Appendix F

Existing Monitoring Protocols

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Appendix F: Existing Monitoring Protocols

F.1 Introduction

This appendix discusses existing monitoring protocols that have been adopted by the Mojave Water Agency (MWA) to monitor compliance with the Mojave Basin Area Judgment and the Warren Valley Judgment. This information supplements the information on existing and proposed monitoring activities presented in Section 10. Senate Bill 1938 (S.B. 1938) states, "the local agency shall adopt monitoring protocols that are designed to detect changes" in:

- Groundwater levels
- Groundwater quality
- Inelastic land surface subsidence
- The flow and quality of surface water that directly affects groundwater levels or quality or is caused by groundwater pumping in the basin.

These protocols "shall be designed to generate information that promotes efficient and effective groundwater management." The following sections describe current monitoring activities in the Mojave Basin Area and in the Morongo Basin/Johnson Valley Area.

F.2 Mojave Basin Area

In the Mojave Basin Area, much of the monitoring required by S.B. 1938 is conducted by Agency and Watermaster staff. The MWA Board acts as Watermaster for administration of the Mojave Basin Area Judgment. In addition, the Agency has engaged the U.S. Geological Survey (USGS) in a cooperative water resources program by which the USGS performs monitoring activities in the MWA service area.

F.3 Mojave Basin Area Watermaster

By order of the Mojave Basin Area Judgment, the Mojave Basin Area Watermaster performs monitoring to ensure that the mandates of the Judgment are enforced. Monitoring requirements are described in the Judgment after Trial (1996) and in the Mojave Basin Area Watermaster Annual Reports. The following is a summary of monitoring currently performed by the Watermaster.

F.3.1 Water Production and Verification

The Judgment requires that annual water production records be collected and verified for parties to the Judgment within each of the five subareas. These records are used to document water usage and to determine Replacement Water and Makeup Water Obligations as well as determining estimates of consumptive use.

In addition, the MWA catalogues wells as part of the Minimal Producer Monitoring Program. Minimal Producers are defined as those producers who have an annual production of less than 10 acre-feet (af) and are not subject to the Judgment. The MWA estimates total production by Minimal Producers in each subarea.

F.3.2 Replacement Water Tracking

If a producer's water production exceeds their Free Production Allowance in any year the producer must pay the Watermaster a Replacement Water Assessment. The Watermaster then has the responsibility to acquire Replacement Water to replace the overpumped amount. Pursuant to the Judgment, the Watermaster pays MWA to import State Water Project water to meet this Replacement Water obligation.

F.3.3 Mojave River Flow Data

The Watermaster uses Mojave River flow data provided by USGS as part of the cooperative water resources program (see below). Mojave River flows are estimated at the following locations:

- Forks: Total flow at the Forks is measured by combining discharges measured for the West Fork of the Mojave River and for Deep Creek.
- Lower Narrows: Lower Narrows flow is estimated from the Lower Narrows gage, at which flow measurements are taken on a weekly basis. The Watermaster makes a determination of how much of this flow is base flow and how much is storm flow. The method used to make this determination is described on page C-2 of the Judgment.
- Alto/Centro Boundary: Because there is no gage at the Alto to Centro boundary, the Mojave River flow at this location is assumed to equal the base flow determined at the Lower Narrows plus the amount of reclaimed water discharged into the Mojave River by Victor Valley Wastewater Reclamation Authority (VVWRA).
- Barstow: Flow records are taken from the Barstow gage.
- Afton: Flow records are taken from the Afton Canyon gage.

F.3.4 Precipitation

The Watermaster utilizes precipitation data compiled from records obtained by the National Oceanographic and Atmospheric Administration (NOAA) and San Bernardino County at Lake Arrowhead, Victorville, and Barstow.

The Watermaster's hydrological inventory includes estimates for deep percolation of percolation for Alto and Baja. These values do not change from year to year and are equal to the following values, which are the same as contained in Table 5-2 of the Watermaster Annual Report of the Mojave Basin Area Watermaster:

- Alto: 3,500 acre-feet per year (afy)
- Baja: 100 afy

F.3.5 Victor Valley Wastewater Reclamation Authority (VVWRA) Discharges

VVWRA provides the Watermaster with records of discharge of reclaimed water into the Mojave River in the Transition Zone.

