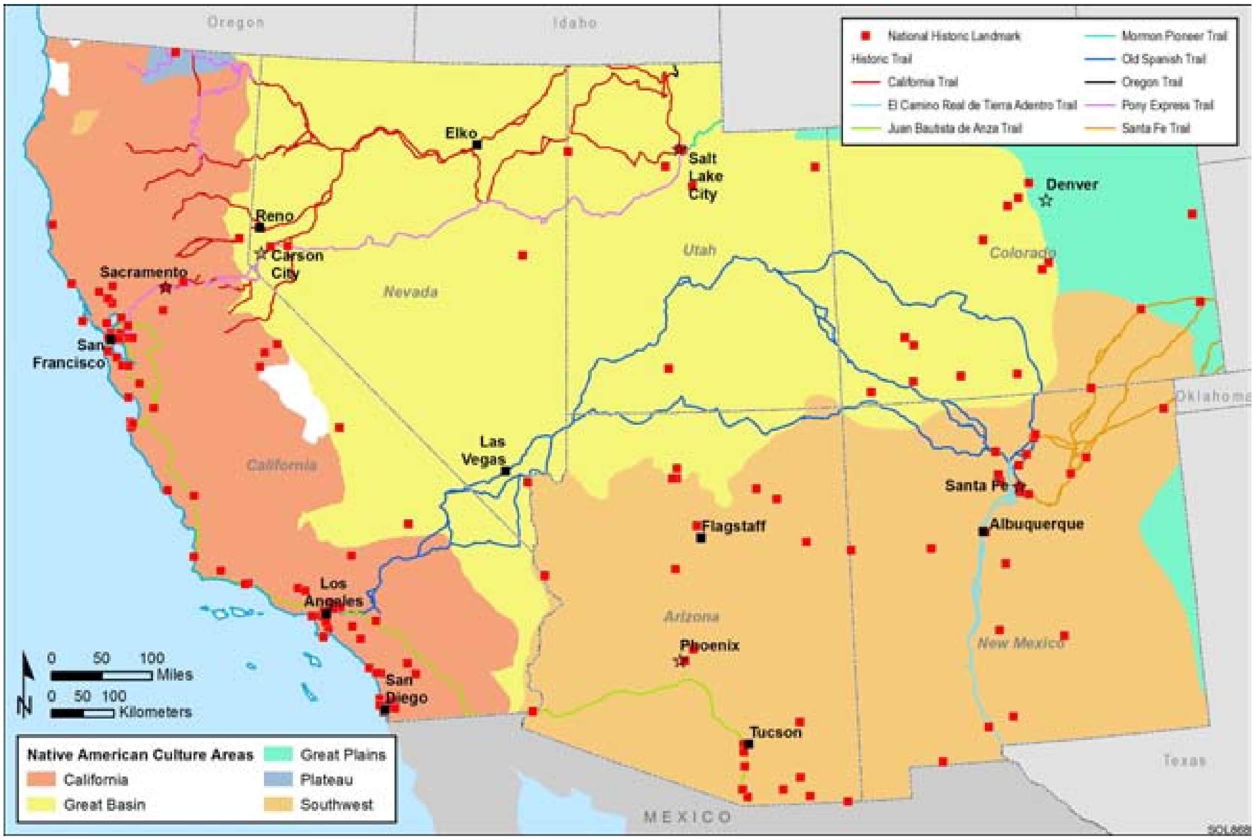

FIGURE 4.15-1 Major Culture Areas, Congressionally Designated National Historic Trails, and National Historic Landmarks within the Six-State Study Area

4.15.3 Traditional Cultural Properties

Traditional cultural properties are historic properties (that is, they are eligible for listing in the NRHP) that are important to a community's practices and beliefs and that are necessary for maintaining the community's cultural identity. Locations of specific traditional cultural properties within the BLM-administered lands considered suitable for solar energy development are not currently available but are part of the ongoing discussions during government-to-government consultations with Native American Tribes and through the public comment process for all cultural groups (also see Section 4.16).

TABLE 4.15-4 Time Periods and Examples of Characteristic Cultural Resources for Culture Areas in the Six-State Study Area

Culture Area	Paleoindian	Middle Period or Archaic	Late or Sedentary Period
California	*9000 (?) to 6000 BC* Open campsites Animal kill or processing sites	*6000 to 3000 BC* Open campsites Coastal villages Plant and seafood processing sites	*3000 BC to AD 1750* Large coastal villages Burial mounds Extensive seafood and sea mammal processing sites Intensive plant processing sites Prehistoric trails Geoglyphs/Intaglios
Great Basin	*9500 + to 6000 BC* Open campsites Cave occupation sites Lithic processing sites Animal kill or processing sites Isolated projectile points	*6000 to 2000 BC* Cave or rockshelter occupation sites Pithouse villages Plant processing sites Fishing sites Lithic processing sites Animal kill or processing sites	*2000 BC to AD 1750* Cave or rockshelter occupation sites Tipi ring sites Cave burials Cairns and cairn lines Small pithouse villages Plant processing sites Storage pits Lithic processing sites Pictograph and petroglyph sites Animal kill or processing sites Prehistoric roads
Southwest	*12,000 to 6000 BC* Open campsites Animal kill or processing sites Cave occupation sites Lithic processing sites Isolated projectile points	*6000 to 1 BC* Open campsites Cave or rockshelter occupation sites Pithouses and storage pits Wattle-and-daub structures Lithic processing sites Pictograph and petroglyph sites	*AD 1 to 1750* Pithouse villages Storage pits Aboveground structures (pueblos) Belowground structures (kivas) Irrigation ditches Roads Navajo hogans and pueblitos Pictograph and petroglyph sites Intaglios Prehistoric roads or trails
Plains	*10,000 to 6000 BC* Open campsites Cave or rockshelter occupation sites Animal kill or processing sites Lithic processing sites Isolated projectile points	*6000 to 1 BC* Open campsites Cave or rockshelter occupation sites Pithouses and storage pits Tipi ring sites Cairns and cairn lines	*AD 1 to 1750* Open campsites Tipi ring sites Wattle-and-daub structures Earthlodge villages Burial mounds Storage pits

TABLE 4.15-4 (Cont.)

