C. Fremont Valley Basin Salt and Nutrient Management Plan

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FREMONT VALLEY BASIN
SALT AND NUTRIENT MANAGEMENT PLAN

DECEMBER 2018

Prepared by the Regional Water Management Group of the
Fremont Basin Integrated Regional Water Management Region

FREMONT VALLEY BASIN

SALT AND NUTRIENT MANAGEMENT PLAN

December 2018

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ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
°F	Degrees Fahrenheit
µg/L	micrograms per liter
µmhos /cm	micromhos per centimeter
AC	Assimilative Capacity
AF	acre-feet
AFY	acre-feet per year
AGR	Agricultural Supply
AVEK	Antelope Valley East Kern Water Agency
Basin Plans	Regional Water Quality Control Board Basin Plans
bgs	below ground surface
BMP	Best Management Practices
BPTC	Best Practicable Treatment or Control
Cal Water	California Water Service Company
CASGEM	California Statewide Groundwater Elevation Monitoring
CCR	California Code of Regulations
CDPH	California Department of Public Health
CEC	Constituents of Emerging Concern
chromium-6	hexavalent chromium
CI	Commercial and Industrial
CIMIS	California Irrigation Management Information System
City	City of California City
DAC	Disadvantaged Community
DDW	Division of Drinking Water
DOF	Department of Finance
DWR	Department of Water Resources
DWT	Deep Well Turbine
EC	electrical conductivity
EC_{ct}	salt tolerance threshold
EDF	Electronic Deliverable Format
EPA	Environmental Protection Agency
ETc	Crop evapotranspiration
ETo	reference evapotranspiration
FRSH	Freshwater Replenishment
FVGB	Fremont Valley Groundwater Basin
GAMA	Groundwater Ambient Monitoring and Assessment
GIS	Geographic Information System
GPCD	gallons per capita per day
GSA	Groundwater Sustainability Agency

GSP	Groundwater Sustainability Plan
GWMP	Groundwater Management Plan
IND	Industrial Service Supply
IRWM	Integrated Regional Water Management
Kc	unique crop factor
lbs/acre	pounds per acre
LID	Low Impact Development
LRWQCB	Lahontan Region Water Quality Control Board
MAF	million acre-feet
MCL	maximum contaminant level
MG	million gallons
mg/L	milligram per liter
MGD	million gallons per day
MHI	mean household income
MOU	Memorandum of Understanding
MPUD	Mojave Public Utilities District
msl	mean sea level
MUN	Municipal and Domestic Supply
N	nitrogen
NA	not applicable
NAC	no Assimilative Capacity
N.D.	no date
NLs	notification levels
NUE	Nitrogen Update Efficiency
OWTS	Onsite Wastewater Treatment Systems
Plan	Salt and Nutrient Management Plan
QA/QC	Quality Assurance/Quality Control
RCWD	Rand Communities Water District
RMSE	root-mean-square-error
RWMG	Regional Water Management Group
RWQCB	Regional Water Quality Control Board
SCADA	Supervisory Control and Data Acquisition
SDWIS	Safe Drinking Water Information System
SGMA	Sustainable Groundwater Management Act
SMCL	secondary maximum contaminant level
SNMP	Salt and Nutrient Management Plan
SWP	State Water Project
SWRCB	State Water Resources Control Board
TDS	total dissolved solids
UAN	Urea Ammonium Nitrate Solution
USDA	United States Department of Agriculture

USGS	U.S. Geological Survey
UV	Ultraviolet Disinfection
UWMP	Urban Water Management Plan
WQO	Water Quality Objective
WWTP	wastewater treatment plant

1. INTRODUCTION

This Salt and Nutrient Management Plan (SNMP or Plan) was prepared for the Fremont Valley Groundwater Basin (FVGB) to fulfill the requirements of the State's *Policy for Water Quality Control for Recycled Water* (Recycled Water Policy). The FVGB SNMP development was led by the City of California City (City), the Antelope Valley East Kern Water Agency (AVEK), and the Mojave Public Utilities District (MPUD), in collaboration with local and regional stakeholders and in accordance with the Recycled Water Policy. The primary purpose of the SNMP is to assist the City, AVEK, MPUD, and stakeholders in complying with the Recycled Water Policy regarding the use of recycled water from municipal wastewater treatment facilities. The Recycled Water Policy supports use of recycled water as a source of water supply while requiring the management of salts and nutrients from all sources on a sustainable basis and maintaining water quality objectives and protection of beneficial uses covered by each of the Regional Water Quality Control Board (RWQCB) Basin Plans (Basin Plans).

The FVGB supports a wide range of beneficial uses in the Plan area (described in Sections 2 and 3). Beneficial uses of individual water bodies in the Plan area are designated and maintained by the RWQCB for the Lahontan Region (LRWQCB) and the Lahontan Region Water Quality Control Plan (Basin Plan). The communities overlying the FVGB include urban areas as well as rural and small agricultural lands. The FVGB is used as the primary supply source in the Plan area, in addition to imported surface water and recycled water generated by the City's Wastewater Treatment Plant (WWTP). Stormwater is not currently being captured for beneficial use in the Plan area. Recycled water is currently used in the City's existing ponds and served to irrigate park and golf course areas. Recycled water supply is projected to increase in the future as the City's population grows and the City expands its WWTP. The City is exploring the feasibility of using recycled water on a second golf course, in addition to expanding use for green belts and other end uses. This SNMP is intended to inform future decisions for use of recycled water and help streamline permitting of future recycled water projects while protecting the basin water quality objectives and beneficial uses.

In the FVGB, there were three planning efforts undertaken in parallel, including the SNMP, the Fremont Basin Integrated Regional Water Management (IRWM) Plan and the Fremont Valley Basin Groundwater Management Plan (GWMP). The City, as the lead agency, coordinated with AVEK and MPUD during preparation of these three planning efforts.

1.1 Plan Purpose

The objectives of the SNMP are to:1) gather available water quality information to evaluate the quality conditions of the basin; 2) identify potential sources of salts and nutrients and quantify loading estimates for identified sources; 3) determine assimilative capacity of the groundwater basin based on hydrologic and geologic characteristics and existing and future land use conditions; 4) develop a preliminary water quality monitoring plan; 5) identify and recommend the most appropriate methods and best management practices for reducing and/or maintaining salt and nutrient loading; and 6) propose an implementation plan that will satisfy the requirements of the State's Antidegradation Policy and Recycled Water Policy. This SNMP includes an analysis of the existing land uses and practices, as well as potential changes to land uses, groundwater resources, and usage of recycled water for managing salt and nutrients in a sustainable manner. Also contained herein is a preliminary monitoring plan for implementation to evaluate the effects of salt and nutrient sources on the FVGB with respect to beneficial uses supported within the basin and applicable water quality objectives.

1.2 Regulatory Framework

The State of California adopted the Recycled Water Policy in 2009, requiring each recycled water provider prepare a SNMP to manage salts, nutrients, and other significant chemical compounds on a watershed- or basin-wide basis. The following is a description of the Recycled Water Policy and the LRWQCB, which is responsible for its implementation in the Plan area.

1.2.1 SWRCB Recycled Water Policy

The State Water Resources Control Board (SWRCB) Recycled Water Policy requires that SNMPs be completed and submitted to the local RWQCB for adoption into the implementation chapter of the regional Basin Plans. SNMPs are to be developed in a cooperative and collaborative manner among water and wastewater agencies and other stakeholders overlying a given groundwater basin or watershed. The purpose of the Recycled Water Policy is to increase the use of recycled water from municipal wastewater sources that meets the definition in Water Code Section 13050(n) in a manner that implements state and federal water quality laws. When used in compliance with the Recycled Water Policy, California Code of Regulations (CCR) Title 22, and all applicable state and federal water quality laws, the SWRCB finds that recycled water is safe for the approved uses, and strongly supports recycled water as a safe alternative to potable water for such approved use.

The Recycled Water Policy was amended in 2013 to specify monitoring requirements for constituents of emerging concern (CECs) in recycled water for groundwater recharge projects. In December 2016, the SWRCB adopted Resolution No. 2016-0061, which directed staff to update its recommendations for monitoring CECs in recycled water and update the Recycled Water Policy considering changes that have taken place since 2013. The proposed amendment to the Recycled Water Policy was released in May 2018 for public comment. A public hearing was held on June 19, 2018 with a written letter submittal deadline of June 26, 2018. The proposed final amendment to the Recycled Water Policy was released in August 2018 with a comment deadline of September 2018. Responses to comments were completed on November 30, 2018, and a summary of changes was released on December 7, 2018.

