

4.9 Hydrology and Water Quality

The purpose of this Section is to describe existing hydrology and water quality within the Project area, analyze potential impacts to hydrology and water quality associated with the development of the proposed Project, and identify mitigation measures that would avoid or reduce the significance of any identified impacts. The primary information sources include Project-specific investigations that are compiled in **Appendix H** and available resources from the USGS and the CGS. Thresholds of significance for the impact analysis are from Appendix G of the 2011 *CEQA Guidelines*.

In addition to the *CEQA Guidelines*, FVMWC's operation of the Project would be overseen by a Technical Review Panel under a GMMMP (Appendix B1), which incorporates additional safeguards and action criteria if adverse conditions occur attributable to the Project.

4.9.1 Environmental Setting

This Section presents an overview of the regional setting that describes the watersheds, climate and vegetation, surface water and groundwater hydrology, and water quality, and identifies the locations of the Project elements within the setting. More comprehensive discussions of each of the local physiography, climate, hydrology, and water quality characteristics of the setting can be found in the references cited in each Section below.

Regional Setting

The Project area is located in the eastern Mojave Desert, San Bernardino County, California (part of the Mojave Desert Geomorphic Province^{1,2}), approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see Figure 3-1). The Mojave Desert Geomorphic Province is a broad interior region of isolated mountain ranges separated by expanses of desert plains. It has an interior enclosed drainage and many playas, also referred to as dry lakes.³ Section 4.6, Geology provides a detailed description of the topography, geology, structural geology, and seismicity.

The Watersheds

The overall drainage basin in which the proposed Project would be constructed consists of four Watersheds, as shown on **Figure 4.9-1**. The Watersheds are considered one topographically-closed drainage basin because all surface water and groundwater drains to the interior of the overall drainage basin. The total area of the combined basin system is approximately 2,320 square miles and consists of the Fenner Watershed (1,090 square miles), the Bristol Watershed (640

¹ Norris, Robert M. and Robert W. Webb, *Geology of California*, Second Edition, 1990, pages 220-225.

² California Geological Survey, *California Geomorphic Provinces*, Note 36, 2002, page 3.

³ The terms playas and dry lakes are generally synonymous, but more specifically, dry lake areas are generally considered to be the innermost center areas of playas.

square miles, which is considered to include the 160 square mile Orange Blossom Wash Watershed), and the Cadiz Watershed (590 square miles).⁴

The Fenner Watershed is located in the northern portion of the Project area. The New York Mountains, located at the northernmost end of the Project area at the head of the Fenner Watershed, are the highest mountains in the Project area, rising to an elevation of approximately 7,532 feet National Geodetic Vertical Datum of 1988 (NGVD).⁵ The mountains bounding the east and west sides of Fenner Valley range in height from 4,165 to 7,178 feet NGVD.⁶ Generally, the Fenner Valley slopes south to southwest toward the Fenner Gap, located at the southern end of the valley between the Marble and Ship Mountains, at an elevation of about 900 feet NGVD. At this location, surface water drainage and groundwater flow from the Fenner Watershed enters the Bristol and Cadiz Watersheds to the south. Surface water has been observed to flow over the Fenner Gap each year at least once since 1991 after rain events of sufficient precipitation volume.⁷

The Bristol and Cadiz Watersheds are located in the southern portion of the Project area, surrounded by the Bristol, Iron, Bullion, Sheep Hole, Calumet and Coxcomb Mountains, ranging in elevations from 1,751 to 4,685 feet NGVD.⁸ The surface water drainage and groundwater flow from the Watersheds in this Project area and drain into the Bristol and Cadiz Dry Lakes, which have surface elevations of approximately 595 and 545 feet NGVD, respectively.⁹ The Bristol and Cadiz Dry Lakes are separated by a low topographic and surface drainage divide. Since the Watersheds are part of a closed drainage system, the only natural outlet for surface water and groundwater is through evaporation at the dry lake surfaces. These surfaces are normally dry but flash flooding from high intensity rain storms can result in standing water that can remain for weeks before evaporating.¹⁰⁻¹¹⁻¹²

As noted above, the Orange Blossom Wash is generally considered a part of the Bristol Watershed. This Watershed is located along the western portion of the Project area between the Marble and Bristol Mountains. The Orange Blossom Wash begins at the Granite Mountains, which are located just outside the western border of the Project area and rise to 6,786 feet NGVD and drains to the southeast into the Bristol Watershed, discussed above.

Cadiz Inc. owns 34,000 acres located at the confluence of the Watersheds, as shown on Figure 4.9-1, and has maintained agricultural operations at this property since the early 1990s. The agricultural operation irrigates its crops with groundwater extracted from wells located in and south of Fenner Gap.

⁴ CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011, Section 1.3.

⁵ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-1.

⁶ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-2.

⁷ Cadiz Inc., *Communication with ESA*, December 9, 2010.

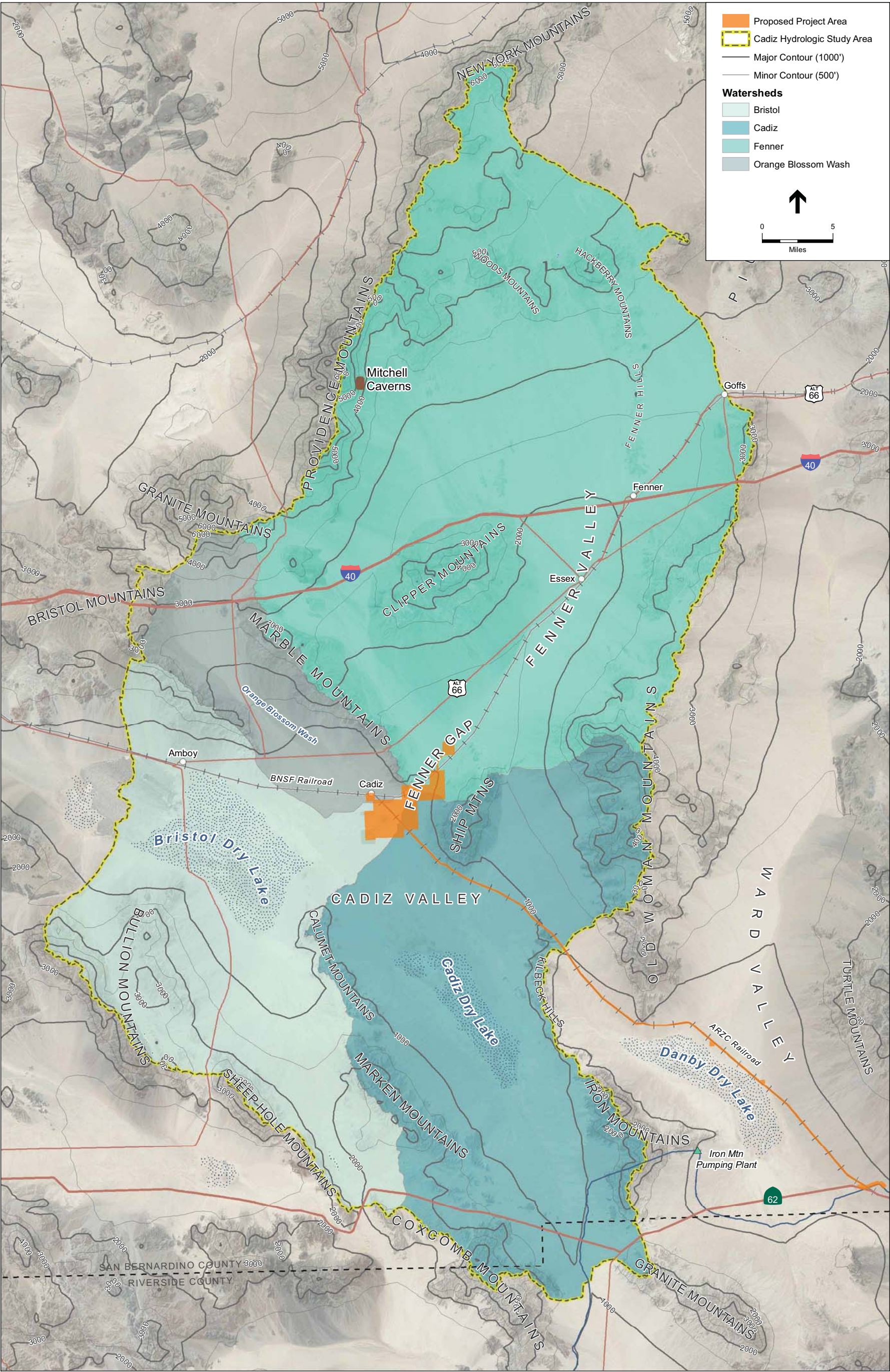
⁸ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-2.

⁹ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-2.

¹⁰ Bassett, A.M., Kupfer, D.H. and F.C. Barstow, *Core Logs from Bristol, Cadiz and Danby Dry Lakes, San Bernardino County, California*, U.S. Geological Survey Bulletin, 1045-D, 1959, pages 97-138.

¹¹ Koehler, J.H., *Groundwater in the Northeast Part of Twentynine Palms Marine Corps Base, Baghdad Area, California*: USGS Water Resources Investigations Report 83-4053, 1983, page 2.

¹² GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Volume I, Report No. 1163*, November 1999, page 29.



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project
Figure 4.9-1
Topographic Map and Watershed Boundaries

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Historical groundwater use is discussed further below. As discussed further below in subsection entitled “Groundwater Hydrology, Summary of Groundwater in Storage”, the volume of groundwater in storage in the alluvium of the Fenner Valley and northern portion of the Bristol Valley area is estimated to be 17 to 34 MAF.¹³ There is additional groundwater in the freshwater zone south of the Fenner Gap, estimated to be between 4 and 10 MAF.¹⁴

The area is also traversed by two active railroad lines: the east-west BNSF rail line traverses the Bristol and Fenner Watersheds; the northwest-southeast ARZC rail line starts at the connection to the BNSF rail line at Cadiz and travels southeast where it crosses the CRA south of Danby Dry Lake.

Relationship of Project Components to the Watersheds

As described in Chapter 3, Project Description, the Project consists of two distinct but interrelated components: the Groundwater Conservation and Recovery Component and the Imported Water Storage Component.

The Conservation and Recovery Component is designed specifically to extract and conserve water originating in the Fenner and northern portion of the Bristol Watersheds that would otherwise migrate to the area below the Dry Lakes in the Bristol and Cadiz Watersheds, where the water currently becomes saline and is lost to evaporation. Five of the existing and approximately 29 proposed production wells¹⁵ would be located within and just south of the Fenner Gap area (see Figure 3-6b) and would extract an average of 50,000 AFY of groundwater over a 50-year period¹⁶ from the alluvial and carbonate geologic units described in Section 4.6, Geology. In order to substantially reduce the loss of potable water to evaporation, subsurface hydraulic control would be created at Fenner Gap by lowering the water table to intercept natural recharge as well as retrieve groundwater to the south of the well field that would otherwise be lost to the Dry Lakes.¹⁷ To create the hydraulic control, groundwater would be withdrawn from operational storage in a localized area, thus modifying the underlying groundwater gradient and preventing the present outflow of groundwater to the Bristol and Cadiz Watersheds, where the water would become saline and then evaporate at the Dry Lakes.¹⁸

¹³ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 3-1.

¹⁴ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, Table 3-1.

¹⁵ CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011, Section 5.5.

¹⁶ CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011, Section 1.5.

¹⁷ CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011, Section 1.6.

¹⁸ Geoscience’s previous analysis demonstrated that pumping in excess of the natural recharge is necessary to reduce the evaporative losses to the dry lakes. Project pumping of 50,000 acre-ft/yr and 75,000 acre-ft/yr was used for determining the volumes of conservation using the ground water model. The analysis showed that conservation of evaporative losses increases with increased Project pumping by retrieving water that was moving down-gradient towards the dry lakes. In other words, Project pumping of 50,000 acre-ft/yr will result in increased conservation of evaporative losses above the natural recharge (32,000 acre-ft/yr) and Project pumping of 75,000 acre-ft/yr will further increase conservation by reducing outflows to the dry lakes. However, due to Project uncertainties with natural recharge, a pumping rate of 50,000 acre-ft/yr was selected for the Project to balance the objective of retrieving water before it can evaporate with the intent to minimize impacts. Pumping of less than the proposed 50,000 acre-ft/yr will result in an increase of loss to the dry lakes relative to Project pumping of 50,000 acre-ft/yr. GEOSCIENCE Support Services, Inc., *Addendum to September 1, 2011 Cadiz Groundwater Modeling and Impact Analysis*, November 2011.

For this Component of the Project, a production wellfield and manifold piping system would be constructed to carry the pumped groundwater to a new 43-mile conveyance pipeline, shown on Figure 3-1. The conveyance pipeline would be buried approximately 15 feet deep along the ARZC railroad ROW on privately-owned, pre-disturbed land (See Chapter 3, Project Description for details on the facilities).

The Imported Water Storage Component would allow participating water providers to send surplus surface water supplies, when available, to the Project area to be recharged into the groundwater aquifer system via spreading basins and held in storage until needed in future years. The spreading basins would be located at and just north of Fenner Gap and would recharge the aquifer system beneath the Project area. This second phase of the Project's operation would be limited to the same 50-year term as the Groundwater Conservation and Recovery Component. When needed, the stored surface water would be pumped out of the aquifer system and returned to the appropriate participating provider. The maximum capacity of the Project's Imported Water Storage Component is 1 MAF at any given time. Based on the available storage capacity in the Fenner Valley, withdrawal of groundwater stored in the aquifer, should the Imported Water Storage Component be implemented, would be limited to a combined maximum of 105,000 AFY. This reflects the maximum 75,000 AFY capacity of the 43-mile conveyance pipeline to the CRA and, potentially, an additional 30,000 AFY that could be conveyed through a converted natural-gas pipeline. The wellfield would be expanded so that 105,000 AFY of imported water could be returned to the CRA and, potentially, the SWP.

The facilities proposed for this component of the Project include an additional 10 to 15 wells in the Project wellfield; construction of spreading basins to recharge the surface water into the groundwater basin; additional roads, piping, power supply, and distribution facilities; and a CRA diversion structure and pump station.¹⁹ With the exception of the pipeline that would connect the Project to the CRA, the Project elements and any potential impacts would be located within the interior drainage basin of the Watersheds. The facilities for the Project would cover, depending on the wellfield configuration chosen; either 155 or 175 acres of the 25,000 acres owned by Cadiz and considered part of the Project. Chapter 3, Project Description provides a more detailed description of the proposed Project.

Climate

The eastern Mojave Desert is characterized as an arid desert climate with low annual precipitation, low humidity, and relatively high temperatures. Winters are mild and summers are hot, with a relatively large range in daily temperatures. Temperature and precipitation vary greatly with altitude, with higher temperatures and lower precipitation at low altitudes and lower temperatures and higher precipitation at higher altitudes.

The seasonal weather patterns of the eastern Mojave Desert region are primarily controlled by semi-permanent high and low pressure systems located over North America and the Pacific

¹⁹ CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011, Section 1.5.2.

Ocean.²⁰ During the summer months, a semi-permanent high-pressure cell (the Pacific High), centered over the north Pacific about 1,600 miles west of the California coast, typically diverts low-pressure, moisture-carrying weather systems north of California.²¹ The Pacific High contracts and moves southward during the winter months, allowing storms to cross California. Another semi-permanent high-pressure cell (the Great Basin High) is centered over southern Idaho during the winter months and deflects cold Canadian low-pressure weather cells to the east of the Project area.²² During the summer, a seasonal low-pressure weather cell (the California Low) often develops over the vicinity of the Project area as a result of intense surface heating.

Two weather stations have provided long-term data in the vicinity of the Project area.²³ One of two Amboy weather stations is located on the northern margin of Bristol Playa at an elevation of 625 feet. Mitchell Caverns weather station is located on the flank of the Providence Mountains, northwest of Clipper Valley, at an elevation of 4,330 feet. Stations with shorter and less complete records in the vicinity include the San Bernardino County stations of Goffs, Essex, and Kelso. The weather station data was used for rainfall and runoff models in the analysis of this Project.

Precipitation

Most of the precipitation (both rainfall and snowfall) in the eastern Mojave Desert occurs during the months of November through March.²⁴ However, summer thunder storms and flash floods are not uncommon. The frequency and intensity of rainfall from year to year is unpredictable. Winter rainfall typically occurs in events lasting several hours to a day or more. These winter events are most commonly the result of frontal weather conditions, and rainfall during such events is generally steady. Snow tends to accumulate at elevations above 5,000 feet on the mountain ranges surrounding the Watersheds. On average, 20 to 30 frontal systems move through the region each winter.²⁵ Most of these systems weaken as they reach the Project area.

The amount of precipitation in the Watersheds varies with differences in elevation, as shown in **Figure 4.9-2**, which shows isohyets²⁶ of average annual precipitation based on the Parameter-Elevation Regressions on Independent Slopes Model (PRISM) map for the period 1971 through 2000.²⁷ PRISM uses point estimates of climate data and a digital elevation model to generate estimates of climate elements, such as average annual, monthly, and event-based precipitation, among others.²⁸ This isohyet map shows average annual precipitation that varies from about 4 inches in Cadiz Valley to more than 12 inches in the New York Mountains.

²⁰ Houghton, John G., Clarence M. Sakamoto, and Richard O. Gifford, *Nevada's Weather and Climate*, Nevada Bureau of Mines and Geology, Special Publication No. 2, 1975, page 8-11.

²¹ Baldwin, John L., *Climates of the United States*, 1973, page 6.

²² Houghton, John G., Clarence M. Sakamoto, and Richard O. Gifford, *Nevada's Weather and Climate*, Nevada Bureau of Mines and Geology, Special Publication No. 2, 1975, page 8-11.

²³ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-3.

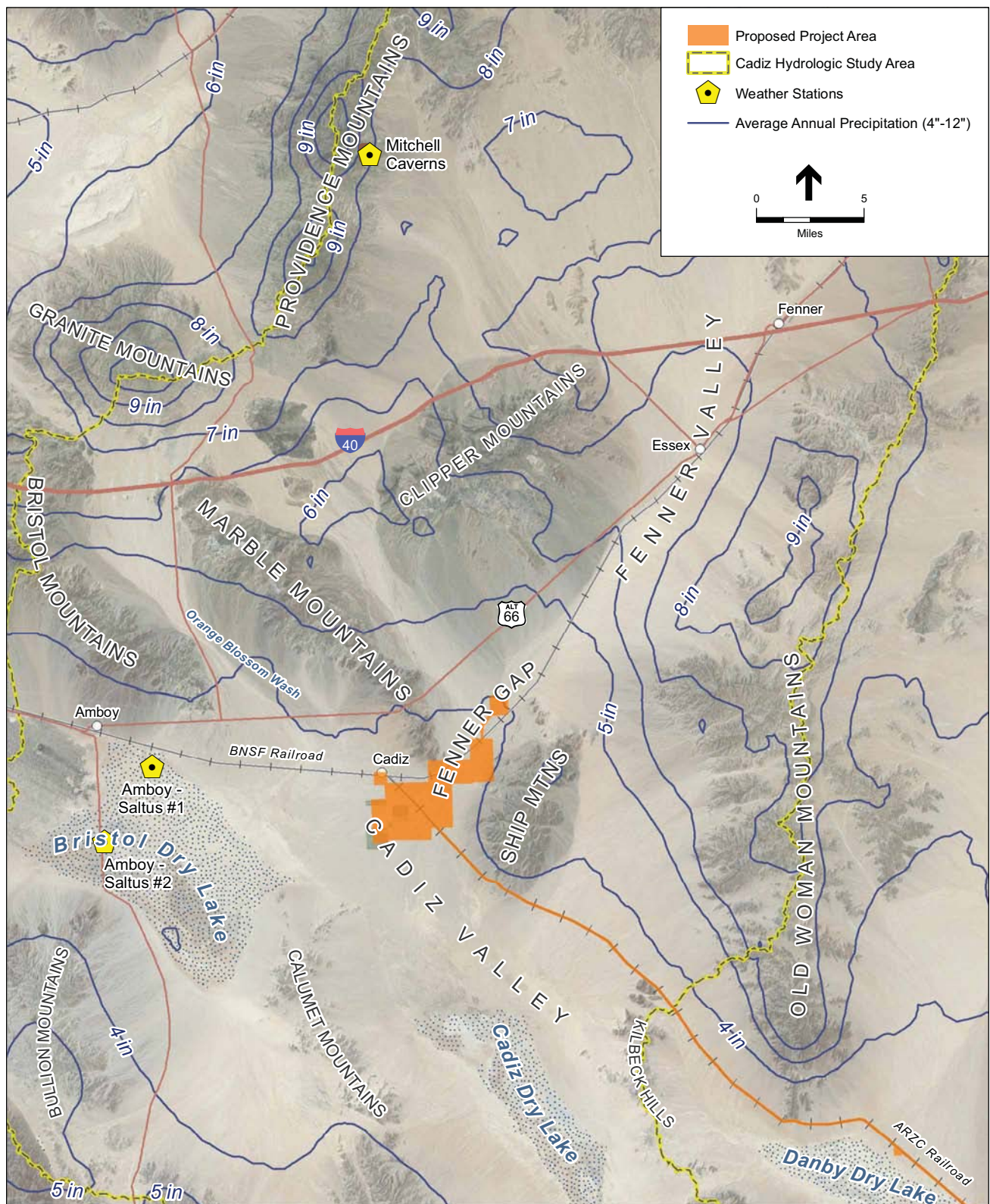
²⁴ U.S. Ecology, Inc., *California Low-Level Radioactive Waste Disposal Facility License Application*, 1989, page 2200-3.

²⁵ California Air Resources Board, *Climate of the Southeast Desert Air Basin*, July 1975, page 6.

²⁶ A line drawn on a map connecting points that receive equal amounts of rainfall.

²⁷ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, 2-3.

²⁸ PRISM Climate Group, *Latest PRISM Data*, www.prism.oregonstate.edu, accessed October 2010.



SOURCE: Bing Maps, 2011; PRISM Climate Group, 2004
ESRI, 2010; Cadiz Inc., 2011; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-2

Precipitation Isohyets for the 1971-2000 Period

The long-term annual average precipitation at Mitchell Caverns weather station from 1948 and 2004 was 10.47 inches.²⁹ The Amboy weather station has two recording devices - Saltus Number 1 and Saltus Number 2 - located at different elevations along the north shore of Bristol Playa. Saltus Number 1, at elevation 625 feet, has recorded a long-term annual average precipitation of 3.36 inches from 1967 through 1988. Saltus Number 2, located at an elevation 595 feet, has recorded a long-term annual average precipitation of 3.63 inches (1973 through 1993).³⁰

Temperature

Air temperature in the eastern Mojave Desert region follows a general pattern of high summer and low winter readings.³¹ Daily patterns are also typical, with temperatures dropping to an early morning low and climbing to a mid-afternoon high, before falling again to the next morning's low temperature. During the winter, the Great Basin high-pressure zone generally protects the region from cold Canadian airflows, typically keeping temperatures above freezing at the lower elevations.

Average winter temperatures are between 50 degrees F and 55 degrees F, with average daily maximums near 65 degrees F and average daily minimums near 40 degrees F. Average daily temperatures in the summer months are over 85 degrees F. Maximum summer temperatures usually hover around 100 degrees F but occasionally exceed 120 degrees F. Average minimum summer temperatures are approximately 70 degrees F. The summer temperature typically varies 20 degrees F to 30 degrees F in one day.

The weather stations in the area at Saltus No.1 at Amboy and at Mitchell Caverns also record air temperature. The minimum monthly temperature at Amboy has been reported as 50.7 degrees F in January and the maximum monthly temperature is 94.7 degrees F in July. The minimum monthly temperature at Mitchell Caverns is 46.3 degrees F in January and the maximum monthly temperature is 82.1 degrees F in July. The average annual temperatures at Amboy and Mitchell Caverns are 71.8 degrees F and 62.6 degrees F, respectively.³²

Relationship of Precipitation to Elevation

Davisson and Rose³³ describe environmental factors that complicate the distribution of precipitation through southeastern California and western Nevada. These factors include the rain-shadow effect of the Sierra Nevada, San Gabriel, and San Bernardino Mountains, and storms

²⁹ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-3.

³⁰ California Department of Water Resources, *Rainfall Records*, <ftp://ftp.water.ca.gov/users/dfmhydro/Rainfall%20Dept-Duration-Frequency/Rain%20D%20DDF%20Daily/DDF%20D%20X01%20X19-%20i/X10%20D%20Amboy%20Saltus%202.xls> and, <ftp://ftp.water.ca.gov/users/dfmhydro/Rainfall%20Dept-Duration-Frequency/Rain%20D%20DDF%20Daily/DDF%20D%20X01%20X19-%20i/X10%20D%20Amboy%20Saltus%201.xls>, accessed October 2010.

³¹ U.S. Ecology, Inc., *California Low-Level Radioactive Waste Disposal Facility License Application*, 1989, page 2200-9.

³² Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Impact Report and Final Environmental Impact Statement, Volume 1*, September 2001, page 5-64.

³³ Davisson, M.L. and T.P. Rose, *Estimating Annual Precipitation in the Fenner Basin of the Eastern Mojave Desert, California*, U.S. Dept. of Energy, May 2000, page 1.

moving up from the Gulf of California that create more precipitation in the eastern Mojave Desert than in the western Mojave Desert. The rain-shadow effect of the Sierra Nevada Mountains has its greatest impact on precipitation just east of the Sierra Nevada and decreases eastward into Nevada. In general, Davisson and Rose show that precipitation versus elevation is higher east of the 116° W longitude than west of it. All of the Watersheds tributary to the Project area lie to the east of this demarcation and are therefore expected to have higher precipitation with increases in elevation as compared to watersheds in the western Mojave Desert.

The relationship of average annual precipitation to elevation within the Watersheds tributary to the Project area is important because estimates of average annual precipitation (both rain and snowfall) are employed in a variety of models used for estimating groundwater recharge. These models, including those used by Geoscience and CH2M Hill, as discussed further below, assume groundwater recharge with specified percentages of average annual precipitation within each watershed.

Climate Change

Although climate change impacts are uncertain and cannot be precisely modeled, existing evidence, including the effects of warming in the West over the last century, demonstrate that climate change will likely affect future snowpack accumulation, precipitation, water supply, runoff patterns, sea level, incidents of flooding and droughts, evapotranspiration rates, water requirements and water temperature.

U. S. Bureau of Reclamation Regional Study

The Omnibus Public Land Management Act of 2009 (Public Law 111-11) Subtitle F – SECURE Water was passed by Congress into law on March 30, 2009. Also known as the SECURE Water Act, the statute includes the finding that data, research, and development will help ensure future water supplies. In April 2011, the U.S. Department of the Interior, Bureau of Reclamation (USBR) published the *Reclamation Climate Change and Water, Report to Congress, 2011*.³⁴ This report presented a climate change evaluation of seven western U.S. basins (Colorado, Columbia, Klamath, Missouri, Upper Rio Grande and Pecos, Sacramento – San Joaquin, and Truckee-Carson).

The evaluation examined temperature and precipitation trends over the 20th century, predicted temperature and precipitation trends over the 21st century, and the potential effects on hydrology and water resources. The report cautions that there is considerable variation in data and that variations may be artifacts of analysis methodology. Overall, temperatures have risen over the past century and are expected to continue rising. Precipitation is expected to remain at about the same levels but will occur less as snow and more as rain. Geographically, the northwest will be somewhat wetter and the southwest will be somewhat drier. However, these trends have many variations and need to consider more at a regional level, as discussed below.

³⁴ U.S. Department of the Interior, Bureau of Reclamation, *SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water, Report to Congress, 2011*, April 2011

The proposed Project is located immediately adjacent to the western edge of the Colorado Basin, with the Piute and Old Woman Mountains forming the boundary. Climate records from 1896 to 2009 were used to evaluate historical trends.³⁵ The 25-year moving average basis indicates that the mean temperature has risen about 2 degrees Fahrenheit (F) between 1908 and 2007. Precipitation has remained at approximately the same levels at about 14 inches. The data shows large annual variations (less than 9 to more than 20 inches).

