CHAPTER 3: AFFECTED ENVIRONMENT

Introduction

This chapter describes the unique factors that influence water resource management in the Preserve and the resources that could be affected by the implementation of any of the alternatives described in *Chapter 2: Alternatives*. The resource descriptions provided in this chapter serve as a baseline to compare the potential effects of the management actions proposed in the alternatives. The following resource topics are described in this chapter:

- Environmental Setting
- Water Resources
- Wildlife
- Cultural Resources
- Wilderness Character

Environmental setting and water resources are important for context and are foundational for water resource management, but are not resources that are analyzed for effects. Resource issues that were considered and dismissed from further analysis are listed in *Chapter 1: Purpose of and Need for Action* and are not discussed further in this EA. A description of the effects of the proposed alternatives on wildlife, cultural resources, and wilderness character is presented in *Chapter 4: Environmental Consequences*.

Environmental Setting

The Preserve includes an ecologically diverse yet fragile desert ecosystem consisting of vegetative attributes that are unique to the Mojave Desert, as well as components of the Great Basin and Sonoran Deserts.

Topography

The topography of the Preserve is characteristic of the mountain and basin physiographic pattern, with tall mountain ranges separated by corresponding valleys filled with alluvial sediments. Primary mountain ranges in the Preserve, from west to east, include the Granite, Kelso, Providence, Clark, New York, and Piute Mountains. Major alluvial valleys include Soda Lake (dry lake bed), Shadow Valley, Ivanpah Valley, Lanfair Valley, and Fenner Valley. Other physiographic features include the Kelso Dune system, Cinder Cone lava beds, and Cima Dome. The Preserve encompasses a 7,000-foot elevational range, with its highest point at Clark Mountain (7,929 feet [2,417 meters]) and its lowest point at Soda Lake (932 feet [284 meters]) (U.S. Geological Survey [USGS] 2009).

Geologic Overview

The geologic history of the Mojave Desert is typified by northwest striking faults active in the Late Cenozoic, which are associated with the greater San Andreas Fault System. Faulting was active into the Quaternary period and produced primarily northwest-trending mountain ranges (Bedford 2003). Geologic formations in the Preserve generally consist of consolidated rocks in the mountains and hills and the unconsolidated deposits in the valleys. The mountains consist primarily of igneous and metamorphic rocks of the Paleogene age (formerly referred to as pre-Tertiary age) of between 66 and 23 million years ago. In the valleys, the unconsolidated Pleistocene deposits (about 1.6 million years old) consist of gravels, sand, silt, and clay (NPS 2005a) containing deep aquifers (NPS 1999). Several of the highest mountain ranges, including the Clark, Ivanpah, and Providence Mountains, contain outcrops of carbonate sedimentary rocks in which cavities and caverns (such as Mitchell Caverns) have formed in dissolved limestone formations. Examples of past volcanic activity are found throughout the Preserve in cinder cones, lava flows, the Cima Dome formation, and the Hole in the Wall area (USGS 2009).

Climate Trends and History

The Mojave Desert is in the rain shadow of the San Gabriel and San Bernardino Mountains to the west and is characterized by very hot summers and cool winters. Climate conditions are among the most extreme and variable in the world, with significant changes in temperature and precipitation based on elevation, time of day, and season (NPS 2006).

Precipitation historically has ranged from 4 inches (10 centimeters) in lower areas such as Soda Lake to more than 12 inches (30 centimeters) annually in the New York Mountains. Summer precipitation comes in short, localized, and intense thunderstorms. Most precipitation occurs between November and March, when low-intensity frontal storms produce soaking rains and occasional light snowfall. Average annual potential evapotranspiration greatly exceeds the average annual precipitation, except during short periods during the winter, which is when most runoff and groundwater recharge occurs (Dekker and Hughson 2014; Hevesi et al. 2003; NPS 1999).

Events in the tropical Pacific and northern Pacific Ocean are linked to short-term variation in precipitation across the Mojave Desert region and are generally related to El Niño (increase in sea-surface temperature) and La Niña events (decrease in sea-surface temperature). El Niño events produce above-normal precipitation more frequently and result in significantly higher precipitation amounts compared with La Niña events (NPS 2006). Over much of the past 15 years, the Mojave Desert region has generally been in a La Niña cycle, resulting in lower precipitation and drought conditions (Hereford et al. 2002).

Historical precipitation records show multiyear droughts from the 1890s, through the 1960s. The wettest period in the last century was between 1976 and 1998 (NPS 2006; Abatzoglou et al. 2009; Hughson et al. 2011). The southwestern United States has been in a state of drought for well over a decade, with observed increased seasonal and average annual temperatures (Cook et al. 2009; Loehman 2010). Over the 2010–2013 period, the Mojave Desert region experienced an average temperature increase of 1- to 2-degrees and a precipitation decrease of up to 4 inches (10 centimeters), compared with long-term averages (WRCC 2013). This current multiyear drought is among the most extreme in 500 years (Cook and Krusic 2004; Loehman 2010).