1.2.2 Lahontan Regional Water Quality Control Board

The Recycled Water Policy requires RWQCBs to review SNMPs and consider them for adoption as Basin Plan Amendments (or other official action) within one year of submission. The LRWQCB (Region 6) is the agency responsible for protecting water quality in the FVGB and oversees the development and implementation of the SNMPs for groundwater basins in accordance with the Recycled Water Policy. This SNMP was developed in a collaborative effort with local and regional stakeholders, including the LRWQCB. In addition, the LRWQCB has been part of the SNMP development by attending regular IRWM stakeholder meetings during which development of this SNMP was discussed, and by participating in two focused RWQCB meetings conducted in April and May of 2018 (with staff and RWQCB members, respectively). These meetings provided a forum for explaining the SNMP development, approaches and progress made; they also provided an opportunity to receive feedback from the LRWQCB on the overall methodology proposed and the schedule for review and approval of the SNMP by the LRWQCB. Regulatory coordination with the LRWQCB is further described in Section 2 as part of the stakeholder outreach process.

1.2.2.1 Basin Plan Water Quality Objectives

Basin Plans by RWQCBs are mandated by both the Federal Clean Water Act and the State Porter-Cologne Water Quality Act. There are nine RWQCBs statewide and regional boundaries are based on watersheds. Each RWQCB makes water quality decisions for its region in the Basin Plans that address the protection of beneficial uses, develop water quality objectives, and direct the implementation of programs to achieve water quality objectives. Basin Plans establish water quality standards for surface water and groundwater in a given basin based upon designated uses of water and numerical objectives that must be maintained to protect beneficial uses. The LRWQCB Basin Plan for the FVGB provides the basis for the regulatory guidelines, specific beneficial uses, and water quality objectives for groundwater and surface water within its region; and it provides implementation plans that describe permitting options, waste discharge prohibitions, monitoring and enforcement, salt and nutrient controls, and other control measures to preserve and protect water quality objectives and beneficial uses for groundwater and surface waters.

The LRWQCB Basin Plan establishes the following beneficial uses of groundwater for the FVGB: municipal and domestic supply (MUN), agricultural supply (AGR), industrial service supply (IND), and freshwater replenishment

(FRSH). Basin-specific water quality objectives for the FVGB are not identified in the Basin Plan; therefore, water quality objectives which apply to all groundwaters in the Basin Plan are used for the FVGB. Per the Lahontan Basin Plan, groundwater designated as MUN shall not contain concentrations of chemical constituents in excess of the maximum contaminant level (MCL) or secondary MCL (SMCL) based upon drinking water standards specified in CCR Title 22. Water designated for AGR uses is not to contain concentrations of chemical constituents in amounts that adversely affect the water for beneficial uses for agricultural purposes.

These designated beneficial uses are the basis for the designation of water quality objectives within the Basin Plan, as follows:

Bacteria, Coliform - In groundwaters designated as MUN, the median concentration of coliform organisms over any seven-day period shall be less than 1.1/100 milliliters.

Chemical Constituents - Groundwaters designated as MUN shall not contain concentrations of chemical constituents in excess of the primary MCL or SMCL based upon drinking water standards specified in the following provisions of CCR Title 22, which are incorporated by reference into the Basin Plan: Table 64431-A of Section 64431 (Inorganic Chemicals), Table 64431-B of Section 64431 (Fluoride), Table 64444-A of Section 64444 (Organic Chemicals), Table 64449-A of Section 64449 (Secondary Maximum Contaminant Levels-Consumer Acceptance Limits), and Table 64449-B of Section 64449 (Secondary Maximum Contaminant Levels-Ranges). This incorporation-by-reference is prospective including future changes to the incorporated provisions as the changes take effect. Waters designated as AGR shall not contain concentrations of chemical constituents in amounts that adversely affect the water for beneficial uses (i.e., agricultural purposes).

Radioactivity - Groundwaters designated as MUN shall not contain concentrations of radionuclides in excess of the limits specified in Table 4 of Section 64443 (Radioactivity) of CCR Title 22, which is incorporated by reference into the Basin Plan. This incorporation-by-reference is prospective including future changes to the incorporated provisions as the changes take effect.

Taste and Odor - Groundwaters shall not contain taste or odor-producing substances in concentrations that cause nuisance or that adversely affect beneficial uses. For groundwaters designated as MUN, at a minimum, concentrations shall not exceed adopted SMCLs specified in Table 64449-A of Section 64449 (Secondary Maximum Contaminant Levels-Consumer Acceptance Limits), and Table 64449-B of Section 64449 (Secondary Maximum Contaminant Levels-Ranges) of CCR Title 22, which is incorporated by reference into the Basin Plan. This incorporation-by-reference is prospective including future changes to the incorporated provisions as the changes take effect.

The numerical water quality objectives for groundwater in the FVGB are the recommended SMCL of 500 milligrams per liter (mg/L) for total dissolved solids (TDS) with upper limit SMCL of 1,000 mg/L and short-term limit of 1,500 mg/L. Nitrate as nitrogen (N) has a water quality objective of 10 mg/L based on the MCL for groundwater designated as MUN in the Basin Plan (Table 1). This SNMP evaluated the assimilative capacity of the FVGB both based on the recommended SMCL of 500 mg/L and upper limit SMCL of 1,000 mg/L for TDS. For the purpose of this SNMP, the upper limit SMCL of 1,000 mg/L for TDS and the MCL of 10 mg/L for nitrate-N were considered as the water quality objectives for the assimilative capacity of the FVGB.

Table 1: Basin Plan Objectives for TDS and Nitrate-N

Constituents	Basin Plan Objectives
TDS	Recommended SMCL of 500 mg/L; Upper Limit SMCL of 1,000 mg/L; Short-Term Limit of 1,500 mg/L
Nitrate-N	10 mg/L

1.2.3 Antidegradation Policy Summary

SWRCB Resolution 68-16, known as the Antidegradation Policy, requires that the LRWQCB regulate the discharge of waste materials to maintain the high quality of waters of the State. Waste Discharge Requirements for facilities must ensure that beneficial uses of groundwater are not unreasonably affected. In addition, the facility must meet a standard of Best Practicable Treatment or Control (BPTC) for discharged wastes.

The "Statement of Policy with Respect to Maintaining High Quality of Waters in California," known as the Antidegradation Policy, was adopted in 1968 and requires the continued maintenance of existing high quality waters. It provides conditions under which a detrimental change in water quality is allowable, including that a change must:

- Be consistent with maximum benefit to the people of the State;
- Not unreasonably affect present and anticipated potential beneficial uses of water, and;
- Not result in water quality less than that prescribed in water quality control plans or policies.

1.3 Sustainable Groundwater Management Act

The Sustainable Groundwater Management Act (SGMA) was passed into California law in 2014 and took effect in January 2015. SGMA requires that state-designated high and medium priority groundwater basins form one or more Groundwater Sustainability Agencies (GSAs) by June 30, 2017, and that the GSAs must develop and implement one or more Groundwater Sustainability Plans (GSPs) by January 31, 2020 for critically overdrafted groundwater basins, or by January 31, 2022 for non-critically overdrafted groundwater basins. GSPs are considered a roadmap for how groundwater basins will reach and maintain long-term sustainability.

Prior to the passage of SGMA, the California Department of Water Resources (DWR) developed the California Statewide Groundwater Elevation Monitoring (CASGEM) program to track seasonal and long-term trends in groundwater elevations in California's groundwater basins. The CASGEM priorities were used to rank the priority of each groundwater basin in California as either very low, low, medium, or high. The FVGB has been designated as a low priority groundwater basin. In addition, DWR identified the basins and subbasins that are in conditions of critical overdraft. Twenty-one basins and subbasins were identified; the FVGB was not identified as a critically-overdrafted basin.