With the increased temperatures, precipitation has been occurring as less snow and more as rain, although with many geographic variations. A June 2007 survey of western water conditions concluded that mountain recharge of groundwater basins may decline due to thinning snowpack and precipitation falling as rain rather than snow.³⁶ In contrast, while mountain recharge may decline, much of this recharged water may run off onto the region's fans and basins and potentially increase recharge on fans and groundwater basin floors. At present, whether the overall recharge will increase, decrease or stay the same is unknown at any scale in the West. As previously noted, variations may be artifacts of analysis methodology.

The results suggest that temperatures throughout the Colorado River Basin may continue to increase over the 21st century.³⁷ In the Upper Colorado River Basin, the basin-average mean-annual temperature is projected to increase by approximately 6 to 7 degrees F. When conditions are averaged across both the Upper and Lower Colorado River Basins, the expected increase is roughly 5 to 6 degrees F.

The same climate projections suggest that mean-annual precipitation averaged over the basin is only expected to change by a small amount during the 21st century. Annual variability in precipitation is expected to persist within the Colorado River Basin, and the basin likely will continue to experience both wet and dry periods throughout the 21st century.

The seasonality of runoff is also projected to change as summarized in **Table 4.9-1**, below, which summarizes the projected changes in the nature of runoff in the Colorado River above the Imperial Dam near the U.S.-Mexico border.³⁸ Warming is expected to lead to more rainfall-runoff during the cool season rather than snowpack accumulation. This logically leads to increases in December–March runoff and decreases in April–July runoff. However, the basin-wide results also show that seasonal runoff changes vary by subbasin and appear to be affected by factors other than annual warming (e.g., baseline climate, seasonal aspects of precipitation change).

³⁵ U.S. Department of the Interior, Bureau of Reclamation, *SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water, report to Congress, 2011*, April 2011, page 21.

³⁶ Michael Dettinger, *Western Ground Water and Climate Change —Pivotal to Supply Sustainability or Vulnerable in its Own Right?*, National Groundwater Association, June 2007, page 5.

³⁷ U.S. Department of the Interior, Bureau of Reclamation, *SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water, report to Congress, 2011*, April 2011, pages 25-26.

³⁸ U.S. Department of the Interior, Bureau of Reclamation, *SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water, report to Congress, 2011*, April 2011, page 35.

**TABLE 4.9-1
SUMMARY OF SIMULATED CHANGES IN DECADE-MEAN HYDROCLIMATE
FOR THE COLORADO RIVER ABOVE THE IMPERIAL DAM**

Parameter	2020s	2050s	2070s
Mean Annual Temperature (degrees F)	1.8	3.7	5.1
Mean Annual Precipitation (percent)	-0.4	-1.6	-0.7
Mean December–March Runoff (percent)	3.5	-3.0	1.3
Mean April–July Runoff (percent)	0.3	-6.6	-6.1

SOURCE: Table from U.S. Department of the Interior, Bureau of Reclamation, SECURE Water Act Section 9503(c) – *Reclamation Climate Change and Water, Report to Congress, 2011*, April 2011, page 35.

Based on current reservoir operational constraints (e.g., storage capacity, flood control rules, constraints on reservoir water releases to satisfy various obligations), it appears that projected reductions in natural runoff and changes in runoff seasonality would lead to reduced water supplies under current system and operating conditions. This follows the understanding that storage opportunities during winter runoff season currently are limited by flood control considerations at several tributary reservoirs in the Colorado River Basin and that increased winter runoff under climate change will not necessarily translate into increased storage of water leading into the spring season. Capture of snowmelt runoff traditionally has occurred during the late spring and early summer seasons. Reductions in runoff during the spring and early summer season likely would translate into reductions in storage capture and likewise reductions in water supply for warm season delivery.

State Studies

In California, climate change is expected to result in similar responses. Mean annual temperatures are anticipated to increase. As with the Bureau of Reclamation study above, there is great uncertainty in the ongoing studies as to whether average annual precipitation over the upcoming 50-year time period would increase, decrease, or remain similar to the previous 50 years. The variation of annual precipitation amounts within that average is expected to become more extreme.³⁹ For surface water sources of supply, climate change can shift the timing of streamflow and alter the way water supply reservoirs are managed (i.e., filling and release). In contrast, climate change impacts on groundwater sources of supply are currently largely unknown due to the high degree of variability of aquifers and site-specific effects, such as surface groundwater interactions and rates of recharge.

The California DWR released a report in 2008 that used 2050 climate change projections for runoff and precipitation.⁴⁰ DWR used four climate change scenarios from the Intergovernmental Panel on Climate Change, and then applied its existing analytical tools to quantify possible

³⁹ California Climate Change Center, *Climate Change Scenarios and Sea Level Rise Estimates for the California 2009 Climate Change Scenarios Assessment*, August 2009, page 13.

⁴⁰ California Department of Water Resources, *Progress on Incorporating Climate Change into Management of California's Water Resources* (March 2008), page 3-1.

effects of climate change on California's water resources. Amongst other impacts, DWR concluded that climate change may produce changes in timing, location, quantity and variability of precipitation, which may be outside of the range for which current infrastructure was designed.

DWR released its comprehensive report, *Climate Change Characterization and Analysis in California Water Resources Planning Studies*, in 2010. This report is an exhaustive survey of previous DWR planning studies that addressed the impact of climate change in predicting future climate conditions and impact on water resources. Thirteen ongoing and past planning studies were reviewed in detail. Seventeen different analysis characteristics are highlighted for each study including planning horizon, spatial coverage, climate analysis approach, number of Global Climate Models (GCMs) used, scenario selection, sea level rise, hydrologic simulation period, and streamflow sequence for operations modeling.⁴¹ DWR concluded that climate change is likely to increase storm frequency and severity with some increase in winter runoff in mountain basins due to higher-elevation snow levels during storms. Also, the snowpack will melt earlier in the season with less late-season runoff.⁴²

NRDC and Terra Tech partnered to prepare a report focusing on regional climate change effects in *Climate Change, Water, and Risk: Current Water Demands are Not Sustainable*. The study found that more than 1,100 counties — one-third of all counties in the lower 48 — will face higher risks of water shortages by mid-century as the result of global warming. More than 400 of these counties will face extremely high risks of water shortages.⁴³ This report found that residents in Riverside and San Bernardino counties are at an “extremely high risk” of not having enough water to meet demands by mid-century if changes are not made to combat climate change and curb water use.⁴⁴ Two of the principal reasons for the projected water constraints are shifts in precipitation and potential evapotranspiration (PET). Evapotranspiration is the sum of evaporative loss of water from the ground surface and transpiration losses through vegetation. PET is a calculated metric used to represent evapotranspirative losses under idealized conditions, where a full water supply is available for evapotranspiration. Together, changes in precipitation and potential evapotranspiration have significant effects on available precipitation, estimated as water falling either as rain or snow that would not be consumed by the potential evapotranspiration.⁴⁵ With such potential for reduced precipitation, runoff may potentially be reduced in the short-term in the region.

In California, if heat-trapping emissions continue unabated, more precipitation would be expected to fall as rain instead of snow, and the snow that does fall would melt earlier, reducing the Sierra Nevada spring snowpack by as much as 70 to 90 percent.⁴⁶ How much snowpack would be lost depends in part on future precipitation patterns; the projections for which remain uncertain.

⁴¹ California Natural Resources Agency, Department of Water Resources, *Climate Change Characterization and Analysis in California Water Resources Planning Studies*, Dec 2010, page xiv.

⁴² California Natural Resources Agency, Department of Water Resources, *Climate Change Characterization and Analysis in California Water Resources Planning Studies*, Dec. 2010, page 2.

⁴³ NRDC and Terra Tech, *Climate Change, Water, and Risk: Current Water Demands are Not Sustainable*, July 2010

⁴⁴ NRDC and Terra Tech, *Climate Change, Water, and Risk: Current Water Demands are Not Sustainable*, July 2010, page 2.

⁴⁵ NRDC and Terra Tech, *Climate Change, Water, and Risk: Current Water Demands are Not Sustainable*, July 2010, page 2.

⁴⁶ <http://cal-adapt.org/snowpack/decadal/>

However, even under wetter climate projections, the loss of snowpack would pose challenges to water managers; hamper hydropower generation, and recreational activities. By 2050, scientists project a loss of at least 25 percent of the Sierra snowpack. This loss of snowpack means less water will be available for Californians to use.⁴⁷

While several studies have examined the impact of climate change on California's surface water resources, very little research has been conducted on the impacts of climate change on groundwater, namely "for specific groundwater basins, or for general groundwater recharge characteristics or water quality."⁴⁸ In fact, while "historic patterns of groundwater recharge may change considerably,"⁴⁹ it is unknown whether recharge rates will increase or decrease.⁵⁰ Warmer, wetter winters, leading to an increase in the amount and timing of runoff, could increase groundwater recharge.⁵¹ Increased temperatures, which cause precipitation to fall as rain instead of snow, could increase the intensity of storm runoff that may overflow stream channels and recharge aquifers. In contrast, the intensity of the runoff could result in additional losses to the oceans. Further, this additional runoff may occur when basins are lacking storage space or are already being recharged at maximum capacity.⁵² Alternatively, decreases in spring runoff and increases in evapotranspiration due to higher temperatures could reduce the amount of water available for groundwater recharge.⁵³

While there is general consensus in this trend, the magnitudes and onset of impacts discussed in the planning recommendations are "uncertain and are scenario-dependent."⁵⁴ One recent report examines the effects of climate change on groundwater in California's Central and West Coast Basins.⁵⁵ The report identifies the oft-cited impacts to the state's surface water supply: reduction of annual snowpack, changes in the timing and intensity of precipitation, and sea level rise, but concedes that with regard to groundwater, "[v]ery simply, no one knows for sure, but close monitoring, planning, and responses to changes will likely be necessary."⁵⁶

⁴⁷ <http://www.water.ca.gov/climatechange/>

⁴⁸ Pacific Institute for Studies in Development, *Climate Change and California Water Resources: A Survey and Summary of the Literature*, prepared for the California Energy Commission, Public Interest Energy Research Program, July 2003, In California Water Plan Update, 2005, page 20.

⁴⁹ California Department of Water Resources, *Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water*, October 2008, page 23.

⁵⁰ Pacific Institute for Studies in Development, *Climate Change and California Water Resources: A Survey and Summary of the Literature*, prepared for the California Energy Commission, Public Interest Energy Research Program, July 2003, In California Water Plan Update, 2005.

⁵¹ Pacific Institute for Studies in Development, *Climate Change and California Water Resources: A Survey and Summary of the Literature*, prepared for the California Energy Commission, Public Interest Energy Research Program, July 2003, In California Water Plan Update, 2005.

⁵² Pacific Institute for Studies in Development, *Climate Change and California Water Resources: A Survey and Summary of the Literature*, prepared for the California Energy Commission, Public Interest Energy Research Program, July 2003, In California Water Plan Update, 2005, pages 17-18.

⁵³ Pacific Institute for Studies in Development, *Climate Change and California Water Resources: A Survey and Summary of the Literature*, prepared for the California Energy Commission, Public Interest Energy Research Program, July 2003, In California Water Plan Update, 2005, pages 17-18.

⁵⁴ California Department of Water Resources, *Progress on Incorporating Climate Change into Management of California's Water Resources*, October 2008, page 16.

⁵⁵ Water Replenishment District of Southern California, *Will Climate Change Affect Groundwater in the Central and West Coast Basins?*, Technical Bulletin Volume 10, 2007.

⁵⁶ Water Replenishment District of Southern California, *Will Climate Change Affect Groundwater in the Central and West Coast Basins?*, Technical Bulletin Volume 10, Winter 2007, page 2.

In summary, due to the great uncertainty in the ongoing studies of the effect of climate change on groundwater, it is not possible to predict whether annual recharge rates at the Project site will increase, decrease, or remain the same due to climate change. The basin's groundwater supply is mainly generated by precipitation (both rain and snow) that occurs in the upper elevations of nearby mountain ranges. Once it has infiltrated and becomes groundwater, precipitation moves very slowly down gradient toward the Project area. Groundwater beneath the Project area has been found to be hundreds of years old.⁵⁷ Accordingly, any decline in the amount of precipitation falling on the mountains surrounding the Watershed tributary to the Project area is unlikely to significantly affect the Project area over the life of the Project. Even if natural recharge declines during the Project's 50-year timeframe, impacts from Project operations will be less than significant because to account for potential worst-case conditions, two additional scenarios were simulated assuming an average annual recharge of 16,000 and 5,000 AFY.

Even if natural recharge declines during the Project's 50-year timeframe, impacts on the aquifer from Project operations will be less than significant as discussed below in Section 4.9.3 (Impact and Mitigation Analysis.) To account for potential worst-case conditions, such as a drastic reduction in recharge rates over a 50-year period that could result from a changing climate, two conservative recharge scenarios were simulated for 100-years assuming an average annual recharge of 16,000 and 5,000 AFY. (See *Methodology* discussion in Section 4.9.3 below.) The Project impacts that were examined in light of long-term dry conditions include groundwater quality, the migration of saline water, groundwater in storage, subsidence, groundwater drawdown and depth impacts. The models discussed below demonstrate that even if the next 100 years were extremely dry and natural recharge was reduced by up to 85 percent, the Project would still result in a less than significant impact to groundwater resources.

Dry Lakes (Playas)

The Bristol and Cadiz Watersheds are topographically and structurally closed, so the only natural outlets for surface water and groundwater are evaporation from the lowest elevations in the Project area at Bristol and Cadiz Dry Lakes at 595 and 545 feet NGVD, respectively.⁵⁸ The terms playas and dry lakes are generally synonymous, but more specifically, dry lake areas are generally considered to be the innermost center areas of playas.

⁵⁷ M.L. Davisson, *Discussion Regarding Sources and Ages of Groundwater in Southeastern California*, Lawrence Livermore National Laboratory, March 2000, pages 5-6 (using radiocarbon dating to measure dissolved inorganic carbon in Fenner Gap groundwater).

⁵⁸ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-2.

The Dry Lake surfaces are devoid of vegetation due to the saline conditions and are usually dry. However, runoff from winter storms and late summer thunderstorms can result in occasional standing water.^{59, 60, 61, 62, 63} As discussed above, the weather stations at Amboy have recorded that the Bristol Playa receives an average of more than 3 inches per year of rainfall. In addition, evidence of shallow streams and sheet flow from surrounding areas are observed on and adjacent to the playas (inspected November 9, 2010). Standing water has been observed on Bristol Dry Lake at least once each year since 1991.⁶⁴

The playas are made up of a variety of surface types that change from the interior where the Dry Lakes are located, towards the outer perimeter where vegetation begins.⁶⁵ The sediments in the innermost area are generally composed of clay and silt with smaller amounts of sand. In the innermost areas of the playas, the soil beneath the surface can be damp to moist. The moist nature is predominantly due to the annual wetting from rainfall, surface runoff from surrounding areas, and some possible contribution from the capillary rise of groundwater.⁶⁶ The depth to groundwater at the lowest points of the Dry Lakes can be shallow and has been measured to be less than 15 feet, as discussed in more detail in the groundwater subsection below.

The evaporation of water from the Dry Lakes over the past several million years has resulted in thick deposits of salts (primarily sodium chloride [halite or table salt] and calcium sulfate [gypsum]) and brine-saturated sediments.^{67,68} Deposits of economically viable evaporite salt minerals are currently being harvested by salt production companies, as discussed in Section 4.11, Mineral Resources. The salts bind the sediments of the playa surface in the innermost areas into a relatively hard, porous crust that is devoid of vegetation.^{69, 70} The puffy surfaces are formed from surficial capillary water movement causing salts to precipitate and clays to swell on the surface, resulting in a network of polygons and hummocky relief.⁷¹ The salts binding the surface

⁵⁹ Bassett, A.M., Kupfer, D.H. and F.C. Barstow, *Core Logs from Bristol, Cadiz and Danby Dry Lakes, San Bernardino County, California*, U.S. Geological Survey Bulletin, 1045-D, 1959, pages 97-138.

⁶⁰ Koehler, J.H., *Groundwater in the Northeast Part of Twentynine Palms Marine Corps Base, Baghdad Area, California: USGS Water Resources Investigations Report 83-4053*, 1983, page 2.

⁶¹ URS Consultants, Inc., *Draft Environmental Impact Report for the Proposed Cadiz Valley Agricultural Development*, 1993, page 4-5.

⁶² Cadiz Inc., *Communication with ESA*, December 9, 2010.

⁶³ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Report No. 1163, Volume 1*, November 1999, page 29.

⁶⁴ Cadiz Inc., *Communication with ESA*, December 9, 2010.

⁶⁵ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-2.

⁶⁶ Capillary rise is the ability of a liquid to flow against gravity where liquid spontaneously rises in porous materials like soil. It occurs because of intermolecular attractive forces between the water molecules and soil surface particles. When the pore spaces are sufficiently small, the combination of surface tension (which is caused by cohesion within the liquid) and forces of adhesion between the liquid and soil particles act to lift the liquid. Capillary rise can be on the order to 10 to 20 feet.

⁶⁷ Rosen, M.R., *Sedimentologic, Geochemical and Hydrologic Evolution of an Intracontinental, Closed-Basin Playa (Bristol Dry Lake, CA): A Model for Playa Development and Its Implications for Paleoclimate*, 1989, pages 39, 140.

⁶⁸ HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol Playa, San Bernardino County, California*, August 2011, pages 8-9.

⁶⁹ Czarnecki, J.B., *Geohydrology and Evapotranspiration at Franklin Lake Playa, Inyo County, California: USGS Water Supply Paper 2377*, 1997, page 5.

⁷⁰ HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol Playa, San Bernardino County, California*, August 2011, pages 6, 8.

⁷¹ HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol Playa, San Bernardino County, California*, August 2011, pages 6, 8.

sediments are predominantly composed of sodium, calcium, and chloride, a chemical signature significantly different from other playas in the western U.S. region.⁷² The soil and water chemistry of the Bristol and Cadiz Playas have very low quantities of the sodium salts of carbonate, bicarbonate, and sulfate that are known to cause severe fugitive dust storms on the Owens Lake and Franklin Playas.⁷³ The dominance of chloride at the Bristol and Cadiz Playas results in salts that produce much less dust-producing salt efflorescence, and are more efficient at retaining water and maintaining the surface crust. Because of the difference in chemical composition, the salt crust is not dependent on groundwater; annual precipitation and surface runoff are sufficient to maintain its integrity.

Moving further out from the interior, the surface salt crust is still present but the soil beneath the salt crust becomes noticeably dryer with the subtle increase in elevation. This further indicates that the salt crust is maintained by rewetting from the annual rainfall and surface sheet flow from surrounding areas, and does not require the capillary rise of groundwater.⁷⁴ The depth to groundwater was measured on May 5, 2011, in two wells located at the northeast margin of the Bristol Playa approximately ½-mile northeast of the playa edge where vegetation begins to occur. The depths to groundwater in Wells HAL 1 and MW-5 (located at R Area Wells on Figure 4.9-5, below) were 93.40 and 85.05 feet below ground surface, respectively.⁷⁵ This suggests that the salt crust observed within the playa areas further out from the centers are not maintained by groundwater because the depth to groundwater is too deep to provide affect the surface by capillary action. A cross-sectional plot of depths to groundwater from the salt production trenches in the center of Bristol Dry Lake outward toward the Cadiz agricultural operation irrigation wells calculated the depth to groundwater at the playa edge where the vegetation begins to be 65 feet.⁷⁶ This depth is well below the maximum potential action of capillary rise again suggesting that the salt crust is not dependent on groundwater.

At the margins of the playas, the concentrations of salt in the soil decrease and plants are able to survive. Three dominant shrub species grow in the areas around the playa margins. These are the four-wing saltbush (*Atriplex canescens* [Pursh] Nutt), the cattle saltbush (*Atriplex polycarpa*) and creosote bush (*Larrea tridentata* [D.C.] Coville).⁷⁷ Four-wing saltbush dominates the area immediately adjacent to the playas with creosote and cattle saltbush absent or rare. The four-wing saltbush was observed to extend for at least one-half mile further out from the playa centers and has been observed more than one mile away. As discussed above, depth to groundwater in this area is over 65 feet below ground surface. Four-wing saltbush tends to root to a maximum depth of about 20 feet below ground surface and is a facultative phreatophyte, a plant that has the ability

⁷² HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol Playa, San Bernardino County, California*, August 2011, page 9.

⁷³ HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol Playa, San Bernardino County, California, Executive Summary*, August 2011.

⁷⁴ HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol Playa, San Bernardino County, California*, August 2011, page 14; Appendix C, page 29.

⁷⁵ Cadiz Inc., *Communication with ESA, based on well measurements collected on August 4, 2011*.

⁷⁶ HydroBio, *Vegetation, Groundwater Levels and Potential Impacts from Groundwater Pumping Near Bristol and Cadiz Playas, San Bernardino, California*, September 2011, page 7.

⁷⁷ HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol Playa, San Bernardino County, California*, August 2011, page 1.

to derive a portion of its water supply from groundwater, if present within the reach of its roots.⁷⁸ However, with the depths to groundwater in this area much deeper than the roots of this plant species, the four-wing saltbush around the Bristol and Cadiz Playas could not be deriving water supplies from groundwater, indicating that the existing surface water supply provides sufficient water for this plant life.

The other main plants in the playa margin area are creosote and cattle saltbush, both shallow-rooted species that harvest water near the surface; their roots are generally confined to the upper half meter of soil. As such, creosote and cattle saltbush are also not dependent on groundwater and both the existing, as well as the proposed, pumping of groundwater in this area would have no effect on vegetation.⁷⁹

Surface Hydrology

Intermittent Streams

As previously discussed, the Watersheds form a closed drainage system with no surface outflow; all surface water in the Project area drains to Bristol and Cadiz Dry Lakes.⁸⁰ The only outlets for surface water are direct evaporation of precipitation and intermittent surface water flow, transpiration by vegetation, and evaporation from the Dry Lake surfaces.⁸¹ Figures 3-2 and 3-3a provide conceptual illustrations of the flow of surface water and groundwater through the Fenner Gap and Orange Blossom Wash through Fenner Gap and ultimately to the Dry Lakes where the water becomes saline and evaporates.

In general, the amount of surface water flow is dictated by the intensity and duration of precipitation, topography, rock type, soil, and vegetation cover. A portion of the precipitation falling in any watershed area is intercepted by vegetation and retained in the vegetation or transpired back to the atmosphere. Another portion of the precipitation wets and adheres to the soil before returning to the atmosphere through evaporation. Another portion of the precipitation infiltrates into the soil and continues to migrate downward into the water table. In general, if precipitation exceeds infiltration capacity, overland flow occurs.

There are no perennial (year-round) streams in the Watersheds.⁸² Intermittent streams are distributed throughout the Watersheds. Ephemeral runoff within the Fenner Watershed flows into the Schulyer Wash, the principal drainage in the Fenner Valley Watershed, and then flows through Fenner Gap to either Bristol or Cadiz Dry Lake. Ephemeral runoff within the Orange Blossom Wash flows into Bristol Dry Lake. Ephemeral flow in the Bristol and Cadiz Watersheds flows into the Bristol or Cadiz Dry Lakes, respectively.

⁷⁸ National Conservation Resource Service, *Fourwing Saltbush (Atriplex canescens (Pursh.)Nutt*, Factsheet, January 2002.

⁷⁹ HydroBio, *Vegetation, Groundwater Levels and Potential Impacts from Groundwater Pumping Near Bristol and Cadiz Playas, San Bernardino, California*, September 2011, page 7.

⁸⁰ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-2.

⁸¹ Shafer, R.A., *Report on Investigations of Conditions which Determine the Potentials for Development in the Desert Valleys of Eastern San Bernardino County, CA*, Southern California Edison Company, 1964, page 75.

⁸² Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Impact Report and Final Environmental Impact Statement, Volume 1*, September 2001, page 5-72.

Springs

Spring water is any natural discharge of water from rock or soil defined as “water derived from an underground formation from which water flows naturally to the surface of the earth” at an identified location.⁸³ Some naturally-occurring springs and wet areas associated with the springs are present at higher elevations within the mountain ranges, as shown on **Figure 4.9-3**.⁸⁴ No springs, wetlands, or phreatophyte vegetation are known in the lower elevations within the intervening basins and washes because the depth to groundwater in the alluvium is too great. The closest naturally occurring spring to the Project elements (production wells and spreading basin) is the Bonanza Spring located more than 11 miles north of Fenner Gap in the Clipper Mountains. Bonanza Spring is at an elevation of about 2,100 feet NGVD, substantially above the adjacent Fenner Valley floor at about 1,350 feet NGVD. More distant springs are found in the upper elevations of the Granite, Marble, Clipper, and Old Woman Mountains. These natural springs and supporting man-made features provide important watering holes for big horn sheep. Recent field mapping of the Marble Mountains has revealed numerous ephemeral pools or tinajas⁸⁵ fed exclusively by surface run-off and guzzlers (a barrel reinforced by a concrete apron that directs rainfall into a pool).⁸⁶

An evaluation of the springs concluded that there is no physical connection of the springs in the higher elevation mountains to the groundwater in the aquifer in the valleys where Project pumping would occur.⁸⁷ **Figure 4.9-4** provides a conceptual cross-sectional view that illustrates the locations of the springs relative to surface water and groundwater. The springs receive all of their water supply first before the remaining water flows down slope or infiltrates into the fractured rock, subsequently migrating down slope into the alluvium of the valley floors. In addition, the alluvium is likely to be unsaturated as it thins over bedrock highs, further demonstrating a lack of any hydraulic continuity between groundwater in the alluvial aquifer in the valley floor and springs located in the mountains. There is no observed hydraulic continuity between groundwater in fractured granitic bedrock where the springs exist and the regional groundwater table of the alluvial aquifer (See Appendix H-3).

Groundwater Hydrology

The following Sections discuss the setting for groundwater and water quality, including hydrogeologic units, groundwater flow patterns, estimated volume of groundwater in storage, and estimated annual recharge. The geology, soils, structural geology, and seismicity of the Project area are discussed in further detail in Section 4.6, Geology and Soils, which includes discussing potential subsidence impacts from the withdrawal of groundwater.