Culture Area	Paleoindian	Middle Period or Archaic	Late or Sedentary Period
Plains (Cont.)		Animal kill or processing sites Lithic processing sites Plant processing sites	Cave or rockshelter occupation sites Small pithouse villages Cairns and cairn lines Animal kill and processing sites Lithic processing sites Plant processing sites Pictograph and petroglyph sites Prehistoric trails

Source: Modified from BLM (2007a).

TABLE 4.15-5 Major Culture Areas and Historic Period Site Types (AD 1550 to present) Listed by State

State	Culture Areas	Range of Historic Resources
Arizona	Southwest, Great Basin	Historic trails, buildings, structures, towns, fur trade sites, agricultural sites, ranching sites, mining-related sites, logging sites, military camps and outposts, missions, Civilian Conservation Corps (CCC) camps, and railroads
California	California, Great Basin	Historic trails, missions, buildings, structures, towns, forts, mining-related sites, logging-related sites, agricultural sites, railroads, CCC camps, and military camps and outposts
Colorado	Great Basin, Plains, Southwest	Historic trails, buildings, structures, towns, fur trade sites, agricultural sites, ranching sites, mining-related sites, logging sites, military outposts, CCC camps, and railroads
Nevada	Great Basin	Historic trails, buildings, structures, towns, fur trade sites, agricultural sites, ranching sites, mining-related sites, logging sites, military outposts, missions, and railroads
New Mexico	Southwest, Plains	Historic trails, buildings, structures, towns, fur trade sites, agricultural sites, ranching sites, mining-related sites, logging sites, military outposts, and railroads
Utah	Great Basin	Historic trails, buildings, structures, towns, fur trade sites, agricultural sites, ranching sites, mining-related sites, logging sites, military outposts, and railroads

TABLE 4.15-6 Reportable Inventory Data for BLM-Administered Lands

State	BLM Acres Surveyed in State	Number of BLM Properties in State
Arizona	918,830	13,334
California	1,955,127	30,528
Colorado	1,749,469	44,263
Nevada	2,627,612	51,529
New Mexico	1,657,095	37,806
Utah	2,508,075	45,411

Source: Lasell (2010).

TABLE 4.15-7 BLM Properties Determined Eligible for the NRHP in the Six-State Study Area

State	Number of Eligible Sites
Arizona	1,624
California	919
Colorado	4,958
Nevada	3,334
New Mexico	7,777
Utah	8,493

Source: Lasell (2010).

4.16 NATIVE AMERICAN CONCERNS

Federally recognized Tribes have a unique relationship with the federal government on the basis of their original sovereign and independent status as defined in treaties, statutes, Executive Orders, and court decisions. The federal government is required to take into account the interests of federally recognized Native American Tribes when proposing actions that could affect those interests. Interests of Native Americans include not only cultural resources but economic development, access to energy resources, health and safety, environmental justice, and protection of the environment. While these interests are common to all segments of society and are treated throughout the PEIS, federal laws require federal agencies to consult on a government-to-government basis with affected Native American Tribes regarding environmental issues and to take into account Native American concerns. All federally recognized Tribes that

TABLE 4.15-8 National Historic Landmarks within 25 mi (40 km) of BLM-Administered Lands Suitable for Solar Energy Development in the Six-State Study Area[a]

National Historic Landmark	Distance[b] to Nearest Solar-Suitable Area
Arizona	
Air Force Facility Missile Site 8 (571-7) Military Reservation	5 mi
El Tovar Hotel	10 mi
Grand Canyon Power House	10 mi
Grand Canyon Railroad Station	9 mi
Grand Canyon Park Operations Building	10 mi
Navajo Nation Council Chamber	10 mi
Painted Desert Inn	8 mi
Phelps Dodge General Office Building	5 mi
Tumacacori Museum	21 mi
California	
Parson's Memorial Lodge	20 mi
Colorado	
Mesa Verde Administrative District	12 mi
Pike's Stockade	5 mi
Nevada	
Fort Churchill	1 mi
Senator Francis G. Newlands House	9 mi
New Mexico	
Georgia O'Keefe Home and Studio	23 mi
Hawikuh	12 mi
Launch Complex 33	13 mi
Mesilla Plaza	2.5 mi
Utah	
Bryce Canyon Lodge	7 mi

[a] National Historic Landmarks in this list are based on a GIS coverage of landmarks in each state and may not be a complete list.

[b] To convert mi to km, multiply by 1.609.