While low and very low priority groundwater basins are not the focus of SGMA at this time, it is anticipated that they will need to develop GSAs and GSPs at a later time as determined by DWR and the SWRCB. The FVGB is designated as a "low priority" groundwater basin at this time; thus, the agencies within the Plan area are not subject to SGMA GSA and GSP requirements. However, the City, AVEK, and MPUD have initiated efforts to prepare the Plan area for SGMA compliance through the development of the Fremont Valley Basin GWMP for the FVGB (Woodard & Curran 2018). This GWMP was developed in coordination with the development of the SNMP and is intended to act as a "pre-GSP" document. The City, AVEK, and MPUD, as well as other key stakeholders in the Region, may elect to form a GSA in the future and develop a GSP. This SNMP will support and inform the future development of a GSP for the FVGB with respect to basin management strategies, monitoring and implementation strategies related to water quality from recycled water use.

1.4 Document Organization

This SNMP is prepared according to the Recycled Water Policy requirements and includes the following sections:

- Section 1, Introduction: Provides information on the purpose of the SNMP development, regulatory background, and document organization.

- Section 2, Stakeholder Involvement: Describes the collaborative process undertaken during the development of the SNMP, including stakeholder involvement and outreach, stakeholder identification processes, stakeholder meetings, and regulatory coordination.
- Section 3, Plan Area: Presents background information of the Plan area with respect to climate, land use, water resources, water demand, and other planning efforts undertaken in the Plan area.
- Section 4, Basin Characterization: Presents a summary description of the basin hydrogeology, groundwater conditions, and groundwater quality with respect to salt and nutrients in particular.
- Section 5, Water Demand and Supplies: Presents the current and future projections of water demand and supply conditions in the Plan area.
- Section 6, Basin Management Goals: Describes the recycled water and stormwater goals within the FVGB.
- Section 7, Salt and Nutrient Loading Analysis: Presents the approach and methodology used for characterization of salt and nutrients, loading analysis, and findings.
- Section 8, Antidegradation Analysis: Presents the approach and methodology used for antidegradation assessment and findings.
- Section 9, Monitoring Plan: Describes a preliminary monitoring plan developed for the SNMP to evaluate the effects of salt and nutrient sources on the FVGB.
- Section 10, Plan Implementation: Presents groundwater management strategies and projects to manage salt and nutrients from potential sources on a sustainable basis to protect beneficial uses and water quality objectives of the basin in the context of potential changes to future land use, groundwater resources, and recycled water use.
- Section 11, References: Provides a list of documents referenced in the SNMP.

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2. STAKEHOLDER INVOLVEMENT

The Recycled Water Policy states that development of a SNMP shall be a stakeholder-driven process. The Fremont Valley Basin SNMP was developed in a collaborative setting with input from a wide range of stakeholders through a series of meetings and workshops. As described in this section, most of the stakeholder participation and outreach occurred during stakeholder group and working group meetings in the context of the Fremont Basin IRWM planning effort. The stakeholder outreach framework developed for the Fremont Basin IRWM Plan was utilized to coordinate meetings, communicate with stakeholders, obtain input on technical analysis and direction of the Plan, and guide the development of the Plan. This section contains descriptions of the process used to identify stakeholders, stakeholder group composition, meetings, and regulatory coordination processes.

2.1 Stakeholder Composition

The development of the SNMP was led by the City in close collaboration with AVEK, MPUD, and other regional stakeholders. SNMP outreach efforts were directed at stakeholders from local water agencies, state and federal agencies, municipalities, regulatory agencies, and local community groups, including tribal communities, disadvantaged communities (DACs), and other community associations. Cities, districts, water purveyors, and other organizations that participated in the development of the SNMP are listed in Table 2. The City coordinated with the stakeholders to reach consensus regarding the level of stakeholder participation appropriate for the larger IRWM planning effort and to identify ways to effectively involve as many stakeholders as practical. Figure 1 shows the boundary of the FVGB and the IRWM Plan area. The IRWM boundaries coincide with the SNMP Plan area along the southern portion of the FVGB and encompass a greater region than the SNMP Plan area in the northern part of the FVGB. Figure 2 shows the boundaries of the participating cities, agencies, and communities located within the Plan area. The boundaries for this SNMP area coincide with the FVGB boundaries.

The stakeholder process undertaken through the Fremont Basin IRWM Plan encouraged stakeholder involvement in the concurrent development of the SNMP and the Fremont Valley Basin GWMP. The Fremont Basin IRWM Region (Region) was formed in 2011 to be the most inclusive, contiguous area to represent the common water management issues and needs of the Region. The primary hydrologic feature of the Fremont Basin IRWM Region is its position overlying the FVGB (Figure 1). The Regional Water Management Group (RWMG) for the IRWM Region (consisting of the City, MPUD, and AVEK) was created in 2014 to facilitate collaboration and coordination throughout the Region. The RWMG developed an initial stakeholder list to aid in publicizing the IRWM Plan and soliciting groups that may want to participate in the IRWM Plan, SNMP, and GWMP development. Because groundwater from the FVGB is the primary water source in the Region, issues related to groundwater supply and quality are a priority concern for the Region. For this reason, the IRWM stakeholder list was considered appropriate for the SNMP effort. The RWMG is discussed further in Section 2.1.1.

The City led outreach efforts to IRWM stakeholders for the SNMP using the Fremont Basin IRWM email list and website. The email list was developed based on groups that had shown interest in the program and those that attended IRWM stakeholder meetings. Individual stakeholders were also identified and contacted directly by email and phone to introduce them to the IRWM Plan, as well as the GWMP and SNMP efforts. The IRWM Plan website was developed for the Region to inform the public of upcoming stakeholder meetings and other related-efforts, including updates related to the GWMP and SNMP development. This website can be accessed at https://www.facebook.com/profile.php?id=100010202116257. Additionally, the City maintains a portion of their website dedicated to IRWM planning efforts, including the GWMP and SNMP development (http://www.californiacity-ca.gov/CC/index.php/fremont-basin-irwm). Through the email list and website, the RWMG solicits participation from interested stakeholders and keeps the public informed about the progress regarding the three parallel planning efforts (Fremont Basin IRWM Plan, Fremont Valley Basin SNMP, and Fremont Valley Basin GWMP). Additional information about stakeholder outreach can be found in Section 2.2.

Table 2: Fremont Valley Basin SNMP Stakeholders (based on the Fremont Basin IRWM Program)

Entity Type	Agencies and Organization	
Wholesale, Retail Water Agencies, and Local Water Purveyors	Antelope Valley-East Kern Water Agency City of California City California Water Service Company	Mojave Public Utilities District Rancho Seco Inc. Rand Communities Water District Rosamond Community Services District
Wastewater Agencies	City of California City Kern County	Mojave Public Utilities District
Flood Control Agencies	City of California City	Kern County
Municipal and County Governments and Special Districts	City of California City Cantil	Kern County Mojave Chamber of Commerce
Environmental Organizations	Desert Tortoise Preserve Committee Friends of Jawbone Canyon	Eastern Kern County Resource Conservation District
Industry Organizations	Kern County Ag Commissioner Kern County Farm Bureau	Golden Queen Mining Mojave Air and Space Port
State Agencies	Department of Water Resources	Lahontan Regional Water Quality Control Board
Federal Agencies	Bureau of Land Management	
Media	Mojave Desert News	
DAC Representatives	Rancho Seco, Inc	Rand Communities Water District
Native American Tribes	Tubatulabal Indian Tribe	Tejon Tribe
Other Stakeholders	Private Land Owners	