Climate Projections

Reconstructions of the Earth's climate over the past 2,000 years have shown that while temperature fluctuations have varied, each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850. The period from 1983 to 2012 was likely the warmest 30-year period of the last 1,400 years in the Northern Hemisphere (Intergovernmental Panel on Climate Change [IPCC] 2015).

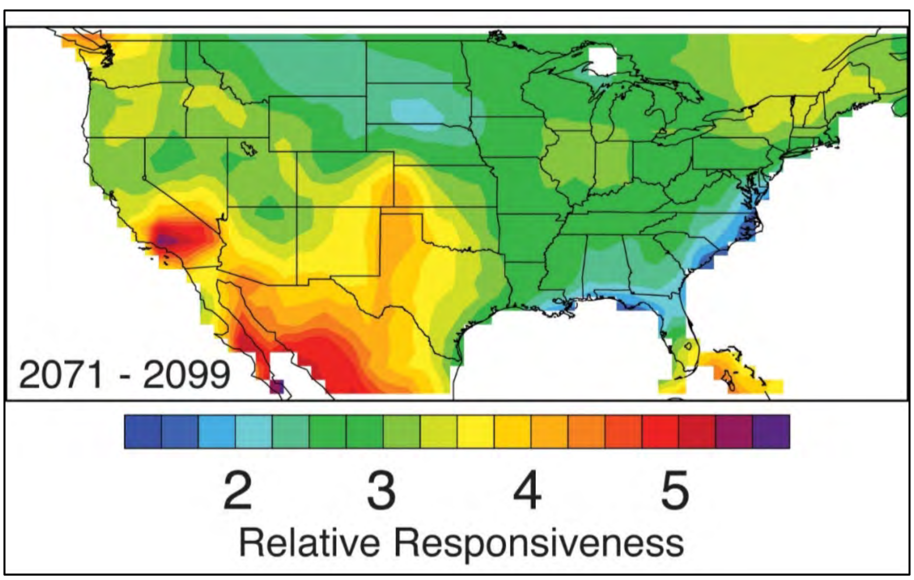
General effects of climate change are not uniform across regions (Brekke et al. 2009). Climate models predict that the arid regions of the southwestern United States will become increasingly dry and that a transition to a more arid climate is already underway (Seager et al. 2007; Lenart et al. 2007; Loehman 2010). Precipitation data going back to 1895 demonstrate this trend, with the four driest years occurring in 2013, 2014, 2002, and 2007; and the wettest year in the Mojave Desert occurring in 2005 (Hughson et al. 2011; WRCC 2017). Southern California, including the Mojave Desert, is predicted to be one of several climate change "hotspots," with a more arid climate and increased variability of precipitation from year to year (Diffenbaugh et al. 2008) (Figure 8). Climate models predict a general drying trend: with increasing air temperatures and reduced precipitation (Seager et al. 2007). Projected changes to the climate in the southwestern deserts include the following:

- Continued increases in temperature, but at a rate faster than observed in recent decades (Loehman 2010)
- Periods of extreme temperatures (heat waves) may increase in frequency, intensity, and duration over the next century (Diffenbaugh et al. 2005)
- Intensification of extreme hot periods, combined with warm-season drying (Diffenbaugh and Ashfaq 2010)
- Precipitation events (e.g., intense rain and associated flooding) are expected to be more extreme and occur roughly twice as often as they historically have (Kharin et al. 2007)

Arid ecosystems are particularly sensitive to climate change because the organisms in these regions are already adapted to live near their physiological limits for water and temperature stress. Slight changes in temperature and precipitation patterns in arid ecosystems can significantly alter the composition, abundance, and distribution of species (Loehman 2010). Temperature-related changes to ecosystems are likely to lead to an upward elevational shift of some woodland and montane communities, an expansion of desert scrub communities, and a northward migration of southwestern deserts.

Increased temperatures, reduced winter frost, and drought could also facilitate the expansion of forest pathogens and increased mortality of pinyon-juniper woodlands (Hughson et al. 2011). Recent droughts have resulted in widespread and significant mortality of shrubs and perennial grasses in parts of the Sonoran and Mojave Deserts (McAuliffe and Hamerlynck 2010; Hereford et al. 2006; Loehman 2010). The ecosystem effects of climate change have already shown effects on some desert wildlife species, including desert bighorn sheep (Epps et al. 2006), and biologists are increasingly concerned about extirpation or extinction of some species due to shrinking or disappearing habitats (NPS 2006).

Figure 8. U.S. Climate Change Hotspots



Source: Diffenbaugh et al. 2005

Changing climate conditions in the southwestern deserts, including increased temperatures, reduced precipitation, lower snowpack, and increased evapotranspiration, are likely to result in significant changes to the hydrologic cycle and water sources for both human use and ecosystem function. In desert systems like those found in the Preserve, this would likely result in reduced infiltration of precipitation into perched aquifers that are the source for many of the seeps, springs, and developed water features. Reduced recharge to deep alluvial aquifers will limit groundwater availability for water supply, though the effects may take centuries (Hughson et al. 2011).