F.3.6 Subsurface Flow

The Watermaster's hydrogeologic inventory includes estimates for subsurface flow between subareas. These values do not change from year to year and are equal to the following values, which are the same as contained in Table 5-2 of the Watermaster Annual Report of the Mojave Basin Area Watermaster:

- Este to Alto: 200 afy
- Oeste to Alto: 800 afy
- Alto to Centro: 2,000 afy
- Centro to Baja: 1,581 afy

F.3.7 Makeup Water

Minimum annual flows must be maintained between Alto and Centro. Each year, the Watermaster estimates the total flow between each of these subareas. If the amount is less than the minimum amount required by the Judgment, the producers in the upstream subarea must pay the Watermaster for makeup water to be delivered to the downstream subarea. Typically, the Watermaster will import State Water Project water to meet this Makeup Water obligation.

The flow from Alto to Centro equals the subsurface flow plus the Mojave River base flow plus the VVWRA wastewater discharge into the Mojave River plus any Makeup Water delivered the previous year.

F.3.8 Wastewater Imports

The Watermaster records the amount of reclaimed wastewater imported into MWA from Lake Arrowhead Community Services District, Crestline Sanitation District, and Big Bear Area Regional Wastewater Agency.

F.3.9 State Water Project Imports

The Watermaster records the amount of State Water Project imported by the MWA by month. This water is categorized by subarea and also includes water delivered to the solar generating facility at Kramer Junction.

F.3.10 Groundwater Levels

Groundwater levels were established in Exhibit H of the Judgment for key wells in the Mojave River floodplain. These wells and their associated groundwater levels as measured from the ground surface to standing water are:

- Wells H1-1 and H1-2 in the Victorville/Alto Zone (upper Narrows area) are to be maintained at seven (7) feet
- Well H2-1 in the Lower Narrows/Transition zone is to be maintained at ten (10) feet
- Well H3-1 in the Harvard/Eastern Baja Riparian Forest Habitat (Camp Cady area) is to be maintained at 7 feet. Well H3-2, also in the Camp Cady area, is to be maintained at one (1) foot above ground surface to ensure adequate surface water habitat

F.3.11 Ungaged Surface Water Inflows

The Watermaster's hydrogeologic inventory includes estimates of ungaged inflow into each subarea. These values do not change from year to year and are equal to the following values, which are the same as contained in Table 5-2 of the Watermaster Annual Report of the Mojave Basin Area Watermaster:

- Este: 1,700 afy
- Oeste: 1,500 afy
- Alto: 3,600 afy
- Baja: 952 afy

F.3.12 Consumptive Use

The Watermaster estimates agricultural, urban and phreatophyte consumptive use for each subarea. Phreatophyte consumptive use was set by the Judgment in amounts shown in Table 5-1 of the Watermaster Annual Report. It is assumed by the Judgment that these amounts are dedicated to and consumed by phreatophytes. Agricultural and urban consumptive use is estimated by Watermaster based on population, reference ET, evaluation of various categories of uses and the records of annual verified production and minimal producer production. Exhibit F of the Judgment prescribes the following consumptive use rates specifically for evaluating transfers of FPA between M&I and Agricultural uses. Industrial uses are evaluated on a case by case basis.

- Municipal: 50%
- Agriculture: 50%
- Industrial: case by case
- Lakes or Aquaculture surface acres x 7 feet

Actual consumptive use is evaluated annually, subject to changing water use conditions and consistent with Watermaster's responsibilities pursuant to paragraph 24 of the Judgment.

F.4 U.S. Geological Survey

As part of a cooperative water services program between MWA and USGS, the USGS performs monitoring of groundwater levels, groundwater quality, surface water flows, and regional water level changes and subsidence. Each of these is described below.

F.4.1 Groundwater Levels and Water Quality

The USGS monitors 491 wells within and in the areas adjacent to the MWA Service Area, from which water level data and water quality samples are collected. These measurements are categorized as follows:

- 403 biennial water level wells
- 53 annual water level wells
- 25 semi-annual water level wells

- 10 water quality wells (An additional 35 wells are either biennial water level wells, annual water level wells, or semi-annual water level wells but are not included in the total of USGS monitoring wells.)

F.4.2 Surface Water Monitoring

The USGS operates and maintains the following gaging stations on the Mojave River:

- Deep Creek near Hesperia
- West Fork Mojave River above Mojave River Forks Reservoir near Hesperia
- Mojave River at Lower Narrows near Victorville
- Mojave River near Barstow
- Mojave River at Afton

Flows from these gaging stations are used by the Mojave Basin Area Watermaster to determine annual water balances within each subarea (see Section F.3).