TABLE 4.15-9 Congressionally Designated National Historic Trails within the Six-State Study Area

National Historic Landmark	Distance[a] to Nearest Solar-Suitable Area
Arizona	
Juan Bautista de Anza National Historic Trail	Adjacent (0.25 mi)
Old Spanish National Historic Trail	Adjacent (0.25 mi)
California	
California National Historic Trail	14 mi
Juan Bautista de Anza National Historic Trail	1.5 mi
Old Spanish National Historic Trail	Adjacent (0.25 mi)
Pony Express National Historic Trail	45 mi
Colorado	
Old Spanish National Historic Trail	Adjacent (0.25 mi)
Santa Fe National Historic Trail	26 mi
Nevada	
California National Historic Trail	Adjacent (0.25 mi)
Old Spanish National Historic Trail	Adjacent (0.25 mi)
Pony Express National Historic Trail	Adjacent (0.25 mi)
New Mexico	
El Camino Real de Tierra Adentro National Historic Trail	Adjacent (0.25 mi)
Old Spanish National Historic Trail	Adjacent (0.25 mi)
Santa Fe National Historic Trail	1.4 mi
Utah	
California National Historic Trail	65 mi
Mormon Pioneer National Historic Trail	111 mi
Old Spanish National Historic Trail	Adjacent (0.25 mi)
Oregon National Historic Trail	159 mi
Pony Express National Historic Trail	3 mi

[a] To convert mi to km, multiply by 1.609.

have traditional territory within solar-suitable areas are listed in Tables 4.16-1 and 4.16-2. Appendix K contains a listing of all federally recognized Tribes in the six-state study area that were contacted regarding this PEIS, copies of the letters sent to the Tribes, a complete listing of each Tribe receiving the letter, and responses from Tribes.

Resources important to Tribes fall into several categories with distinct management requirements derived from federal legislation, Executive Orders, and court decisions (see Table 4.16-3). These resources may be distinguished on the basis of whether they are located on Tribal or on federal lands, and whether they are Tribal assets or are nonassets that legally must be managed in consultation with Tribes. In general, cultural resources located on federal lands that are important to Tribes, unless specifically reserved in treaties

TABLE 4.16-1 Tribes Whose Traditional Tribal Use Area Includes BLM-Administered Lands Being Analyzed for Solar Development

Culture Area	Tribe
California	Cahuilla
	Kamia
	Kitanemuk
	Kumeyaay
	Serrano
Great Basin	Chemhuevi
	Kawaiisu
	Northern Paiute
	Owens Valley Paiute
	Southern Paiute
	Ute
	Washoe
	Western Shoshone
Great Plains	Arapaho
	Cheyenne
Southwest	Acoma
	Akimel O'odham (Pima)
	Chiricahua Apache
	Cocopah
	Halchidoma
	Havasupai
	Hopi
	Hualapai
	Jacome
	Jano
	Jemez
	Jicarilla Apache
	Laguna
	Maricopa
	Mescalero Apache
	Mohave
	Navajo
	Pecos
	Piro
	Quechan (Yuma)
	Rio Grande Keresans
	South Tiwa
	Tohono O'odham (Papago)
	Tompiro
	Yavapai
	Zuni

TABLE 4.16-2 Tribes Contacted for this PEIS with Traditional Territory in Solar-Suitable Areas

State	Organization
Arizona	Ak Chin Indian Community Council
	Cocopah Tribal Council
	Colorado River Indian Tribes Museum
	Colorado River Tribal Council
	Fort McDowell Yavapai Tribal Council
	Fort Yuma Quechan Tribe
	Gila River Indian Community Council
	Havasupai Tribal Council
	Hopi Tribal Council
	Hualapai Tribal Council
	Kaibab Paiute Tribal Council
	Navajo Nation
	Pascua Yaqui Tribal Council
	Salt River Pima-Maricopa Indian Community Council
	San Carlos Tribal Council
	San Juan Southern Paiute Council
	Tohono O'odham Nation
	Tonto Apache Tribal Council
	White Mountain Apache Tribe
	Yavapai-Apache Nation Tribal Council
	Yavapai-Prescott Board of Directors
California	Agua Caliente Band of Cahuilla Indians
	Augustine Band of Mission Indians
	Barona Group of the Capitan Grande
	Benton Paiute Reservation
	Big Pine Paiute Tribe of the Owens Valley
	Big Sandy Rancheria
	Bishop Paiute Tribe
	Bridgeport Indian Colony
	Cabazon Band of Cahuilla Mission Indians
	Cahuilla Band of Mission Indians
	Campo Band of Mission Indians
	Cedarville Rancheria
	Chemehuevi Tribal Council
	Cold Springs Rancheria
	Ewiiaapaayp Band of Kumeyaay Indians
	Fort Bidwell Reservation
	Fort Independence Indian Reservation
	Fort Mojave Tribal Council
	Inaja-Cosmit Reservation
	Kern Valley Indian Community
	Kwaaymii Laguna Band of Indians
	La Jolla Band of Luiseño Indians
	La Posta Band of Mission Indians

TABLE 4.16-2 (Cont.)