In summary, the combined effects of cyclical drought and a changing climate are expected to result in a continued warming and drying trend for the Mojave Desert region, more variable precipitation when it does occur, and a reduced availability of surface water in the Preserve (Dekker and Hughson 2014).

Regional Context

Figure 9 shows the Preserve and surrounding region and highlights development, transportation corridors, and other factors contributing to the regional context. Existing and planned land management or development projects in the Mojave Desert region that are relevant to this plan and the resources affected by this plan are described below under the broad topics of existing infrastructure, federal land management, energy development, water development, and proposed development projects.

Existing Infrastructure

Modern human development of the Mojave Desert over the past century has resulted in a patchwork of developed areas and disturbed corridors. These include but are not limited to:

- I-15 to the north
- I-40 to the south
- UPRR, which traverses the Preserve
- Mountain Pass mine, north of the Preserve
- Numerous abandoned mines
- Numerous highways and roads
- Transmission lines traversing the Preserve
- Gas and petroleum pipelines
- Canals and aqueducts
- Small towns, ranches, and other settlements

While the Mojave Desert remains a vast and undeveloped landscape, the culmination of these and other developments has resulted in the fragmentation of natural habitat and movement corridors for broad-ranging wildlife species, such as desert bighorn sheep (Epps et al. 2007 and Creech et al. 2014).

Federal Land Management

Most of the land in the Mojave Desert is owned by the federal government, most of which is managed by the BLM. In addition to the Preserve, the NPS manages three other major sites in the Mojave Desert: Joshua Tree National Park, Death Valley National Park, and Lake Mead National Recreation Area. The Department of Defense (DOD) manages five major military installations in the Mojave Desert: Fort Irwin National Training Center (Fort Irwin), Twentynine Palms Marine Corps Air Ground Combat Center (Twentynine Palms), China Lake Naval Air Station (China Lake), Nellis Air Force Base (Nellis) and Edwards Air Force Base (Edwards).

Preserve Projects and Plans

The Preserve has several recent or current projects, including:

- West Pond EA to improve habitat for the Mohave tui chub;
- Translocation of Bighorn Sheep to Eagle Crags Mountains 2005 Finding of No Significant Impacts (FONSI) to augment the bighorn population at China Lake;

- Abandoned Mine Safety Installations 2011 FONSI to implement abandoned mine safety options;
- Barber Peak Trail Loop Reroute 2011 FONSI to avoid the Hole in the Wall campground; and
- Ivanpah Desert Tortoise Research Facility to support tortoise population recovery efforts.

Military Land Expansion

Since 2000, the U.S. Army has been working to expand Fort Irwin by about 110,000 acres. The 2008 EA and Finding of No Significant Impact authorized the translocation of Mojave Desert tortoise from Fort Irwin to adjacent BLM lands (BLM 2008). As of 2016, translocation of tortoises is complete.

Likewise, the U.S. Marine Corps has been preparing to expand Twentynine Palms (DOD 2012). The expansion will be analyzed in a supplemental Environmental Impact Statement (EIS) to the 2012 EIS for the acquisition and expansion of the military installation. Translocation of desert tortoises onto BLM land is also proposed, but the efforts have been complicated by concerns about impacts on desert tortoise populations and have included plans for tortoise translocation, fencing, and monitoring. Translocation plans are currently on hold until the analysis is complete.

National Monument Designation

In February 2016, President Obama designated three new national monuments in the Mojave Desert, encompassing 1.8 million acres: Mojave Trails National Monument, Sand to Snow National Monument, and Castle Mountains National Monument.

Mojave Trails National Monument (1.6 million acres) is located south of the Preserve and was established to protect historic resources including Native American trading routes, World War II–era training camps, and historic Route 66. It also includes areas with geological and ecological importance, as well as 350,000 acres of previous designated wilderness. It is managed by the BLM.

Sand to Snow National Monument (154,000 acres) is located southwest of the Preserve at the transition between the desert ecosystem of Joshua Tree National Park and the high-elevation forests within San Bernardino National Forest. It is co-managed by the BLM and U.S. Forest Service. It includes numerous archeological sites, diverse ecological resources, and recreation assets.