F.4.3 Regional Water Level Changes and Land Subsidence

The USGS performed a study of land subsidence in the following four study areas using Interferometric Synthetic Aperture Radar (InSAR) methods (Sneed et al. 2003):

- El Mirage area (Oeste)
- Lockhart-Harper Lake area (Centro)
- Newberry Springs area (Baja)
- Lucerne Valley area (Este)

The study was performed as part of a cooperative program with the USGS. This program will continue in the future, and will be expanded to determine the relationship between groundwater levels and land surface elevation changes.

F.5 Morongo Basin/Johnson Valley Area

F.5.1 Warren Valley Basin Watermaster

The Warren Valley Basin Watermaster performs monitoring in accordance with the Rules and Regulations of the Warren Valley Watermaster (1995). The Hi-Desert Water District acts as Watermaster. The following is a summary of monitoring currently performed by the Watermaster.

F.5.1.1 Water Production and Verification

The Judgment requires that annual water production records be collected and verified by producers exceeding one afy of production. The Watermaster is required to charge a production levy against any producer that exceeds their production right.

F.5.1.2 Water Level Measurement

The Watermaster takes water level measurements four times each year on a quarterly basis.

F.5.1.3 Water Quality

Each producing well must be tested by the well owner for nitrates and total dissolved solids every six months.

Locations of surface water monitoring stations (stream gauges) and wells that are monitored for groundwater elevations are shown on Figure F-1. Locations of wells that are sampled for groundwater quality are shown on Figure F-2.

F.6 CIMIS Weather Stations

The California Irrigation Management Information System (CIMIS) is a repository of meteorological data collected throughout the State of California. CIMIS is an integrated network of over 100 computerized weather stations located at key agricultural and municipal sites within the state. Comprehensive and timely weather data are collected daily from each weather station. The data are automatically transmitted each night to a computer in Sacramento. Weather data are analyzed for accuracy and stored in the CIMIS database to provide on-demand, localized weather information.

Based on weather data, CIMIS can calculate estimates of the amount of water evaporated from the soil and the amount actually transpired by irrigated grass at the weather station site. Growers can then calculate the appropriate amounts of water to apply to their fields. The ultimate purpose of CIMIS is to encourage growers and turf managers to adopt and use water budget irrigation scheduling so that water is used as efficiently as possible.

CIMIS has operated six stations within the Mojave IRWM Region boundaries; station 117 near the City of Victorville, station 192 near Lake Arrowhead and station 233 near Joshua Tree are currently active. Three other stations have been active in the past, two in Barstow and one in Newberry Springs. Locations of these CIMIS stations are shown on Figure F–3. Data available on CIMIS stations is shown below in Table F–1.

Table F-1 CIMIS Stations

Station #, Name	County	Start	End
60 - Barstow	San Bernardino	20-Nov-86	20-Feb-92
110 - Newberry Springs	San Bernardino	21-Feb-92	27-Dec-96
117 - Victorville	San Bernardino	1-Feb-94	ACTIVE
134 - Barstow NE	San Bernardino	8-Jan-97	30-Oct-13
192 – Lake Arrowhead	San Bernardino	11-Mar-04	ACTIVE
233 – Joshua Tree	San Bernardino	16-Nov_11	ACTIVE