State	Organization
California *(Cont.)*	Lone Pine Paiute Shoshone Reservation
	Los Coyotes Band of Cahuilla & Cupeno Indians
	Manzanita Band of Mission Indians
	Morongo Band of Mission Indians
	North Fork Rancheria
	Pala Band of Mission Indians
	Pauma/Yuima Band of Mission Indians
	Pechanga Band of Mission Indians
	Picayune Rancheria of Chukchansi Indians
	Ramona Band of Mission Indians
	San Manuel Band of Mission Indians
	San Pasqual Band of Mission Indians
	Santa Rosa Band of Mission Indians
	Santa Ysabel Band of Diegueno Indians
	Soboba Band of Luiseño Indians
	Sycuan Band of the Kumeyaay Nation
	Timbi-sha Shoshone Tribe
	Torres-Martinez Desert Cahuilla Indians
	Tubatulabals of Kern Valley
	Twenty-Nine Palms Band of Mission Indians
	Viejas Band of Mission Indians
	Woodfords Community Council
Colorado	Southern Ute Tribe
	Ute Mountain Ute Tribe
Idaho	Shoshone-Bannock Tribes
Montana	Northern Cheyenne Tribal Council
North Dakota	Standing Rock Sioux Tribal Council
New Mexico	Jicarilla Apache Nation
	Mescalero Apache Tribe
	Navajo Nation, Alamo Chapter
	Navajo Nation, Ramah Chapter
	Ohkay Owingeh
	Pueblo of Acoma
	Pueblo of Cochiti
	Pueblo of Isleta
	Pueblo of Jemez
	Pueblo of Laguna
	Pueblo of Nambe
	Pueblo of Picuris
	Pueblo of Pojoaque
	Pueblo of San Felipe

TABLE 4.16-2 (Cont.)

State	Organization
New Mexico *(Cont.)*	Pueblo of San Ildefonso Pueblo of Sandia Pueblo of Santa Ana Pueblo of Santa Clara Pueblo of Santo Domingo Pueblo of Taos Pueblo of Tesuque Pueblo of Zia Pueblo of Zuni
Nevada	Battle Mountain Band Council Carson Community Council Dresslerville Community Council Duckwater Tribal Council Elko Band Council Ely Shoshone Tribe Fallon Paiute Shoshone Tribal Business Council Fort McDermitt Tribal Council Inter-Tribal Council of Nevada Las Vegas Tribal Council Lovelock Tribal Council Moapa Business Council Pahrump Paiute Tribe Pyramid Lake Paiute Tribal Council Reno-Sparks Tribal Council Shoshone-Paiute Business Council South Fork Band Council Stewart Community Council c/o Washoe Tribe of Nevada/California Summit Lake Paiute Tribal Council Te-Moak Tribe of Western Shoshone Tribal Council Walker River Paiute Tribal Council Washoe Tribal Council Wells Indian Colony Band Council Winnemucca Tribal Council Yerington Paiute Tribe Yomba Tribal Council
Oklahoma	Apache Tribe of Oklahoma Cheyenne-Arapaho Tribes of Oklahoma Comanche Nation Fort Sill Apache Tribe of Oklahoma Kiowa Tribe of Oklahoma
South Dakota	Cheyenne River Lakota Sioux Tribe Crow Creek Sioux Tribal Council Oglala Sioux Tribal Council Rosebud Sioux Tribal Council

TABLE 4.16-2 (Cont.)

State	Organization
Texas	Ysleta del Sur Pueblo
Utah	Goshute Business Council Northwestern Band of Shoshone Nation Paiute Indian Tribe of Utah Tribal Council Paiute Indian Tribe of Utah, Cedar Band Paiute Indian Tribe of Utah, Indian Peak Band Paiute Indian Tribe of Utah, Kanosh Band Paiute Indian Tribe of Utah, Koosharem Band Paiute Indian Tribe of Utah, Shivwits Band Skull Valley Band of Goshute Indians General Council Ute Indian Tribe White Mesa Ute Tribe
Wyoming	Eastern Shoshone Business Council Northern Arapaho Business Council

or statutes, are neither Indian trust assets nor Indian trust resources. Federal regulations characterize them as "properties of traditional religious and cultural importance to an Indian Tribe" (36 CFR 800.16(1)(1)). They are to be managed by federal agencies in consultation with affected federally recognized Tribes. Cultural resources important to Tribes include cemeteries, campsites, and dwelling places associated with Tribal ancestors; traditional hunting, fishing, and gathering places; traditionally important plant and animal species and their habitats; and sacred places, landscapes, and resources important to the free practice of traditional Native American religions and the preservation of traditional Native American cultures.

Cultural resources are trust resources when a fiduciary obligation on the part of the United States has been defined in treaties, statues, or Executive Orders. For example, a treaty may guarantee the right to Native Americans to exploit fisheries or minerals on lands they are ceding. In addition, the Native American Graves Protection and Repatriation Act (NAGPRA) establishes Native Americans as owners of Native American burials and associated artifacts on federal lands and requires that they be repatriated in consultation with the affected Tribal group.

Native Americans tend to view their environment holistically. Rather than stressing the division of their environment into its constituent parts, each part is intrinsically and inextricably connected to the whole. From this perspective, the whole is more than the sum of its parts and damage to one part damages the whole (Stoffle and Zedeño 2001). Often this holistic view extends beyond the physical environment. Distinctions between the natural and the cultural and the animate and the inanimate as viewed by Western societies may have little meaning from a traditional Native American perspective. Because of this world view, resources important to them generally extend beyond cultural resources to natural resources, including plants, animals, ecosystems, geophysical features, water, and air. Elements of many of these concerns are shared