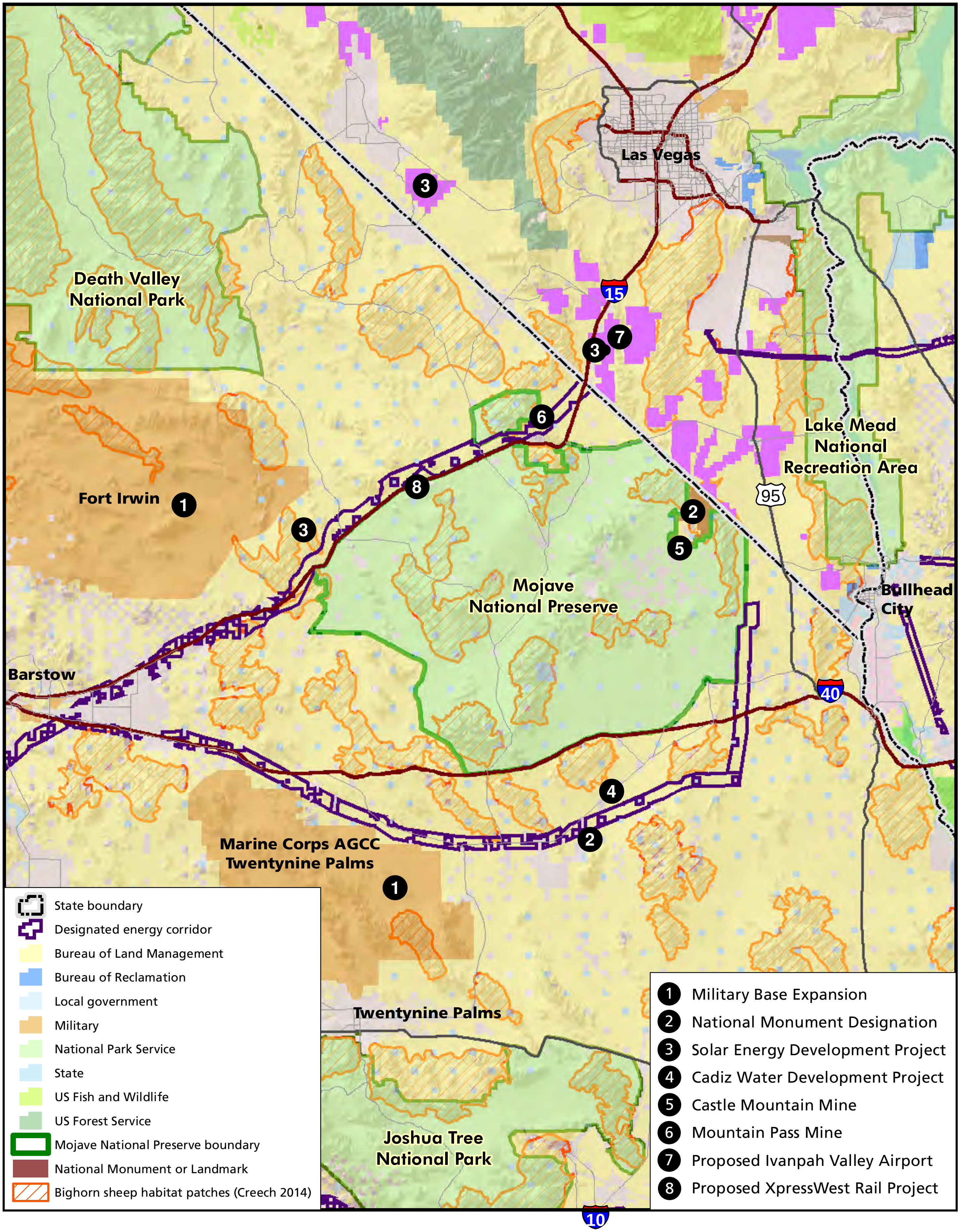
Castle Mountains National Monument (20,920 acres) is immediately adjacent to the Preserve and includes portions of the Castle Mountain Range and Lanfair Valley. It is managed by the NPS. This monument provides an important connection for wildlife (including desert bighorn sheep), and the valley floor includes an important alluvial aquifer. The monument surrounds the existing Castle Mountain Mine, which is located on private land and is not part of the monument designation.

Energy Development

In the past decade, the Mojave Desert has become an attractive location for large utility-scale solar energy development. Federal land management plans and multiple solar projects have been proposed and completed in the recent past.

Western Solar Plan

In 2012, the BLM, in cooperation with the Department of Energy (DOE), prepared a programmatic EIS to evaluate the potential environmental, social, and economic effects associated with the development and implementation of agency-specific programs that would


Las Vegas
Death Valley National Park
Fort Irwin
Lake Mead National Recreation Area
Mojave National Preserve
Bullhead City
Barstow
Marine Corps AGCC Twentynine Palms
Twentynine Palms
Joshua Tree National Park
15
95
40
10
State boundary
Designated energy corridor
Bureau of Land Management
Bureau of Reclamation
Local government
Military
National Park Service
State
US Fish and Wildlife
US Forest Service
Mojave National Preserve boundary
National Monument or Landmark
Bighorn sheep habitat patches (Creech 2014)
1 Military Base Expansion
2 National Monument Designation
3 Solar Energy Development Project
4 Cadiz Water Development Project
5 Castle Mountain Mine
6 Mountain Pass Mine
7 Proposed Ivanpah Valley Airport
8 Proposed XpressWest Rail Project

facilitate utility-scale solar energy development in six western states: Arizona, California, Colorado, Nevada, New Mexico, and Utah (BLM 2015).