Figure F–1
Groundwater and Surface Water Monitoring Sites

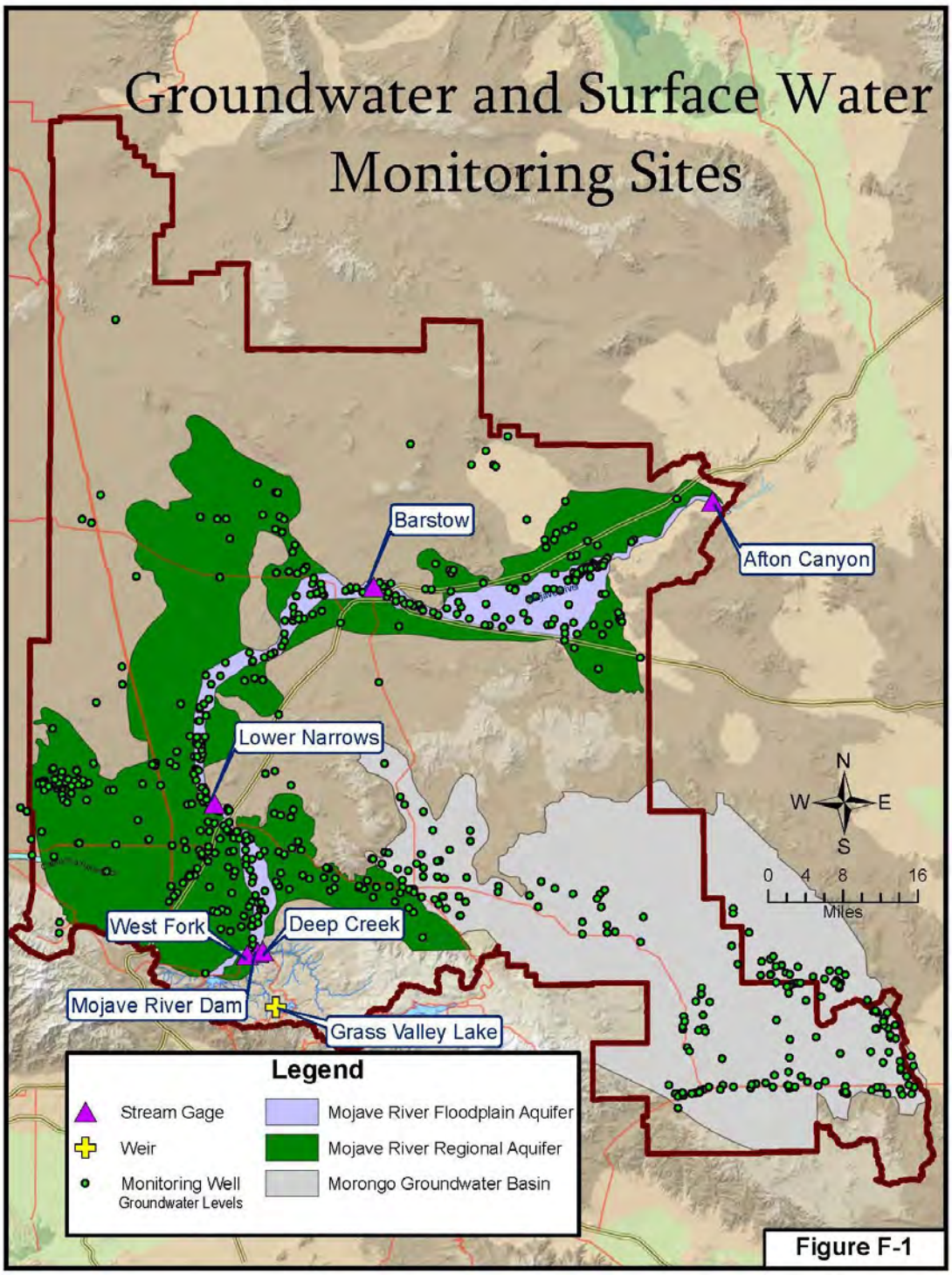


Figure F–2