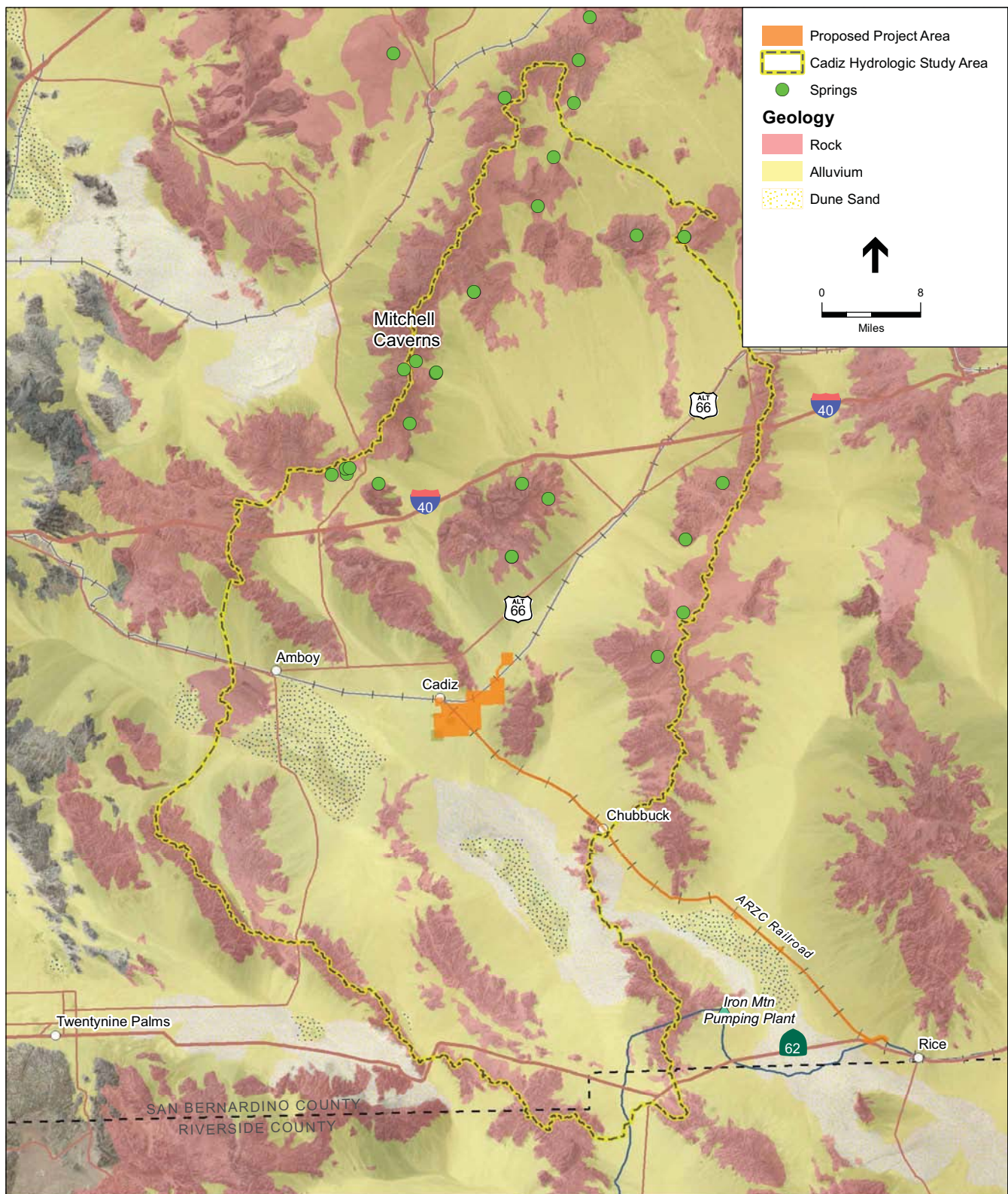
⁸³ Code of Federal Regulations, Title 21, Chapter 165, Part 110(a)(2)(vi).

⁸⁴ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-8.

⁸⁵ A tinaja is a depression in bedrock that can temporarily hold rainwater.

⁸⁶ Kenney GeoScience conducted several field visits from late 2010 to November 2011 in the Marble Mountains and was unable to identify any springs. A report of his field survey is included in Appendix H4.

⁸⁷ CH2M Hill, *Assessment of Effects of the Cadiz Groundwater Conservation Recovery and Storage Project Operations on Springs*, August 2011, page 1.

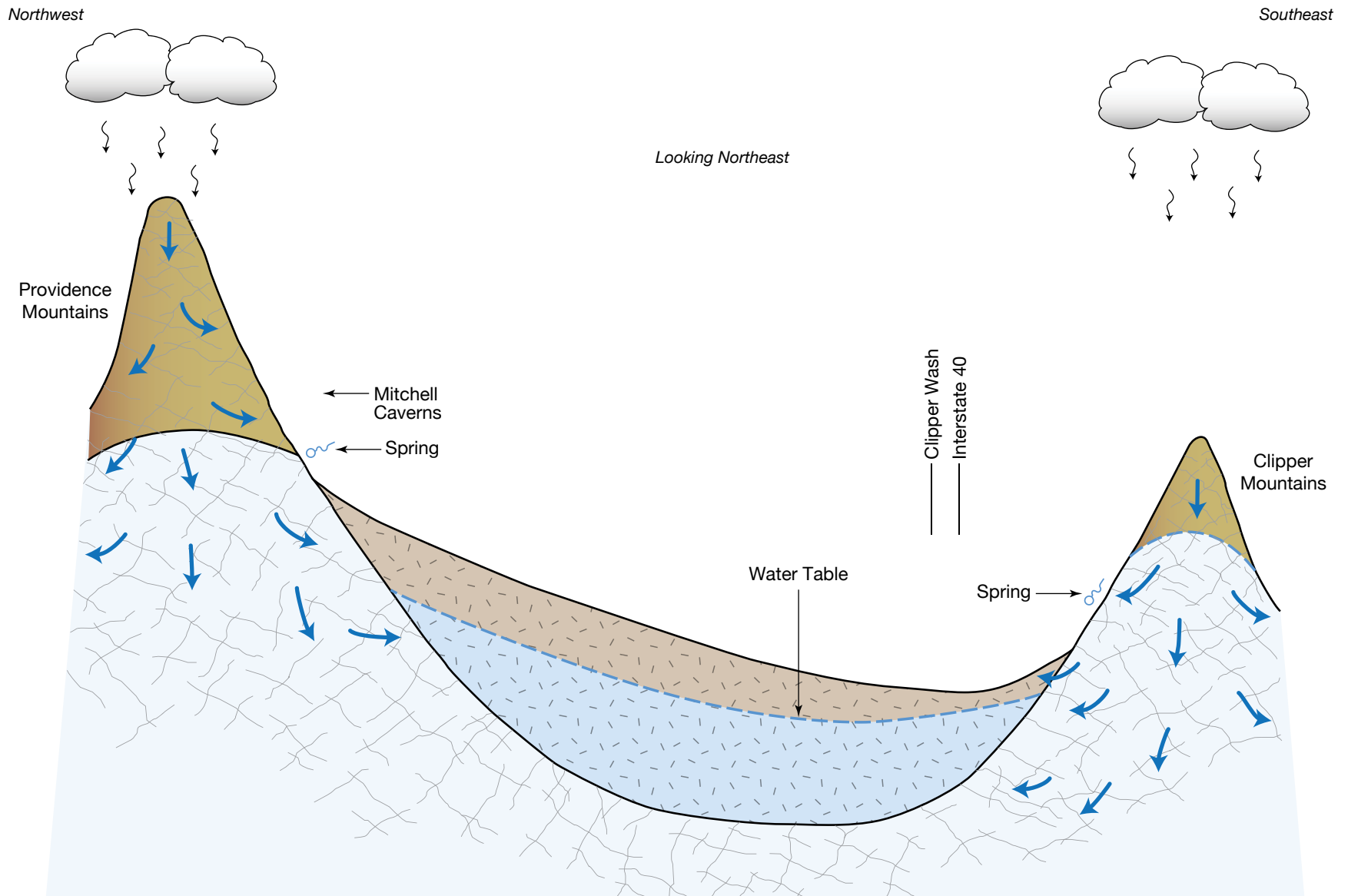


SOURCE: Bing Maps, 2011; ESRI, 2010
Cadiz Inc., 2011; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-3

Location of Springs in the Fenner Watershed



NOT TO SCALE

SOURCE: CH2MHill, 2010; and ESA, 2011.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-4
Conceptual Cross-Section Showing Water Sources
of Springs in the Fenner Watershed

Overview of Groundwater Source and Movement

In general, groundwater within the Watersheds flows in the same direction as the slope of the land surface. In the Fenner Valley, groundwater flows southward and discharges through the Fenner Gap toward the Bristol and Cadiz Dry Lakes. In Orange Blossom Wash, located between the Marble and Bristol Mountains, groundwater flows southeast from the Granite Mountains and then turns south into the Bristol Dry Lake.⁸⁸

The primary sources of replenishment to the groundwater system in the Project area include direct infiltration of precipitation (both rainfall and snowfall) into fractured bedrock exposed in mountainous terrain and infiltration of ephemeral stream flow in sand-bottomed washes, particularly in the higher elevations of the Watersheds.⁸⁹ As previously discussed, the source of most of the groundwater recharge within the Watersheds occurs in the higher elevations, since the higher elevations receive the highest volumes of precipitation.^{90,91}

Figures 3-2, 3-3a, and 4.9-4 present conceptual models of groundwater occurrence and movement in the Project area. The figures present schematic cross-sections showing the occurrence of groundwater in fractured bedrock in the mountain ranges that is recharged by precipitation. Precipitation flows down the mountain slopes by infiltrating into rock fractures or flowing overland if the volume of flow is sufficient to overcome infiltration. In some cases in the higher elevations, the infiltrating water may be diverted to the land surface or groundwater may intersect land surface creating a spring, but only in the higher elevations on the mountain slopes. Ultimately, this infiltrating water moves vertically downward into the alluvial materials and fractured bedrock of the regional groundwater system, tens to hundreds of feet below the ground surface. Groundwater continues to flow downgradient through principal aquifer systems.

Groundwater in the aquifers moves downgradient through Fenner Valley and Orange Blossom Wash into the Bristol and Cadiz depressions, where it eventually discharges to the Dry Lakes. In addition, groundwater in the aquifers to the west, south, and east of the Dry Lakes also migrates downgradient to the Dry Lakes. As discussed above, evaporation of water from the Dry Lakes over the past several million years has resulted in thick deposits of salt (primarily sodium chloride and calcium sulfate) and brine-saturated sediments.⁹² Additional groundwater recharge occurs from annual precipitation and as surface water runoff observed from the surrounding areas.⁹³

Hydrogeologic Units

Based on available geologic, hydrologic, and geophysical data, the principal formations in the study area that can readily store and transmit groundwater (aquifers) have been divided into three

⁸⁸ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-9.

⁸⁹ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, pages 2-7, 2-8.

⁹⁰ Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Impact Report and Final Environmental Impact Statement, Volume 1*, September 2001, page 5-64.

⁹¹ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-3.

⁹² Rosen, M.R. *Sedimentologic, Geochemical and Hydrologic Evolution of an Intracontinental, Closed-Basin Playa (Bristol Dry Lake, CA): A Model for Playa Development and Its Implications for Paleoclimate*, 1989, pages 39, 140.

⁹³ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, pages 2-7, 2-8.

general units: an upper (younger) alluvial aquifer; a lower (older) alluvial aquifer; and a bedrock aquifer consisting of Tertiary fanglomerate, Paleozoic carbonates, and fractured and faulted granitic rock as discussed in Section 4.6, Geology and Soils.⁹⁴ In general, these three units are in hydraulic continuity with each other and the separations are primarily due to stratigraphic differences.

The upper alluvial aquifer consists mainly of Quaternary alluvial sediments consisting of stream-deposited sand and gravel with lesser amounts of silt.⁹⁵ The thickness of this aquifer ranges from approximately 200 to 800 feet.⁹⁶ To the west of the Fenner Gap, the upper aquifer is separated from the lower aquifer system by discontinuous layers of silt and clay. The average thickness of the upper aquifer in the Fenner Gap is approximately 500 feet. The upper aquifer is very permeable in places and can yield 3,000 gallons per minute (gpm) or more to wells with less than 20 feet of drawdown.

The lower alluvial aquifer consists of older sediments, including interbedded sand, gravel, silt, and clay of late-Tertiary to early age.⁹⁷ The maximum thickness of the lower alluvial sediments is unknown but may reach over 6,000 feet below Bristol Dry Lake.⁹⁸ Where these materials extend below the water table, they yield water freely to wells but generally may be less permeable than the upper aquifer sediments.^{99, 100} The Cadiz agricultural wells are screened primarily in the lower alluvial aquifer and typically yield 1,000 to 2,000 gpm.¹⁰¹

Based on findings from recent drilling in the Fenner Gap, Tertiary fanglomerate, fractured and faulted granitic rock, and Paleozoic carbonates, located beneath the lower alluvial aquifer, contain groundwater and are considered a third aquifer unit.^{102, 103} Groundwater movement and storage in the carbonates primarily occurs in secondary porosity features (i.e., fracture zones associated with faulting and cracks, and dissolution cavities that have developed over time). The full extent, potential yield, and storage capacity of this carbonate aquifer has not been fully quantified at this time. Approximately 1,000 feet of the carbonate unit is present in some portions of the Fenner

⁹⁴ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 25.

⁹⁵ Moyle, W.R., *Water Wells and Springs in Bristol, Broadwell, Cadiz, Danby and Lavic Valleys and Vicinity, San Bernardino and Riverside Counties, California*, California Department of Water Resources Bulletin 91-14, 1967, page 9.

⁹⁶ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis*, Volume 1, September 2011, page 25.

⁹⁷ Moyle, W.R., *Water Wells and Springs in Bristol, Broadwell, Cadiz, Danby and Lavic Valleys and Vicinity, San Bernardino and Riverside Counties, California*, California Department of Water Resources Bulletin 91-14, 1967, page 9.

⁹⁸ Maas, J., *Depth to Basement Calculated from Gravity Data*, Proprietary Report to Cadiz Land Company, Inc., 1994, In CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-5.

⁹⁹ Moyle, W.R., *Water Wells and Springs in Bristol, Broadwell, Cadiz, Danby and Lavic Valleys and Vicinity, San Bernardino and Riverside Counties, California*, California Department of Water Resources Bulletin 91-14, 1967, page 9.

¹⁰⁰ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Volume 2, Report No. 1163*, November 1999, page 40.

¹⁰¹ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, page 25.

¹⁰² GEOSCIENCE Support Services, Inc., *Geohydrologic Assessment of the Fenner Gap Area*, April 2010, page 13.

¹⁰³ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, pages 4-12, 4-13.

Gap.¹⁰⁴ As such, the carbonate aquifer would constitute an additional source of groundwater that has not been included in the storage and recovery estimate mentioned earlier in this Section and discussed further below. The result of this exclusion, despite the observed data demonstrating significant quantities of groundwater in the carbonate unit, would be that the storage and recoverable groundwater estimates for the area are conservative and substantially underestimate the actual volumes.

The mountain ranges that define the boundaries of the regional watersheds are comprised predominantly of granitic and metamorphic basement rock, as described above. This less permeable basement complex forms the margins and bottoms of the aquifer systems, is generally less permeable, and typically yields smaller quantities of water to wells.¹⁰⁵ However, as noted above, recent drilling into bedrock in the Fenner Gap indicates that the upper portions of the basement rock is fractured and yields significant quantities of groundwater.^{106, 107} In addition, fracturing is more extensive along faults, resulting in additional storage volume as well as significant conduits for groundwater flow through the Fenner Gap.¹⁰⁸ The groundwater in the basement rock has also been excluded from the storage estimates discussed below. The result would be that the storage estimates are conservative and underestimate the actual volumes. The estimates for the storage volumes of groundwater are discussed further below.

Groundwater Use

The total amount of groundwater currently pumped in and surrounding the Project area has been minimal until the last decade. The primary groundwater uses in the region are the Cadiz Inc. agricultural operations, the BNSF railroad, the salt production companies, and the few residents in and around the communities of Chambless, Essex, and Goffs. **Figure 4.9-5** illustrates the locations of wells based on a well survey¹⁰⁹ and includes the Cadiz agricultural wells in addition to saline water wells at Bristol Playa.¹¹⁰

Freiwald¹¹¹ estimates that between 1954 and 1981, groundwater pumping in Fenner Valley remained constant at approximately seven to eight AFY. Shafer¹¹² reports that approximately 14,300 AF of fresh water were pumped from the Bristol and Cadiz Valleys from 1910 (when the first fresh water well was drilled) to 1964, or an average pumping rate of approximately

¹⁰⁴ Kenney GeoScience, *Geologic Structural Evaluation of the Fenner Gap Region Located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California*, August 2011, page 16.

¹⁰⁵ Freiwald, David A., *Ground-Water Resources of Lanfair and Fenner Valleys and Vicinity, San Bernardino County, California*, U.S. Geological Survey Water Resources Investigation Report 83-4082, July 1984, page 6.

¹⁰⁶ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Volume 1, Report No. 1163*, November 1999, page 40.

¹⁰⁷ GEOSCIENCE Support Services, Inc., *Geohydrologic Assessment of the Fenner Gap Area*, April 2010, page 12.

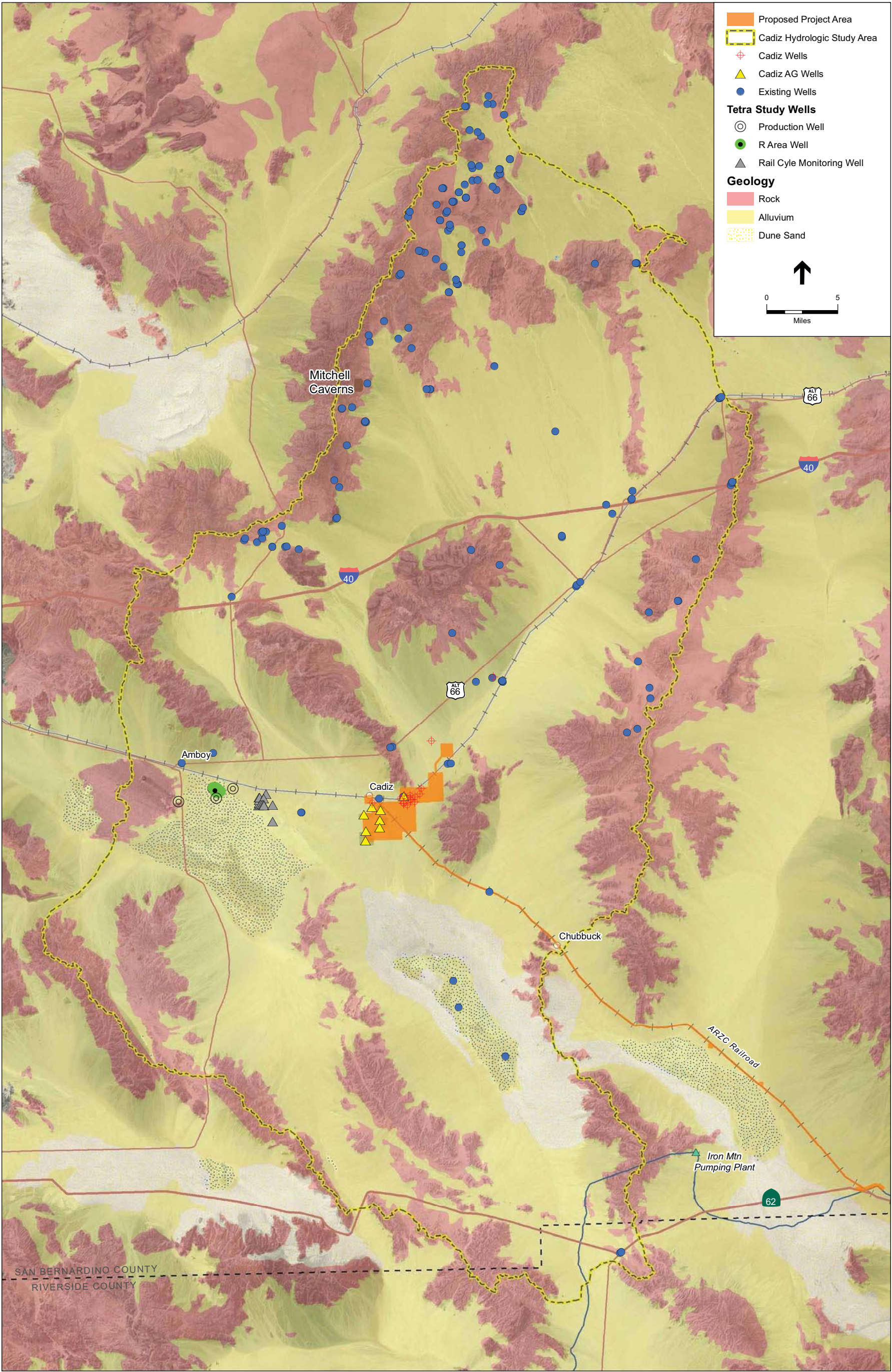
¹⁰⁸ Kenney Geoscience, *Geologic Structural Evaluation of the Fenner Gap Region located Between the Southern Marble Mountains and Ship Mountains, San Bernardino County, California*, 2011.

¹⁰⁹ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-8.

¹¹⁰ Tetra Technologies, *Location of Various Exploration Boreholes, Coreholes, Wells, and Production Pits, Bristol Dry Lake, California*, Plate 1, November 1999.

¹¹¹ Freiwald, David A., *Ground-Water Resources of Lanfair and Fenner Valleys and Vicinity, San Bernardino County, California*, U.S. Geological Survey Water Resources Investigation Report 83-4082, July 1984, page 11.

¹¹² Shafer, R.A., *Report on Investigations of Conditions which Determine the Potentials for Development in the Desert Valleys of Eastern San Bernardino County, CA*, Southern California Edison Company, June 1964.



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; Tetra Tech, 1999; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-5
Location of Known Wells in the
Fenner, Bristol, and Cadiz Watersheds

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265 AFY. These historical pumping rates do not include the Cadiz Inc. agricultural operations, and it is assumed that these uses presently continue.

Yearly groundwater production for the Cadiz Inc. agricultural operations averaged between 5,000 to 6,000 AFY from 1986 through 1998. Between 1998 and 2002, agricultural use averaged 5,600 AFY. Annual use since 2002 is listed in **Table 4.9-2** below.¹¹³⁻¹¹⁴⁻¹¹⁵⁻¹¹⁶

**TABLE 4.9-2
CADIZ ANNUAL GROUNDWATER USE FOR AGRICULTURE
2002 THROUGH 2010**

Year	Acre-Feet
2002	5,495
2003	5,095
2004	4,255
2005	4,509
2006	4,439
2007	3,405
2008	1,970
2009	1,882
2010	1,867

SOURCE: Cadiz Inc., *6th Annual Groundwater Monitoring Report, January 2003 - December 2003, Cadiz Valley Agricultural Development*, January 2009, page 13; Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Impact Report and Final Environmental Impact Statement*, September 2001, page 5-80; Cadiz Inc., *11th Annual Groundwater Monitoring Report, January-December 2008, Cadiz Valley Agricultural Development*, June 2009, page 13; Cadiz Inc., *10th Annual Groundwater Monitoring Report, January 2007 - December 2007 & Five-Year Summary Report, Cadiz Valley Agricultural Development*, April 2008, page 14.

The decrease in recent years is primarily due to changes in crop cultivation and increased irrigation efficiency.¹¹⁷ The Cadiz Inc. agricultural operations currently utilize seven wells for irrigation. These wells are all located downgradient of the Fenner Gap (see Figure 4.9-5).

Tetra Technologies, the salt production company operating on Bristol and Cadiz Dry Lakes, is the only other groundwater user in the area that has identified and recorded groundwater production

¹¹³ Cadiz Inc., *6th Annual Groundwater Monitoring Report, January 2003 - December 2003, Cadiz Valley Agricultural Development*, January 2009, page 13.

¹¹⁴ Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Impact Report and Final Environmental Impact Statement, Volume 1*, September 2001, page 5-80.

¹¹⁵ Cadiz Inc., *11th Annual Groundwater Monitoring Report, January-December 2008, Cadiz Valley Agricultural Development*, June 2009, page 13.

¹¹⁶ Cadiz Inc., *10th Annual Groundwater Monitoring Report, January 2007 - December 2007 & Five-Year Summary Report, Cadiz Valley Agricultural Development*, April 2008, page 14.

¹¹⁷ Cadiz Inc., *13th Annual Groundwater Monitoring Report, January-December 2010, Cadiz Valley Agricultural Development*, June 2011, page 12.

in excess of 25 AFY (see California Water Code Section 4999 et. seq. [Section 4999]). According to public records, Tetra Technologies pumps groundwater directly from beneath its property, which overlies the Bristol Dry Lake. Tetra's annual groundwater production has generally averaged about 500 AFY since 1986 with a high of 574 AF reported in 1996. Like Tetra Technologies, National Chloride Company has a similar salt production operation over Bristol Dry Lake but it is believed that it extracts a smaller but proportionately similar quantity of groundwater annually, as it is a smaller operation and it has not filed public records reporting its annual use.

As discussed in Section 4.11, Mineral Resources, calcium chloride and sodium chloride are produced by the salt production operations on both Bristol and Cadiz Dry Lakes. Highly saline water beneath the surface is pumped from saline groundwater wells and into trenches for the concentration of salts in evaporation ponds. These well locations are shown on Figure 4.9-5.

Other than the entities discussed above, there are no significant groundwater users in Fenner Valley that are known or that have filed a statement pursuant to Section 4999 stating that they are pumping in excess of 25 AFY. Significant groundwater users are defined by the State as users of in excess of 25 AFY. Within the Watersheds area there are only a few scattered residents or very small communities. For example, as of 2007, the community of Amboy had only four residents.¹¹⁸ Estimates vary, but the USGS estimates each person's domestic use of water is approximately 80 to 100 gallons per day.¹¹⁹

Groundwater Flow Patterns and Depths

In general, groundwater within the Watersheds flows in the same general direction as the slope of the land surface.¹²⁰ **Figure 4.9-6** presents a generalized contour map of existing groundwater elevations and horizontal flow patterns in the Watersheds.¹²¹ The contours in this figure are based on water levels measured in more than 80 wells.¹²² In some cases, published water level elevations have been adjusted to reflect more accurate reference elevations, obtained from updated topographic maps of the area.

In the Fenner Valley, groundwater generally flows southward and downgradient, discharging through the Fenner Gap toward Bristol and Cadiz Playas. The depths to groundwater in the Fenner Valley range from 200 to 400 feet bgs.¹²³ Because the extinction depth¹²⁴ is about 15

¹¹⁸ Mike Anton, Los Angeles Times, *Destiny in the Desert*, January 2007

¹¹⁹ U.S. Geological Survey, Water Questions and Answers, accessed at ga.water.usgs.gov/edu/qa-home-percapita.html

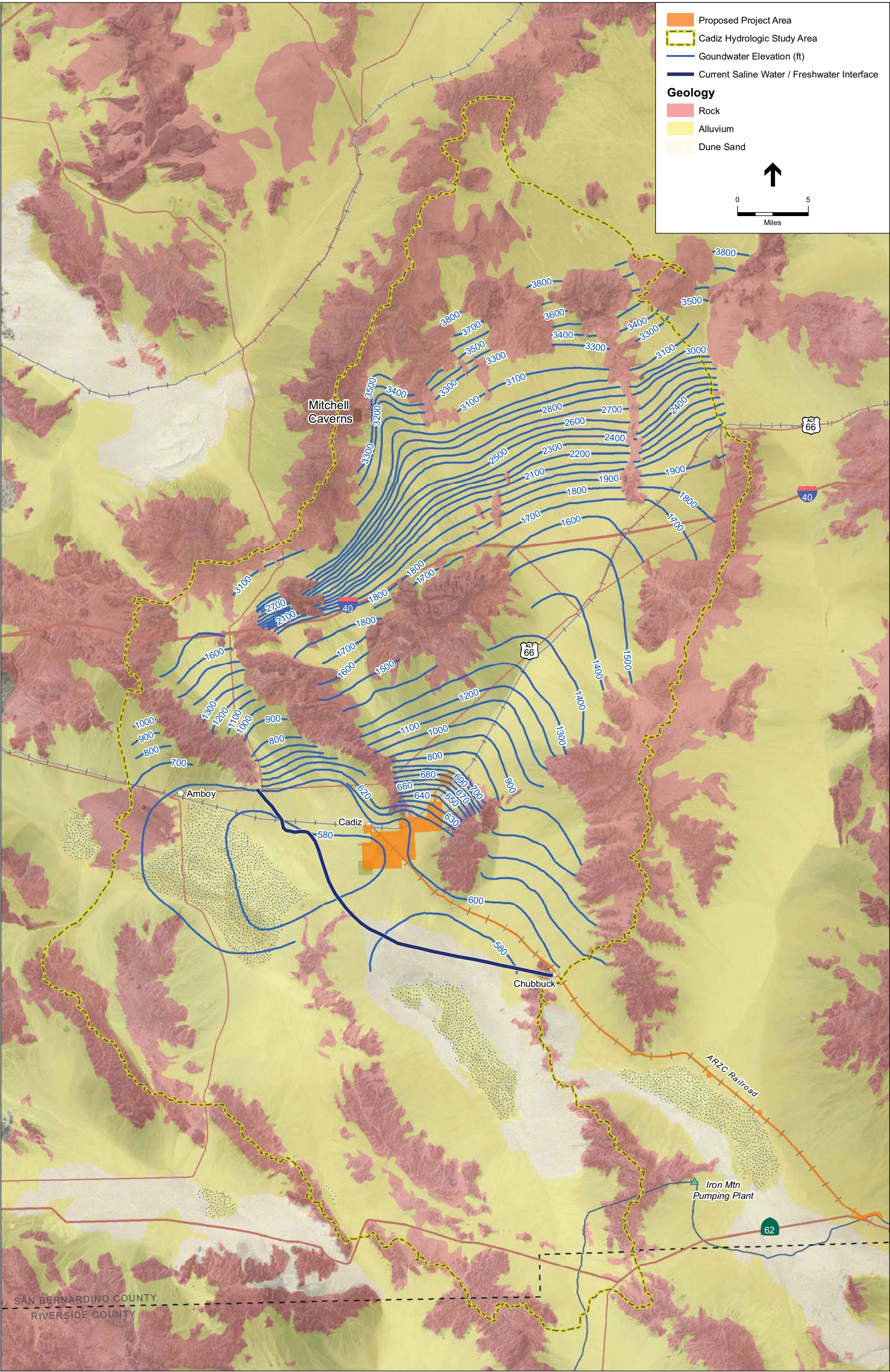
¹²⁰ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, pages 2-8, 2-9.