TABLE 4.16-3 Resources Important to Tribes

Resource Type	Description
Archaeological sites	The physical remains of human activities, including artifacts, structures, and special use sites. All prehistoric and some historic archaeological sites in the United States are associated with ancestral Native American populations. These sites often include a buried (subsurface) component.
Indian trust assets	Lands, natural resources, or other assets held in trust or restricted against alienation by the United States for Native American Tribes or individual Native Americans (DOI 2000).
Indian trust resources	Those natural resources, either on or off Indian lands, retained by or reserved by or for Indian Tribes through treaties, statutes, judicial decisions, and Executive Orders, which are protected by a fiduciary obligation on the part of the United States (DOI 2008).
NAGPRA remains	Native American human remains, funerary objects, sacred objects, or objects of cultural patrimony found on federal lands or residing in museums receiving federal funding.
Properties of traditional religious and cultural importance to an Indian Tribe	Often referred to as “traditional cultural properties,” these features may be eligible for listing on the NRHP. They include sacred sites, burial grounds, ancestral sites, traditional gathering places, and culturally important landscapes and natural resources (36 CFR 800.16(l)(1)).
Sacred sites	Any specific location on federal land that is identified by an Indian Tribe or Indian individual determined to be an appropriately authoritative representative of an Indian religion, as sacred by virtue of its established religious significance to, or ceremonial use by, an Indian religion (GSA 1999).
Tribal lands	All lands within the exterior boundaries of an Indian reservation and all dependent Indian communities (36 CFR 800.16(x)).
Treaty rights	Rights reserved to Native Americans by treaties, including hunting, fishing, gathering, and mineral rights.
Traditional cultural properties	Properties eligible for inclusion in the NRHP because of their association with cultural practices or beliefs of a living community that are rooted in the community’s history and are important in maintaining the continuing cultural identity of the community (Parker and King 1998).

TABLE 4.16-4 Natural Resources Traditionally Widely Used by Native Americans in the Arid Southwest

Resource	On Valley Floors	In Surrounding Terrain
Animals	Black-tailed jackrabbit	Bighorn sheep
	Desert cottontail	Mule Deer
	Pronghorn	
	Badger	
	Fox	
	Porcupine	
	Wood rats	
	Desert tortoise	
	Chuckwalla	
Birds	Golden eagle	Golden eagle[a]
	Hawks	Hawks
	Burrowing owl	Migrating water fowl
	Quail	
	Doves	
Plants	Mesquite	Pine nuts
	Agave (mescal)	Acorns
	Cactus fruit	
	Buckwheat	
	Seed-bearing grasses	
	Berries	
	Greasewood	
	Sagebrush	
	Saltbush	
	Cat's claw	
	Desert Willow	
Minerals	Clay for pottery	Turquoise
	Salt	Quartz crystals
		Mineral pigments

[a] Eagles, eagle parts, eagle nests, and eagle habitat are culturally significant resources for some Tribes. Existing and former nesting sites may be regarded as sacred sites or traditional cultural properties.

Source: Stoffle and Zedeño (2001).

with the population as a whole and are discussed elsewhere in Chapter 4. Archaeological sites, structures, landscapes, trails, and traditional cultural properties are discussed in Section 4.15; mineral resources in Section 4.8; water resources in Section 4.9; ecological resources in Section 4.10; air quality in Section 4.11; visual resources in Section 4.12; and the acoustic environment in Section 4.13. This section focuses on concerns that are specific to Native Americans or to which Native Americans bring a distinct perspective. For example, in the arid areas considered in this PEIS, water is a concern that crosses all ethnic boundaries. Over the years, Native Americans have lost access to the water resources upon which they traditionally depended. This situation has severely restricted and altered their traditional resource base. In addition, water sources such as springs, tanks, wells, and rivers often have religious importance. Additional resources of importance are listed in Table 4.16-4 for the arid Southwest, but the list is not intended to be exhaustive for the broad six-state region covered in this PEIS.

4.17 SOCIOECONOMICS

The socioeconomic environment potentially affected by the development of solar resources on federal land encompasses the six western states in which the SEZs considered in this PEIS are located. Nine key measures of economic development are described in the following sections: (1) employment, (2) unemployment, (3) personal income, (4) sales tax revenues, (5) individual income tax revenues, (6) population, (7) vacant rental housing, (8) state and local government expenditures, and (9) state and local government employment. For each development measure, data are presented for 2010, the first year during which construction impacts associated with solar developments would be assessed, and for a recent preceding period. Forecasts for each measure are based on population forecasts produced by the U.S. Census Bureau for the period 2004 to 2030 (U.S. Bureau of the Census 2008a).

4.17.1 Employment

In 2007, almost 66% (17.2 million) of all employment in the six-state study area (26.2 million) was concentrated in California (Table 4.17-1). Employment in Arizona and Colorado stood at 2.9 million and 2.6 million, respectively; the remaining states supported 3.5 million jobs. Employment in the six-state study area as a whole is projected to increase to 27.3 million in 2010.

Over the period 1990 to 2007, annual employment growth rates were higher in Nevada (4.3%), Arizona (3.2%), and Utah (3.1%) than elsewhere in the six-state study area. At 1.1%, the growth rate in California was somewhat less than the average rate of 1.5%.

TABLE 4.17-1 State Employment (millions, except where noted)[a]

State	1990	2007	Average Annual Growth Rate, 1990–2007 (%)	2010 (projected)
Arizona	1.7	2.9	3.2	3.1
California	14.3	17.2	1.1	17.8
Colorado	1.7	2.6	2.6	2.7
Nevada	0.6	1.3	4.3	1.4
New Mexico	0.7	0.9	1.9	0.9
Utah	0.8	1.3	3.1	1.4
Total	19.7	26.2	1.7	27.3

[a] Because of rounding, column totals may not be exact.

Source: U.S. Department of Labor (2008a).