Groundwater Quality Monitoring Sites

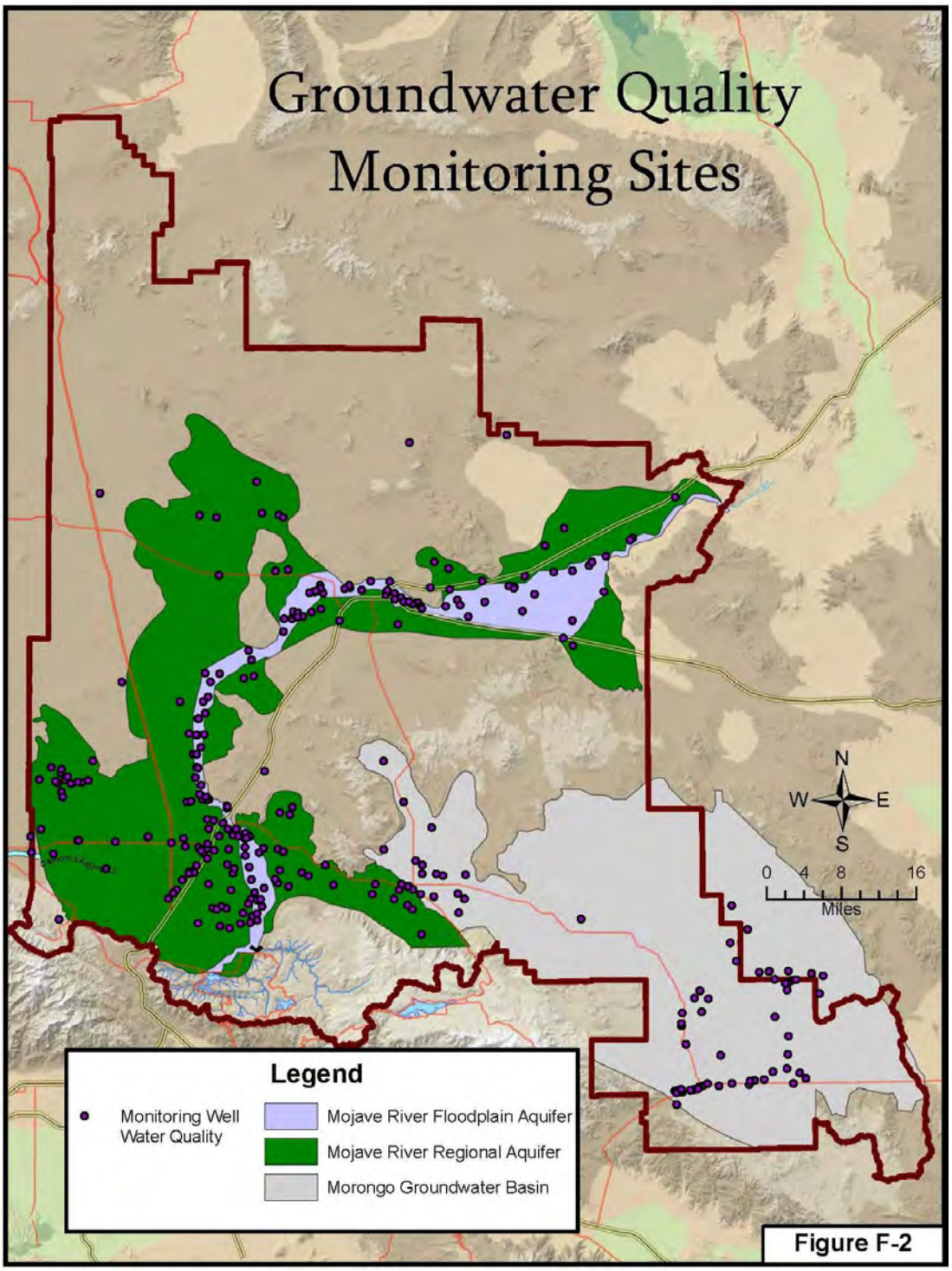
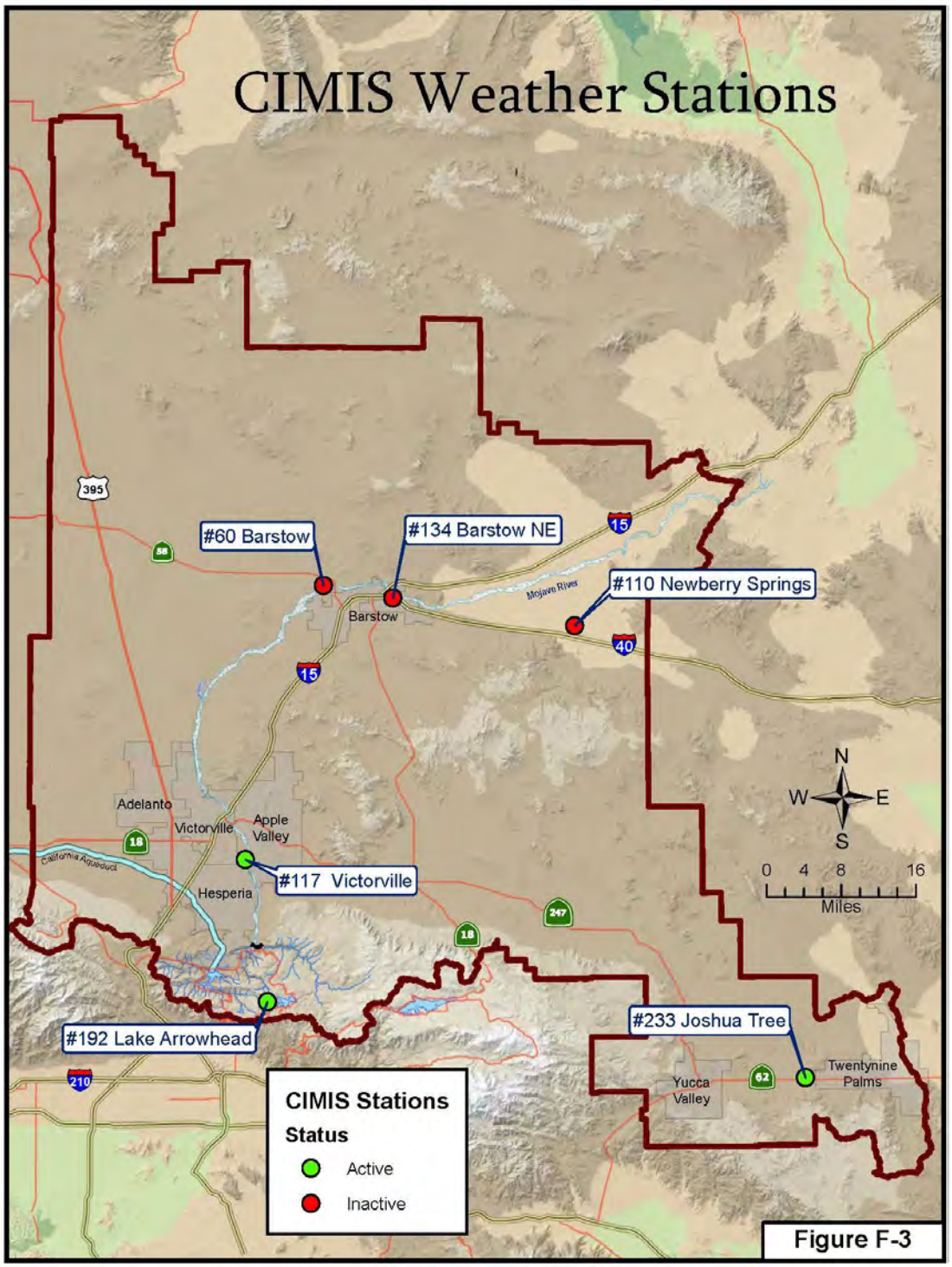