Figure 1: Fremont Basin IRWM Region

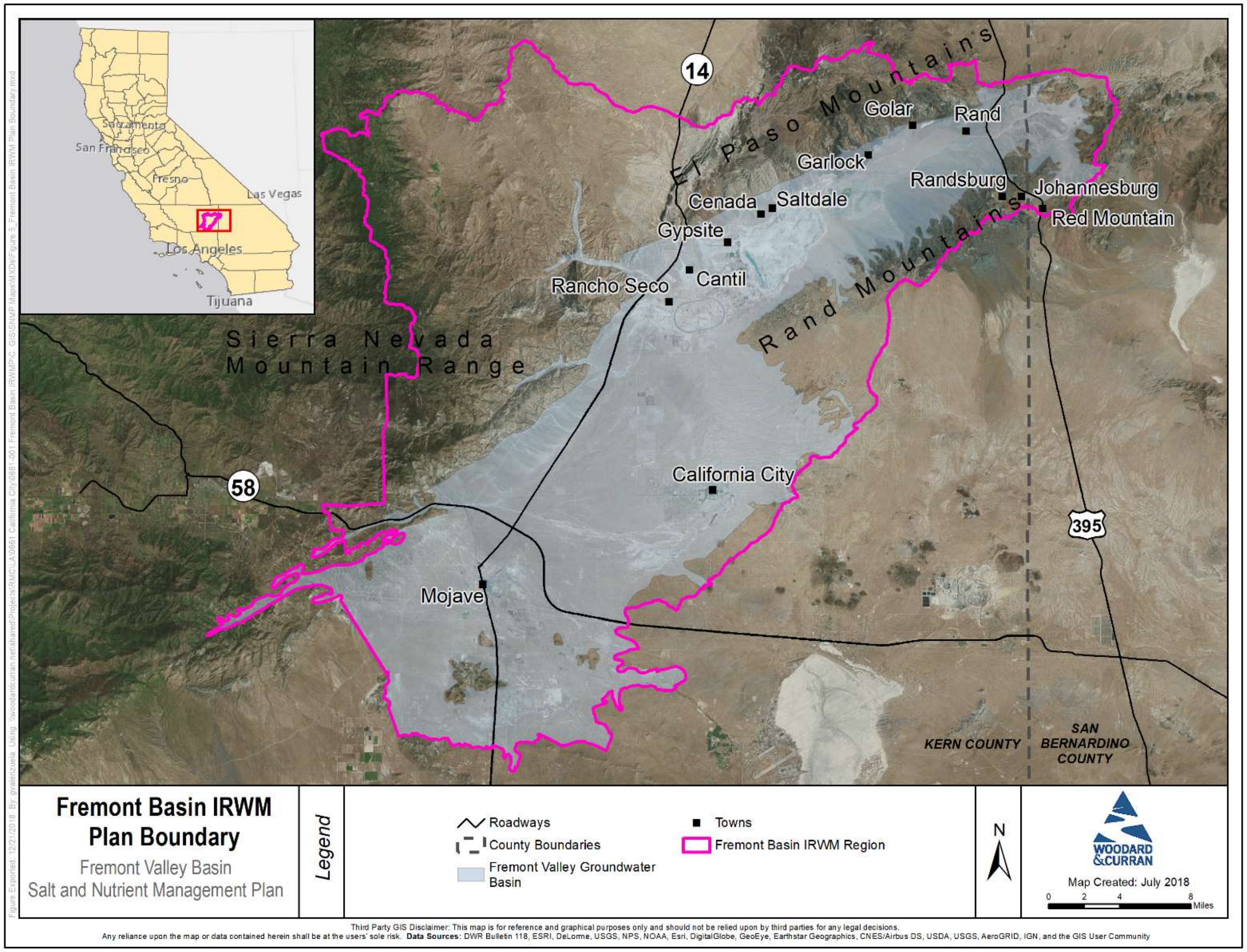
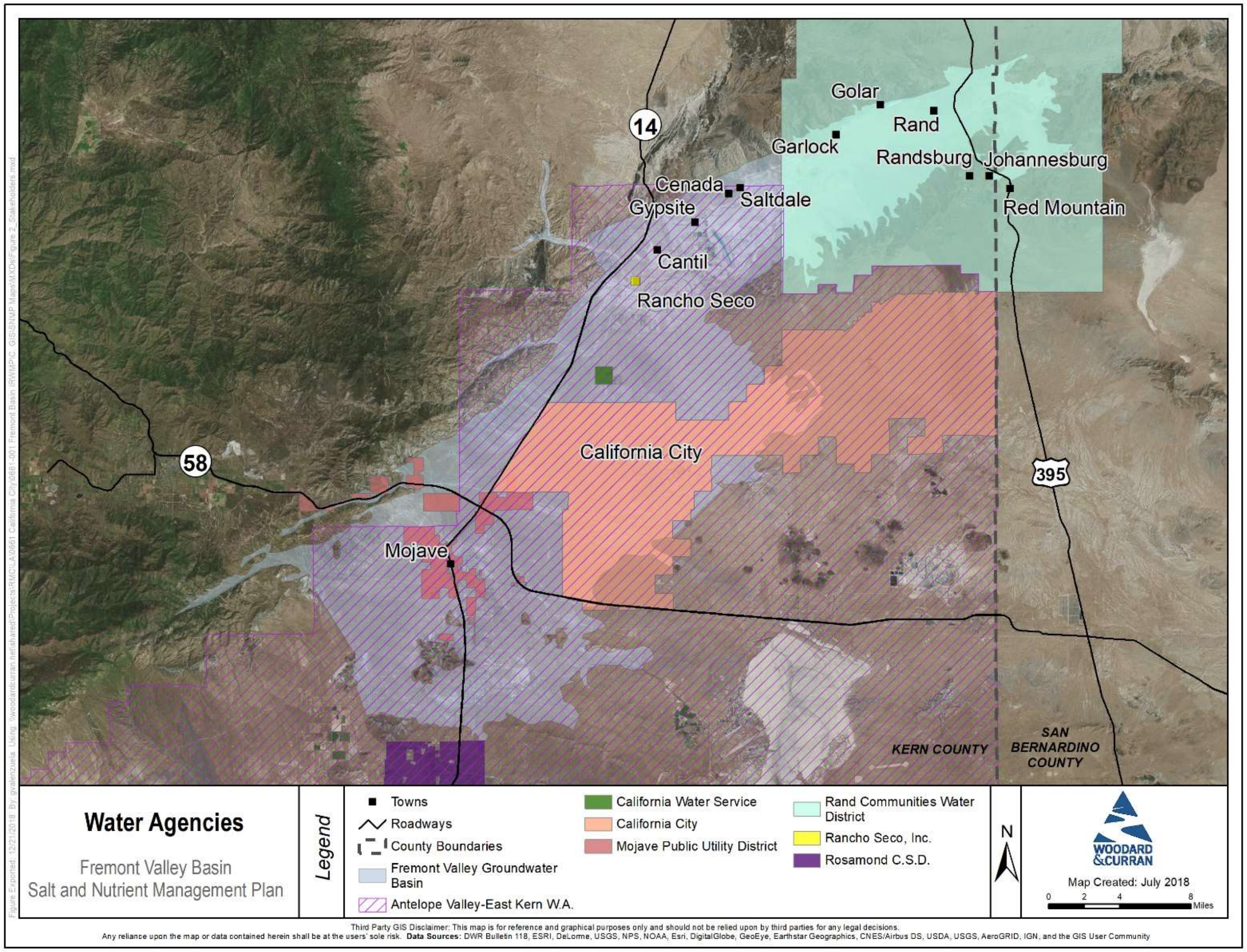


Figure 2: Water Agencies Participating in Fremont Valley Basin SNMP Development



The Fremont Basin IRWM stakeholders that have been identified and contacted through outreach efforts represent a range of interests specific to the Plan area. These stakeholders are listed in Table 2.

As part of the larger stakeholder effort for the Fremont Basin IRWM Plan development, the RWMG also identified DACs and tribal communities to identify, invite, and involve groups that could represent the interests and needs of these communities. The goals of the DAC outreach efforts are to encourage participation by DACs, solicit input for updates, and educate target audiences about the purpose and benefits of the three planning efforts for the IRWM, SNMP, and GWMP. Because the majority of the Fremont Basin IRWM Region is considered disadvantaged (having a median household income [MHI] below 80 percent of the Statewide MHI) or severely disadvantaged (MHI less than 60 percent of the Statewide MHI), the majority of the stakeholder outreach efforts involved DACs. To facilitate participation of DACs in the Plan development process, the RMWG made multiple efforts to reduce potential barriers to DAC involvement. For example, the RWMG held stakeholder meetings in different locations throughout the Plan area, including more isolated areas where representatives of DACs and severely DACs have better access to attend meetings. Additionally, because not all stakeholders have the same access to online sources and email, stakeholder meeting announcements are communicated through multiple media sources, including newspaper announcements, the City website, the Fremont Basin Facebook page, email notifications, and phone calls to specific groups, when appropriate.

There were no tribal interests or water issues specific to Native American Tribal Communities that were identified through this outreach process.