4.17.2 Unemployment

In the majority of the states in the study area, unemployment rates declined over the period 1996 to 2007 (Table 4.17-2). Current unemployment rates in California (7.3%), Colorado (5.2%), and Nevada (6.6%) were slightly higher than the corresponding average for the preceding 17-year period. With the exception of California, relatively small labor forces exist in each state. However, there are fairly large numbers of local workers who are presently unemployed in each state and, therefore, potentially are available to work on the proposed energy developments within the states.

4.17.3 Personal Income

California generated almost 70% of the total personal income in the six-state study area, producing almost $1.5 trillion in 2006 (Table 4.17-3). The state was expected to generate more than $1.5 trillion in 2009. For the six states combined, personal income is expected to rise from $2.1 trillion in 2006 to $2.2 trillion in 2010.

Annual growth in personal income was highest in Nevada (6.0%) over the period 1990 to 2006. Personal income growth rates in Arizona (4.5%), Utah (4.1%), and Colorado (4.0%) were all more than one percentage point higher than the six-state average rate of 2.8%.

TABLE 4.17-2 Unemployment Data[a]

State	Average 1990–2007 (%)	Current Rate (%)	Currently Unemployed Persons
Arizona	5.2	5.1	158,189
California	6.7	7.3	1,351,959
Colorado	4.5	5.2	144,133
Nevada	5.2	6.6	92,890
New Mexico	6.0	4.1	39,003
Utah	4.1	3.5	48,928

[a] Data for current unemployment rates and the number of unemployed persons are for July 2008.

Source: U.S. Department of Labor (2008a–c).

TABLE 4.17-3 State Personal Income ($ billions 2007, except where noted)[a]

State	1990	2006	Average Annual Growth Rate, 1990–2006 (%)	2010 (projected)
Arizona	99.4	202.5	4.5	223.4
California	1,028.2	1,477.1	2.3	1,542.6
Colorado	102.7	193.5	4.0	200.6
Nevada	39.4	99.9	6.0	111.2
New Mexico	36.0	59.8	3.2	61.7
Utah	40.9	78.0	4.1	82.5
Total	1,346.6	2,110.8	2.8	2,222.0

[a] Because of rounding, column totals may not be exact.

Sources: U.S. Department of Commerce (2008); U.S. Department of Labor (2008d).

4.17.4 Sales Tax Revenues

Sales tax revenues are projected to grow for the six states as a whole from $79.0 billion in 2002 to $88.7 billion in 2010 (Table 4.17-4). Growth is also expected in each individual state over the period 2002 through 2009, with revenues in the largest generating state, California, projected to reach $57.1 billion in 2010.

Higher than average annual growth in sales tax revenues during the period 1992 to 2002 occurred in Nevada (7.8%), Arizona (6.4%), Utah (5.6%), and Colorado (5.1%). The average annual growth rate for the six states as a whole during the period 1992 to 2002 was 3.8%.

TABLE 4.17-4 State Sales Taxes ($ billions 2007, except where noted)[a]

State	1992	2002	Annual Growth Rate 1990–2002 (%)	2010 (projected)
Arizona	5.0	9.2	6.4	11.3
California	39.0	52.1	2.9	57.1
Colorado	3.8	6.2	5.1	6.8
Nevada	2.5	5.3	7.8	6.7
New Mexico	2.3	3.0	2.7	3.2
Utah	1.8	3.2	5.6	3.6
Total	54.4	79.0	3.8	88.7

[a] Because of rounding, column totals may not be exact.

Sources: U.S. Bureau of the Census (2008b); U.S. Department of Labor (2008d).

4.17.5 Individual Income Tax Revenues

In 2002, California generated 81% of state individual income tax revenues in the six-state study area, producing $41.9 billion (Table 4.17-5). Colorado was the second largest state income tax producer, with $3.9 billion in 2002. Revenues for the entire region are projected to increase from $51.7 billion in 2002 to $57.0 billion in 2010. Revenues in California are expected to reach $46.0 billion in 2010.

Most of the six states experienced moderately large annual increases in state individual income tax revenues (see Table 4.17-5). Growth rates in New Mexico (5.8%), Utah (5.4%), and California (5.2%) were all higher than the average of 5.1% for the six-state study area. Relatively slow growth in individual income tax revenues (3.8%) was experienced in Arizona during this period.

4.17.6 Population

Total population in the six-state study area stood at 49.4 million people in 2000; it is expected to reach 56.8 million by 2010 (Table 4.17-6). Population in the region is concentrated in California, which at 33.9 million people, had almost 70% of the total regional population in 2000. Population in California is expected to increase to 38.1 million by 2010. In 2000, each of the remaining states, with the exception of Arizona (5.1 million), had less than 5 million persons.

TABLE 4.17-5 State Individual Income Taxes ($ billions 2007, except where noted)[a]

State	1992	2002	Annual Growth Rate 1990–2002 (%)	2010 (projected)
Arizona	1.8	2.7	3.8	3.3
California	25.2	41.9	5.2	46.0
Colorado	2.4	3.9	5.1	4.3
Nevada	0.0	0.0	–[b]	–
New Mexico	0.7	1.2	5.8	1.2
Utah	1.2	1.9	5.4	2.2
Total	31.2	51.7	5.1	57.0

[a] Because of rounding, column totals may not be exact.

[b] A dash indicates that there is currently no state individual income tax in Nevada.

Sources: U.S. Bureau of the Census (2008b); U.S. Department of Labor (2008d).