¹²¹ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, Figure 2-16.

¹²² GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Report No. 1163*, November 1999, Table 19 and Appendix C.

¹²³ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, Figures 2-2, 2-16.

¹²⁴ The extinction depth is that depth below which minimal to no evaporation can occur.



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; GSSI, 2011; Tetra Tech, 1999; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-6

2009 Groundwater Elevation Contours

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feet,¹²⁵ there would be only minimal to no evaporation of groundwater from the aquifer in the Fenner Watershed. The gradient ranges from approximately 180 feet per mile in the north central area of Fenner Valley to approximately 25 feet per mile around Essex between the Clipper and Piute Mountains.

In Orange Blossom Wash, groundwater flows generally southeast from the Granite Mountains and then turns south as it reaches Bristol Playa. The depths to water range from 1,300 feet bgs at the upper end of the wash to 350 feet bgs where the wash enters the Cadiz Valley. The gradient ranges from 104 feet per mile at the upper end of the wash to 26 feet per mile where the flow enters Cadiz Valley.

At the Fenner Gap, groundwater flow is from northeast to southwest at a gradient of approximately 10 feet per mile.¹²⁶ Depths to groundwater in Observation Well 5/14-13 ranged from 296.80 to 297.32 feet bgs in calendar year 2010.¹²⁷ Groundwater then flows through the Fenner Gap and into the playas.

Once in the playa areas and beneath the Dry Lakes, the gradient flattens out to zero. The gradients beneath the playas decrease to zero because the water has no outlet from these basins other than evaporation through the Dry Lake surfaces. Trenches dug in central portions of Bristol Playa for salt production show water levels ranging from 8 to 12 feet deep.¹²⁸ As previously noted, the depth to groundwater was measured on May 5, 2011, in two wells located at the northeast margin of the Bristol Playa approximately ½-mile northeast of the playa edge where vegetation begins to occur. The depths to groundwater in Wells HAL 1 and MW-5 (Figure 4.9-5) were 93.40 and 85.05 feet below ground surface, respectively.¹²⁹ The groundwater levels measured in the Cadiz agricultural wells, as reported in their annual reports, have changed very little since 1996, even on a month to month basis.¹³⁰ Figures 3-2 and 3-3a provide a schematic cross section from Fenner Valley to the Fenner Gap to Bristol Dry Lake. The depths to groundwater increase to about 65 to 80 feet bgs along the eastern margin of the playa.¹³¹

Aquifer Parameters

Within the Fenner Gap area, in general, the alluvial units and the carbonate unit are in hydraulic continuity with each other, and the separation is primarily due to stratigraphic differences or the extent of interconnecting secondary porosity with the carbonate unit.

¹²⁵ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, page 36.

¹²⁶ GEOSCIENCE Support Services, Inc., *Geohydrologic Assessment of the Fenner Gap Area*, April 2010, page 12.

¹²⁷ Cadiz Inc., *13th Annual Groundwater Monitoring Report, January-December 2010, Cadiz Valley Agricultural Development*, June 2011, page A-8.

¹²⁸ HydroBio, *Fugitive Dust and Effects from Changing Water Table at Bristol Play, San Bernardino, California*, January 2011, page 7.

¹²⁹ Cadiz Inc., *Communication with ESA*, August 4, 2011.

¹³⁰ Cadiz, *13th Annual Groundwater Monitoring Report, January – December 2010, Cadiz Agricultural Development*, June 2011, page 10.

¹³¹ HydroBio, *Vegetation, Groundwater Levels and Potential Impacts from Groundwater Pumping Near Bristol and Cadiz Playas, San Bernardino, California*, September 2011, pages 5-7.

In developing the aquifer model, Geoscience calibrated data from several pump tests to match the observed water level data.¹³² Hydraulic conductivities, assuming an average annual recharge estimate of 32,000 AFY, were 0.2 to 543 feet per year (ft/yr) for the alluvium, 500 to 1,500 ft/yr for the carbonates, 60 ft/yr for the fanglomerate/lower Paleozoic sequence/weathered granitic rocks in the Fenner Gap, and 75 ft/yr for the weathered granitic rocks/detachment fault zone in the Fenner Gap. The unconfined storage coefficient (also referred to as the effective porosity or specific yield) was estimated at 0.15, and the confined storage coefficient was estimated at 0.00001. Cadiz's Production Well PW-1, located in the Fenner Gap, draws water primarily from the upper and lower alluvial aquifers and yields up to 3,000 gpm with less than 20 feet of drawdown.¹³³ Cadiz agricultural wells draw water from the upper alluvial aquifers and typically yield from 1,000 gpm to more than 2,000 gpm. The storativities reflect semi-confined conditions. The alluvial aquifer exhibits leakage effects suggesting hydraulic continuity with the underlying carbonate unit.

Summary of Groundwater in Storage

CH2M Hill updated groundwater storage estimates¹³⁴ that had previously been developed by Geoscience.¹³⁵ To do so, they used recent field investigations that were conducted by both CH2M Hill and Geoscience. The volume of groundwater in storage was estimated by CH2M Hill to be about 17 to 34 MAF in the alluvium of the Fenner Valley, the freshwater portion of the Orange Blossom Wash, and northern portion of the Bristol Valley area (freshwater defined as total dissolved solids [TDS] of less than 1,000 mg/l).¹³⁶ Of this total, approximately 12 to 24 MAF of freshwater are within the Fenner Watershed, an estimate comparable to the previous Geoscience estimates. The freshwater zone south of the Fenner Gap in the Orange Blossom Wash and the northern portion of the Bristol Watershed is estimated to be between 4 and 10 MAF.¹³⁷

As noted above, the storage estimate does not include the carbonate and fractured portion of bedrock units beneath the alluvium. Recent drilling has revealed that these units also store groundwater.¹³⁸ As such, the estimated volume of groundwater in storage is a conservative underestimate; the actual volume of groundwater in storage is larger by an undetermined amount.

Summary of Recharge Estimates

The following subsections discuss the development of recharge estimates. The estimates focus primarily on recharge to the Fenner Watershed because the Project proposes to intercept groundwater at the Fenner Gap and prevent it from being lost to evaporation at the Dry Lakes. The estimates do not account for the additional recharge to the Dry Lakes from the areas west, south, and east of the playas and therefore are conservative.

¹³² GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, pages 32-33.

¹³³ GEOSCIENCE Support Services, Inc., *Geohydrologic Assessment of the Fenner Gap Area*, April 2010, page 2.

¹³⁴ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, pages 3-1, 3-2.

¹³⁵ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Volume 1, Report No. 1163*, November 1999, page 64-67.

¹³⁶ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, pages 3-1, 3-2.

¹³⁷ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, Table 3-1.

¹³⁸ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 3-1.

As discussed below, a number of earlier hydrology studies and recharge estimates have been made beginning as early as 1929 using a variety of approaches and methods. However, the earlier efforts were either general in nature (descriptive but no actual recharge calculations) or were relying on minimal sets of data and assumptions to account for the lack of extensive site-specific data. The earlier recharge estimates are summarized below for historical purposes only. The recent recharge estimates discussed further below include more local and site-specific information with larger data sets, thus enabling more reasonable and accurate recharge estimates. As a result, the most recent recharge estimates are used for modeling the aquifer response to groundwater pumping and evaluating the nature and extent of potential model-predicted impacts.

Previous Recharge Estimates

The Fenner Watershed and the surrounding local area has been the subject of numerous hydrology and water supply investigations since the USGS first studied the area in 1929, when the USGS published Water Supply Paper 578.¹³⁹ This study did not provide any recharge estimates, but noted the hydrologic characteristics of the region. Since then, numerous studies have been conducted. For example, two studies in the 1960s also evaluated the hydrologic characteristics of the Watershed, but again did not evaluate recharge rates. The first study that provided recharge estimates was conducted by Schafer for the Southern California Edison Company in 1964.¹⁴⁰ The second was conducted for the California Department of Water Resources in 1967.¹⁴¹ However, these earlier studies relied on limited and incomplete precipitation, water well records, and elevation survey data. Consequently, these earlier recharge estimates vary greatly and are considered less reliable than more the recent estimates of recharge.

1980 to 1984 Estimates

In the 1980s, several recharge estimates were made for the Fenner Watershed resulting in varying recharge estimates. The USGS released two studies in 1984 analyzing recharge. While the first did not reach a conclusion on recharge amounts,¹⁴² the second USGS study estimated the recharge at 270 AFY using assumptions for the gradient, cross-section, and transmissivity.¹⁴³ Later in 1984, Geothermal Surveys¹⁴⁴ conducted another study using site-specific transmissivity from new wells, but still with an assumed cross-section and gradient, arriving at an estimate of 18,000 to 36,000 AFY. An estimate of recharge as 1 percent to 10 percent of assumed average annual precipitation yielded results of 780-7,800 AFY. An estimate of recharge as 10 percent of assumed annual precipitation at elevation above 2,400 feet yielded a result of 20,600 AFY estimate of annual recharge. The same year, David Keith Todd, Consulting Engineers, using

¹³⁹ Thompson, D.G., *The Mojave Desert Region, California: A Geographic, Geologic, and Hydrologic Reconnaissance*, USGS Water Supply Paper 578, 1929.

¹⁴⁰ Schafer, R.A., *Report on Investigations or Conditions which Determine the Potentials for Development in the Desert Valleys of Eastern San Bernardino County, California*, Southern California Edison Company, June 1964.

¹⁴¹ California Department of Water Resources, *Water Wells and Springs in Bristol, Broadwell, Cadiz, Danby and Lavic Valleys and Vicinity*, Bulletin No. 91-14, 1967.

¹⁴² Bedinger, M.S., Langer, W.H., and Moyle, W.R., *Maps Showing Ground Water Units and Withdrawal, Basin and Range Province, Southern California*, U.S. Geological Survey Water-Resources Investigations Report 83-4116-A, July 1984.

¹⁴³ Freiwald, David, A., *Groundwater Resources of Lanfair and Fenner Valleys and Vicinity*, San Bernardino County, California, U.S. Geological Survey Water Resources Investigation Report 83-4082, 1984.

¹⁴⁴ Geothermal Surveys, Inc., *Ground Water Resources Investigation near Cadiz, San Bernardino County, California*, August 1984, prepared for Cadiz Agricultural Project I, In GEOSCIENCE Support Services, Inc., *Interim Report, Evaluation of Water Resources in Bristol, Cadiz and Fenner Basins*, September 1995, page 5.

assumed values for the gradient and area of saturated cross-section, as well as an estimated transmissivity, estimated the recharge in the Fenner Valley Watershed to be 11,000 AFY.¹⁴⁵

1995-1998 Modeling

In 1995, Geoscience prepared the first aquifer model for the Project using the USGS aquifer modeling tool referred to as MODFLOW. MODFLOW is a modular finite-difference flow model, which is a computer code that solves the groundwater flow equation. The program is used by hydrogeologists to simulate the flow of groundwater through aquifers. Since its original development in the early 1980s, the USGS has released four major releases, and MODFLOW is now considered to be the *de facto* standard code for aquifer simulation. The initial Geoscience modeling effort estimated a range of recharge to the Fenner Watershed of 13,000 to 33,000 AFY.¹⁴⁶

In 1997, Metropolitan conducted a series of studies for the Fenner Gap region in support of an environmental impact report. Utilizing a watershed model and MODFLOW, Geoscience updated their recharge estimates to between 15,000 and 37,000 AFY.¹⁴⁷ Two years later, the Technical Review Board for Metropolitan, using an assumption of recharge as 3 percent to 7 percent of precipitation, estimated recharge to range between 14,000 AFY and 33,000 AFY using a chloride balance calculation.¹⁴⁸

The first detailed and extensive studies were conducted by Geoscience in support of the earlier Metropolitan EIS/EIR, beginning in the early 1980's and culminating with their 1999 Technical Report.¹⁴⁹ Geoscience based its work on precipitation records, water level data from 50 wells in the region, and isotopic data verifying the recent age of the water. Geoscience then had its work peer-reviewed by an outside firm. Their 1999 estimate of recharge to the Fenner Watershed indicated a range of 15,000 to 37,000 AFY with an average annual estimate of 30,000 AFY.¹⁵⁰ The extent of this range is due to uncertainty in the assignment of each model parameter value, with some parameters having greater influence on the total recoverable water estimate than others. For example, the model is highly sensitive to the parameter values of field capacity and soil thickness; uncertainty in the estimates of these values has a great influence on the total

¹⁴⁵ Todd, David K., *Groundwater Resource Investigations near Cadiz, San Bernardino County, California*, October 1984; Todd, David K., *Supplemental Information on Groundwater Resources near Cadiz, California*, November 1984.

¹⁴⁶ GEOSCIENCE Support Services, Inc., *Interim Report, Evaluation of Water Resources in Bristol, Cadiz and Fenner Basins, Prepared for Cadiz Land Company, Inc. and Mojave Water District*, September 1995, Table 9.

¹⁴⁷ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Volume 1*, Report No. 1163, November 1999, page 41.

¹⁴⁸ Wood, Warren. W., *Use and Misuse of the Chloride Balance Method in Estimating Ground Water Recharge*, in *Groundwater*, Vol. 37, No.1, January 1999, Pages 2-3. This assumption was determined to be valid by using a chloride balance calculation developed by Wood (1999). The use of a chloride balance calculation is based on the principle that the recharge (the water mass flux) to a water table can be determined if the average chloride concentration for a given area are known in both precipitation and groundwater. Chloride is chosen for this evaluation because it is generally the most conservative ionic species (nonreactive with aquifer materials) commonly found in groundwater.

¹⁴⁹ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Volume 1*, Report No. 1163, November 1999.

¹⁵⁰ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Volume 1*, Report No. 1163, November 1999, page 41.

recoverable water estimate. The model is relatively insensitive to values of soil moisture, however, which have very little influence on the total recoverable water estimate.¹⁵¹

Geosciences's prior watershed model was used to evaluate the available water resources within the Bristol, Cadiz, and Fenner Watersheds. The primary difference between the Bristol, Cadiz, and Fenner Watershed model of Geoscience and other models from USGS is the approach taken to determine the values of the individual components of the models. The USGS watershed model begins by calculating the amount of water infiltrating into the groundwater basin. That amount is subtracted from the total volume of water available to the watershed, and the models then determine the surface runoff and other components of the water balance as fractions of the remaining water. The approach for the Geoscience watershed model, on the other hand, was to determine the runoff component of the water balance first. Once established, the runoff was subtracted from the total amount of water, and all of the other components (i.e. infiltration, vegetation interception, evapotranspiration, soil moisture, and percolation) were calculated based on the amount of water remaining.

As a comparative analysis to the watershed model described above, a regional water balance was performed for the same watershed area (i.e. Bristol, Cadiz, and Fenner) by Geoscience. A water balance is the quantitative evaluation of the equation of hydrologic equilibrium which relates inflow, outflow, and the resulting change in storage. Inflow terms include percolation into the groundwater system and surface runoff. The only outflow terms for surface and subsurface water entering the Watershed are evaporation from Bristol and Cadiz Dry Lakes and groundwater pumping. No subsurface outflow occurs because the Watershed system is closed. Assuming that no change in storage occurs within the Watershed, the sum of the inflow terms (percolation plus runoff) should equal the sum of the outflow terms (evapotranspiration and pumping).¹⁵²

The particular method of calibration used by Geoscience was the "history matching" technique. In this method, a transient calibration period from 1986 to 1997 was chosen to represent a historical time period where water levels, pumping, natural recharge, and evapotranspiration are known with a reasonable degree of accuracy. Once the initial model data was inputted, model-generated water levels for the period from 1986 to 1997 were compared with measured water levels for selected wells. Of equal importance, individual recharge and discharge components calculated by the model were compared to estimated historical recharge and discharge. Adjustments in hydrogeologic parameters, such as hydraulic conductivity, transmissivity, storativity and leakance, and extinction depth of evapotranspiration were then made within tolerable limits until a satisfactory match was obtained. Parameter changes during model calibration were assigned to groups of cells. Adjustment of individual parameters for individual model cells was not considered.

¹⁵¹ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Volume 1*, Report No. 1163, November 1999, page 58.

¹⁵² GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Volume 1, Report No. 1163*, November 1999, page 59.

Geoscience estimated the range of groundwater recharge to the Fenner, Bristol, and Cadiz Watershed areas to be 20,000 to 58,000 AFY.¹⁵³ The volume of groundwater in storage within aquifers of the Fenner Watershed was estimated by Geoscience to range from 13 to 23 million AF.¹⁵⁴

Maxey-Eakin Model Studies

A series of studies were conducted in 2000 to estimate recharge using the “Maxey-Eakin” model. The basic premise of a Maxey-Eakin recharge estimate is that the rate of groundwater replenishment is proportional to the annual rainfall. Recharge estimates using a Maxey-Eakin method requires predicting how precipitation (rain and snow) varies with elevation change on an annual basis in localized areas. From these data, a percentage of annual precipitation will contribute to groundwater recharge. Hence, a Maxey-Eakin model predicts recharge as a function of precipitation.¹⁵⁵

Review comments by the U.S. Geological Survey, Water Resources Division on Metropolitan’s Draft EIR on the Cadiz Groundwater Storage and Dry-Year Supply were accompanied by an independent recharge estimate to the Fenner Basin based on a Maxey-Eakin method.¹⁵⁶ The Maxey-Eakin model is a simple empirical model that utilizes estimates of recharge for elevation zones based on average annual precipitation. The model was developed for Central Nevada. Using the Maxey-Eakin model, the USGS estimated recharge at between 2,550 (worst case scenario) and 11,200 AFY.¹⁵⁷ Timothy Durbin conducted a separate review, and using the Maxey-Eakin model, estimated recharge at 5,000 AFY.¹⁵⁸ John D. Bredehoeft also conducted a review in 2000 using the Maxey-Eakin model, and determined that recharge was between 5,000 and 6,000 AFY.¹⁵⁹ These estimates did not use site-specific geological and hydrological parameters. Finally, a study conducted for the Lawrence Livermore National Laboratory in May of 2000 applied the Maxey-Eakin model and determined that recharge was between 16,214 AFY using a regional precipitation elevation curve, and 29,185 AFY using the local curve.¹⁶⁰

¹⁵³ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Volumes 1 and 2, Report No. 1163*, November 1999, page 120 and Appendix F.

¹⁵⁴ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Storage and Dry-Year Supply Program, Environmental Planning Technical Report, Groundwater Resources, Volume 1, Report No. 1163*, November 1999, page 66.

¹⁵⁵ Davisson, M/L. and T.P. Rose, *Maxey-Eakin Methods for Estimating Groundwater Recharge in the Fenner Watershed, Southeastern, California*, Lawrence Livermore National Laboratory, May 2000, page 3.

¹⁵⁶ U.S. Geological Survey, *Review of the Cadiz Groundwater Storage and Dry-Year Supply Program Draft Environmental Planning Technical Report, Groundwater Resources, Volumes 1 and 2, 2000, Memorandum from J.F. Devine to M.S. Brady*, February 2000.

¹⁵⁷ U.S. Geological Survey, *Review of the Cadiz Groundwater Storage and Dry-Year Supply Program Draft Environmental Planning Technical Report, Groundwater Resources, Volumes 1 and 2, 2000, Memorandum from J.F. Devine to M.S. Brady*, February 2000.

¹⁵⁸ Durbin Timothy, *Comments on Draft EIR/EIS Cadiz Groundwater Storage Project Cadiz and Fenner Valleys, San Bernardino County, California*; Prepared for County of San Bernardino, February 21, 2000, in Bredehoeft, John, *Cadiz Groundwater Storage Project, Cadiz and Fenner Valleys, San Bernardino County, California*, August 2001, page 8.

¹⁵⁹ Bredehoeft, John, *Cadiz Groundwater Storage Project, Cadiz and Fenner Valleys, San Bernardino County, California*, August 2001, page 4.

¹⁶⁰ Davisson, M/L. and T.P. Rose, *Maxey-Eakin Methods for Estimating Groundwater Recharge in the Fenner Watershed, Southeastern, California*, Lawrence Livermore National Laboratory, May 2000, page 6.

Current Recharge Estimates

To address the discrepancies in recharge estimates in previous studies, in 2010, CH2M Hill reviewed previous Geoscience modeling studies and conducted additional studies to provide an updated assessment of: 1) potential recoverable water that could be conserved over the long term (by intercepting water that would otherwise discharge by evaporation from Bristol and Cadiz Dry Lakes), and 2) groundwater in storage in the Fenner Valley and northern Bristol Valley area. This updated assessment included collection of additional field data, development of a watershed soil-moisture budget model based on the USGS INFIL3.0 model, and development of a three-dimensional groundwater flow model, based on the USGS MODFLOW-2000 computer code, of the Fenner Gap area.¹⁶¹ This updated assessment included collection of additional field data, development of a watershed soil-moisture budget model based on the USGS INFIL3.0 model, and development of a three-dimensional groundwater flow model, based on the USGS MODFLOW-2000 computer code, of the Fenner Gap area.

The USGS released INFIL3.0 in 2008, software technology previously unavailable for prior studies conducted by Geoscience in 1999.¹⁶² INFIL3.0 computes daily, monthly, and annual average water-balance components for multi-year simulations.¹⁶³ MODFLOW-2000, another more recent model unavailable in the 1999 Geoscience study, is an enhancement to the previous MODFLOW numerical model originally documented by the USGS in 1984 because it requires that a conceptual model be developed of the groundwater system to be simulated, including, lateral and vertical extents of the system, definition of top and bottom of aquifers and confining units, boundary conditions (such as no-flow rock, specified inflows and outflows, constant heads where groundwater levels are maintained as constant, or some combination of these), hydrogeologic properties of aquifers, and observations to calibrate against (e.g., measured groundwater levels).¹⁶⁴

The USGS computer program INFIL3.0 was used to assess the quantity of recharge to the groundwater system and, therefore, recoverable water. The USGS released INFIL3.0 in 2008. INFIL3.0 is a grid-based, distributed-parameter, deterministic water-balance watershed model used to estimate the areal and temporal net infiltration below the root zone.¹⁶⁵ The model is based on earlier versions of INFIL code that were developed by the USGS in cooperation with the Department of Energy to estimate net infiltration and groundwater recharge at the Yucca Mountain high-level nuclear-waste repository site in Nevada. Net infiltration is the downward movement of water that escapes below the root zone and is no longer affected by evapotranspiration and is capable of percolating to, and recharging, groundwater. Net infiltration may originate as three sources: rainfall, snow melt, and surface water runoff (runoff and streamflow).

Using the USGS INFIL3.0 model and its three-dimensional groundwater flow model, CH2M Hill's assessments indicated that a reasonable estimate of potential recoverable water is about

¹⁶¹ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, pages 1-2, 1-3.

¹⁶² CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, pages 1-3.

¹⁶³ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page ES-3.

¹⁶⁴ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 4-13.

¹⁶⁵ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, pages 4-8, 4-9.

32,000 AFY and the volume of groundwater in storage is reasonably estimated to be between about 17 to 34 MAF in the alluvium of the Fenner Valley and northern Bristol Valley area.¹⁶⁶ CH2M Hill used estimates of the following variables: volume of aquifer, determined as the volume between the groundwater table and the base of the alluvium (saturated thickness), percent of aquifer saturated thickness that is expected to be an aquifer (to exclude clay and silt intervals that do not yield water readily), and estimated specific yield.¹⁶⁷ Using low and high ranges provided for each of these variables based on Geoscience's previous estimates from 1999, CH2M Hill concluded the range of groundwater in storage in the focus area fell within the above range.¹⁶⁸

CH2M Hill also presented estimates of potentially recoverable water, water that would otherwise discharge to the Bristol and Cadiz Dry Lakes and then evaporate. The estimates were developed using the USGS INFIL3.0 watershed soil moisture budget model and then tested through application of the USGS MODFLOW-2000 model of groundwater flow through the Fenner Gap.¹⁶⁹ CH2M Hill found that total recoverable water is equal to the amount of recharge to the groundwater system in the Fenner Watershed, which is approximately equal to the amount of groundwater flow through Fenner Gap through the alluvial and carbonate rock units (flow through other rock units is expected to be substantially less than through these two hydrogeologic units).¹⁷⁰ By intercepting this groundwater flow through the gap, a reduction of evaporation from Bristol and Cadiz Dry Lakes is expected, but there would be no reduction in groundwater storage.

CH2M Hill's model provided an annual recharge estimate of approximately 32,000 AFY, consisting of 30,191 AFY from the Fenner Watershed and 2,256 AFY from Orange Blossom Wash.¹⁷¹ The time period of input data was from 1948 to 2008. As discussed above, this volume of water currently migrates downgradient to the Dry Lakes where it becomes hypersaline and is then lost to evaporation. Consequently, over a 50-year time period, the cumulative evaporative loss would be 1.6 MAF.¹⁷² The total volume of water migrating to the Dry Lakes is actually more than 32,000 AFY due to additional surface water and groundwater recharge from the areas west, south, and east of the Dry Lakes.

The annual quantities of recharge vary with annual precipitation. However, in general, the period prior to 1975 was much drier than the long-term average, while the period after 1975 was much wetter than average.¹⁷³ As such, the period 1958 through 2007 covers both long-term dry and long-term wet periods and represents a reasonable average. As previously noted in this chapter and in other sections of this Draft EIR, climate change is predicted to result in more extremes in precipitation year over year. Over the 50-year life of the Project, the annual average precipitation

¹⁶⁶ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page ES-1.

¹⁶⁷ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 3-1.

¹⁶⁸ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page. 3-1.

¹⁶⁹ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 4-13.

¹⁷⁰ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, pages 4-8, 4-9.

¹⁷¹ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, pages 4-8.

¹⁷² GEOSCIENCE Support Services, Inc., *Supplemental Assessment of Pumping Required for the Cadiz Groundwater Conservation and Recovery and Storage Project*, September 2011, page 4.

¹⁷³ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 2-3.

may or may not increase compared to the previous 50 years and weather events could be more extreme.

Water Quality

Fenner Watershed

The quality of the groundwater in the Fenner Gap and Fenner Valley area is relatively good, with total dissolved solids (TDS) concentrations typically in the range of 300 to 400 milligrams per liter (mg/L).¹⁷⁴ The federal secondary Maximum Contaminant Level (MCL) for TDS in drinking water is 500 milligrams per liter (mg/L).¹⁷⁵ However, all groundwater having a TDS below 3,000 mg/L is considered by the State to be a potential domestic or municipal source of water supply and the Upper Limit secondary MCL is 1,000 mg/L.¹⁷⁶

More detailed water quality data is available from wells sampled in the Fenner Valley area between 1901 and 1961.¹⁷⁷ Laboratory analytical results indicated groundwater is predominantly a sodium (37 to 96 mg/L) bicarbonate (114 to 162 mg/L) water, with occasional higher concentrations of calcium (up to 43 mg/L). Chloride concentrations ranged from 35 to 67 mg/L, below the federal secondary MCL for chloride in drinking water of 250 mg/L.¹⁷⁸

Dry Lakes

At Bristol and Cadiz Dry Lakes, the evaporation of surface water and shallow groundwater has concentrated dissolved salts, resulting in TDS concentrations as high as 298,000 mg/L.¹⁷⁹ Groundwater salts are predominantly made up of sodium chloride with lower concentrations of calcium, magnesium, and sulfate. The location of the interface between the low-TDS “fresh” groundwater and high-TDS “saline” groundwater underlying the Dry Lakes has been mapped on the basis of data from agricultural wells, observation wells, and historical data from other wells in the area using 1,000 mg/L TDS as the saline water/freshwater interface.¹⁸⁰ Figure 4.9-6 includes the current estimated saline water/freshwater interface located as a northwest to southeast contour between the playas and the agricultural operations.