2.1.1 Regional Water Management Group

The RWMG was formed to facilitate coordination, collaboration, and communication between all stakeholders in the IRWM Region. On October 21, 2014, the City, MPUD, and AVEK signed a memorandum of understanding (MOU) forming the Fremont Basin RWMG, defining the organization, responsibilities, and governance structure for the Fremont Basin RWMG. The City is the lead agency tasked with providing meeting organization and startup funding for the IRWM Plan. The RWMG agreed to fund the development of the first Fremont Basin IRWM Plan, including the development of the SNMP and the Fremont Valley Basin GWMP, and to provide and share information for the Plan development, review drafts, adopt the final IRWM Plan, and assist with future grant applications (California City, MPUD, AVEK, 2014).

The RWMG acts as the oversight body for the Fremont Basin IRWM Region and is leading the effort to maintain sustainable groundwater management in the FVGB through the development of the GWMP and SNMP. The RWMG makes decisions about SNMP development and implementation based on the recommendations and information received from the stakeholder group and specialized working groups that provide input on key topics. The role of the RWMG is to provide leadership and guidance for planning and project implementation in the Region. The RWMG oversees the development of the SNMP to support the IRWM Plan, including coordination and data collection. The group also directs program activities, reviews projects submitted to the IRWM Plan, and submits grant applications to the State on behalf of the IRWM Region. The RWMG performs strategic and financial decision-making and conducts program advocacy to optimize water resources protection in the FVGB.

To perform its role, the RWMG meets publicly at least quarterly to discuss policy and IRWM project selection with stakeholders, including DACs and tribal communities. The RWMG seeks to achieve consensus from the stakeholder group on key topics related to the IRWM Plan, the Fremont Valley Basin GWMP, and SNMP development at stakeholder meetings. Decisions within the RWMG are based on input and recommendations from the working groups, stakeholder group, DACs, and tribes; and decisions are made using broad facilitated agreement, led by the RWMG.

2.2 Stakeholder Outreach and Meetings

Stakeholders are an important part of the SNMP development process. Stakeholder involvement ensures the SNMP is developed to incorporate the interests of a variety of stakeholders, including non-profit groups, public agencies, organizations, and individuals. Stakeholders are not required to provide financial contributions to be engaged in the regional planning effort. Instead, they are encouraged to participate in the SNMP development through providing information and participating at stakeholder meetings and in working groups.

Stakeholder meetings were a key component in the Plan development as they provided an opportunity for stakeholders to contribute information, express concerns, provide recommendations, and relay information to and from their organizations. Through the Fremont Basin IRWM Plan development process, three initial stakeholder group meetings were held between September 2015 and March 2016 to establish the program and prepare for a planning grant; and 12 stakeholder group meetings were held on a semi-monthly basis from July 2017 to June 2018 in conjunction with the Fremont Valley Basin SNMP development (funded by an IRWM Plan planning grant). Stakeholder meetings to date (including dates and locations) are summarized in Table 3. Meeting dates were announced on the Fremont Basin IRWM Facebook page and City website, as well as via email announcements sent to the stakeholder group.

Stakeholder meetings in 2015 and 2016 were primarily focused on introducing the Region to the IRWM Program and applying for IRWM Planning grant funding for IRWM Plan development. During the development of the SNMP in 2017 and 2018, meetings with stakeholders were held to discuss various topics, including the framework for SNMP, status of the SNMP development, data collection and needs for the basin characterization with respect to groundwater levels and water quality, roles and responsibilities of the agencies participating in the SNMP development, and future SNMP implementation. Though all stakeholder meetings covered material used for the SNMP development, five stakeholder meetings held in July 2017, September 2017, November 2017, March 2018, and August 2018 focused specifically on the SNMP development. Table 3 summarizes the stakeholder meetings held during the SNMP development including the SNMP topics covered, meeting dates, and locations. The Draft SNMP was released by the LRWQCB for public review on August 31, 2018, with comments on the draft SNMP due October 5, 2018. The Draft SNMP was presented publicly at a stakeholder meeting on September 20, 2018. Figure 3 presents the timeline of the overall stakeholder and collaborative process for the SNMP development.

In addition to the stakeholder meetings, several working group meetings were held during the SNMP development process to discuss data collection efforts, methodologies applied, and preliminary findings. Meeting dates, locations, and topics are summarized in Table 4. Similar to the stakeholder meetings, dates for the working group meetings were announced on the Fremont Basin IRWM websites, as well as via email announcements sent to the stakeholder group.

Figure 3: SNMP Collaborative Process

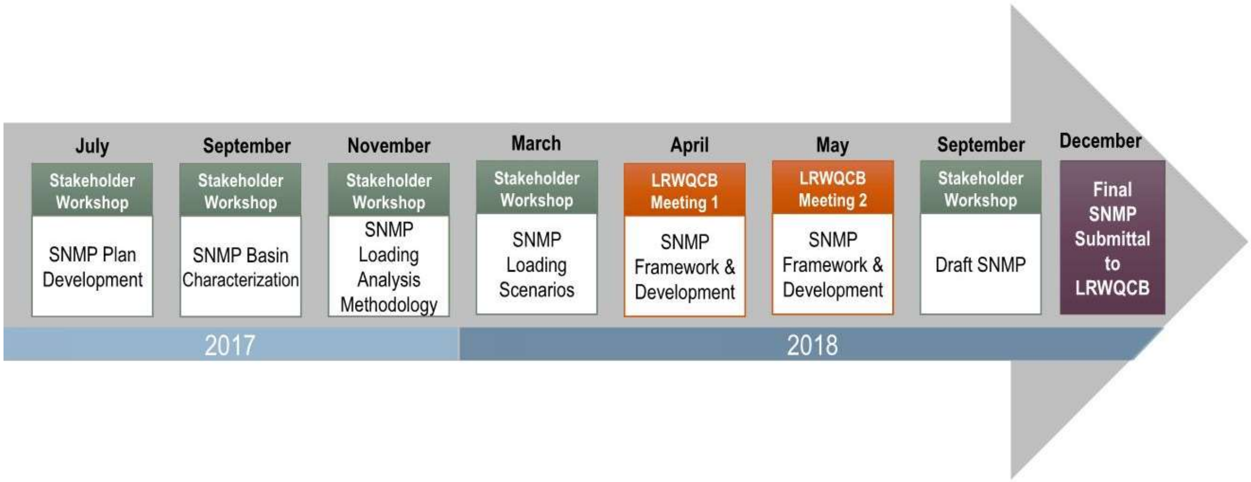


Table 3: Stakeholder Meetings

SNMP-Related Meeting Topics	Meeting Date	Meeting Location
Fremont Basin IRWM/GWMP/SNMP Plan Development and Stakeholder Process	July 27, 2017	California City Arts and Community Center
Region Description	August 15, 2017	California City Hall
Groundwater Characterization – Fremont Basin IRWM Integration with SNMP, Groundwater Well Locations and Elevations, Groundwater Quality Data	September 21, 2017	Jawbone Station Visitors Center
Supply and Demand; Water Management Objectives	October 19, 2017	Mojave Veterans Memorial Building
SNMP Update and Loading Analysis Methodology	November 16, 2017	Johannesburg Community Center
Climate Change Impacts and Project Solicitation	December 14, 2017	California City Arts and Community Center
Fremont Basin IRWM Plan Project Review and Prioritization	January 18, 2018	California City Hall
Supply and Demand and Projects	February 15, 2018	Mojave Veterans Memorial Building
SNMP Update and Loading Analysis Scenarios	March 15, 2018	Jawbone Station Visitors Center
Public Draft SNMP	September 20, 2018	Mojave Veterans Memorial Building

Table 4: SNMP Working Group Meetings

Meeting Topic/Date	Meeting Date	Meeting Location
Groundwater Data Collection and Outreach	July 27, 2017	California City Arts and Community Center
Groundwater Data Collection and Outreach	August 15, 2017	California City Hall
Groundwater Data Collection and Outreach	September 21, 2017	Jawbone Station Visitors Center
Regional Water Supply and Demand	October 19, 2017	Mojave Veterans Memorial Building
Regional Planning Targets and Strategies; Groundwater Data Collection and Outreach	November 16, 2017	Johannesburg Community Center
Regional Objectives and Projects	December 14, 2017	California City Arts and Community Center
Regional Water Supply and Demand	January 18, 2018	California City Hall
Regional Water Supply and Demand; Projects	February 15, 2018	Mojave Veterans Memorial Building
Regional Projects	March 15, 2018	Jawbone Station Visitors Center

2.2.1 Technology and Information Access

In addition to stakeholder meetings and working group meetings, two websites provide an avenue for stakeholders to find information about the planning efforts: the Fremont Basin IRWM Region Facebook page and the City 's website. The Fremont Basin IRWM Region Facebook page helps facilitate the overall stakeholder coordination and promote two-way communication between the RWMG and the stakeholders by allowing group members to post comments and information to the site. The webpage, managed by the City, also provides an avenue for the public to send messages to the RWMG through the Facebook messaging function. The RWMG uses the Facebook page and the Fremont Basin IRWM page on the City's website to alert the public about future stakeholder meetings and events and post documents related to the IRWM Plan development and its components, including SNMP development efforts. Resources provided include meeting agendas, presentations, and minutes, and the IRWM Plan itself (in which the SNMP is an appendix).