TABLE 4.17-6 State Population (millions, except where noted)[a]

State	1990	2000	Annual Growth Rate 1990–2000 (%)	2010 (projected)
Arizona	3.7	5.1	3.4	6.6
California	29.8	33.9	1.3	38.1
Colorado	3.3	4.3	2.7	4.8
Nevada	1.2	2.0	5.2	2.7
New Mexico	1.5	1.8	1.8	2.0
Utah	1.7	2.2	2.6	2.6
Total	41.2	49.4	1.8	56.8

[a] Because of rounding, column totals may not be exact.

Source: U.S. Bureau of the Census (2008a,c).

Population in the six-state study area grew at an annual average rate of 1.8% from 1990 to 2000. Growth within the region was fairly uneven over the period, with relatively high annual growth rates in Nevada (5.2%) and Arizona (3.4%). Growth rates in Colorado and Utah were closer to the average for the region, with lower than average rates in California (1.3%).

4.17.7 Vacant Rental Housing

With the largest population in the six-state study area, California also has the largest housing market and the largest number of vacant rental housing units (Table 4.17-7). The total number of vacant rental units in the state stood at 190,000 in 2000 (53% of the six-state total) and is expected to reach 213,600 in 2010. Elsewhere in the region, Arizona (61,900 units) had the second largest number of vacant rental units in 2000. The number of units in the six-state study area as a whole stood at 356,000 in 2000 and is expected to reach 417,200 by 2010.

The total number of vacant rental units in the six-state study area slightly declined over the period 1990 to 2000 (annual rate of –2.5%). Three states, Colorado (–5.3%), California (-3.5%), and Arizona (–1.9%), have seen higher than average declines in vacant units; Utah has experience a slight decline (-0.7%); while Nevada (5.1%) and New Mexico (2.8%) have experienced relatively large increases in vacant rental units.

4.17.8 State and Local Government Expenditures

The distribution of funding for state and local government services is concentrated in California, with $378.0 billion in government expenditures in 2002, which was almost 74% of all

TABLE 4.17-7 Vacant Rental Housing Units (thousands, except where noted)[a]

State	1990	2000	Annual Growth Rate 1990–2000 (%)	2010 (projected)
Arizona	75.0	61.9	–1.9	80.1
California	271.9	190.0	–3.5	213.6
Colorado	55.3	31.9	–5.3	35.8
Nevada	19.2	31.7	5.1	42.6
New Mexico	20.2	26.7	2.8	29.0
Utah	14.7	14.0	–0.7	16.0
Total	456.3	356.0	–2.5	417.2

[a] Because of rounding, column totals may not be exact.

Source: U.S. Bureau of the Census (2008c).

government expenditures in the six-state study area (Table 4.17-8). Expenditures in California are expected to reach $414.7 billion in 2010. Other states with fairly large state and local government expenditures are Arizona ($41.6 billion in 2002) and Colorado ($39.6 billion in 2002). Expenditures in the six-state study area as a whole totaled $513.3 billion in 2002 and are expected to reach $562.7 billion by 2010.

Annual growth rates in state and local government expenditures have been fairly high throughout the six-state study area, with an overall annual average rate of 5.0% for the period 1990 to 2002. A number of the states, notably Nevada (7.0%) and Utah (6.0%), were more than one percentage point higher than the regional average, while growth rates in California (4.7%) were slightly lower than average during the period.

4.17.9 State and Local Government Employment

The majority (67%) of state and local government employment in the six-state study area region in 2006 was centered in California (Table 4.17-9). Government employment in the state stood at 1.8 million in 2002 and is projected to reach 1.9 million in 2010. Other states with fairly large government employment in 2006 were Arizona (285,100) and Colorado (255,000). Total state and local government employment in the six-state study area was 2.7 million in 2006 and is expected to reach 2.9 million in 2010.

Growth in government employment in the six states has varied over the period 1990 to 2006. While the average for the region stood at 2.0% over the period, government in

TABLE 4.17-8 Total State and Local Government Expenditures ($ billions 2007, except where noted)[a]

State	1992	2002	Annual Growth Rate 1990–2002 (%)	2010 (projected)
Arizona	24.0	41.6	5.6	51.0
California	239.7	378.0	4.7	414.7
Colorado	22.7	39.6	5.7	43.4
Nevada	9.4	18.6	7.0	23.6
New Mexico	10.0	16.2	5.0	17.3
Utah	10.8	19.3	6.0	12.7
Total	316.6	513.3	5.0	562.7

[a] Because of rounding, column totals may not be exact.

Sources: U.S. Bureau of the Census (2008b); U.S. Department of Labor (2008d).

TABLE 4.17-9 Total State and Local Government Employment (thousands, except where noted)[a]

State	1995	2006	Annual Growth Rate 1990–2006 (%)	2010 (projected)
Arizona	218.8	285.1	2.4	314.5
California	1,479.6	1,818.7	1.9	1,899.5
Colorado	204.9	255.0	2.0	264.3
Nevada	73.5	103.3	3.1	115.0
New Mexico	110.7	127.9	1.3	132.0
Utah	104.8	128.8	1.9	136.2
Total	2,192.3	2,718.8	2.0	2,861.5

[a] Because of rounding, column totals may not be exact.

Source: U.S. Bureau of the Census (2008b).

Nevada, for example, increased employment by 3.1%, with a smaller increase in Arizona (2.4%). Most of the states were within half a percentage point of the regional average, while New Mexico (1.3%) experienced slower growth rates in government employment.

4.18 ENVIRONMENTAL JUSTICE

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," formally requires federal agencies to incorporate environmental justice as part of their missions (*Federal Register*, Volume 59, page 7629, February 16, 1994). Specifically, it directs them to address, as appropriate, any disproportionately high and adverse human health or environmental effects of their actions, programs, or policies on minority and low-income populations.