Figure F–3
CIMIS Weather Stations



Satellite images

SEBAL (Surface Energy Balance Algorithm for Land) is a new technology that uses data gathered by satellite-based sensors to compute the energy balance at the earth's surface. Evapotranspiration (ET) is predicted as a residual of the energy balance, without having to know crop or vegetation type, or other ground-based information, except routine weather data. ET is computed at the instant of the satellite image, and can be extrapolated to daily and monthly values for use in hydrologic investigations. The spatially discrete information generated by SEBAL supports water management innovation at the farm, district, river basin, national and international scales.

SEBAL is an image-processing model comprised of twenty-five computational steps that calculate ET flux and other energy exchanges at the earth's surface using digital image data collected by Landsat, MODIS, or other remote-sensing satellites measuring visible, near-infrared and thermal infrared radiation. Basically, ET is computed from an energy balance equation for each image pixel.

SEBAL is most applicable in situations where the magnitude and/or spatial distribution of consumptive depletion must be accurately estimated. From a water management perspective, these needs tend to emerge as river basins or groundwater basins approach closure, the condition where little or no potential remains to develop additional supplies, and attention focuses on managing consumptive depletion. MWA has historically used and can potentially continue to use SEBAL as part of comprehensive basin modeling efforts.

Additional monitoring protocols developed as part of this Plan are presented in Section 10.

F.7 Monitoring and Management Component Historical Background Data

This section provides a brief description of issues that pertain to particular aspects of the groundwater basins underlying the MWA. These aspects are described here or a reference to locate a more thorough discussion in another chapter is provided to avoid redundancy.

F.7.1 Identification, Management, and Protection of Wellhead and Recharge Areas

The MWA does not currently have a plan for well identification, management, and protection of wellhead and recharge areas.

F.7.2 Well Abandonment and Destruction Program

The MWA does not have a specific well abandonment and destruction program that they administer. Rather, the Agency relies on the County of San Bernardino to provide policy guidance and regulation of well abandonment and destruction. The County has adopted standards contained in the California Water Well Book.

The destruction of abandoned groundwater wells should be performed in accordance with state standards. California Water Code Section 13750.5 requires that those responsible for the destruction of water wells possess a C-57 Water Well Contractor's License. Whenever a water well is destroyed, a report of completion must be filed with the California Department of Water Resources within 60 days of the completion of the work.

F.7.3 Replenishment of Extracted Water

Water is extracted from the groundwater basins within the MWA's boundaries as the primary source of agricultural, municipal, and industrial water. These basins have been adjudicated in the Mojave River Basin Judgment (previously described) and the Morongo Basin Judgment (also previously described). As discussed in Section 3: Water Supply and Demand of the IRWM Plan, Table 3-6 shows that the total storage available in MWA's existing bank accounts is over 130,000 af of January 1, 2014. This stored water was all excess SWP water that MWA has purchased over past years and stored in various groundwater basins for use when SWP is limited or there are groundwater shortages.

F.7.4 Monitoring Levels and Storage

The MWA, as well as many other water purveyors and agencies with overlapping boundaries, monitor groundwater levels and estimate storage. A full discussion of past and present monitoring is provided in Section 10. A discussion of possible future monitoring is provided under the Monitoring Section in Section 10, Data Management, Technical Analyses, and Plan Performance.