2.2.2 Process Used to Identify Stakeholders

The RWMG played a crucial role in identifying stakeholders in the Plan area by developing an initial stakeholder list to publicize the development of the SNMP. To initiate stakeholder involvement, stakeholders interested in participating in the Plan development process were emailed periodically to provide meeting information and electronic newsletters through the IRWM Plan development. The process the RWMG currently uses to identify and involve new stakeholders includes posting public announcements about the stakeholder meetings on the Fremont Basin IRWM webpages; soliciting recommendations for new groups to contact during stakeholder meetings; and targeting specific groups via email, phone calls, and letters. Stakeholders are welcome to join the stakeholder group and attend stakeholder meetings at any time. The California Native American Heritage Commission was directly contacted to identify stakeholders in the Region as well.

Extensive outreach efforts were conducted to bolster stakeholder participation during development of the IRWM Plan and SNMP. Outreach efforts included the development of working groups that focus on various subject areas, conducting monthly stakeholder meetings, and conducting targeted outreach to DACs and tribal groups through emails, phone calls, and media advertisements.

2.3 Regulatory Coordination

The LRWQCB has been an active part of the SNMP development process. Two meetings in April 2018 and May 2018 were conducted with the LRWQCB (staff and LRWQCB members, respectively) to provide an update on the SNMP development process, discuss the timeline for SNMP completion, and coordinate with the LRWQCB regarding the review and approval timeline of the SNMP. Both meetings included presentations on various aspects of the SNMP development, including data collection efforts, the proposed approach for loading analysis, key assumptions, and future scenarios considered for groundwater management and recycled water use. The meeting held in May 2018 (with LRWQCB members) was intended to discuss technical details of the SNMP development and obtain concurrence on critical elements of the technical analysis and the development approach proposed for the SNMP. The SNMP was completed according to the proposed approach discussed with the LRWQCB and submitted to the LRWQCB on July 27, 2018 for review with the final version submitted to the LRWQCB in December 2018 for approval.

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3. PLAN AREA

This section provides a description of the Plan area covered by this SNMP, including the physical setting and water resources. Other planning efforts undertaken in parallel with the SNMP in the Plan area are also described briefly. Current and future water demand and supply conditions are further described in Section 5.

3.1 Plan Area Description

The Plan area is located in eastern Kern County, bounded by the Antelope Valley to the south, the Rand Mountains to the north, the southern ranges of the Sierra Nevada Mountains to the west, and San Bernardino County to the east (Figure 1). The City, located on the western edge of the Mojave Desert, is the only municipality within the Plan area (Figure 2). Small unincorporated communities in or near the Plan area include Mojave, Cantil, Rancho Seco, Gypsite, Cenada, Saltdale, Garlock, Rand, Goler, Johannesburg, Randsburg, and Red Mountain. Major highways giving access to the Plan area include State Route 14, a north-south aligned highway that traverses the Plan area, and State Route 58, a south-east aligned highway that crosses the Plan area's southwest boundary.

3.2 Fremont Valley Groundwater Basin

The FVGB underlies the Fremont Valley and is predominantly contained in eastern Kern County with a small, northeastern region within San Bernardino County. The FVGB is identified in DWR's Bulletin 118 (*California's Groundwater*) as Groundwater Basin Number 6-46, and underlies approximately 335,000 acres (DWR 2004). Figure 4 shows the boundary of the FVGB and adjacent basins and subbasins as defined by DWR Bulletin 118. The FVGB is bounded on the northwest by the El Paso Mountains and the Sierra Nevada mountains; on the east by crystalline rocks of the Summit Range, Red Mountains, Castle Butte, Bissell Hills, and Rosamond Hills; and on the southwest by the Antelope Valley Groundwater Basin. The FVGB is categorized as low priority in DWR's CASGEM program (DWR 2014).

The Fremont Valley is a relatively flat area with a depression near the center, the Koehn Lake. The Koehn Lake is a dry lake with the bed elevation at approximately 1,880 feet above mean sea level (msl). Ground surface elevation increases toward the surrounding mountains and reaches elevations up to 3,300 feet msl.

Recharge to the basin is derived primarily from direct percolation of precipitation on the valley floor and runoff from the surrounding tributary watersheds. Most of the runoff is caused by infrequent thunderstorms in the El Paso Mountains. Surface water in the Fremont Valley drains toward Koehn Lake, except in Oak Creek where it drains in an easterly direction (Figure 5). The FVGB also receives subsurface flow from the Antelope Valley Groundwater Basin. Groundwater flow generally moves in an easterly direction along the surrounding mountains and then flows in the northerly direction towards Koehn Lake.

Long-term groundwater level data obtained from the CASGEM program and the U.S. Geological Survey (USGS) indicate that the groundwater levels in the FVGB have declined significantly since 1955, attributed to the prolonged drought period from 1945 to 1964 and excessive groundwater extraction in the FVGB in the late 1950s through 1970s. Based on the same data, groundwater levels appeared to stabilize after the 1980s and have started recovering since that time as a result of decreased groundwater pumping for agriculture and surface water deliveries to urban users being introduced to the Plan area.

While data are limited, based on the information from DWR and previous investigations, groundwater in the alluvium is generally unconfined, although locally confined conditions occur near Koehn Lake (DWR 2004).