The analysis of the impacts of solar energy development on environmental justice issues follows guidelines described in the Council on Environmental Quality's (CEQ's) *Environmental Justice Guidance under the National Environmental Policy Act* (CEQ 1997). The analysis method has three steps: (1) description of the geographic distribution of low-income and minority populations in the affected area; (2) assessment of whether the impacts of construction and operation would produce impacts that are high and adverse; and (3) if impacts are high and adverse, determination as to whether these impacts disproportionately affect minority and low-income populations.

Construction and operation of energy projects in the six-state study area could affect environmental justice if any adverse health and environmental impacts resulting from any phase of development were significantly high. If the analysis determines that health and environmental impacts on the general population are not significant, there can be no disproportionate impacts on minority and low-income populations. If impacts are significant, disproportionality would be determined by comparing the proximity of any high and adverse impacts to the location of low-income and minority populations.

The analysis of environmental justice issues associated with the development of solar facilities considered impacts at the state level in six western states: Arizona, California, Colorado, Nevada, New Mexico, and Utah. A description of the geographic distribution of minority and low-income groups was based on demographic data from the 2000 Census (U.S. Bureau of the Census 2008b) to describe the minority and low-income composition in the affected area. The following definitions were used to identify minority and low-income population groups:

- **Minority.** Persons are included in the minority category if they identify themselves as belonging to any of the following racial groups: (1) Hispanic, (2) Black (not of Hispanic origin) or African American, (3) American Indian or Alaska Native, (4) Asian, or (5) Native Hawaiian or Other Pacific Islander.

  Beginning with the 2000 Census, where appropriate, the census form allows individuals to designate multiple population group categories to reflect their ethnic or racial origin. In addition, persons who classify themselves as being of multiple racial origins may choose up to six racial groups as the basis of their racial origins. The term "minority" includes all persons, including those classifying themselves in multiple racial categories, except those who classify themselves as not of Hispanic origin and as White or "Other Race" (U.S. Bureau of the Census 2008c).

  The CEQ guidance proposed that minority populations should be identified where either (1) the minority population of the affected area exceeds 50%, or (2) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.

  The PEIS applies both criteria in using the Census Bureau data for census block groups, wherein consideration is given to the minority population that is both more than 50% and 20 percentage points higher than in the state (as a whole) (the reference geographic unit).

- **Low-Income.** Individuals who fall below the poverty line are in the low-income category. The poverty line takes into account family size and age of individuals in the family. In 2009, for example, the poverty line for a family of five with three children below the age of 18 was $25,603. For any given family below the poverty line, all family members are considered to be below the poverty line for the purposes of analysis (U.S. Bureau of Census 2008c).

Data in Table 4.18-1 show the minority and low-income composition of total population located in the six states based on 2000 census data and CEQ guidelines. Individuals identifying themselves as Hispanic or Latino are included in the table as a separate entry. However, because Hispanics can be of any race, this number includes individuals also identifying themselves as being part of one or more of the population groups listed in the table.

A large number of minority individuals reside in four of the six states potentially affected by solar developments on BLM land. In New Mexico, 55% of the population is classified as minority, with 53% in California, 36% in Arizona, and 35% in Nevada. While the state percentage of minority individuals does not exceed the six-state national average by 20 percentage points or more in any of the states, the number of minority persons in New Mexico and California exceeds 50% of the total population, meaning that these states have minority populations according to CEQ guidelines.

The proportion of low-income individuals does not exceed the six-state average by 20 percentage points or more in any of the states and does not exceed 50% of the total population in any of the states, meaning that there are no low-income populations in these states, according to CEQ guidelines.

TABLE 4.18-1 State Minority and Low-Income Populations for the Six-State Study Area

Category	Arizona	California	Colorado	Nevada	New Mexico	Utah
Total population	5,130,632	33,871,648	4,301,261	1,998,257	1,819,046	2,233,169
White, Non-Hispanic	3,274,258	15,816,790	3,202,880	1,303,001	813,495	1,904,265
Hispanic or Latino	1,295,617	10,966,556	735,601	393,970	765,386	201,559
Non-Hispanic or Latino minorities	560,757	7,088,302	362,780	301,286	240,165	127,345
One race	484,385	6,185,307	290,059	252,055	214,372	96,037
Black or African American	149,941	2,181,926	158,443	131,509	30,654	16,137
American Indian or Alaska Native	233,370	178,984	28,982	21,397	161,460	26,663
Asian	89,315	3,648,860	93,277	88,593	18,257	36,483
Native Hawaiian or other Pacific Islander	5,639	103,736	3,845	7,769	992	14,806
Some other race	6,120	71,681	5,512	2,787	3,009	1,948
Two or more races	76,372	903,115	72,721	49,231	25,793	31,308
Total minority	1,856,374	18,054,858	1,098,381	695,256	1,005,551	328,904
Low-income	698,669	4,706,130	388,952	205,685	328,933	206,328
Percent minority	36.2	53.3	25.5	34.8	55.3	14.7
Percent low-income	13.6	13.9	9.0	10.3	18.1	9.2

Source: U.S. Bureau of the Census (2008c).

4.19 REFERENCES

Note to Reader: This list of references identifies Web pages and associated URLs where reference data were obtained for the analyses presented in this PEIS. It is likely that at the time of publication of this PEIS, some of these Web pages may no longer be available or their URL addresses may have changed. The original information has been retained and is available through the Public Information Docket for this PEIS.

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