¹⁷⁴ Metropolitan Water District of Southern California and Bureau of Land Management, *Cadiz Groundwater Storage and Dry-Year Supply Program Final Environmental Impact Report and Final Environmental Impact Statement, Volume 1*, September 2001, page 5-81.

¹⁷⁵ Code of Federal Regulations, *National Secondary Drinking Water Regulations*, Title 40: Protection of Environment, Chapter 1, Environmental Protection Agency: Part 143.3.

¹⁷⁶ State Water Resources Control Board, *Adoption Of Policy Entitled Sources Of Drinking Water*, Resolution No. 88-63, as Revised by Resolution No. 2006-0008, 2006, Page 2.

¹⁷⁷ Shafer, R.A., *Report on Investigations of Conditions which Determine the Potentials for Development in the Desert Valleys of Eastern San Bernardino County, CA*, Southern California Edison Company, June 1964.

¹⁷⁸ Code of Federal Regulations, *National Secondary Drinking Water Regulations*, Title 40: Protection of Environment, Chapter 1, Environmental Protection Agency: Part 143.3.

¹⁷⁹ Shafer, R.A., *Report on Investigations of Conditions which Determine the Potentials for Development in the Desert Valleys of Eastern San Bernardino County, CA*, Southern California Edison Company, June 1964, page 75.

¹⁸⁰ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Conservation and Storage Project, Phase I - Conservation Scenarios*, August 2011, page 11.

Colorado River Aqueduct

The USBR conducts water sampling at a number of locations in the Colorado River, including just below the Parker Dam that holds Lake Havasu.¹⁸¹ The water quality of these samples would be expected to closely represent the water quality of water Metropolitan pumps from Lake Havasu for distribution through the CRA. **Table 4.9-3** summarizes the range of concentrations of various water quality parameters for 12 sampling events collected in 2007.

**TABLE 4.9-3
SUMMARY OF 2007 WATER QUALITY PARAMETERS
BELOW PARKER DAM (mg/L)**

Total Dissolved Solids	647 to 673.8
Calcium	12.1 to 12.4
Magnesium	4.4 to 4.7
Chloride	14.1 to 14.3
Sulfate	40.0 to 40.7
Sodium and Potassium	15.9 to 16.1
Carbonate	12.5 to 12.9

SOURCE: Colorado River Basin Salinity Control Program, Monthly Salinity Data at 20 Key Stations in Colorado River Basin, <http://www.usbr.gov/uc/progact/salinity/pdfs/ColoradoRiverbelowParkerDam.pdf>.

Water imported via the CRA has a TDS averaging around 650 mg/l during normal water years.¹⁸² During the high water flows of 1983–1986, salinity levels in the CRA dropped to a historic low of 525 mg/l. However, during the 1987–1990 drought, higher salinity levels returned. High TDS in water supplies leads to high TDS in wastewater, which lowers the usefulness of the water and increases the cost of recycled water. In addition to the link between water supply and water quality, high levels of TDS in water supplies can damage water delivery systems and home appliances.

To reduce the effects of high TDS levels on water supply reliability, Metropolitan approved a Salinity Management Policy in April 1999. In addition to fostering interstate cooperation on this issue, the seven Colorado River basin states formed the Colorado River Basin Salinity Control Forum (Forum). To lower TDS levels in Colorado River supplies, the Forum develops programs designed to prevent a portion of the abundant salt supply from moving into the river system. The Colorado River Basin Salinity Control Program targets the interception and control of non-point sources, such as surface runoff, as well as wastewater and saline hot springs. As a result of the Salinity Management Policy, TDS levels in Colorado River water sampled just below Parker Dam have been reduced to below 600 mg/L since 1985.¹⁸³

¹⁸¹ Colorado River Basin Salinity Control Program, *Monthly Salinity Data at 20 Key Stations in Colorado River Basin*, <http://www.usbr.gov/uc/progact/salinity/pdfs/ColoradoRiverbelowParkerDam.pdf>, accessed August 2011.

¹⁸² Vallecitos Water District, *2010 Urban Water Management Plan*, http://www.vwd.org/uploads/1_Section_5_Water_Quality_Final.pdf, accessed August 2011.

¹⁸³ U.S. Bureau of Reclamation, *Quality of Water, Colorado River Basin, Progress Report No. 22*, 2005, Appendix A, page 69.

4.9.2 Regulatory Framework

The following Sections provide the federal, state, regional, and local regulatory framework for the Project.

Federal

Clean Water Act

The Clean Water Act (CWA, 33 USC 1251-1376) is the major federal legislation governing water quality. The objective of the CWA is “to restore and maintain the chemical, physical, and biological integrity of the Nation’s waters.” The CWA established the basic structure for regulating discharges of pollutants into the waters of the U.S. and gave the EPA the authority to implement pollution control programs. Sections 303 and 304 provide for water quality standards, criteria, and guidelines. The statute employs a variety of regulatory and non-regulatory tools to reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff.

Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) is the principal federal law in the United States that ensures safe drinking water for the public. Pursuant to the Act, the EPA is required to set standards for drinking water quality and oversee all states, localities, and water suppliers who implement these standards.

SDWA applies to every public water system in the United States. There are currently more than 160,000 public water systems providing water to almost all Americans at some time in their lives. The Act does not cover private wells.

The SDWA requires the EPA to establish National Primary Drinking Water Regulations (NPDWRs) for contaminants that may cause adverse public health effects. The regulations include both mandatory levels (Maximum Contaminant Levels, or MCLs) and non-enforceable health goals (Maximum Contaminant Level Goals, or MCLGs) for each included contaminant.

State and Regional

SWRCB Resolution 68-16

The SWRCB has broad authority over discharges to waters of the State. California has adopted a “non-degradation policy” (Statement of Policy with Respect to Maintaining the High Quality of Waters in California; Resolution 68-16; October 1968) for State waters, whereby actions that tend to degrade the quality of groundwater are prohibited. Oversight of this policy is done through the RWQCBs, although the RWQCB does not have permit authority over injection/extraction activities, which do not constitute a discharge to water. However, the RWQCB would review injection/extraction activities to ensure groundwater quality standards are met. The California Department of Public Health (DPH) regulates drinking water quality and may advise the individual RWQCBs on discharge requirement.

SWRCB Notice of Extraction and Diversion of Water

Division 2 of Part 5 of the California Water Code, commencing with Section 4999, requires every person who extracts groundwater within the counties of Riverside, San Bernardino, Los Angeles, and Ventura in excess of 25 AFY to file a notice with the SWRCB on forms provided by the SWRCB.

Porter-Cologne Water Quality Control Act

The Porter-Cologne Water Quality Control Act (Division 7 of the California Water Code) provides the basis for water quality regulation within California and defines water quality objectives as the limits or levels of water constituents that are established for reasonable protection of beneficial uses. The SWRCB administers water rights, water pollution control, and water quality functions throughout the State, while the Colorado River Basin RWQCB conducts planning, permitting, and enforcement activities. The Porter-Cologne Act requires the RWQCB to establish a regional Basin Plan with water quality objectives, while acknowledging that water quality may be changed to some degree without unreasonably affecting beneficial uses. Beneficial uses, together with the corresponding water quality objectives, are defined as standards, per federal regulations. Therefore, the regional basin plans form the regulatory references for meeting state and federal requirements for water quality control. Changes in water quality are allowed if the change is consistent with the maximum beneficial use of the state, does not unreasonably affect the present or anticipated beneficial uses, and does not result in water quality less than that prescribed in the water quality control plans. The basin plan for this location is discussed below.

Colorado River Basin Regional Water Quality Control Basin Plan

The preparation and adoption of water quality control plans (Basin Plans) are required by the California Water Code (Section 13240). According to Section 13050 of the California Water Code, Basin Plans consist of a designation or establishment for the waters within a specified area of beneficial uses to be protected, water quality objectives to protect those uses, and a program of implementation needed for achieving the objectives. Because beneficial uses, together with their corresponding water quality objectives, can be defined per federal regulations as water quality standards, the Basin Plans are regulatory references for meeting the state and federal requirements for water quality control. In relevant part, Article X, Section 2 of the California Constitution declares:

“[B]ecause of the conditions prevailing in this State, the general welfare requires that the water resources of the State be put to beneficial use to the fullest extent of which they are capable, and that the waste or unreasonable use or unreasonable method of use of water be prevented, and that the conservation of such waters is to be exercised with a view to the reasonable and beneficial use thereof in the interest of the people and for the public welfare...” (emphasis added)

The Colorado River Basin RWQCB is responsible for establishing the beneficial uses of surface water and groundwater within its basin. The beneficial uses listed in the Basin Plan applicable to the Project are listed below in **Table 4.9-4**.¹⁸⁴

**TABLE 4.9-4
GROUNDWATER BENEFICIAL USE DESIGNATIONS**

Water Body	MUN	AGR	IND
Groundwater (Bristol Hydrologic Unit)	X	X	X
Groundwater (Cadiz Hydrologic Unit)	X	X	
Groundwater (Fenner Hydrologic Unit)			
MUN - Municipal and Domestic Supply - Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply. AGR - Agricultural Supply - Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing. IND - Industrial Service Supply - Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, and oil well repressurization. X = existing beneficial use			
SOURCE: Regional Water Quality Control Board, <i>Water Quality Control Plan, Colorado River Basin – Region 7</i> , June 2006, Table 2-5.			

The Colorado River Basin RWQCB is responsible for issuing permits to ensure the protection of the above beneficial uses. All water placed for recharge in the spreading basins would have to comply with the water quality objectives (WQOs). The RWQCB recognizes that establishing specific numerical groundwater water quality goals involves complex considerations since the quality of groundwater varies with depth, location, and a variety of factors. For groundwater, the RWQCB's overall goal is to maintain the existing water quality of all non-degraded groundwater basins where feasible and minimize the quantities of contaminants reaching any groundwater basin. Specific relevant groundwater WQOs are as listed below.¹⁸⁵

TDS: Discharges of wastes or wastewater shall not increase the TDS content of receiving waters, unless it can be demonstrated to the satisfaction of the Regional Board that such an increase in total dissolved solids does not adversely affect beneficial uses of receiving waters.

Taste and Odors: Ground waters for use as domestic or municipal supply shall not contain taste or odor producing substances in concentrations that adversely affect beneficial uses as a result of human activity.

Bacteriological Quality: In ground waters designated for use as domestic or municipal supply (MUN), the concentration of coliform organisms shall not exceed the limits specified in California Code of Regulations, Title 22, Chapter 15, Article 3.

¹⁸⁴ Regional Water Quality Control Board, *Water Quality Control Plan, Colorado River Basin – Region 7*, June 2006, Table 2-5.

¹⁸⁵ Regional Water Quality Control Board, *Water Quality Control Plan, Colorado River Basin – Region 7*, June 2006, Page 3-8.

Chemical And Physical Quality: Waters designated for use as domestic or MUN shall not contain concentrations of chemical constituents in excess of the MCLs. Ground waters designated for use as domestic or MUN shall not contain concentrations of chemical constituents in excess of the limits specified in California Code of Regulations, Title 22, Chapter 15, which provides the primary and secondary MCLs.¹⁸⁶ The specific TDS standards are 500 mg/L as the recommended maximum, 1,000 mg/L as the upper limit, and 1,500 mg/L as the short-term maximum. As previously discussed, the Project uses 1,000 mg/L to define the brine-freshwater interface.

NPDES General Construction Storm Water Permit

The RWQCB administers the National Pollution Discharge Elimination System (NPDES) storm water permitting program in the Colorado River Basin region. Construction activities disturbing one acre or more of land are subject to the permitting requirements of the NPDES General Permit for Discharges of Storm Water Runoff Associated with Construction Activity (General Construction Permit). The Project must submit a Notice of Intent to the RWQCB to be covered by the General Construction Permit prior to the beginning of construction. The General Construction Permit requires the preparation and implementation of a Storm Water Pollution Prevention Plan (SWPPP). The SWPPP must be prepared before construction begins. The SWPPP would include specific construction-related Best Management Practices (BMPs) to prevent soil erosion and loss of topsoil. BMPs implemented could include, but would not be limited to, physical barriers to prevent erosion and sedimentation, construction of sedimentation basins, limitations on work periods during storm events, use of swales, protection of stockpiled materials, and a variety of other measures that would substantially reduce or prevent erosion from occurring during construction.

Law of the River (Colorado River Allocations)

The Colorado River is the most important waterway in the Region. The River supplies water for use within the Region and elsewhere. Apportionment of water available for diversion from the River is made in accordance with a number of documents collectively referred to as the Law of the River. These include interstate compacts, federal legislation, water delivery contracts, state legislation, a treaty with Mexico, United States Supreme Court decrees, and federal administrative actions. Presently, California is receiving waters unused by other states. The 2003 Quantification Settlement Agreements created California's "soft landing" by reducing California's Colorado River water usage from 5.2 million AFY to 4.4 million AFY in a normal year over 15 years through the conservation and transfer of water from agricultural to urban uses in San Diego County Water Authority's, Metropolitan's, and Coachella Valley Water District's jurisdictions, through quantifying the agencies' priority water rights to the River and allocating water in times of shortage. This effort was called the "Interim Surplus Guidelines." The Interim Surplus Guidelines adopted rules for deciding when there was surplus water in the Colorado River, and how such a surplus could be used, as California wound down its excess use.

¹⁸⁶ California Code of Regulations, Title 22, Chapter 15.

County and Local

San Bernardino County Groundwater Management Ordinance

The Desert Groundwater Management Ordinance (Title 3, Division 3, Chapter 6, Article 5, Section 33.06551 of the San Bernardino County Code of Ordinances) imposes permitting requirements and procedures for certain new groundwater extraction wells in the Desert Region of the County. The ordinance requires new wells to obtain a permit, which is a discretionary action subject to CEQA. The stated purpose of the ordinance is to ensure safe yield and health of aquifers in the Desert Region of the County. The ordinance does not apply to entities that are exempt, or have prepared a Groundwater Management Plan and that have entered into a MOU with the County governing operation, monitoring, and reporting procedures of the proposed new well(s).

4.9.3 Impact and Mitigation Analysis

Significance Criteria

Based on the *CEQA Guidelines, Appendix G*, a project may be deemed to have a significant effect on the environment with respect to hydrology and water quality if it would:

- Violate any water quality standards or waste discharge requirements;
- Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted);
- Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner, which would result in substantial erosion or siltation on- or off-site;
- Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner, which would result in flooding on- or off-site;
- Create or contribute runoff water, which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff;
- Otherwise substantially degrade water quality;
- Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map;
- Place within a 100-year flood hazard area structures, which would impede or redirect flood flows;
- Expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam; or
- Result in inundation by seiche, tsunami, or mudflow.

Methodology

Various site-specific and regional reports and maps were reviewed to evaluate the potential impacts of the Project to hydrology and water quality. Hydrologic data was evaluated from regional investigations, as well as site-specific hydrologic data collected from wells on the Project site and generated from models of the aquifer behavior. The Conservation and Recovery and Imported Water Storage Components are evaluated separately below.

Using the available geologic and hydrologic data collected to date, Geoscience prepared a three-dimensional, density-dependant groundwater flow and transport model to simulate the aquifer system in the Project area, including the Fenner Valley, the Fenner Gap, and the Cadiz Valley area that includes most of the Bristol Playa and the northern portion of the Cadiz Playa (Appendices I1 and I2).^{187, 188} The groundwater model was used to simulate the potential response of the aquifer system to Project operations using two variations of the wellfield configuration and three variations of potential annual recharge volumes over a period of 50 years of groundwater production at 50,000 AFY, followed by 50 years of recovery (no groundwater production). The output of the simulations are the modeled drawdown of groundwater levels, the potential movement of the freshwater-saline water interface, and the amount of potential subsidence (subsidence is addressed in Section 4.6, Geology).

The modeled scenarios vary by recharge amounts. The Project scenario assumes an annual recharge of approximately 32,000 AFY in the Fenner Watershed and Orange Blossom Wash based on CH2M Hill's updated evaluation of recharge.¹⁸⁹ This recharge volume estimate is derived from the USGS INFIL3.0 Model, is based on long-term precipitation records, and represents the long-term average annual recharge within the Fenner Watershed that ultimately migrates to the Bristol and Cadiz Dry Lakes, becomes saline, and evaporates. However, because a few earlier evaluations of available recharge predicted a lower potential range for recharge, two sensitivity scenarios were applied to model conservative, worst-case aquifer responses where the average annual recharge over a 100-year time period is reduced to 16,000 and 5,000 AFY respectively.¹⁹⁰ As previously noted, the modeling did not include recharge that occurs west, south, and east of the Bristol and Cadiz Dry Lakes. Consequently, the groundwater model provides the most conservative aquifer responses as the inclusion of recharge from other watersheds would reduce the predicted groundwater level drawdown and migration of the freshwater - saline water interface. The modeling also considered two different production well configurations: Well Configuration A would use five existing Cadiz agricultural wells, two new high capacity wells, and 15 new lower-capacity wells; Configuration B would use five existing

¹⁸⁷ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume I*, September 2011.

¹⁸⁸ GEOSCIENCE Support Services, Inc., *Supplemental Assessment of Pumping Required for the Cadiz Conservation, Storage, and Recovery Project*, September 20, 2011.

¹⁸⁹ CH2M Hill, *Cadiz Groundwater Conservation and Storage Project*, July 2010, page 4-8.

¹⁹⁰ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume I*, September 2011, page 35.

Cadiz agricultural wells and 29 new lower-capacity wells.¹⁹¹ (See Section 3.6.1 for further discussion of the proposed wellfield configuration options.)

The two wellfield configurations were used to address the potential range in recharge rates and thus transmissivity variations of the aquifer. Because the wellfield placement will be sited after initial modeling runs on an initial group of wells, the wellfield construction will be “phased.” That is, a group of wells will be constructed initially in the Fenner Gap area. Initial pumping tests on these wells will be used to validate regional aquifer characteristics. Based on the findings from the field data, the model will be recalibrated and subsequent well locations will be placed in the optimum locations from the regional aquifer tests.¹⁹²

Groundwater Management, Monitoring, and Mitigation Plan

The GMMMP prepared for the Project to provide for the adaptive management of the basin includes seven measures to monitor Project operations and potential effects on critical resources. Four of the seven measures include, as necessary, corrective actions to be implemented to insure protection of these identified critical resources (Appendix B1).¹⁹³ Three of the seven measures only include verification measures to confirm previous technical conclusions of no possible impacts. These monitoring and response measures are presented in Chapter 6 of the GMMMP. These measures are referred to as Project Design Features in this EIR and they are numbered according to the GMMMP section in which they are described (e.g., Project Design Feature 6.2 – Third Party Wells is Section 6.2 of the GMMMP). These Project Design Features from the GMMMP include a monitoring element, action criteria, and corrective measures to address a potential issue if the action criteria are triggered. The action criteria are set below the threshold for impact significance as established in accordance with CEQA for each impact area, thus insuring adequate time to implement the corrective actions and avoid significant impact. As described in the following impact analysis, where appropriate these GMMMP measures are incorporated into the EIR as mitigation measures to address issue areas where potentially significant impacts could occur and mitigation is required under CEQA. In these cases, implementation of these GMMMP measures would be required as part of the CEQA mitigation compliance process. In other cases, the GMMMP measures are not required as mitigation measures for CEQA purposes but they are summarized here where applicable so that the reader understands that, in accordance with the GMMMP, such measures would be implemented as part of the Project even though the impact for those resource issues is found to have no impact or to be less than significant and no mitigation is required. The Project Design Features from the GMMMP that are required to ensure less than significant impacts to hydrologic resources are listed below.

- GMMMP Project Design Feature 6.2 – Third Party Wells
- GMMMP Project Design Feature 6.4 – Induced Flow of Lower Quality Water From Bristol and Cadiz Dry Lakes

¹⁹¹ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, page 47.

¹⁹² GEOSCIENCE Support Services, Inc., *Addendum to September 1, 2011 Cadiz Groundwater Modeling and Impact Analysis*, November 2011.

¹⁹³ CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011.

Groundwater Conservation and Recovery Component

Impacts to Water Quality Standards or Waste Discharge Requirements

Significance Threshold

Would the proposed Project result in a significant impact by degrading water quality or violating waste discharge requirements?

Impact Analysis

Surface Water Quality

The Groundwater Conservation and Recovery Component of the Project would include the construction of production wells, piping, and associated pumps, controls, and power appurtenances to extract groundwater and transport the water southeast to the CRA. Construction of these facilities would disturb soils that could result in substantial erosion and/or siltation. In addition, construction equipment and the associated chemical usage could result in spills that could impact surface water quality. Construction of the Project wells and pipeline would not be subject to the NPDES Construction General Permit for Discharges of Stormwater since there are no Waters of the U.S. affected by the production the wells or pipeline. FVMWC would be required to obtain WDRs from the RWQCB for discharging well completion water to detention basins. This production water discharge is a routine action in developing potable wells resulting in de minimis impacts to water quality. The WDRs would establish conditions for ensuring that production water percolates into the ground and does not runoff into the neighboring washes.

In addition to the majority of the project facilities that would be constructed within the Watersheds, two observation wells would be installed as a part of Monitoring Feature 2 east and outside of the Watersheds to monitor groundwater levels in adjacent basins and verify that the Project would have no impacts on groundwater levels outside of the Watersheds. The Piute-1 observation well would be installed outside and east of the Watersheds in the Piute Wash Watershed north of the intersection of Interstate 40 and Highway 95, and the Danby-1 observation well would be installed in the Danby Basin along the ARZC rail line northeast of Danby Lake (Figure 3-4). Construction of these two wells and access to the wells would also disturb soils and could result in erosion and siltation.

Construction of Project facilities may not require coverage under the Construction General NPDES Permit for Discharges of Stormwater since the pipeline alignment and wellfield may not affect waters of the U.S. and since the Piute Wash observation well would affect less than one acre. As a result, preparation of a Stormwater Pollution Prevention Plan (SWPPP) may not be required. However, since construction activities may result in surface runoff quality impacts, Mitigation Measure **HYDRO-1** has been developed to ensure that construction-related Best Management Practices (BMPs) are implemented to prevent soil erosion and to control hazardous materials used during construction from adversely affecting surface water runoff. With implementation of Mitigation Measure **HYDRO-1**, impacts to surface water quality from construction activities would be less than significant.

Groundwater Quality

Figures 4.9-7, 4.9-8, and 4.9-9 present the model-predicted locations of the saline water/freshwater interface for the 32,000, 16,000, and 5,000 AFY recharge scenarios.¹⁹⁴ Each figure includes the model-predicted movement after 50 years of groundwater production at 50,000 AFY, followed by the recovery of groundwater levels after 50 years of no groundwater production.

The interface is predicted to migrate within the shallower alluvium layers but not the deeper rocks of the alluvial, carbonate, and granitic units because the alluvium is more transmissive. The interface migration is eastward and northward from the Dry Lakes toward the wellfield. **Table 4.9-5** summarizes the model-predicted migration distances.¹⁹⁵

**TABLE 4.9-5
SUMMARY OF MODEL-PREDICTED SALINE WATER-FRESHWATER
INTERFACE MIGRATION DISTANCES**

Scenarios	Maximum Migration of Saline Water/Freshwater Interface	
	End of 50 Years (Project Operation Period)	End of 100 Years (Recovery Period)
Model Scenario		
Project Scenario (32,000 AFY recharge)	10,400 feet northeast	11,500 feet northeast
Sensitivity Scenario 1 (16,000 AFY recharge)	9,700 feet northeast	11,100 feet northeast
Sensitivity Scenario 2 (5,000 AFY recharge)	6,300 feet northeast	9,200 feet northeast

SOURCE: GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, page 53.

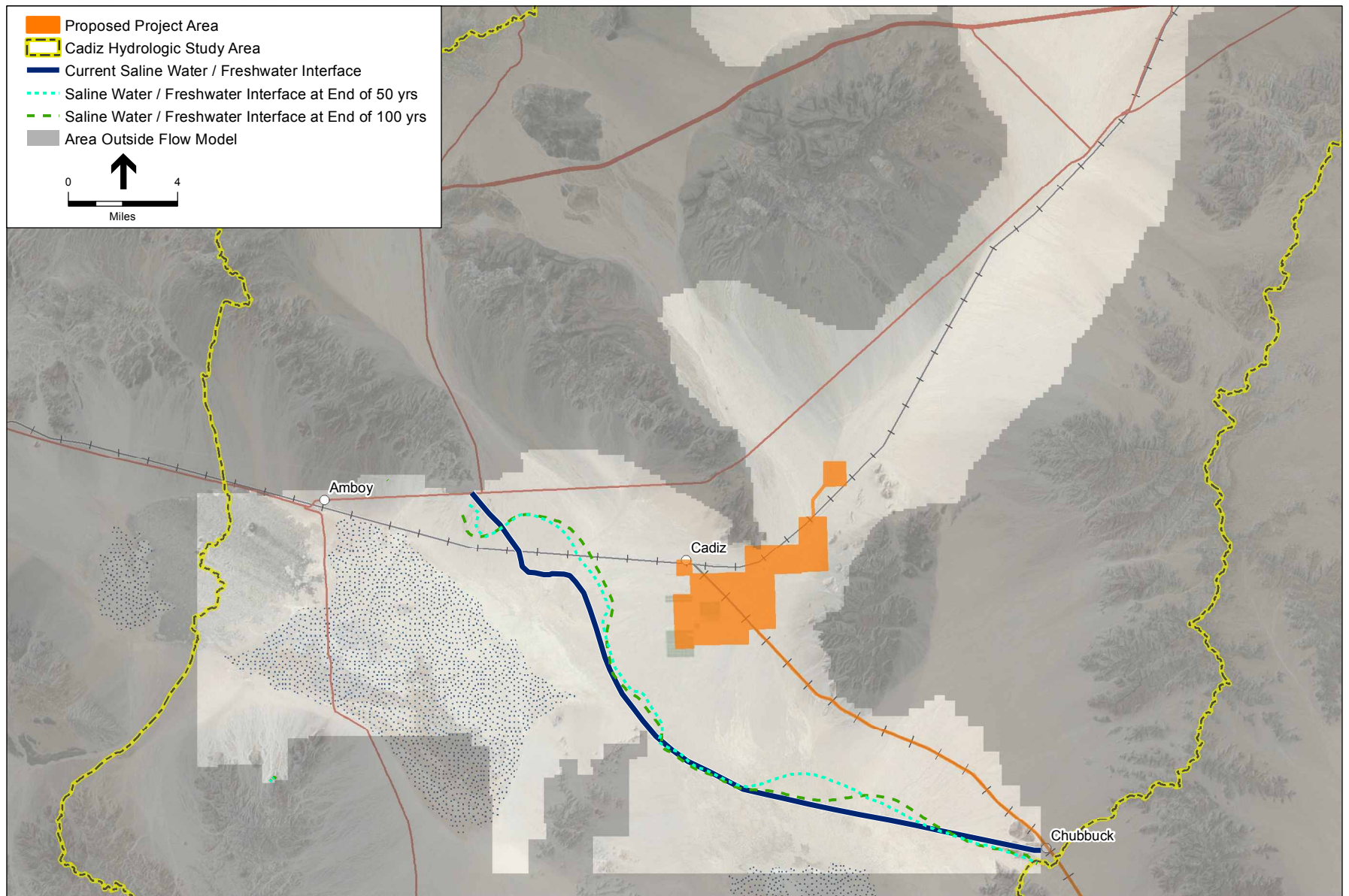
An average of 50,000 AFY of groundwater would be extracted from the aquifers in the Fenner Gap area for the 50-year life of the Project. The extraction of the groundwater would change groundwater flow patterns such that the freshwater/saline water interface currently located between the Bristol and Cadiz Playas and the proposed wellfield would migrate toward the production wells in the Fenner Gap.