F.7.5 Facilitating Conjunctive Use Operations

The Regional Water Management Plans published in 1992 and 2004 were designed to provide facilities that would assist in accepting as much SWP entitlement as possible for percolation into the groundwater basin for storage and use. This update to the IRWM Plan continues to describe ways to maximize surface water use with groundwater replenishment to stabilize the Mojave Regional and Floodplain Aquifers. The projects and management actions that are described in Section 6, Project Review and Prioritization, are designed to facilitate conjunctive use operations to the fullest. Please refer to Section 6 for a fuller discussion of these facilities.

F.7.6 Well Construction Policies

The MWA does not have specific well construction policies that they administer. Rather, the Agency relies on the County of San Bernardino to provide policy guidance and regulation of well construction. The County has adopted standards contained in the California Water Well Book.

The construction of groundwater wells should be performed in accordance with state standards. California Water Code Section 13750.5 requires that those responsible for the construction of water wells possess a C-57 Water Well Contractor's License. Whenever a water well is constructed, the driller must file a report of completion, called the *Well Completion Report*, DWR 188, with the California Department of Water Resources (DWR) within 60 days after completion of the work.

F.7.7 Groundwater Cleanup

The MWA does not have groundwater cleanup programs, nor does it track contaminated sites. MWA currently relies on the County of San Bernardino Department of Public Health Services, and its programs to deal with any of these issues. The Department of Public Health Services in turn relies on the State programs to track identification and remediation of known groundwater contamination.

The California Department of Toxic Substances Control (DTSC) is a part of the California Environmental Protection Agency (Cal EPA) and is responsible, among other programs, for dealing with improper hazardous waste management by overseeing site cleanups. As part of their cleanup program, DTSC has prepared guidelines for the investigation, monitoring and remediation of groundwater at hazardous substance release sites. The California Integrated Waste Management Board enforces the minimum environmental standards imposed by the State Water Resources Control Board upon closed, illegal or abandoned disposal sites.

The Regional Water Quality Control Board (RWQCB) maintains a Site Cleanup List. It incorporates data from the DTSC as well as the San Bernardino County Environmental Management Department's site inventory of hazardous material storage sites and underground storage tanks. The RWQCB's cleanup list shows sites that have degraded or threaten to degrade groundwater quality, including spill sites, above ground tank sites, and Department of Defense sites. The list is available to the public on the Internet at the following link: https://geotracker.waterboards.ca.gov/.

F.7.8 Groundwater Protection

Groundwater is a vital resource for the Mojave Region and must be diligently protected – both to maintain or improve quality and to ensure quantities are available to meet current and planned uses.

The general goal of groundwater protection activities is to maintain the groundwater and the aquifer in order to maintain a high quality supply available for use. Activities to meet this goal include continued and increased monitoring, data sharing, education and coordination with other departments and agencies that have local or regional authority or programs.

Efforts to protect groundwater quality can range in scale from protecting the entire watershed to protecting an individual well site. On the largest scale, an entire watershed can be managed in a way that protects the quality of groundwater and other natural resources within the watershed boundaries. In some cases, natural barriers may isolate aquifers from other regions in the watershed and groundwater protection efforts can be focused on the aquifers used for drinking water supplies. Wellhead protection and source water protection efforts involve protecting portions of the aquifer by protecting the land directly overlying well capture zones and areas of an aquifer that serve to recharge groundwater.

In the Mojave Region, there are a number of efforts underway by a variety of entities that focus on groundwater and other resource management.

F.7.8.1 Groundwater Monitoring

Current groundwater monitoring efforts are discussed in Section 10.

F.7.8.2 Well Site Management Activities

Well site management activities include a wide array of functions directed at creating consistency and quality in the drilling, construction, inspection and operation of municipal drinking water production wells. Diligent well site management provides multiple benefits ranging from reducing the opportunity for a well to become a direct conduit for contamination to providing early detection of potential compromises in groundwater quality at production wells. Activities include:

- Well Site Control – the Well Site Control Zone encompasses the area immediately surrounding the well. The purpose of this zone is to provide protection from vandalism, tampering, or other threats at the well site.
- Regular Well Inspection, Testing and Maintenance – Electrical systems that operate the pumps are inspected annually. A visual inspection of the well and the chlorination unit is performed at this time.
- Well Construction Standards – Municipalities follow California State standards developed by DWR that address a number of aspects of well construction intended to help prevent contamination of groundwater via the well.