Figure 4: Groundwater Basin Boundaries

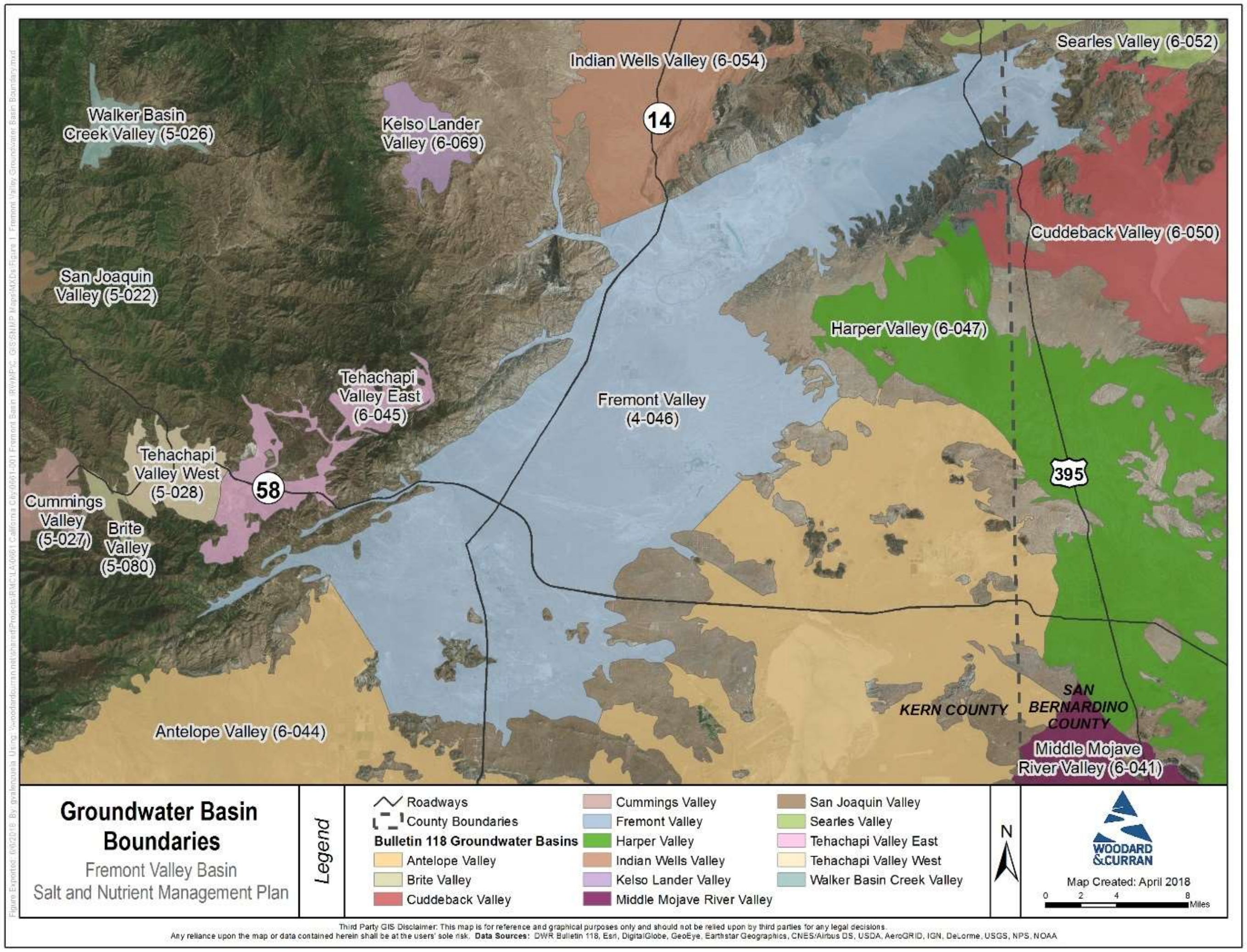
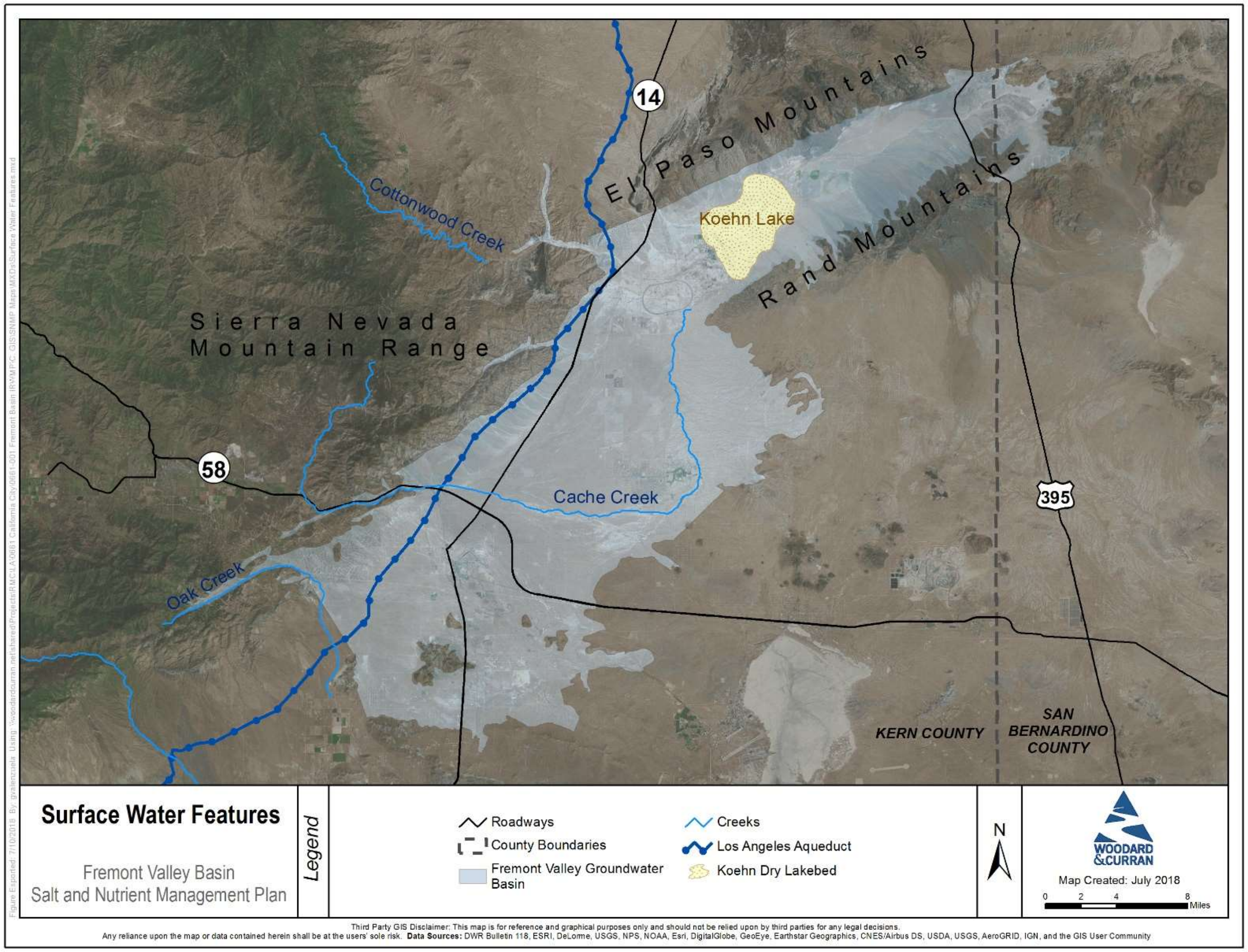


Figure 5: Surface Water Features



3.3 Physical Setting

3.3.1 Climate

The Fremont Valley Basin SNMP area is located in the high desert at an elevation of 2,300 to 4,000 feet msl with the lowest elevation of about 1,880 feet msl at the Koehn Lakebed. The climate is semi-arid and characterized by warm, dry summers and mild, cool winters. The mean daily temperatures range from 33° Fahrenheit (F) in the winter to 98°F in the summer (Western Regional Climate Center no date (N.D.)). Native flora in the Plan area are dominated by sparse, drought-resistant vegetation that can tolerate both extreme heat and cold weather. Examples include Joshua trees, mesquite, sagebrush, desert cymopterus, and Mojave Creosote bush scrub. Carpets of wildflowers bloom during wet years, depending on rainfall intensity in the spring (City of California City N.D.a).

3.3.1.1 Precipitation

There are three precipitation stations with long-term records located within the Fremont Valley watershed: Mojave, Tehachapi, and Randsburg (Figure 6). The Mojave Station is located in the southern portion of the FVGB. Historical data available at the Mojave Station are presented in Table 5 for average monthly values based on data collected between 1904 and 2016. Figure 7, Figure 8, Figure 9 show the annual precipitation and cumulative departure from annual mean precipitation between 1945 and 2017 at the Mojave, Tehachapi, and Randsburg stations, respectively. Cumulative departure curves are plotted relative to the long-term average precipitation and are used to delineate temporal trends in the precipitation data. A departure curve ascending to the right is considered a positive slope and indicates an accumulation of years of above average precipitation. Conversely, a departure curve descending to the right is a negative slope and indicates an accumulation of years of below average precipitation.

Data indicate precipitation is highest at the Tehachapi Station and lowest at the Mojave Station. Annual precipitation at the Mojave Station ranged from 0.75 inches to 15.51 inches at an average of 5.1 inches (Figure 7). Annual precipitation at the Tehachapi Station ranged from 2.52 inches to 27.77 inches at an average of approximately 10.1 inches (Figure 8). Annual precipitation at the Randsburg Station ranged from 0.83 inches to 15.58 inches at an average of 5.9 inches (Figure 9). The cumulative departure curves at the Mojave Station indicate that the Fremont Valley has experienced wet-dry cycles with a prolonged drought period from·1945 to 1964, a prolonged wet period from 1976 to 1984, and a drought period since 2006. Precipitation on the valley floor may have significant losses from evaporation and transpiration; however, during an exceptionally wet season, flashfloods may occur and runoff may originate on or cross the valley floor to reach the Koehn Lake (Stetson 2009).