The Western Solar Plan included amendments to 89 BLM land use plans, including the CDCAP, not only to support solar energy development on public lands, but also to minimize potential environmental, cultural, and socioeconomic impacts. As part of the Western Solar Plan, the BLM identified priority areas (solar energy zones or SEZs) that are well suited for utility-scale production of solar energy, variance areas outside of SEZs where solar development would be open to applications, and areas to be excluded from utility-scale solar energy development (BLM 2015).

The two closest SEZs to the Preserve are Riverside East SEZ in Riverside County, California, and Dry Lake SEZ in Clark County, Nevada (BLM 2014). Both SEZs are more than 50 miles from the Preserve; however, several variance areas are directly adjacent to the Preserve.

Desert Renewable Energy Conservation Plan

In 2016, the BLM, in cooperation with the U.S. Fish and Wildlife Service (USFWS), California Energy Commission, and CDFW, released the final programmatic EIS and Land Use Plan Amendment to streamline the permitting of renewable energy projects while advancing federal and state natural resource conservation goals within the Mojave and Colorado/Sonoran Deserts in seven counties in California, including San Bernardino County, where the Preserve is located. The DRECP is intended to conserve special status species habitat and vegetation communities within areas managed under the CDCAP, while designating approximately 388,000 acres for renewable energy development and an additional 40,000 acres for potential development after further environmental review. Approximately 10 million acres of BLM land within the area would be designated for conservation or recreation and therefore would not be available for renewable energy development.

Solar development focus areas are located approximately 10 miles from the Preserve’s western boundary, and a variance area is located approximately 20 miles from the southern boundary. Most of the Preserve is bounded by BLM land that is managed for conservation or recreation and would be removed from consideration for industrial renewable energy development under the DRECP.

Ivanpah Energy Solar Development Project

Located about 15 miles north of the Preserve in the Ivanpah Valley, the 4,000-acre Ivanpah solar electric generating system is currently the largest solar thermal power plant in the world (BrightSource Energy 2015). Due to charges of numerous bird deaths (more than 2,000 wild birds died at the plant between March and August in 2015) and accusations of production shortfalls, the solar plant risked being shut down in the beginning of 2016. However, in March 2016, the California Public Utilities Commission gave the project one year to increase its electricity production to fulfill its supply commitments (Martin 2016), and as of February 2017, it has begun to meet its contractual obligations and will continue to operate (Ryan 2017).

Silver State South Solar Project

In February 2014, the BLM approved the development of a 350-megawatt solar energy facility on approximately 2,400 acres of public lands adjacent to the town of Primm, Nevada (north of the California/Nevada border). The Silver State South Solar Project is adjacent to the Silver State North Project, the first solar plant on public lands to deliver power to the grid (BLM 2014). Construction of Silver State South began in September 2014.

Stateline Solar Farm Project

In February 2014, the BLM approved the development of a 300-megawatt solar facility two miles south of the California/Nevada border and 0.5 mile west of I-15 northeast of the Preserve. The project is currently under construction and encompasses approximately 1,685 acres of public land (BLM 2012).

Soda Mountain Energy Development Project

In April 2016, the BLM approved the Soda Mountain Energy Development Project on 1,767 acres of BLM-managed land about six miles southwest of Baker, west of the Preserve. The facility is in an area of disturbed land that includes I-15 and an active utility corridor for oil and gas pipelines, electricity transmission and communication lines, and facilities (BLM 2013).

The BLM's approved design intends to ensure that the project will not interfere with future efforts to reestablish desert bighorn sheep movement across the interstate highway. There are currently no bighorn sheep on the north side of I-15 in the project area, largely because the highway creates a significant barrier. In reducing the project by nearly 455 acres, the smaller footprint preserves a connectivity point across the highway in the event that bighorn sheep populations are reestablished north of the highway in the future. The smaller footprint will also require less water for construction and operations (Department of the Interior [DOI] 2016). Implementation timeline for the project is unknown.

Water Development

Cadiz Valley Water Conservation, Recovery, and Storage Project (Cadiz Project)

Cadiz, Inc. owns 45,000 acres of land in three areas of the Mojave Desert, near the Preserve to the south. The primary property is in the Cadiz and Fenner Valleys (Cadiz Property) on approximately 34,000 acres of land. Other properties are located in the Piute Wash and near Danby Dry Lake. All three properties are underlain by deep alluvial basin groundwater supplies. Over the last 20 years, Cadiz, Inc. has maintained an agricultural operation at its Cadiz Property. The agricultural operation uses groundwater for irrigation of all crops in production through a network of seven existing water production wells.

The groundwater beneath its Cadiz Property is confined within a closed basin that ultimately flows to two saline groundwater sinks (Bristol and Cadiz Dry Lakes). The proposed water storage project would extract water within the aquifer system to create a local water supply alternative for Southern California water providers. Water would be delivered through an underground conveyance pipeline to the Colorado River Aqueduct for delivery to water users (Cadiz, Inc. 2015). The proposed project involves the Cadiz, Fenner, Bristol, and Orange Blossom Wash Watersheds.