As discussed in the Methodology section above, the potential response of the aquifer system to the extraction of an average of 50,000 AFY of groundwater for 50 years was simulated in a groundwater model based on site conditions and the anticipated long-term average recharge from precipitation to the Fenner Watershed and Orange Blossom Wash of approximately 32,000 AFY. In addition, to account for potential worst-case conditions, two additional scenarios were simulated assuming an average annual recharge of 16,000 and 5,000 AFY. In all cases, the saline water/freshwater interface down to about 1,200 feet bgs was predicted to migrate east and north toward the production wells. The maximum predicted migration distance was approximately 11,500 feet and occurs under the 32,000 AFY annual recharge scenario.¹⁹⁶

¹⁹⁴ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, pages 52-53.

¹⁹⁵ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, pages 52-53.

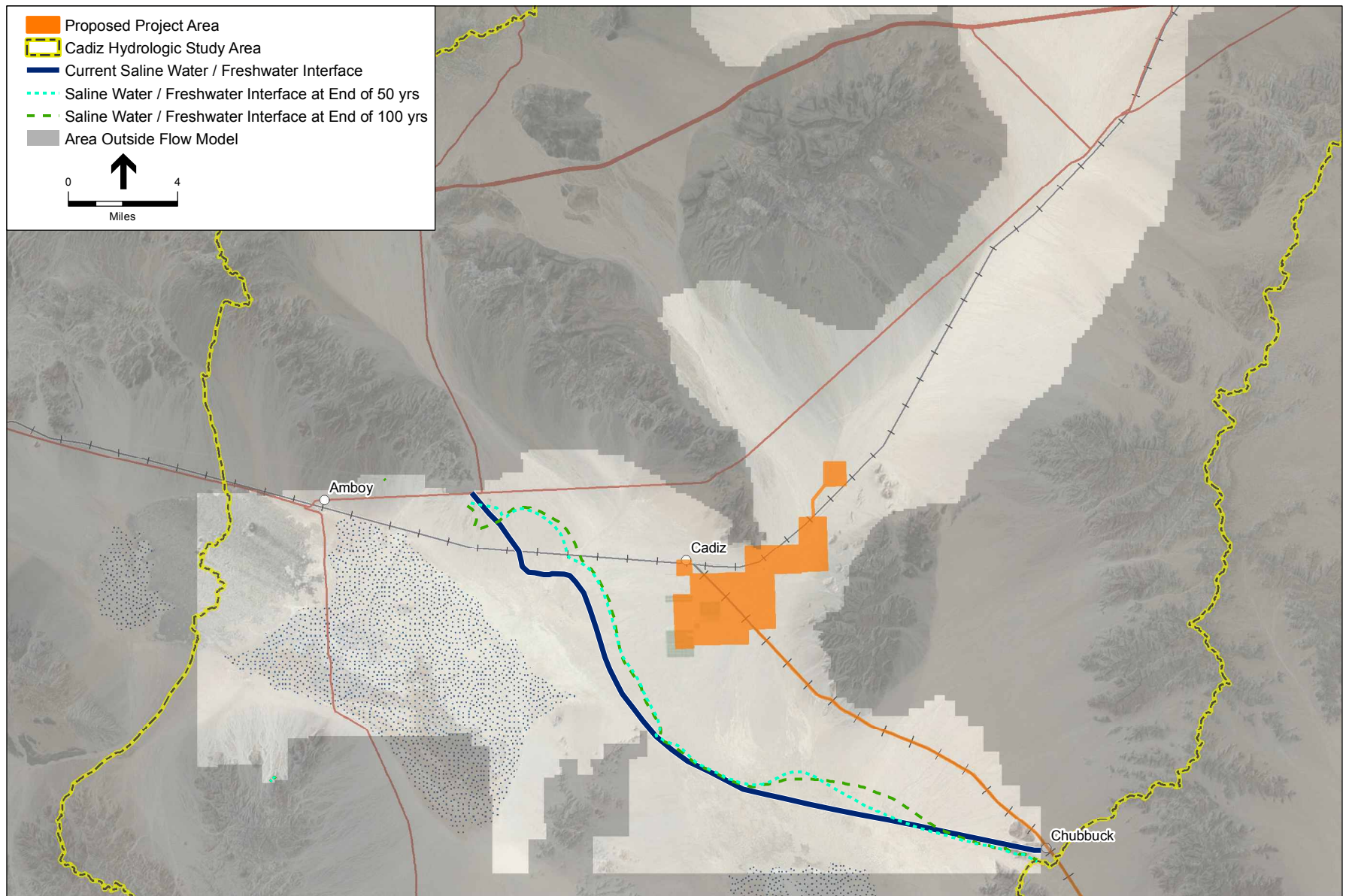
¹⁹⁶ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, pages 52-53, Figures 72-75.



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; GSSI, 2011; Tetra Tech, 1999; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-7
Model-Predicted Saline Water and Freshwater Interface Migration - Project Scenario
(Assumes 32,000 AFY Recharge)

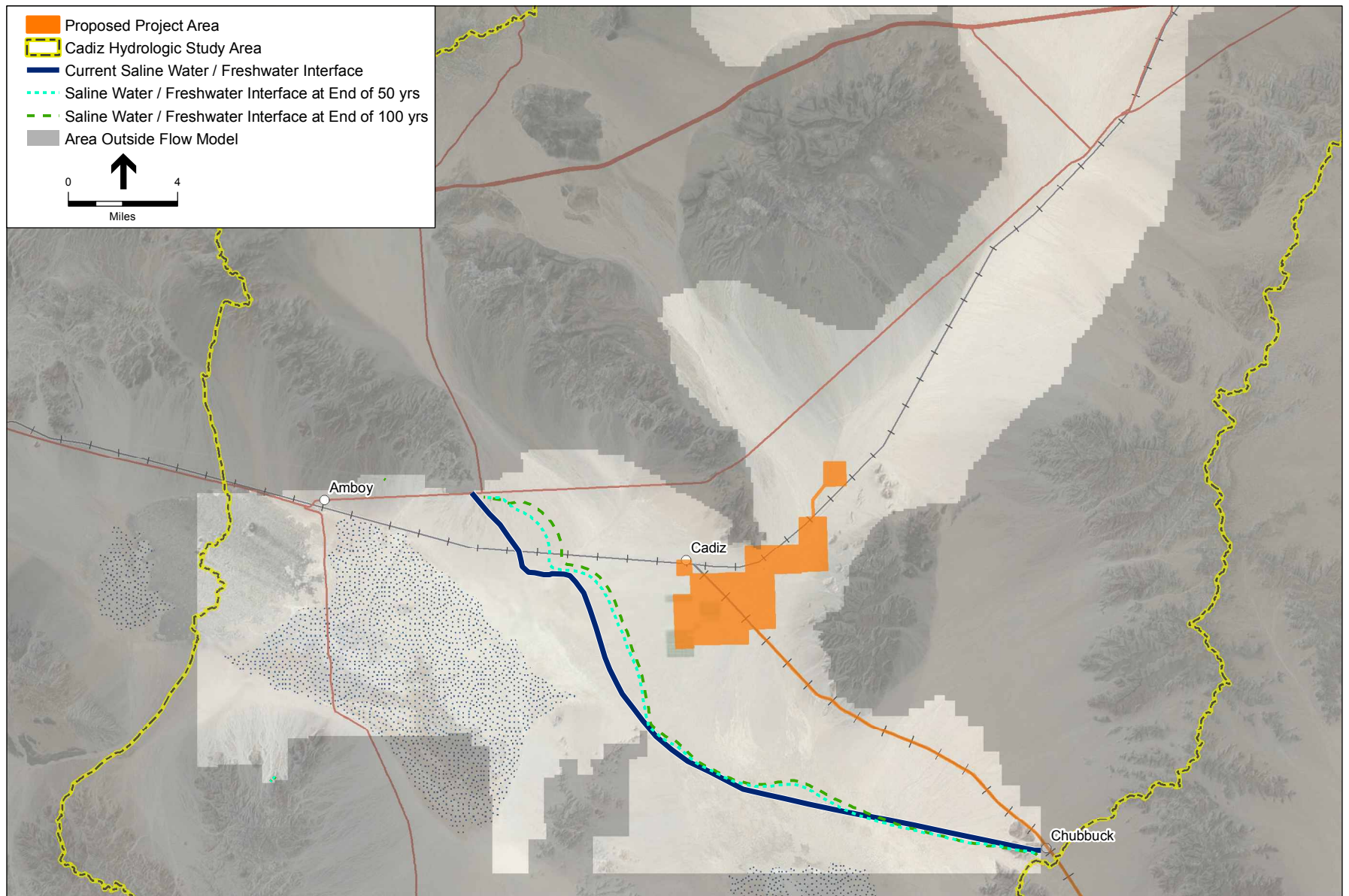


SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; GSSI, 2011; Tetra Tech, 1999; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-8

Model-Predicted Saline Water and Freshwater Interface Migration - Sensitivity Scenario No. 1
(Assumes 16,000 AFY Recharge)



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; GSSI, 2011; Tetra Tech, 1999; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-9

Model-Predicted Saline Water and Freshwater Interface Migration - Sensitivity Scenario No. 2
(Assumes 5,000 AFY Recharge)

As a result, water quality in wells located within the area between the playas and the Project wellfield could be degraded. However, much of this area including the community of Amboy¹⁹⁷ already overlies saline groundwater associated with Bristol Dry Lake. No active production wells are known to exist in the area where groundwater salinity would increase as a result of the saline interface migration. The only active wells in the playa areas are the wells already purposely located in saline water used by the salt production companies for the production of salt minerals. There are currently no active or known planned uses of groundwater in the potentially affected area.

The remaining overlying area affected by potential increased salinity is currently open space. Approximately ½-square mile of the area is currently zoned for agriculture. **Figure 4.9-10** identifies land ownership within the areas that could be affected by saline intrusion. In the future, those property owners within the area affected by the migration of the saline water/freshwater interface due to Project operations would not be able to install a well to pump freshwater from directly below their property. The GMMMP includes project design features to verify model-predicted effects and confirm protection of critical resources. Two project design features address the saline water/freshwater interface: 6.2 - Third Party Wells and 6.4 - Induced Flow of Lower-Quality Water from Bristol and Cadiz Dry Lakes.¹⁹⁸ These project design features provide for either provision of an alternate supply of freshwater to affected property owners or revised operation of the project to remedy the saline interface migration. The Action Criteria and Corrective Measures for these two project design features are summarized in **Tables 4.9-6** and **4.9-7**.

Implementation of the project design features in Chapters 6.2 and 6.4 of the GMMMP would reduce potential water quality impacts to the third-party well owners from the potential saline/freshwater migration to less than significant. Therefore, for purposes of this CEQA analysis of the Project, the project design features presented in Chapters 6.2 and 6.4 of the

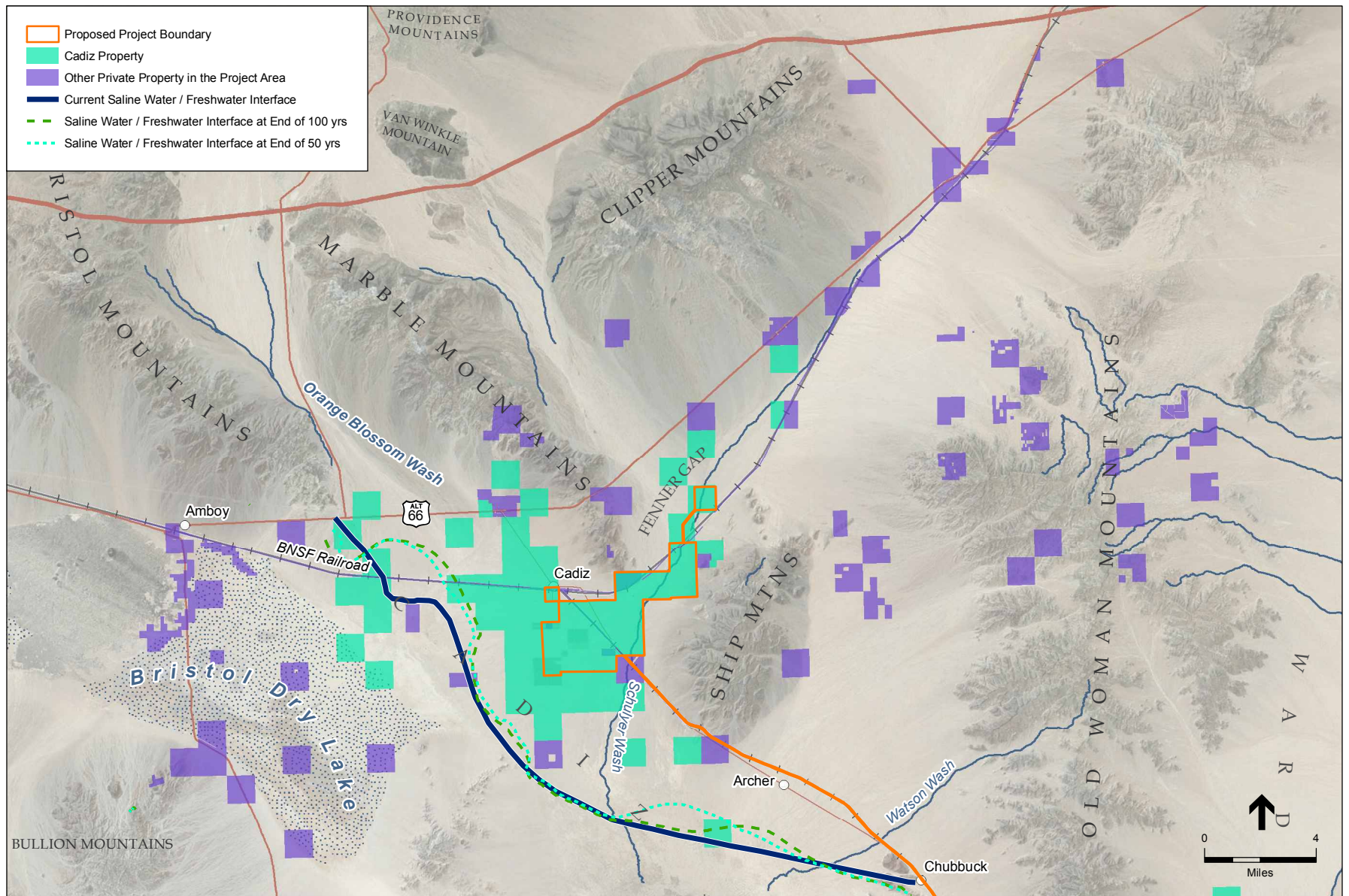
GMMMP are incorporated into this EIR as Mitigation Measures **HYDRO-2** and **HYDRO-3**. Implementation of Mitigation Measure **HYDRO-2** and **HYDRO-3** would ensure that the potential impacts from the water quality degradation and/or migration of the saline/freshwater interface are mitigated to less than significant for third-party wells.

Quality of Groundwater Pumped to the CRA

The following **Table 4.9-8** summarizes water quality parameters for water sampled from the alluvium, carbonate, and bedrock units in Fenner Gap and from the Colorado River just below Parker Dam. Parker Dam holds Lake Havasu on the Colorado River from which Metropolitan pumps water into the CRA. Thus, the Parker Dam water sample results are considered to represent CRA water quality.

¹⁹⁷ Amboy had about ten buildings and a population of 4 as of January 17, 2007. Mike Anton, "Destiny in the Desert", Los Angeles Times, January 2007.

¹⁹⁸ CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011, Sections 6.2 and 6.4.



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-10

Proximity of Private Property to Saline Groundwater Interface

**TABLE 4.9-6
GMMMP PROJECT DESIGN FEATURE 6.2 – THIRD PARTY WELLS**

Action Criteria	Corrective Measures
<p>Drawdown at the Danby observation well (adjacent to Clipper Mountains) greater than projected by the pre-operational groundwater flow simulation models or the receipt of written complaints by well owners regarding decreased groundwater production yield, degraded water quality, or increased pumping costs submitted by neighboring landowners or the salt mining operators on the Bristol and Cadiz Dry Lakes</p>	<p>Upon receipt of the written complaint and during the decision-making process to determine if corrective measures are to be implemented, the FVMWC (or other Project management entity) would arrange for an interim water supply to the affected part as necessary.</p> <p>Additional corrective measures that would be implemented include one or more of the following actions:</p> <ul style="list-style-type: none"> • Deepen or otherwise improve the efficiency of the impacted well(s); • Blend impacted well water with another local source; • Construct replacement well(s); • Pay the impacted well owner for any increased material pumping costs incurred by the well owner; or • Modify Project operations until adverse effects are no longer present at the affected well(s). Modification to Project operations would include one or more of the following: <ul style="list-style-type: none"> – Reduction in pumping from Project wells; or – Revision of pumping locations within the Project wellfield; or – Stoppage of groundwater extraction for a duration necessary to correct the predicted adverse effect on existing wells.

SOURCE: CH2M Hill, Groundwater Management, Monitoring, and Mitigation Plan, November 2011.

The secondary MCLs cited above list the water quality parameters that water purveyors are required to achieve at the point of distribution. In other words, this is the required level of quality at the tap after treatment by the water purveyor. All water that would be pumped from the Project production wells and the water currently in the CRA would be treated by the water purveyors before distribution to the public. As shown in the table above, both the CRA water and the Fenner Gap water currently meet the drinking water standards before treatment. After treatment by the water purveyors, the concentrations would be expected to be even lower.

For the Groundwater Conservation and Recovery Component of the Project, groundwater would be pumped from the alluvial and carbonate units in the Fenner Gap area (Project water) into the water conveyance pipeline from the wellfield to the CRA, where the water would be added to the CRA water and then sent on to the water purveyors. The Project water would have TDS concentrations less than the CRA water, while the sodium and chloride (salt) concentrations of the Project water may be slightly higher than the CRA water. However, as listed in Table 4.9-8 above, all of the parameter concentrations for both waters are currently below MCLs meaning that the water is acceptable for use as drinking water as is. Furthermore, all of the water would be further treated at the water purveyor's treatment facilities. In addition, the maximum volume of Project water that could be added into the CRA in any given year would be 75,000 AF. The maximum carrying volume of the CRA is 1,250,000 AFY. Consequently, the maximum percentage of Project water relative to CRA water would be 6 percent. Based on this overall evaluation, the potential impact would be considered less than significant.

TABLE 4.9-7
GMMMP PROJECT DESIGN FEATURE 6.4 –
INDUCED FLOW OF LOWER LOWER-QUALITY WATER FROM BRISTOL AND CADIZ DRY LAKES

Action Criteria	Corrective Measures
1. Monitored increases in TDS that are higher than projected by the groundwater flow simulation models or, 2. A change in TDS concentration in excess of 1,000 mg/l in the observation well clusters sited along the saline/freshwater interface line.	<ul style="list-style-type: none"> • Deepen or otherwise improve the efficiency of the impacted well(s); or • Blend impacted well water with another local source; or • Construct replacement well(s); or • Pay the impacted well owner for any increased material pumping costs incurred by the well owner; • Modify Project operations until adverse effects are no longer present at the affected well(s). Modification to Project operations would include one or more of the following: <ul style="list-style-type: none"> – Reduction in pumping from Project wells; or – Revision of pumping locations within the Project wellfield; or – Stoppage of groundwater extraction for a duration necessary to correct the predicted adverse effect on existing wells; or • Modification of Project operations to reestablish the natural hydraulic gradient and background concentrations at the margins of Bristol and Cadiz Dry Lakes through one or more of the following: <ul style="list-style-type: none"> – Reduction in pumping from Project wells – Revision of pumping locations within the Project wellfield – Stoppage of groundwater extraction for a duration necessary to correct the predicted impact <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • Installation of an injection or extraction well(s) in conjunction with appropriate injection of lower-TDS water or extraction of higher-TDS water to manage the migration of high-TDS water from the Dry Lakes.

SOURCE: CH2M Hill, Groundwater Management, Monitoring, and Mitigation Plan, November 2011.

To monitor the water quality of water pumped into the CRA, the GMMMP would collect samples, analyze water quality and report results on a set schedule.¹⁹⁹ The results of the analyses would be evaluated to verify that the water quality of water pumped into the CRA is acceptable and that the impact would be less than significant.

¹⁹⁹ CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011, Appendices C and D.

**TABLE 4.9-8
SUMMARY OF GENERAL WATER QUALITY RESULTS**

Parameter	CA Primary MCL	CA Secondary MCL	Alluvium (Well TW-1) (4-Dec-2009)	Carbonate (Well TW-1) (10-Nov-2009)	Colorado River Below Parker Dam (Jan to Dec 2007)
Total Dissolved Solids (TDS)	n/e	500–1,000	260	220	647 to 673.8
Calcium	n/e	n/e	26	24	12.1 to 12.4
Magnesium	n/e	n/e	5.2	5.7	4.4 to 4.7
Chloride	n/e	250–500	34	38	14.1 to 14.3
Sulfate	n/e	250–500	11	32	40.0 to 40.7
Sodium and Potassium	n/e	n/e	52.9	656	15.9 to 16.1
Carbonate	n/e	n/e	100	130	12.5 to 12.9

California Secondary MCLs are Recommended and Upper Limit are from 17 CCR 64449

All concentrations in milligrams per liter (mg/L)

n/e = not established

SOURCES: CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011, page 27; Colorado River Basin Salinity Control Program, *Monthly Salinity Data at 20 Key Stations in Colorado River Basin*, <http://www.usbr.gov/uc/progact/salinity/pdfs/ColoradoRiverbelowParkerDam.pdf>, accessed October 2011.

Mitigation Measures

HYDRO-1: A construction Storm Water Pollution Prevention Plan shall be prepared and included in construction specifications for the Project. At a minimum, the plan shall include the following required Best Management Practices or equivalent measures:

- Install temporary sediment fences or straw wattles at stream crossings or washes to prevent erosion and sedimentation during construction, including at each ARZC railroad trestle along the pipeline alignment.
- Establish designated fueling areas equipped with secondary containment,
- Require drip-pans under all idle equipment on the construction sites,
- Ensure that spill prevention kits are present at all construction sites.

HYDRO-2: Project Design Feature 6.4 found in Chapter 6.4 of the GMMMP shall be implemented to address the potential impacts for the migration of the saline/freshwater water interface to adversely affect groundwater quality. If monitored increases in TDS result in impairment to beneficial uses of groundwater by overlying land owners, one or more of the following corrective measures shall be implemented:

- Deepen or otherwise improve the efficiency of the impacted well(s); or
- Blend impacted well water with another local source; or
- Construct replacement well(s); or
- Pay the impacted well owner for any increased material pumping costs incurred by the well owner; or

- Modify Project operations until adverse effects are no longer present at the affected well(s). Modification to Project operations would include one or more of the following:
 - Reduction in pumping from Project wells; or
 - Revision of pumping locations within the Project wellfield; or
 - Stoppage of groundwater extraction for a duration necessary to correct the predicted adverse effect on existing wells; or
- Installation of an injection or extraction well(s) in conjunction with appropriate injection of lower-TDS water or extraction of higher-TDS water to manage the migration of high-TDS water from the Dry Lakes.

HYDRO-3: Project design features in Chapter 6.2 of the GMMMP shall be implemented to address potential impacts to Third Party wells. If a written complaint by a well owner is received regarding decreased groundwater production yield, degraded water quality, or increased pumping costs submitted by neighboring landowners or the salt mining operators on the Bristol and Cadiz Dry Lakes, the following corrective measures shall be implemented:

- 1) Arrange for an interim water supply to the affected party as necessary.
- 2) Implement additional corrective measures that include one or more of the following actions:
 - Deepen or otherwise improve the efficiency of the impacted well(s); or
 - Blend impacted well water with another local source; or
 - Construct replacement well(s); or
 - Pay the impacted well owner for any increased material pumping costs incurred by the well owner; or
 - Modify Project operations until adverse effects are no longer present at the affected well(s). Modification to Project operations would include one or more of the following:
 - Reduction in pumping from Project wells; or
 - Revision of pumping locations within the Project wellfield; or
 - Stoppage of groundwater extraction for a duration necessary to correct the predicted adverse affect on existing wells.

Significance Conclusion

Less than significant with mitigation.

Impacts to Groundwater Supplies or Groundwater Recharge

Significance Threshold

Would the proposed Project result in a significant impact by substantially depleting groundwater supplies or interfering substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a significant lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?

Impact Analysis

Springs

Figure 4.9-3 identifies recorded springs that occur in the Watersheds. Other man-made watering hole features (guzzlers) exist in the high elevations of the surrounding mountains including the Clipper Mountains, Marble Mountains, and Old Woman Mountains. The natural springs are located in the higher elevations of the mountains and occur from rock fractures on the higher slopes of the mountain ranges. There are no natural springs identified within 11 miles of the wellfield. All of the known springs in the Watershed are located in the higher elevations of the mountain ranges at elevations well above the aquifer system, which is located in the valleys at much lower elevations (see Figure 4.9-3). The springs are fed by recharge to the bedrock aquifer systems within the mountains. As shown on Figure 4.9-2, the proportion of precipitation recharging the mountainous bedrock system is relatively small in comparison to the volume of precipitation that migrates vertically downward through the rock formations eventually reaching the aquifer in the alluvial valleys below. Changes to the water table elevation in the alluvial aquifer do not have any effect on the volume of flow in springs because the springs derive their water from precipitation in the higher elevation mountains, not groundwater from the alluvial aquifer. Therefore, there is no known hydraulic connection between these higher elevation springs and the groundwater in the valley floors. As such, the springs in the mountains are well outside the influence of the proposed production wells that derive water only from the alluvial aquifer.

The lack of physical connection between the springs and groundwater in the aquifers in the Project area is discussed further in CH2M Hill's technical memorandum on springs, as well as earlier in this Section.²⁰⁰ CH2M Hill evaluated two conceptual models of the Bonanza Spring, which are expected to apply to all the springs in the Fenner Watershed. Bonanza Spring is the closest known spring to the Project wellfield at 11 miles to the north. For both conceptual models, the source of water to the springs is precipitation in the mountains that infiltrates into the ground and travels to the springs. There is no information that suggests that these springs are a result of any other source of water, such as deeply circulating groundwater, confined groundwater, or other similar mechanisms attributable to spring formation.

The first concept is based on the observations that there is no information demonstrating a hydraulic connection of those identified springs in the local mountains to groundwater in the alluvial aquifer where the Project pumping would take place. In addition, the alluvium on the

²⁰⁰ CH2M Hill, *Assessment of Effects of the Cadiz Groundwater Conservation Recovery and Storage Project Operations on Springs*, August 2011, page 1.

slopes of the mountains is likely to be unsaturated as it thins over bedrock highs, which further inhibits hydraulic continuity between the alluvial aquifer and springs located in the mountains. There is no observed hydraulic continuity between groundwater in fractured granitic bedrock where the springs exist and the regional groundwater table of the alluvial aquifer. Consequently, because there is little or no hydraulic connection, the Project would have no impact on springs.

In order to thoroughly address concerns about potential impacts on springs, and for the avoidance of doubt, CH2M Hill also considered a hypothetical second concept by assuming the existence of hydraulic continuity between groundwater feeding springs and groundwater in the alluvial aquifer just to see what impact the Project might have under this theoretical condition. The results of this hypothetical assessment demonstrated that, for many reasons, including distance between drawdown in the alluvial aquifer and springs, difference in elevation, the required low transmissivity of fractured bedrock, and hydraulic connectivity, any impact to spring flows would be very minor and likely within the natural climatic variability. Even under this hypothetical and worse case scenario, implementation of the Project would have a less than significant effect on the springs.