F.7.8.3 Wellhead Protection

In 1996, the federal Safe Drinking Water Act (SDWA) was reauthorized. One of the amendments to the act required states to develop and implement a program to assess sources of drinking water and encouraged states to establish source water protection programs. The US Environmental Protection Agency (USEPA) envisions a state Source Water Assessment Program (SWAP) to be a partnership among local, state, and federal agencies to maintain safe, good quality drinking water.

Ten years prior to the 1996 Safe Drinking Water Act amendments, the SDWA established the Wellhead Protection Program (WHPP). Section 1428 of the SDWA (State Programs to Establish Wellhead Protection Areas) was intended to establish state programs that adequately protect the wellhead areas of all public water systems from contaminants that may adversely affect human health. Each state was to prepare a WHPP and submit it to EPA by June 19, 1989. Although there were many wellhead and groundwater protection efforts in California, the State did not develop a WHPP by the 1989 deadline. However, central elements of a WHPP—protection area and zone delineation, inventory of possible contaminating activities (PCAs), and vulnerability analysis—are also elements of a SWAP.

In California, the Department of Public Health (CDPH) Division of Drinking Water and Environmental Management is the lead agency for implementing California's drinking water protection program, called the Drinking Water Source Assessment and Protection (DWSAP) Program. In addition to the federal SDWA, there are California statutes that require development and implementation of programs to protect sources of drinking water. Section 116762.60 of the California Health and Safety Code requires CDPH to develop such a program, and the program is to include a source water assessment program and a wellhead protection program. The DWSAP satisfies the mandates of Section 116762.60 of the California Health and Safety Code and the federal SWAP and WHPP.

F.7.8.4 Drinking Water Source Assessment and Protection

Water agencies within the MWA that have completed assessments for their wells are summarized below in Table F-2, presenting stats of assessments as of September 2003 (the most recent available data at the time this appendix was completed). Assessments for private wells that supply groundwater for drinking water to restaurants, resorts and other commercial establishments have been conducted by CDPH.

Table F-2: Completed Assessment of Wells

Agency	DWSAP # of Sources
City of Adelanto	13
Apple Valley Ranchos Water Company	22
CSA 64	5
CSA 70J	4
GSWC - Barstow	17
Hesperia Water District	N/A
Hi-Desert Water District	16
Joshua Basin Water District	4
Lake Arrowhead CSD	2
MWA[(a)]	N/A
Phelan Piñon Hills CSD	N/A
Twentynine Palms Water District	11
City of Victorville - VWD	25

Source: CDPH's Division of Drinking Water and Environmental Management (DDWEM) established the California DWSAP Program and completes assessments and List of Sources Table. Latest Table available on website is September 2003.

F.7.8.5 Identification and Destruction of Abandoned Wells

The presence of abandoned groundwater wells represents a potential hazard to the quality of the groundwater basin. It is vital for the long-term health of the basin that abandoned wells be located and destroyed.

While it is the landowner's responsibility to destroy an abandoned well, local water agencies should be proactive about making sure that abandoned wells are in fact destroyed. There are currently no coordinated efforts to locate and destroy abandoned wells.

F.7.8.6 Hazardous Materials Response

The use, storage and transportation of hazardous materials and the generation and transportation of hazardous wastes are issues of increasing importance in the protection of life, the environment and property in the Mojave basin – and a concern for groundwater quality protection. Hazardous material emergencies may be the result of threatened releases, highway accidents, clandestine drug laboratories, train derailments, pipeline transportation accidents, and fire and/or spills at fixed facilities.

Hazardous material emergencies are not currently coordinated with MWA.

F.7.8.7 Watershed Management

MWA coordinates with watershed related entities including the Mojave Desert Resource Conservation District and the US Bureau of Land Management.

F.7.8.8 Well Standards

Well standards are administered via the San Bernardino County Department of Public Health. The County's Safe Drinking Water Program protects drinking water resources by maintaining a

permitting system for water well construction and destruction, serving as the Local Primary Agency for small water systems, providing input into the land use process for the County, and by review of on-site sewage disposal conditions.

F.7.9 Water Conservation

Water conservation in the Mojave Desert is a strategic, collaborative effort that has led to a culture of change across the Region. Implementing a variety of strategies is the Alliance for Water Awareness and Conservation (AWAC,) which is a group of 25 member agencies including 15 water districts that help manage the Water Conservation Incentive Program (WCIP). This program offers rebates and other incentive programs that are used to help consumers use less water. AWAC also partners with 10 educational agencies that assist with education and outreach efforts.

F.7.10 Land Use Planning

Land uses in the Mojave Region have been primarily agricultural, urban and open space. Population growth is resulting in urbanization of some of the agricultural lands. MWA coordinates with several County departments in the review of land use plans to facilitate groundwater protection.