Castle Mountain Mine – Water Extraction

The Castle Mountain Mine is northeast of the Preserve and includes portions of the Castle Mountains and Lanfair Valley. The mine is immediately surrounded by the newly established Castle Mountains National Monument. The Castle Mountain Mine is a heap-leach gold mine that was purchased by NewCastle Gold in 2012, with multiple water extraction wells in the Lanfair Valley basin aquifer. Exploration is currently underway at the Castle Mountain Mine site (NewCastle Gold 2017).

Proposed Transportation Development Projects

Several other regional transportation and infrastructure projects have been proposed or planned in the Mojave Desert near the Preserve.

Ivanpah Valley Airport

A new airport to serve the Las Vegas region has been proposed near Primm, Nevada, north of the Preserve. Clark County purchased 6,000 acres of land for the facility, but no development plans have been implemented.

XpressWest (formerly Desert Xpress)

This project is a proposed high-speed passenger railroad between Las Vegas and Southern California. Construction began in 2017 on the first phase of the project, running about 185 miles from Las Vegas to Victorville, California, following the I-15 right-of-way. An environmental review is expected in 2017 for the second phase, which would extend the track 50 miles from Victorville to existing commuter rail service in Palmdale (Department of Transportation [DOT] 2011).

If implemented, these projects could influence or affect resources in the Preserve. However, at this time, these projects are considered speculative.

Water Resources

Groundwater

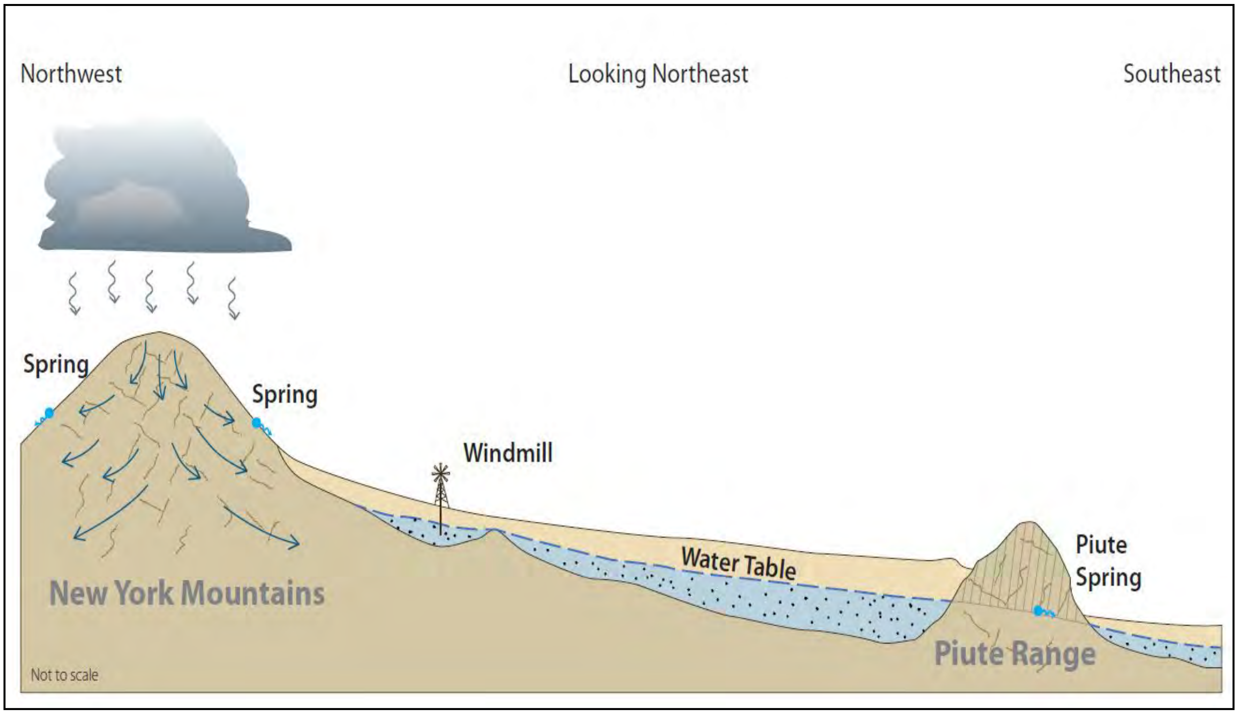
Groundwater is the primary water resource in the Preserve. It occurs primarily in alluvial aquifers and fractured bedrock and carbonate systems. Most of the groundwater recharge in the Preserve results from precipitation seeping into bedrock fractures or running off and infiltrating into alluvium along the edges of mountains or through alluvial fans and arroyo channels (Izbicki et al. 1995). The valleys themselves have limited surface recharge due to low-permeability geologic layers and deep vadose zones (NPS 1999). Greater precipitation and recharge occur at higher elevations along the upper edges of the drainage basins, Although all parts of the Preserve receive occasional precipitation, most precipitation falls at higher elevations, such as the New York Mountains. From higher-elevation areas, some of the precipitation infiltrates and flows through bedrock fractures, eventually surfacing as springs or discharging to the alluvial fill. Additional recharge comes from infiltration of infrequent runoff at lower elevations and subsurface connections between basins (NPS 1999).