Although the physical evidence indicates that the groundwater aquifer is not connected to the springs within the Watersheds and thus that pumping of groundwater under the proposed Project would not affect these springs, to comport with the recommendations of the Groundwater Stewardship Committee (see Appendix B2), the GMMMP includes project design features to verify model-predicted effects and confirm protection of critical resources. The project design features relative to springs is GMMMP Project Design Feature 6.7 – Springs.²⁰¹ Chapter 5 of the GMMMP describes Monitoring Feature 1 to be used to monitor springs within the Watersheds.²⁰²

The monitoring protocol would consist of periodic visual, non-invasive monitoring of spring flows from Bonanza Spring, Whiskey Spring, and Vontrigger Spring shown on Figure 3-4 to confirm the modeling results. The GMMMP provides for quarterly monitoring of the Bonanza Spring as an “indicator spring” because it is the spring that is in closest proximity to the Project wellfield (approximately 11 miles from the center of Fenner Gap), and of all springs within the Fenner Watershed, Bonanza Spring would be the first one that would be affected by the Project operations, if any springs were affected, which is not expected. The Whiskey and Vontrigger Springs, located beyond the Project’s projected effects on groundwater levels in the alluvial aquifers of the Fenner Watershed, would also be monitored to compare variations in spring flow from those springs to variations in spring flow from the Bonanza Spring. This comparison would assist in determining whether any material reduction of flow at the Bonanza Spring is attributable to the Project operation, or instead, is attributable to regional climate conditions.

The springs would be monitored by visual observations and flow measurements. Visual observations would include starting and ending points of observed ponded or flowing water, estimated depth of ponded water and flow rate of flowing water, conductivity, pH and temperature of water, any colorations of water, and general type and extent of vegetation.

²⁰¹ CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011, Section 6.7.

²⁰² CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011, Section 5.2.

As discussed above, the physical evidence indicates that the groundwater aquifer is not connected to the springs within the Watersheds and therefore, pumping of groundwater under the proposed Project would have no impact on these springs and no mitigation is required.

Groundwater Management

As described above, the Project proposes to capture groundwater that is comprised of natural recharge and groundwater already held in storage that would be retrieved before it flows to the Dry Lakes where a portion is lost to evaporation. To capture the water, groundwater would be extracted from the wellfield to intentionally lower the water table. The water table would be lowered to a level at or below the water levels at the Dry Lakes to gain control of the flow and to prevent the water from flowing to the Dry Lakes. This Section explains that the Project would not substantially deplete groundwater supplies in the Project area because the intentional lowering of groundwater levels (1) is necessary to conserve water that would otherwise be lost to evaporation, (2) is part of a comprehensive groundwater management program that is subject to continuous monitoring and adaptive management, if necessary, and (3) would not cause any long-term material impacts to the aquifer system or surface uses within the Project area. Further, the Project is consistent with legal principles applicable to groundwater management in California as discussed below.

Legal Framework

As discussed in the Regulatory Framework Section above, the State Constitution states that water resources should be put to beneficial use to the fullest extent of which they are capable. The Project achieves this goal by maximizing the beneficial use of water in the Fenner and Orange Blossom Watersheds by preventing its loss to salinity and evaporation at the Dry Lakes.

Article X, Section 2 of the California Constitution requires that:

[T]he water resources of the State be put to beneficial use to the fullest extent of which they are capable, and that the waste or unreasonable use or unreasonable method of use of water be prevented, and that the conservation of such waters is to be exercised with a view to the reasonable and beneficial use thereof in the interest of the people and for the public welfare.

All the waters of the State are subject to the mandate that water may only be used for beneficial purposes by reasonable means.²⁰³ The mandate has been construed as applicable to groundwater by the California Supreme Court since 1934²⁰⁴ and since then the California Supreme Court has approved several efforts to ensure that groundwater is put to maximum beneficial use. Beneficial uses include domestic, irrigation, industrial, municipal, recreational and environmental uses.²⁰⁵ Water Code Section 106 provides a legislative declaration that domestic use is the highest use of water in the State.

²⁰³ *City of Barstow v. Mojave Water Agency* (2000) 23 Cal.4th 1224, 1240-42.

²⁰⁴ *Peabody v. Vallejo* (1935) 2 Cal.2d 351.

²⁰⁵ Code of California Regulations: Title 23, Division 3, Article 659 *et seq.*

The State has defined the safe yield of an aquifer as the amount of water that can be withdrawn *without an undesirable result*.²⁰⁶ This standard is not a rigid calculation of natural recharge. The California Supreme Court has held that the concept of safe yield and overdraft must reflect opportunities to increase the supply of groundwater from active management techniques. Basin management programs that seek to dewater aquifer systems in a controlled and deliberate manner to enhance groundwater recharge, avoid losses and waste of groundwater and optimize basin yields has been recommended and encouraged in technical papers, treatises and approved by the California Supreme Court as consistent with the California Constitution's requirement of fullest beneficial use of available water resources.

For example, the California Supreme Court has held that the quantity of water that can be safely extracted in excess of the natural recharge so to realize greater basin replenishment is a "temporary surplus," that is available for production within the notion of safe yield and consistent with the norm of fullest beneficial use.²⁰⁷

We agree with plaintiff that if a ground basin's lack of storage space will cause a limitation of extractions to safe yield to result in a probable waste of water, the amount of water which if withdrawn would create the storage space necessary to avoid the waste and not adversely affect the basin's safe yield is a temporary surplus available for appropriation to beneficial use. Accordingly, overdraft occurs only if extractions from the basin exceed its safe yield plus any such temporary surplus.

As is the case with the Project, the form of waste sought to be addressed by the management strategy employed in the *San Fernando* opinion, included the curtailment of high groundwater levels that resulted in a waste of groundwater.²⁰⁸

The law treats beneficial use, safe yield and overdraft as dynamic thresholds that do not set arbitrary restrictions on groundwater use, but rather seek to ensure that the State's limited water resources are managed for optimal society welfare over the long-term. Likewise, through active basin management the yield of a groundwater basin can be increased in a manner that is consistent with long-term social welfare.

In recognition of these considerations, the Chino Basin Watermaster is presently implementing a groundwater management program that will remove 400,000 AF from the groundwater basin to lower water levels and reduce discharges to the Santa Ana River to de minimus quantities. As is the case with the Project here, the objective was to establish a hydraulic barrier by modifying water levels. The program was approved by the San Bernardino Superior Court in December of 2007.²⁰⁹

The San Bernardino County Desert Groundwater Ordinance also applies a dynamic, and fact-specific approach to its definition of safe yield. Section 33.06553 of County ordinance defines

²⁰⁶ *City of Los Angeles v. City of San Fernando* (1975) 14 Cal.3d 199, 278.

²⁰⁷ *City of Los Angeles v. City of San Fernando* (1975) 14 Cal.3d 199, 280.

²⁰⁸ *City of Los Angeles v. City of San Fernando* (1975) 14 Cal.3d 199, 280.

²⁰⁹ *Chino Basin Municipal Water District v. City of Chino et al.*, San Bernardino County Superior Court Case No. RCV 51010, Order Concerning Motion for Approval of Peace II Documents, December 21, 2007.

Groundwater Safe Yield as the “maximum quantity of water that can be annually withdrawn from a groundwater aquifer (i) without resulting in overdraft (ii) without adversely affecting aquifer health and (iii) without adversely affecting the health of associated lakes, streams, springs and seeps or their biological resources. The safe yield of an aquifer can be increased by management actions such as artificial recharge, including infiltration and other similar actions.” Thus, consistent with State policy and the County ordinance, the Project seeks to increase the recoverable safe yield by strategic management of basin groundwater levels.

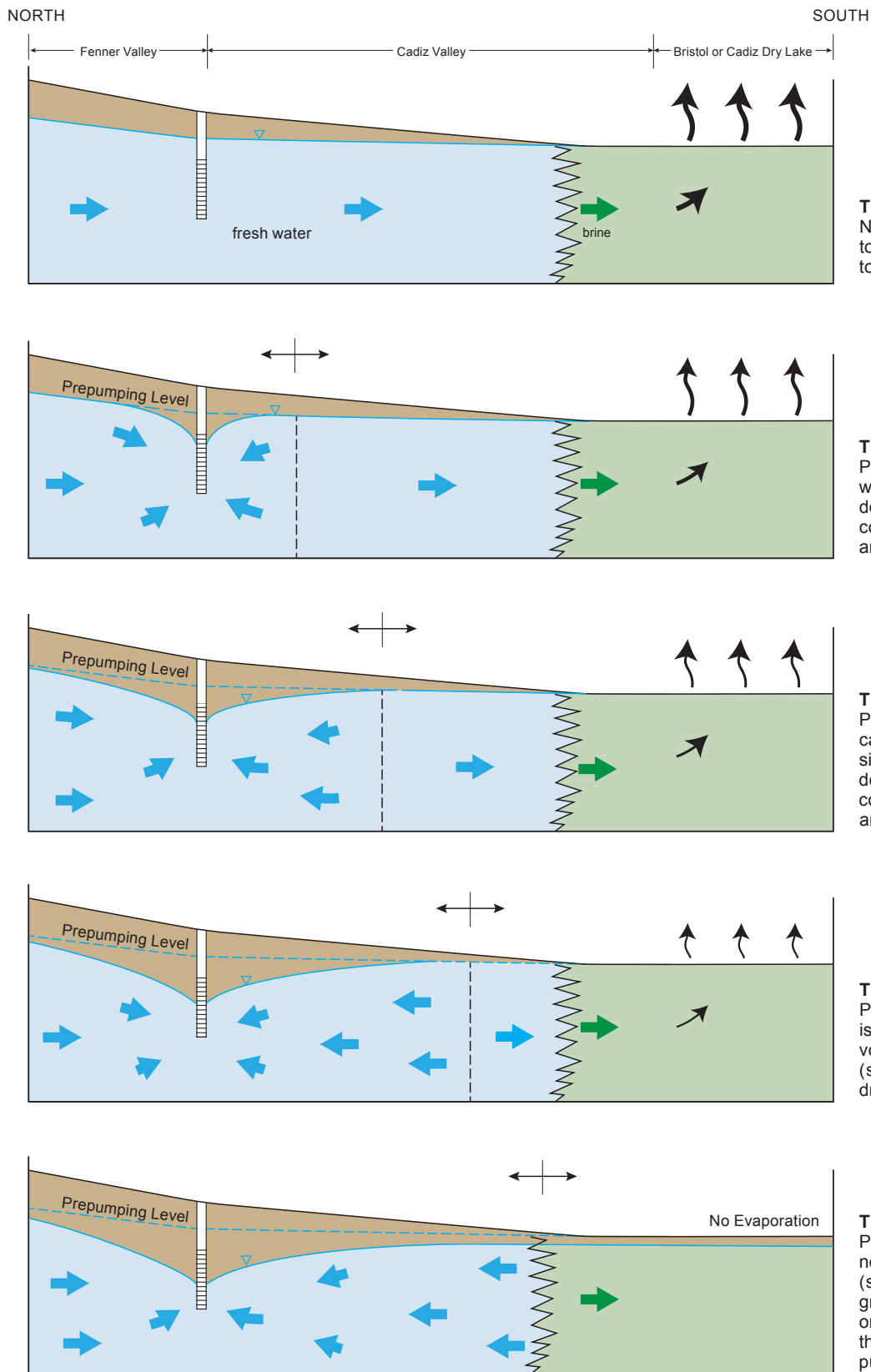
Groundwater Drawdown

The Project proposes to capture an average of 50,000 AFY of groundwater, a portion of which that would otherwise flow through the Fenner Gap as natural recharge and then to the Dry Lakes, become saline, and evaporate. In addition, there is also 4 to 10 MAF of groundwater already in storage down gradient to the west and south of the proposed well-field. Unless management practices can alter the natural gradient, this water will continue migrating towards the Dry Lakes where it will become saline and evaporate. To intercept natural recharge and to retrieve the migratory groundwater below the wellfield, so that it may be conserved and made available for the highest and best use, groundwater would be extracted from the wellfield at Fenner Gap to intentionally lower the water table. The water table would be lowered to at or below the water levels at the Dry Lakes in order to intercept natural recharge and reverse the gradient and prevent the water from flowing to the Dry Lakes.

Figures 4.9-11a and 4.9-11b present conceptual cross sections depicting the flowpaths of groundwater (shown as arrows) over time for the pumping phase followed by the recovery phase. Initially, Time 0 on Figure 4.9-11a depicts the current condition. Under the influence of gravity, groundwater flows from Fenner Valley through Fenner Gap (approximately where the well is shown) into the lower elevation Cadiz Valley. As the groundwater migrates to the dry lakes, the water becomes saline and ultimately is lost to evaporation at the dry lakes.

After pumping begins (Time 1, Figure 4.9-11a), a cone of depression or radius of influence (ROI) is formed at the wellfield, drawing groundwater into the well. Time 1 through Time 4 on Figure 4.9-11a show that the ROI expands over time, broadening its influence and drawing groundwater toward the wellfield away from the dry lakes. As the pumping continues, the water table beneath the dry lakes is anticipated to become deeper such that the rate of evaporation would decrease to essentially zero, further preventing the loss of water to the atmosphere. This illustrates that managing the groundwater basin through the expansion and increased influence of the ROI increases the amount of water conserved, or prevented from comingling with the brine zone and ultimately lost to the atmosphere.

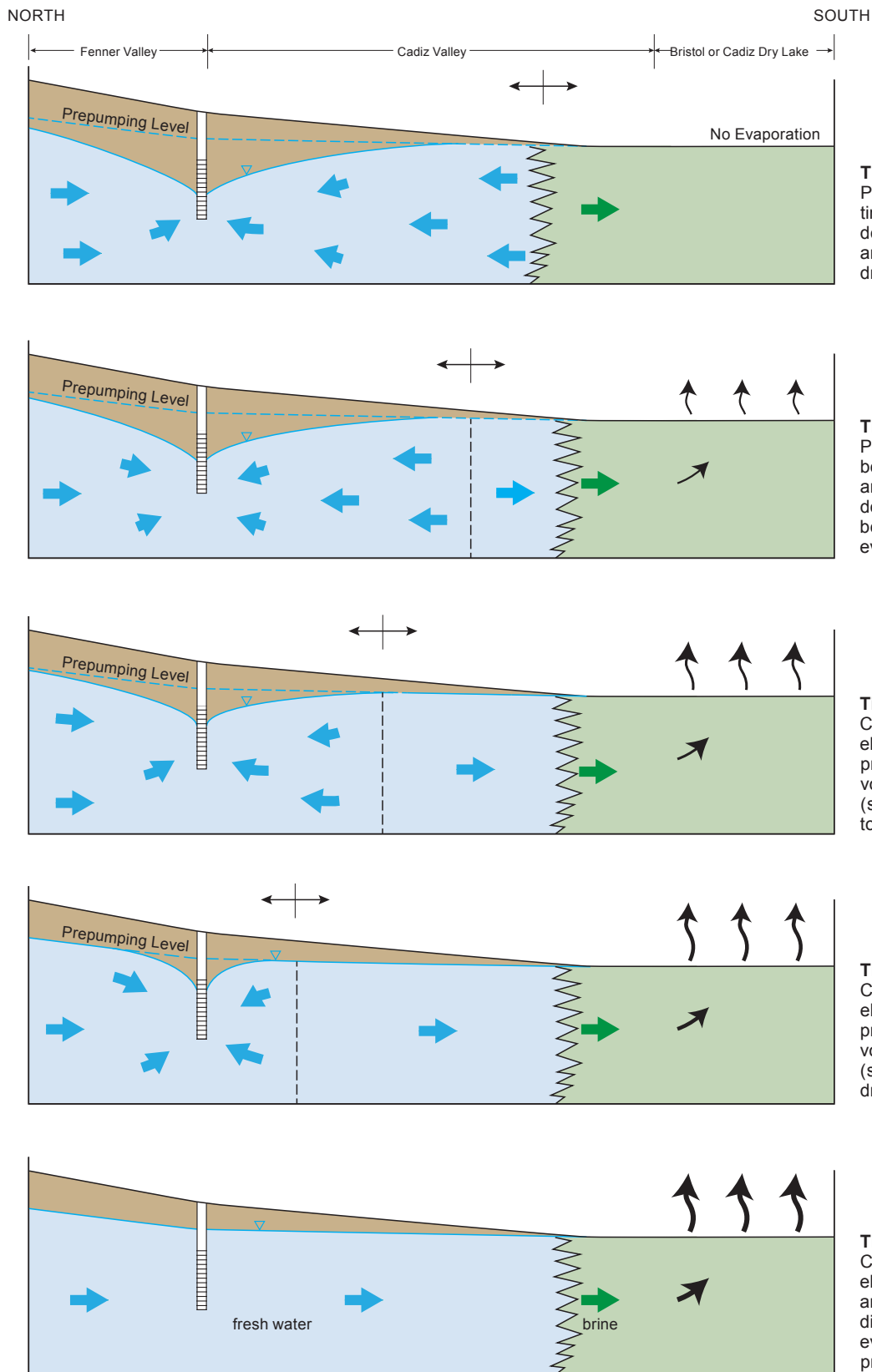
Figure 4.9-11b depicts the changes anticipated after the 50-year term of Project operations. Once the pumping stops, the extent of the ROI will decrease and the water table will completely recover to the current level, as shown at Time 4 on Figure 4.9-11b. Also note that groundwater flow in all areas will return to flowing toward the dry lakes. The evaporation of water from the dry lakes will return to its current rate and water will again be lost to the atmosphere.



SOURCE: CH2M HILL, 2011.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-11
Conceptual Cross Section Showing
Groundwater Flow and Evaporation



SOURCE: CH2M HILL, 2011.

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-11b
Conceptual Cross Section Showing Groundwater Flow and Evaporation during Recovery

Figures 4.9-12, 4.9-13 and 4.9-14 present the model-predicted regional groundwater level drawdown simulations for the 32,000, 16,000, and 5,000 AFY recharge scenarios.²¹⁰ Each figure presents the simulated drawdown after 50 years of groundwater production at an average of 50,000 AFY. All show similar patterns with the majority of drawdown occurring at the area of the production wells in the Fenner Gap area, with decreasing amounts of drawdown moving away from the production wellfield. The groundwater drawdown is limited to the Watersheds.

Table 4.9-9 summarizes the drawdown at the wellfield and beneath Bristol Dry Lake.²¹¹

Water levels would begin to recover once the 50-year pumping period concludes. Complete recovery of water levels to pre-Project levels is estimated to occur at 67 years after the Project pumping stops.²¹² This model demonstrates that the declines in groundwater levels and storage are anticipated to be a condition resulting from management of the basin for beneficial uses that would recover to current pre-Project conditions over time. As discussed below, this drawdown should not result in a significant adverse impact to any critical resource.

With respect to impacts on vegetation, existing depths to groundwater in the Fenner Valley are well over 100 feet bgs. At this depth, no phreatophytic plants can access the water. The plant communities in the region have been found to survive entirely on surface water.²¹³ (See Section 4.4, Biological Resources for further discussion of vegetation resources in the project area).

Near the edge of the Bristol Dry Lake, the depth to groundwater remains over 65 feet deep which is still too deep for phreatophytic plants to access. Near the edge of Cadiz Dry Lake water levels are closer to the surface, but no phreatophytic plants have been identified in this marginal area. Once on the Dry Lake, there is no vegetation due to the salt content in the soil. As a result, any drop in groundwater levels would have no affect on the overlying vegetation.²¹⁴

With respect to local water supply wells, the extraction of groundwater would lower groundwater levels that could affect local water supply wells if the groundwater levels were to drop to below the pump intakes on the wells. Local water demands include the Cadiz Inc. agricultural operations, a few local residents within the Watershed, and the salt production operations at Bristol and Cadiz Dry Lakes. The existing Cadiz agricultural wells would be converted for use by the Project or may remain active as agricultural wells, but would not be adversely affected by the Project.

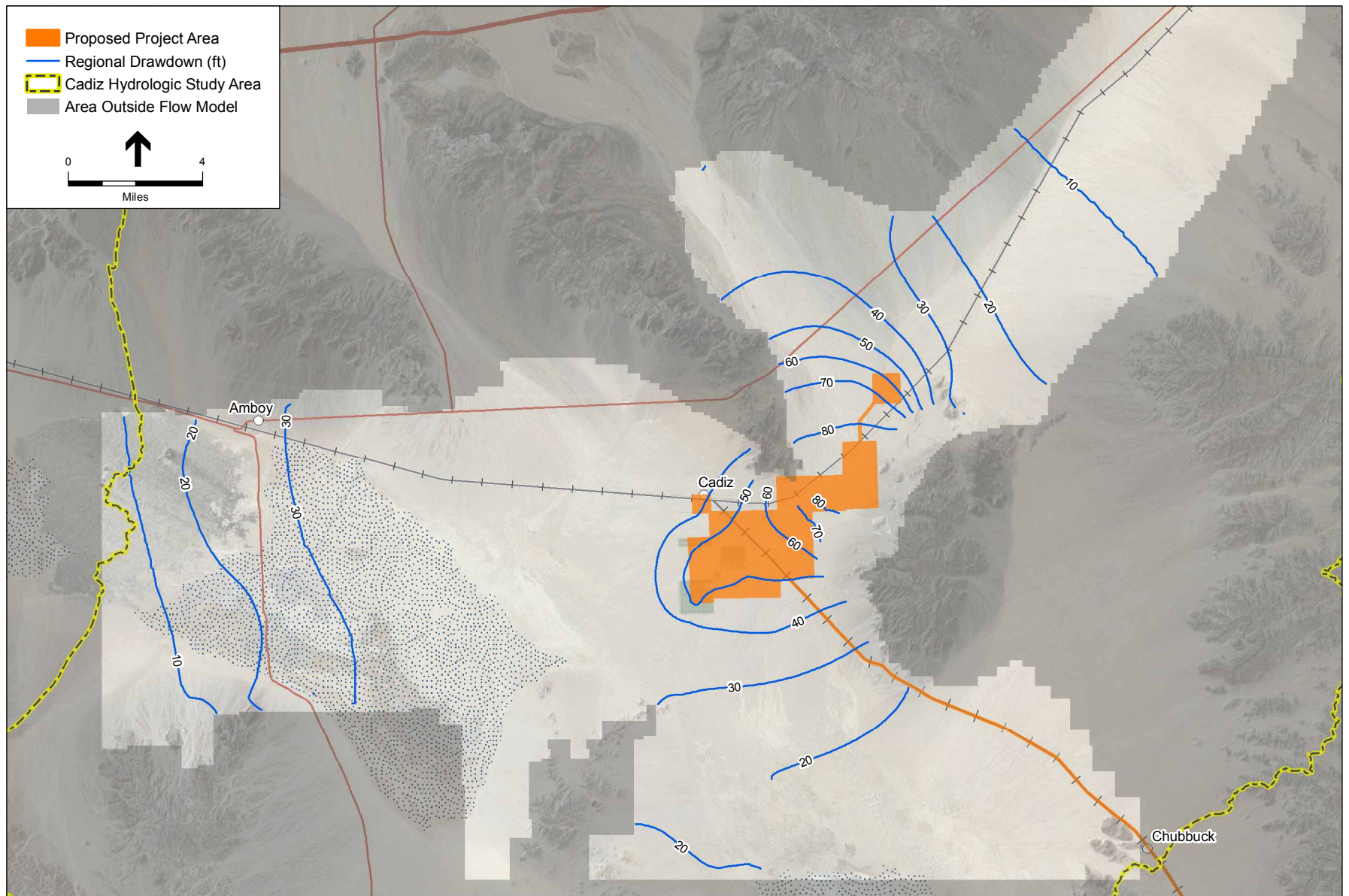
²¹⁰ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, pages 49-50, Figures 64, 66, and 68.

²¹¹ The model does not take into account the second Phase of the Project, the Imported Water Storage Component, which will be subject to further environmental review under CEQA.

²¹² GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, page 53.

²¹³ HydroBio, *Vegetation, Groundwater Levels and Potential Impacts from Groundwater Pumping Near Bristol and Cadiz Playas, San Bernardino, California*, September 2011, pages 5-7.

²¹⁴ HydroBio, *Vegetation, Groundwater Levels and Potential Impacts from Groundwater Pumping Near Bristol and Cadiz Playas, San Bernardino, California*, September 2011, page 7.