Figure 10 illustrates the relationship of precipitation, fractured bedrock, and alluvial aquifers using a cross-section of the Lanfair Valley between the New York Mountains and the Piute Range in the northeast part of the Preserve (which is representative of typical systems in the Preserve).

Groundwater withdrawal and discharge in the Preserve occurs through springs, seeps, wells, and subsurface flow into adjacent groundwater basins; or at points where an aquifer is intercepted by a constructed feature (e.g., a windmill-powered well) (NPS 1999; California Department of Water Resources [CDWR] 2004a, 2004b). As discussed under “Climate Trends and History” above, potential evapotranspiration exceeds precipitation except during portions of the winter months, which limits runoff and groundwater recharge.

Springs and seeps appear when groundwater is forced to the surface by an impermeable geologic stratum below, with a fault line or fissure above. Typically, a spring or seep will flow for a short distance until the water is absorbed back into the penetrable alluvial material in arroyos typical to the region (NPS 1999).

Figure 10. Illustrative Cross-Section of Lanfair Valley



Source: Freiwald 1984.

Fractured Bedrock Groundwater

Groundwater percolating through fractured bedrock supports most of the springs and other water features in the Preserve. Springs and seeps near the base of the mountains are typically the result of geologic conditions, such as a change in rock type, fault, or surface erosion, that expose fractures. The consolidated rocks that form the mountains in the Preserve have limited permeability except for the fractures, and where volcanic and carbonate strata occur. Thus, water storage in fractured bedrock is limited, which results in fluctuations of spring and seep flow in direct relationship to the amount of recent precipitation (NPS 1999).

Alluvial Basin Aquifers

Large valleys in the Preserve are filled with unconsolidated sediments that have collected over millions of years. These sediments, which range from hundreds to thousands of feet deep in the central portion of larger basins, form the deep alluvial basins and associated groundwater aquifers in the Preserve. While groundwater recharge from precipitation and runoff is an ongoing process, much of the water in these deep aquifers was recharged more than 20,000 years ago, during wetter climatic periods (NPS 1999). Groundwater in deep alluvial basins throughout the Mojave Desert is a valuable water source for human use, some of which is being extracted through deep well pumping (CDWR 2003).

Surface Water

Except for occasional flood flows, surface water in the Preserve is limited to short stretches of flowing water below large springs, spring pools, and excavated ponds that intercept groundwater. In addition, numerous small springs and seeps are the most common water sources in Mojave landscape (see “Water Features” section below).

Streams

The best examples of flowing streams in the Preserve are the drainages immediately below large springs where some surface water is reliably found for some distance before it disappears into the alluvium. These areas generally support small bands of wetland and riparian vegetation. The most prominent example of a perennial stream is Piute Springs near the eastern edge of the Preserve, while Cornfield Creek (near Kelso) and Rock Creek (near Government Holes) are ephemeral. Rapid runoff from snowmelt or large storms will also produce surface runoff through otherwise dry arroyos and washes, which can sometimes result in flash flooding (NPS 2009).

A short reach of the lower end of the Mojave River is located near the far western tip of the Preserve. Regionally, the Mojave River is an important water source, flowing east from the San Bernardino Mountains for more than 100 miles. It is usually dry on the surface because most of the water sinks into the porous alluvium of the river channel, providing recharge to the immediate floodplain aquifer and large regional aquifer, both of which are important water supplies for human uses (USGS 2001).

Lakes and Ponds

Ponds and lakes in the Mojave Desert are few, and most have been constructed. The two most prominent open water bodies are the Morningstar Mine Pit Lake and the ponds at Soda Springs.

Morningstar Mine Pit Lake. The Morningstar Mine was an open pit heap-leach gold mine that ceased operation in 1992. The mining operations intercepted a perched aquifer, which required continuous dewatering during operation. Now, the lake at the bottom of the pit is the largest fresh water body in the Preserve, with water levels that have remained fairly constant and with good water quality. The Morningstar Mine Pit Lake was stocked with the endangered Mohave tui chub in 2011. Another example of a mine pit lake is the Vulcan Mine Pit Lake.

Soda Springs Ponds. The Soda Springs complex is located on the far western edge of the Preserve, at the base of the Soda Mountains at the site of the former Zzyzx Resort. This complex includes two constructed ponds and natural spring-fed pools. The Soda Lake aquifer and local recharge are believed to feed Soda Springs (Dickey et al. 1979; Bilhorn and Feldmeth 1985). MC Spring is the primary surface expression of these springs and supports a population of the endangered Mohave tui chub (MC Spring itself is also characterized as a spring and is discussed further under “Springs” below).

A constructed pond, called Lake Tuendae, at Soda Springs is fed by a well completed in the Soda Lake aquifer (Bilhorn and Feldmeth 1985). This pond and several others nearby were constructed as part of the 1940s-era resort development. Lake Tuendae provides habitat for the Mohave tui chub but requires periodic maintenance to clean out cattails and silt (Woo and Hughson 2003).

West Pond is another constructed pond located a short distance southwest of Lake Tuendae. Until a fish kill in 1981, it provided habitat for the Mohave tui chub (Dirling 1997). West Pond intersects the water table of the Soda Lake aquifer, and salinity in the pond had increased due to evaporation, making it unsuitable as Mohave tui chub habitat (Woo and Hughson 2003; Dirling 1997). In 2016, the NPS completed the restoration of West Pond by pumping out the brine, maintaining the surface water elevation, and planting vegetation along the bank. This significantly improved the salinity of the pond, and signs of increased waterfowl use have been observed.

Water Features

A wide variety of water features are in the Preserve, many of which have been modified by human activity. Table 11 lists the number of each type of water feature in the Preserve, Figure 11 describes each, and Figure 12 shows the locations of known water features.

Table 11. Water Features in the Preserve

Water Feature Type		Number	Notes
Springs		238	Most have been developed or manipulated; 182 are located in wilderness
Wells		73	Includes water supply, monitoring, and grazing permit wells
Lakes and ponds		6	Includes mine pit lakes, constructed ponds, and numerous uninventoried stock ponds
Big game guzzlers		6	All are located in wilderness
Small game guzzlers		131	60 are in wilderness; 64 have been recently repaired

Figure 11. Surface Water Feature Expressions in the Preserve

Water Features in Mojave National Preserve

Springs

Flowing spring – (*rheocrene*) a spring that flows directly out of the ground into a perennial or ephemeral stream or may disappear into the ground some distance from the source. *Example: Piute Spring*.

Ponded spring – (*limnocrene*) a pond or small wetland. *Example: MC Spring*. Note that the existence of open water may be the result of regular maintenance, such as at MC Spring, which requires regular removal of vegetation to maintain an open water zone.

Bog – (*helocrene*) a diffuse upwelling seep in an area of boggy or marshy ground. In the Preserve, these are often seasonally ephemeral. *Example: Mid Hills Spring.*

Buried spring – (*hypocrene*) water occurring in an underground tunnel or hole that does not flow to the surface. *Example: Henry Spring.*

Verdant seep – a small zone, typically in or near the channel of an arroyo or canyon, of near-surface moist soil characterized by vegetation; in some cases, these seeps have been developed for livestock. *Example: Cliff Canyon Spring.*

Hanging seep – similar to a verdant seep but emerging from a steep slope or cliff. *Example: Cave Spring.*

Tinaja – a pool in a bedrock depression. In the Preserve, tinajas typically occur in the channel of a mountainous canyon along a reach free of sediment. *Example: Rock Spring*.

Piute Spring supports a flowing stream and riparian habitat

Mid Hills Spring is an ephemeral bog

MC Spring is an open pond and wetland

Developments

Excavation – a subvertical hollow dug into sediments, typically paleospring deposits, creating a seepage face in moist to saturated soil. *Example: Mail Spring.*

Tunnel – a subhorizontal tunnel excavated into sloping sediments intersecting a shallow water table. Ponded water remains inside the tunnel or is brought to the surface by gravity flow through a pipe. Where a pipe exists, it is usually connected to a drinker trough, often some distance away. *Example: Silver-Lead Spring.*

Springbox – a shallow well into near-surface groundwater connected to a subhorizontal pipe placed below the water table. Water leaves the springbox by gravity flow through the pipe to a drinker trough. *Example: White Rock Spring.*

Adit – a large subhorizontal tunnel, often excavated in fractured rock. An adit is distinguished from a tunnel by larger size, greater length, and rock versus sediment, and is sometimes associated with mining activity. Water is brought to the surface by gravity flow through a pipe. *Example: Budweiser Spring.*

Pipe – gravity flow from a pipe derived from an unknown source. This term is included to describe features where the actual water source is unknown. *Example: South Hackberry Spring.*

Mail Spring is an excavated seepage face in spring deposits

Cut Spring is piped from a springbox to a concrete drinker

Budweiser Spring water source is in a tunnel excavated in granitic rock

Wells

Shallow (hand dug) – a well often only a few feet deep that may or may not be shored. A shallow well is distinguished from a springbox by the need to lift water. *Example: Bolder Spring.*

Drilled – a well excavated by rotary drilling. Drilled wells range in depth from several feet up to 1,400 feet (427 meters) for some UPRR wells and the Kelso Depot water supply well. Typically, these wells are completed with metal or PVC casing. Lift is provided by a windmill or submersible pump. Many have been abandoned by welding a metal cap to the top of the casing. Some have been destroyed, while others remain as open boreholes. *Example: Watson Well.*

Watson Well is a capped drilled well

Shallow well at Bolder Spring