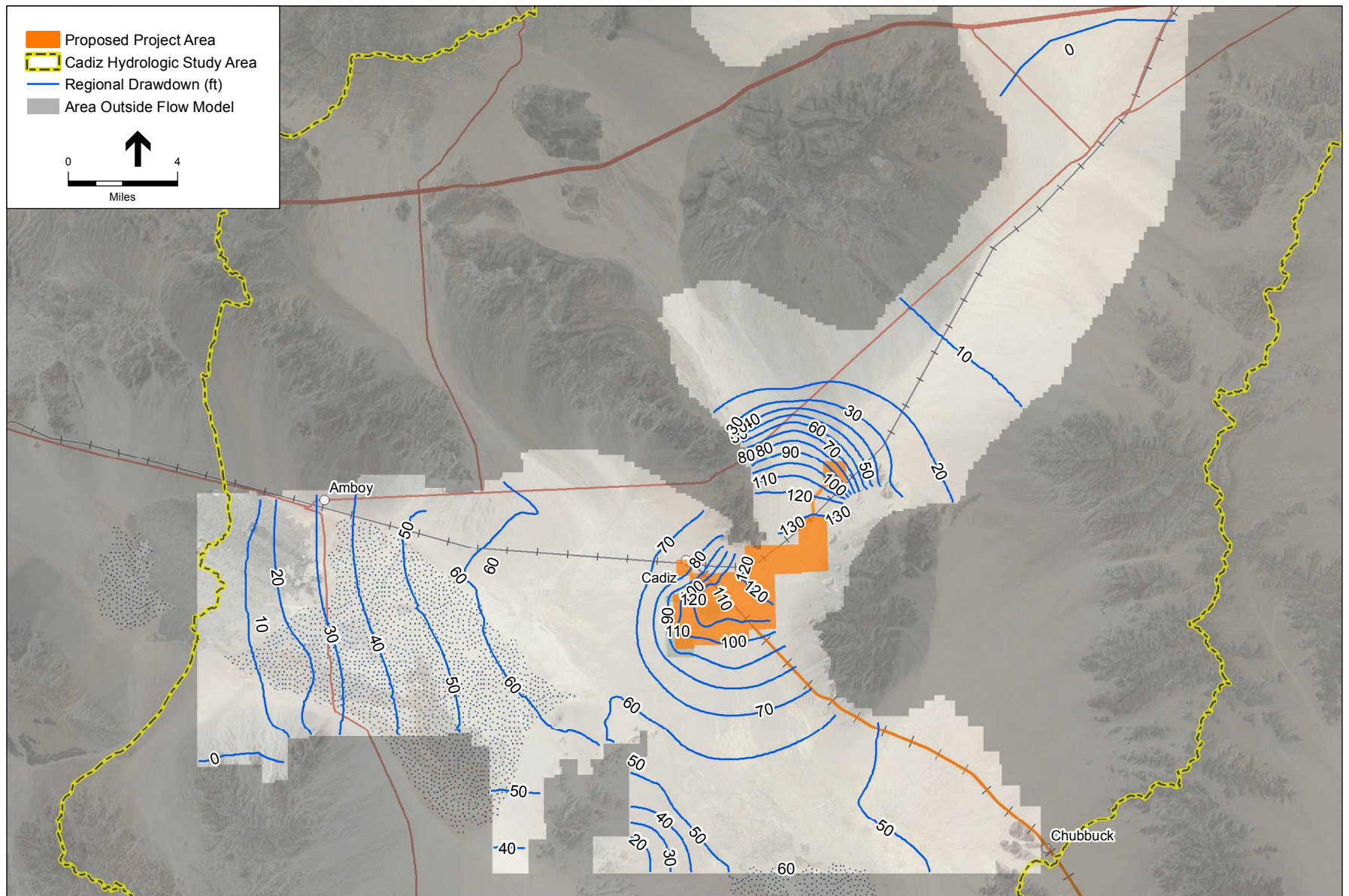


SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; GSSI, 2011; Tetra Tech, 1999; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-12

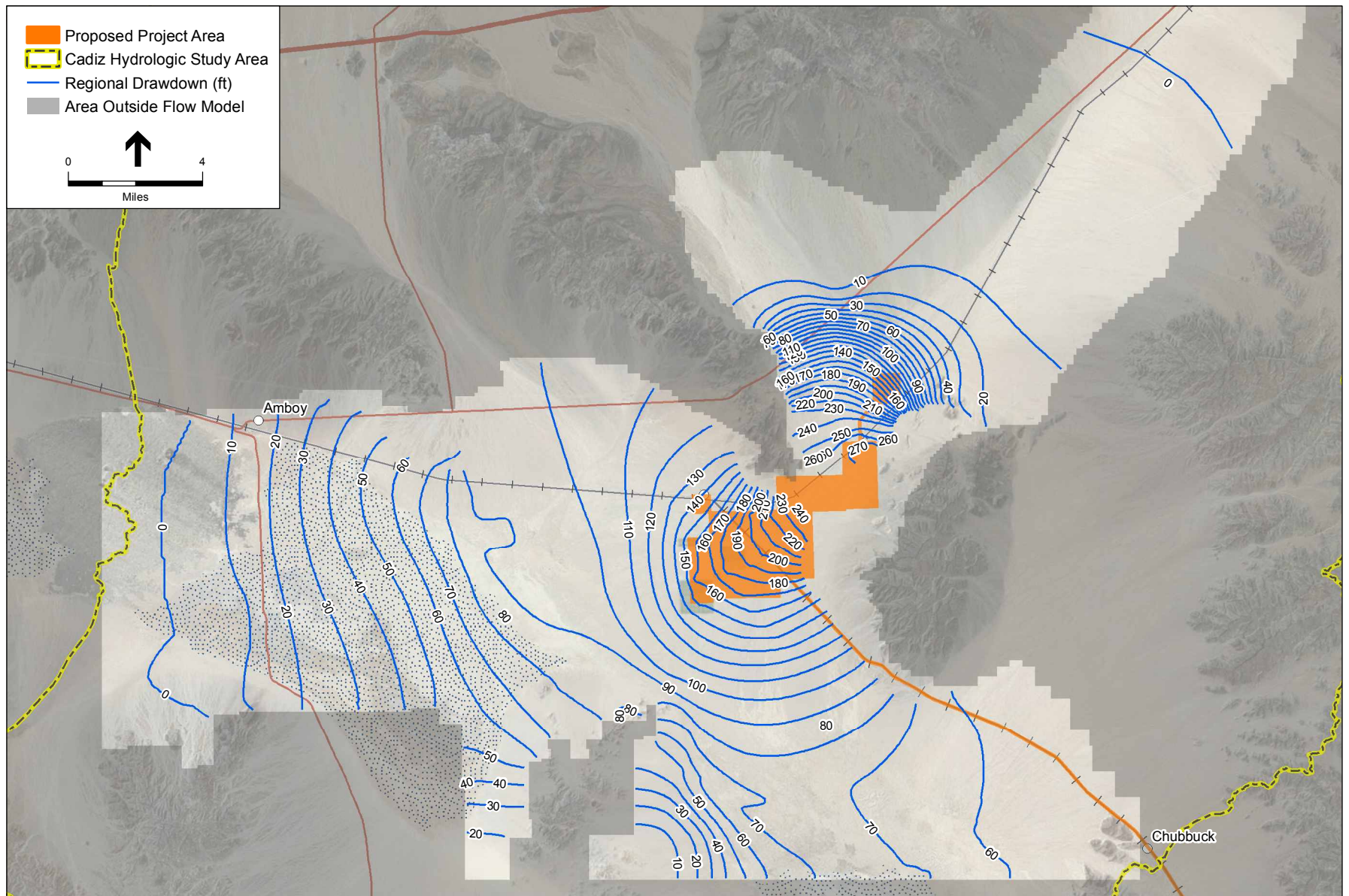
Model-Predicted Regional Drawdown - Project Scenario after 50 Years
(Assumes 32,000 AFY Recharge)
Well Configuration A



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; GSSI, 2011; Tetra Tech, 1999; CH2MHill, 2010; and ESA, 2011

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Figure 4.9-13
 Model-Predicted Regional Drawdown - Sensitivity Scenario No.1 after 50 Years
 (Assumes 16,000 AFY Recharge)
 Well Configuration B



SOURCE: Bing Maps, 2011; ESRI, 2010; Cadiz Inc., 2011; GSSI, 2011; Tetra Tech, 1999; CH2MHill, 2010; and ESA, 2011

Cadiz Valley Water Conservation, Recovery, and Storage Project

Figure 4.9-14
 Model-Predicted Regional Drawdown - Sensitivity Scenario No.2 after 50 Years
 Sensitivity (Assumes 5,000 AFY Recharge)
 Well Configuration B

**TABLE 4.9-9
SUMMARY OF MODEL-PREDICTED DRAWDOWN AMOUNTS**

Model Scenario	End of 50 Years (End of Project Pumping)		End of 100 Years (End of Model Simulation)	
	Drawdown at Wellfield (feet)	Drawdown at Bristol Dry Lake (feet)	Drawdown at Wellfield (feet)	Drawdown at Bristol Dry Lake (feet)
Project Scenario (32,000 AFY Natural recharge)	70 to 80	10 to 30	0 to 10	10 to 20
Sensitivity Scenario 1 (16,000 AFY Natural recharge)	120 to 130	10 to 60	10 to 20	30 to 40
Sensitivity Scenario 2 (5,000 AFY Natural recharge)	260 to 270	0 to 80	50 to 60	10 to 70

SOURCE: GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, page 53.

The model-predicted depths to groundwater in the area of the Cadiz agricultural wells were 197 feet bgs for the 32,000 AFY recharge, 241 feet bgs for the 16,000 AFY recharge, and 315 feet bgs for the 5,000 AFY recharge.²¹⁵ Figure 4.9-5 shows the recorded wells in the Project drawdown area. These wells would experience gradual increase in depth to groundwater over the 50-year Project period. If groundwater levels decreased to below the pump intakes, then the wells would be unable to pump water. The salt production wells used by Tetra Technologies for the production of saline water for their salt production operations are reportedly about 160 feet deep with their pumps set at 120 feet bgs.²¹⁶ The model-predicted depths to groundwater along the edge of the Bristol Dry Lake were 68 feet bgs for the 32,000 AFY recharge, 95 feet bgs for the 16,000 AFY recharge, and 118 feet bgs for the 5,000 AFY recharge.²¹⁷ The modeled drawdown is not predicted to reach below the saline water well pump intakes and therefore, the drawdown would be a less than significant impact.

The salt production operations initially excavate trenches to access the source saline water. The recharge trenches often consist of approximately 10-foot deep trenches up to 100 feet long dug at the lowest elevations of the Dry Lakes. In areas where the groundwater is less than 10 feet bgs, the trenches initially recharge with saline groundwater. As the water evaporates, more saline water is pumped into the trenches from saline water supply wells to add more salts. The water evaporates and the resulting salts concentrate and are sold as a mineral resource. Over time, these trenches lose their ability to recharge groundwater as the trench sides become solidified with halite. As modeled, the lowering of groundwater would occur slowly over time, but could eventually reach depths of 40 feet below current levels beneath the dry lake centers after 50 years. If groundwater levels dropped 40 feet, this method of initially filling the evaporation trenches

²¹⁵ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, pages 51-52.

²¹⁶ Cadiz Inc., *Communication with ESA*, August 4, 2011.

²¹⁷ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, Section 6.2.

would become ineffective at some point in the future and all of the saline water would have to be pumped from saline wells into the trenches.

The GMMMP includes project design features to verify model-predicted effects and confirm protection of critical resources. The project design features for the groundwater drawdown are GMMMP Project Design Features 6.2 – Third Party Wells.²¹⁸ The Action Criteria and Corrective Measures are summarized in Table 4.9-6.

Implementation of the Project Design Features 6.2 as described in Chapter 6.2 of the GMMMP would reduce potential impacts to the third-party well owners due to groundwater drawdown to less than significant. The project design features presented in Chapter 6.2 of the GMMMP are incorporated into this EIR as Mitigation Measure **HYDRO-3**. Implementation of Mitigation Measure **HYDRO-3** would ensure that the potential impacts from groundwater drawdown are mitigated to less than significant for third-party wells.

Storage

As detailed in the Methodology Section above, the overall extraction of up to 2.5 MAF of water from the groundwater basin over a 50-year period would temporarily reduce the volume of water in storage in the groundwater basin, which is currently estimated at between 17 and 34 MAF. The amount of reduction is dependent upon the quantity of natural recharge and discharge from the Basin. The following **Table 4.9-10** summarizes the volumes of storage change at Year 50, when Project pumping stops, and at Year 100, the end of the model simulation depending on the variability in recharge.²¹⁹ The recovery is also extrapolated to estimate the number of years for the storage to recover to pre-Project levels.

**TABLE 4.9-10
SUMMARY OF MODEL-PREDICTED STORAGE RESPONSE**

Model Scenario	Cumulative Change at End of 50 Years (End of Project Pumping)		Cumulative Change at End of 100 Years (End of Model Simulation)		Time for Groundwater Storage to Recover after Project Pumping Stopped in Year 50
	Volume (AF)	Percent of Total Storage	Volume (AF)	Percent of Total Storage	
Project Scenario (32,000 AFY Natural recharge)	-1,090,000	3 to 6	-220,000	1	67
Sensitivity Scenario 1 (16,000 AFY Natural recharge)	-1,680,000	5 to 10	-870,000	3 to 5	103
Sensitivity Scenario 2 (5,000 AFY Natural recharge)	-2,160,000	6 to 13	-1,870,000	6 to 11	390

SOURCE: GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, page 54.

²¹⁸ CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011, pages 76-78.

²¹⁹ GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, pages 53-54.

As summarized above, the 50-year pumping period under the anticipated Project scenario would fractionally reduce the total estimated storage between 3 to 6 percent, after which the Project would terminate and groundwater extraction would cease. Water levels would then completely recover in about 67 years after Project pumping stops. In other words, the decline in storage is anticipated to be a temporary condition and storage would recover to current pre-Project conditions over time. **Table 4.9-11** summarizes the volumes of water that would be saved from evaporation for beneficial uses under the three modeled recharge scenarios.²²⁰

**TABLE 4.9-11
SUMMARY OF CUMULATIVE NET SAVINGS OF WATER**

Model Scenario	Natural Recharge (AFY)	Cumulative Reduction of Evaporative Losses (AF)	Cumulative Depletion of Storage (AF)	Cumulative Net Water Saving from Project (AF)
Project Scenario (32,000 AFY Natural recharge)	32,000	2,210,000	220,000	1,990,000
Sensitivity Scenario 1 (16,000 AFY Natural recharge)	16,000	1,544,000	870,000	674,000
Sensitivity Scenario 2 (5,000 AFY Natural recharge)	5,000	470,000	1,870,000	-1,400,000

SOURCE: GEOSCIENCE Support Services, Inc., *Supplemental Assessment of Pumping Required for the Cadiz Groundwater Conservation and Recovery and Storage Project*, September 2011, pages 6-7.

As summarized in Table 4.9-11, as much as 1,990,000 AF of water would be conserved for beneficial uses under the Project scenario instead of being lost to evaporation. The savings are calculated over a 100-year period, comparing the evaporative losses that would have occurred without the Project and the depletion in storage at the end of 100 years that would occur with the Project. However, as discussed above, the levels of storage are anticipated to fully recover 67 years after the pumping ceases. The only scenario that has a negative net savings is the 5,000 AFY natural recharge scenario. However, there are no permanent adverse impacts even with this scenario because the levels of storage are still anticipated to fully recover.

As described in Section 4.6 of this Draft EIR, groundwater extraction may result in some subsidence from the compression of dewatered clay soils within the wellfield. The reduction of storage space would be minor compared to the availability of storage space in the valley. Depth to groundwater is generally over 100 feet bgs. The minor loss of storage capacity in the basin would not adversely affect future management or beneficial use of the basin. The loss of storage capacity would be a less than significant effect.

The predictive modeling performed by Geoscience concludes that pumping at higher rates during the initial period of the 50-year Project period would reduce evaporation rates more effectively,

²²⁰ GEOSCIENCE Support Services, Inc., *Supplemental Assessment of Pumping Required for the Cadiz Groundwater Conservation and Storage Project*, September 2011, pages 6-7.

thereby conserving larger amounts of water for beneficial use that would otherwise evaporate. For example, pumping rates in excess of natural recharge (in excess of 50,000 AFY) during the first 25 years would increase the quantity of groundwater conserved.²²¹ Figure 4.9-11a illustrates groundwater flow reactions with implementation of the Project operations. Groundwater in storage to the southwest of the wellfield that has already passed through the Fenner Gap is estimated to be between 4 and 10 MAF,²²² and is moving toward the Dry Lakes where it would ultimately join the saline groundwater and evaporate. As shown in Figure 4.9-11a, the proposed Project would reverse the groundwater flow to reduce the hydraulic pressure toward the Dry Lakes and capture some of the water that has already passed through the Fenner Gap and is headed toward the Dry Lakes. Since this extraction in excess of natural recharge as shown in Figure 4.9-11a is necessary to capture water that would otherwise be wasted to salinity and evaporation and since no other groundwater user would be adversely affected, the Project would not result in a significant impact to the aquifer system.

Recharge

The Project will have no impact on the recharge areas, runoff, or percolation of rainfall and snowmelt in the upper areas of the watershed. The continuous natural recharge of groundwater will be completely unaffected. However, as noted above, managing a groundwater basin to maximize beneficial uses that results in temporary extraction greater than annual natural recharge will have beneficial impacts by optimizing yield and reducing waste. The Project will strategically lower groundwater levels to conserve and make beneficial use of the basin while resulting in a less than significant impact with respect to storage capacity or the long-term health of the basin.

The GMMMP includes project design features to verify model-predicted effects and confirm protection of critical resources. The project design features relative to impacts on the basin are GMMMP Project Design Features 6.2 – Third Party Wells²²³ and GMMMP Project Design Features 6.4 – Induced Flow of Lower-Quality Water from Bristol and Cadiz Dry Lakes. The Action Criteria and Corrective Measures for Project Design Features 6.2 and 6.4 are summarized in Tables 4.9-10 and 4.9-7 previously described above.

Summary

The Project will not substantially deplete groundwater supplies or interfere with groundwater recharge. First, the Project's temporary drawdown of water will not result in a significant adverse impact to any critical resource, including vegetation. Second, pumping of groundwater under the proposed Project would have no impact on springs and therefore no mitigation is required. Third, the minor loss of storage capacity in the basin would not adversely affect future management or beneficial use of the basin and is therefore considered less than significant effect. Fourth, the Project will have no impact on the recharge areas, runoff, or percolation of rainfall and snowmelt in the upper areas of the watershed. Lastly, the effects of drawdown on third party

²²¹ GEOSCIENCE Support Services, Inc., *Supplemental Assessment of Pumping Required for the Cadiz Groundwater Conservation and Storage Project*, September 2011, page 10.

²²² GEOSCIENCE Support Services, Inc., *Cadiz Groundwater Modeling and Impact Analysis, Volume 1*, September 2011, page 9.

²²³ CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011, Section 6.2.

wells would be less than significant with implementation of Project Design Features 6.2 and 6.4 as confirmed in Mitigation Measures **HYDRO-3** and **HYDRO-2**.

Mitigation Measures

Implement Mitigation Measure **HYDRO-3**.

Significance Conclusion

Less than significant with mitigation.

Impacts to Drainage Patterns

Significance Threshold

Would the proposed Project result in a significant impact by altering the existing drainage patterns of the area and the courses of streams in a manner that could result in substantial erosion or siltation on- or off-site, or result in substantially increasing the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?

Impact Analysis

The Groundwater Conservation and Recovery Component of the Project would include the construction of production wells, piping, and associated pumps, controls, and power appurtenances to extract groundwater and transport the water southeast to the CRA. The placement of the constructed infrastructure could result in changing the existing drainage patterns by blocking or re-routing existing flow patterns. The changed flow path of water could result in erosion or siltation that could result in damage to structures or the environment from erosion or flooding.

The production wells and monitoring features would be installed in locations outside of defined washes. The well head for each production well would be placed within an approximately ten foot by ten foot pad, slightly raised above grade. The pad would be constructed such that surface water flow from the occasional rain events would be routed around the pad and designed to reduce flow velocities and potential scour. The pipelines connecting the wells to the water conveyance pipeline to the CRA would all be placed underground at about 15 feet below grade. Pipeline locations at the existing railroad drainage crossings would also be underground and covered with an at-grade pad that would be designed to allow unimpeded surface water flow through the undercrossing. The water conveyance pipeline to the CRA is currently being planned primarily for the south side of the railroad track. If site conditions require the pipeline to cross under the railroad tracks, the undercrossing would be still be placed below grade and thus not susceptible to erosion or siltation issues.

Mitigation Measure **HYDRO-4** ensures that above ground structures are not placed within any visible stream drainage or wash in a manner that could result in the restriction of surface water flow. In addition, because the drainage patterns of the intermittent streams in desert areas can change annually, if not with each individual rain event, the infrastructure elements shall be constructed to be protected from future changes to drainage patterns by routing water away and

around the structures in such a manner so as to not concentrate the flow and increase the potential for erosion. Implementation of Mitigation Measure **HYDRO-4** would ensure that the Project would reduce the potential impacts to less than significant levels.

Mitigation Measures

HYDRO-4: Construction plans shall be prepared that use standard best management practices (BMPs) to control drainage around the Project infrastructure. The BMPs shall include placing well pads and above-ground appurtenant facilities outside of visible drainages; and grading well pads to disperse runoff from the site in a manner that minimizes scour potential of storm water. Additional BMPs include the use of physical barriers to prevent erosion and siltation straw wattles, hay bales, setbacks and buffers, and other similar methods that reduce the energy in surface water flow.

Significance Conclusion

Less than significant with mitigation.

Impacts to Housing or Structures Relative to Flooding, Seiche, Tsunami, or Mudflow

Significance Threshold

Would the proposed Project place housing or structures in locations that would be subject to flooding, seiches, tsunamis, or mudflows?

Impact Analysis

The Project does not include the construction of permanent housing. Almost all structures would be placed underground with the exception of some well pads, surface piping, and control structures. None of the Project area is located within the 100-year flood zone maps prepared by FEMA. The area is not subject to seiches, tsunamis, or mudflows. Temporary worker housing may be constructed in the Cadiz area or possibly in the southern area of the Project where the water conveyance pipeline would connect to the CRA or possibly other staging areas. These worker accommodations would be temporary in nature and would be purposely placed away from washes or other visible drainages.

Although not identified as being within 100-year flood maps, the general area is known to experience occasional seasonal short-term flooding. The seasonal flooding could damage above-ground structures such as well heads and supporting power equipment. Implementation of Mitigation Measure **HYDRO-4**, described above, would ensure that the Project would not adversely affect the floodplain.

Mitigation Measures

Implement Mitigation Measure **HYDRO-4**.

Significance Conclusion

Less than significant with mitigation.

Imported Water Storage Component

This component is analyzed on a programmatic basis.

Impacts to Water Quality Standards or Waste Discharge Requirements

Significance Threshold

Would the proposed Project result in a significant impact if the recharge of groundwater to the aquifer were to degrade water quality or violate waste discharge requirements?

Impact Analysis

The Imported Water Storage Component allows participating water providers to send surplus surface water supplies, when available, to the Project area to be recharged into the groundwater aquifer system via spreading basins and held in storage until needed in future years. When needed, the stored surface water would be pumped out of the aquifer system and returned to the appropriate participating provider. The maximum capacity of the Project's Imported Water Storage Component is 1 MAF at any given time. A maximum of 75,000 afy to 105,000 afy would be recharged or extracted from the Basin based on the maximum capacity of the 43-mile pipeline and the natural gas pipeline. The facilities proposed for this Component of the Project include an additional 10 to 15 wells in the Project wellfield; construction of spreading basins to recharge the surface water into the groundwater basin; additional roads, piping, power supply, and distribution facilities; and a CRA diversion structure and pump station.

Importation of CRA or SWP water to the Fenner Watershed could introduce a foreign water source into the aquifer that could alter groundwater chemistry. Influences to groundwater quality could occur from any of the following:

- Percolating CRA or SWP water could transport salts from the unsaturated zones to the aquifer
- CRA or SWP water recharged into the ground would have a slightly higher TDS concentration (about 500 to 600 mg/l) than the indigenous groundwater (about 300 to 400 mg/l) and would therefore increase salt loading in the aquifer
- CRA or SWP water recharged into the ground may contain low levels of contaminants such as perchlorate, nitrates, or other chemical constituents that would be percolated into the aquifer

Table 4.9-8 above summarizes water quality parameters for water sampled from the alluvium, carbonate, and bedrock units in Fenner Gap and from the Colorado River just below Parker Dam, which represent the CRA water quality. As previously discussed, both the CRA water and the Fenner Gap water currently meet the drinking water standards before treatment. After treatment by the water purveyors, the concentrations would be expected to be even lower.

For the Imported Water Storage Component of the Project, CRA (and possibly SWP) water would be pumped to the spreading basins in the Fenner Gap area where the CRA water would infiltrate down into the alluvial aquifer for later recovery when needed. The water would then be pumped back through the water conveyance pipeline from the wellfield to the CRA, where the

water would be returned to the CRA and then sent on to the water purveyors. The CRA water would have higher TDS concentrations than the CRA water, whereas the sodium and chloride (salt) concentrations of the CRA water would be slightly lower than the current concentrations in the groundwater in the alluvium in the Fenner Gap area. However, as listed in Table 4.9-8 above, all of the parameter concentrations for both waters are below MCLs, meaning that both waters are currently acceptable for use as drinking water as is and all of the water would be further treated at the water purveyor's treatment facilities. In addition, the maximum volume of CRA water that could be stored in the alluvial aquifer, at any given time, would be 1,000,000 AF. The volume of water in the Fenner Watershed and the northern portion of the Bristol Watershed to which the CRA water would be added is estimated at 17 to 34 MAF. Consequently, the maximum percentage of CRA water that would be added relative to the volume of water in the aquifer would be only 3 to 6 percent. This represents a substantial dilution. Based on this overall evaluation, the potential impact would be considered less than significant.

Nonetheless, the FVMWC would implement monitoring features that includes sampling the existing Well CI-3, located within Fenner Gap to monitor the effects of imported water to groundwater. Well CI-3 would be sampled on a set schedule and analyzed for TDS, and general mineral and physical parameters, as described in the GMMMP.²²⁴ The results of the analyses would be evaluated to verify that the water quality of the aquifer remains acceptable as a drinking water supply and that the impact would be less than significant.

Mitigation Measures

None required.

Significance Conclusion

Less than significant.

Impacts to Groundwater Supplies or Groundwater Recharge

Significance Threshold

Would the proposed Project result in a significant impact if the recharge of groundwater were to substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?

Impact Analysis

The Imported Water Storage Component would operate under the provision that only the amount of previously recharged water could be extracted from the groundwater basin, thereby resulting in a neutral effect to water volumes in storage in the aquifer. The introduction of up to 105,000 AFY and up to a total of 1,000,000 AF of water at any given time, into the groundwater basin would offset some of the drawdown associated with the Groundwater Conservation and Recovery

²²⁴ CH2M Hill, *Groundwater Management, Monitoring, and Mitigation Plan*, November 2011, Appendices C and D.

Component. In addition, the current depths to groundwater in the proposed recharge area are in excess of 180 bgs, providing room for the storage of additional water.²²⁵ Note that if the imported water were introduced prior to the establishment of the hydraulic barrier or in absence of ongoing managed groundwater production, evaporative losses to the Dry-Lakes could be accelerated and increased. Consequently, the Imported Water component is proposed to be implemented after the Conservation and Recovery Project. Therefore, the Imported Water Storage Component would not adversely affect groundwater supplies or impede naturally occurring groundwater recharge. Therefore, there would be no impact.

Mitigation Measures

None required.

Significance Conclusion

No impact.

Impacts to Drainage Patterns

Significance Threshold

Would the proposed Project result in a significant impact if the existing drainage patterns of the area and the courses of streams would be altered in a manner that could result in substantial erosion or siltation on- or off-site, or result in substantially increasing the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?

Impact Analysis

The Imported Water Storage Component of the Project would include expansion of the wellfield, construction of a recharge basin, extension of the conveyance pipeline, and the upgrading of the existing natural gas pipeline. The extension of the conveyance pipeline would follow existing access roads where possible and would be jack and bored under the BNSF railroad tracks. Given the size of the recharge basin, surface runoff patterns may change because it is unlikely that all existing drainage patterns could be avoided. Placing the recharge basin within well-defined washes could alter downstream floodways, including those that flow to railroad undercrossings. In addition, the access road to the spreading basin may utilize existing undercrossings which could alter drainage patterns. Implementation of Mitigation Measure **HYDRO-5** would ensure that the recharge basin and access road does not affect downstream drainages or floodways.

Mitigation Measures

HYDRO-5: Imported Water Storage Component. Project operators shall prepare a drainage analysis of the recharge basin and access road locations to ensure that diverted stormwater runoff does not affect downstream railroad crossings, roads, or other infrastructure. Recharge basins shall be located outside of major drainages, such as Schulyer Wash. The recharge basins shall be designed using BMPs to divert sheet flow

²²⁵ Cadiz Inc., *13th Annual Groundwater Monitoring Report, January – December 2010, Cadiz Valley Agricultural Development*, June 2011.

storm water around the basins and redistribute the flow downstream without increasing velocity or scour potential.

Significance Conclusion

Less than significant with mitigation.

Impacts to Housing or Structures Relative to Flooding, Seiche, Tsunami, or Mudflow

Significance Threshold

Would the proposed Project place housing or structures in locations that would be subject to flooding, seiches, tsunamis, or mudflows?

Impact Analysis

The Imported Water Storage Component of the Project does not include any construction of permanent housing. Temporary worker housing would use the existing Cadiz-owned worker housing.

The spreading basins and associated additional wells would be at ground level. None of the Project area is located within the 100-year flood zone maps prepared by FEMA. The area is not subject to seiches, tsunamis, or mudflows.

Although not identified as being within 100-year flood maps, the general area is known to experience occasional seasonal short-term flooding. The seasonal flooding could damage above-ground structures such as well heads and supporting power equipment. Implementation of Mitigation Measure **HYDRO-4**, described above, would ensure that the Project would not adversely affect the floodplain.

Similarly, the existing natural gas pipeline is also not located within a 100-year flood zone. Nor would the natural gas pipeline element expose workers or structures to seiches, tsunamis, or mudflows. Thus, no impacts would occur.

Mitigation Measures

Implement Mitigation Measure **HYDRO-4**.

Significance Conclusion

Less than significant with mitigation.

Mitigation Measure Summary Table

Table 4.9-12 on the following page presents the impacts and mitigation summary for Hydrology and Water Quality.

**TABLE 4.9-12
IMPACTS AND MITIGATION SUMMARY**

Proposed Project Impact	Mitigation Measure	Significance Conclusion
Groundwater Conservation and Recovery Component		
Impacts to Water Quality Standards or Waste Discharge Requirements	HYDRO-1, HYDRO-2, and HYDRO-3	Less than significant with mitigation
Impacts to Groundwater Supplies or Groundwater Recharge	HYDRO-3	Less than significant with mitigation
Impacts to Drainage Patterns	HYDRO-4	Less than significant with mitigation
Impacts to Housing or Structures Relative to Flooding, Seiche, Tsunami, or Mudflow	HYDRO-4	Less than significant with mitigation
Imported Water Storage Component		
Impacts to Water Quality Standards or Waste Discharge Requirements	None required	Less than significant
Impacts to Groundwater Supplies or Groundwater Recharge	None required	No impact
Impacts to Drainage Patterns	HYDRO-5	Less than significant with mitigation
Impacts to Housing or Structures Relative to Flooding, Seiche, Tsunami, or Mudflow	HYDRO-4	Less than significant with mitigation