Table 5: Climate in the Fremont Basin

Month	Average Monthly ETo (inches)[1]	Average Rainfall (inches)[2]	Average Max Temperature (F) [2]	Average Min Temperature (F) [2]
January	2.31	1.20	57.8	34.2
February	3.16	1.27	61.2	37.1
March	5.01	0.93	64.7	41.0
April	6.47	0.30	71.3	46.3
May	8.28	0.09	79.9	55.1
June	9.19	0.03	89.9	63.8
July	9.61	0.11	97.6	69.7
August	8.74	0.15	96.4	68.0
September	6.35	0.21	89.0	60.3
October	4.48	0.24	78.5	50.3
November	2.85	0.53	65.7	40.2
December	2.07	0.87	57.2	32.9
Annual	**68.52**	**5.93**	**75.8**	**49.9**

Sources: (1) California Irrigation Management Information System (CIMIS) Data for Palmdale No. 197 Station since April 2005. Accessed 9 August 2017 from: www.cimis.water.ca.gov/Stations.aspx; (2) Western Regional Climate Center, Mojave Station (045756) for the Years 1904 to 2016.

Figure 6: Precipitation Stations in the Fremont Valley Basin Area

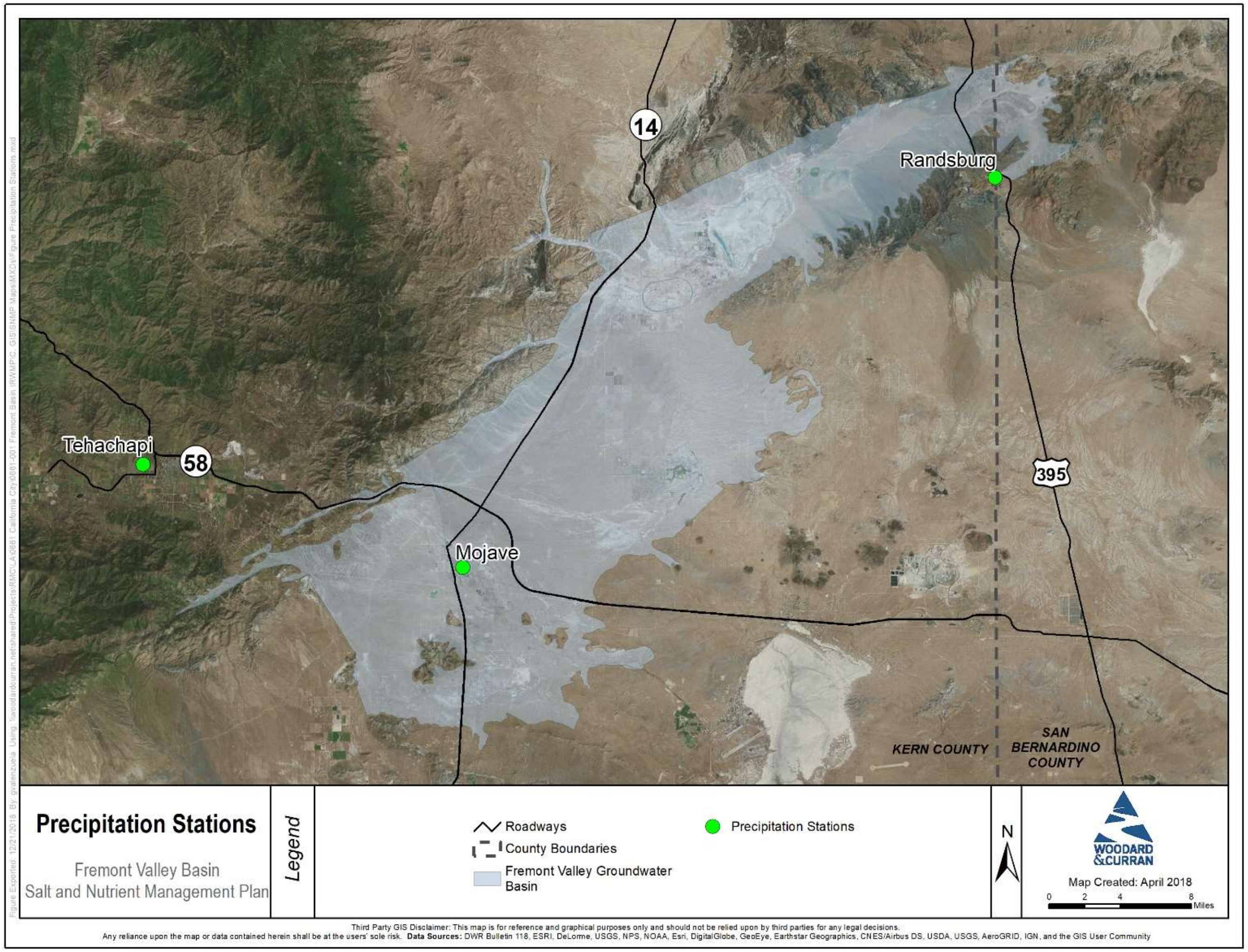
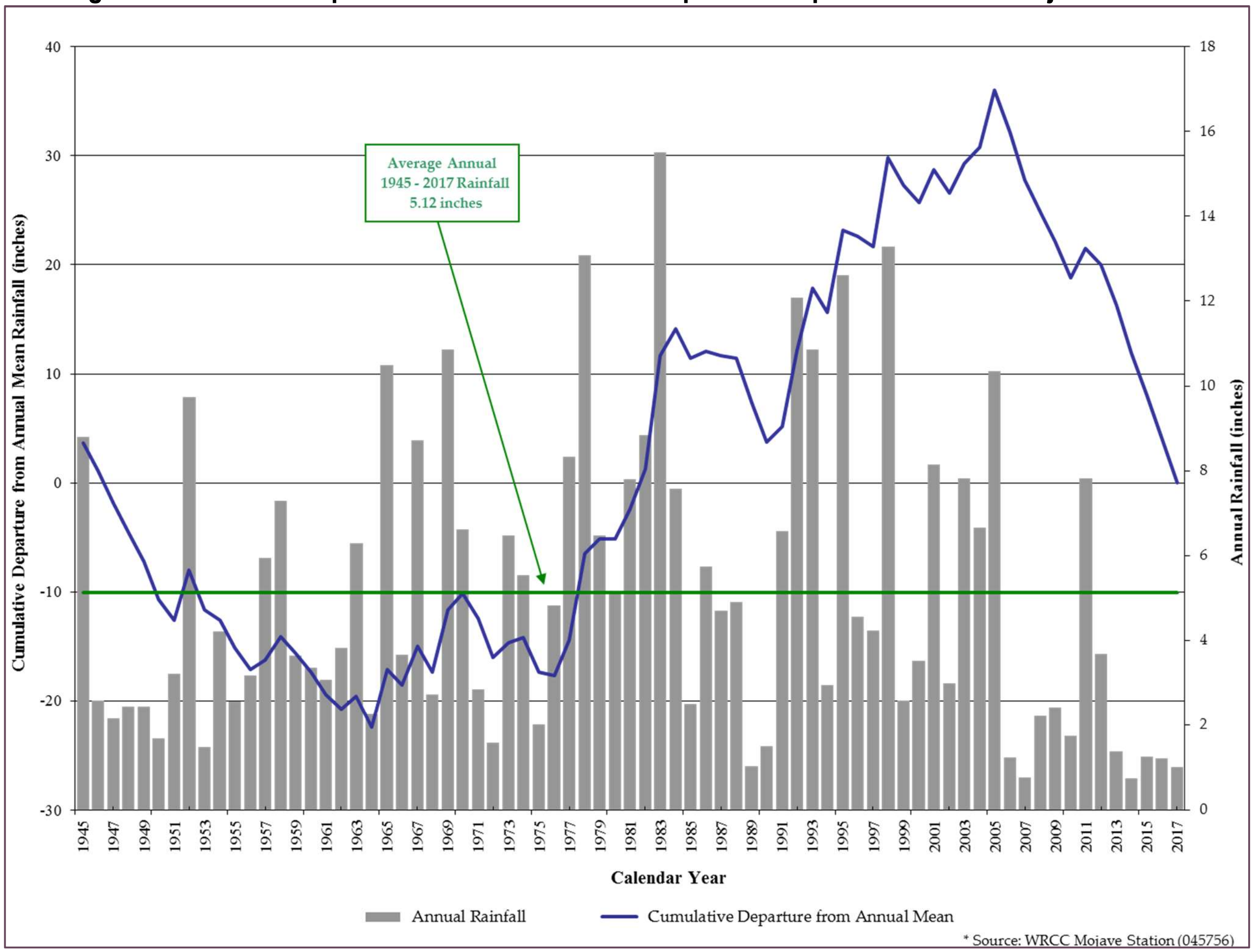
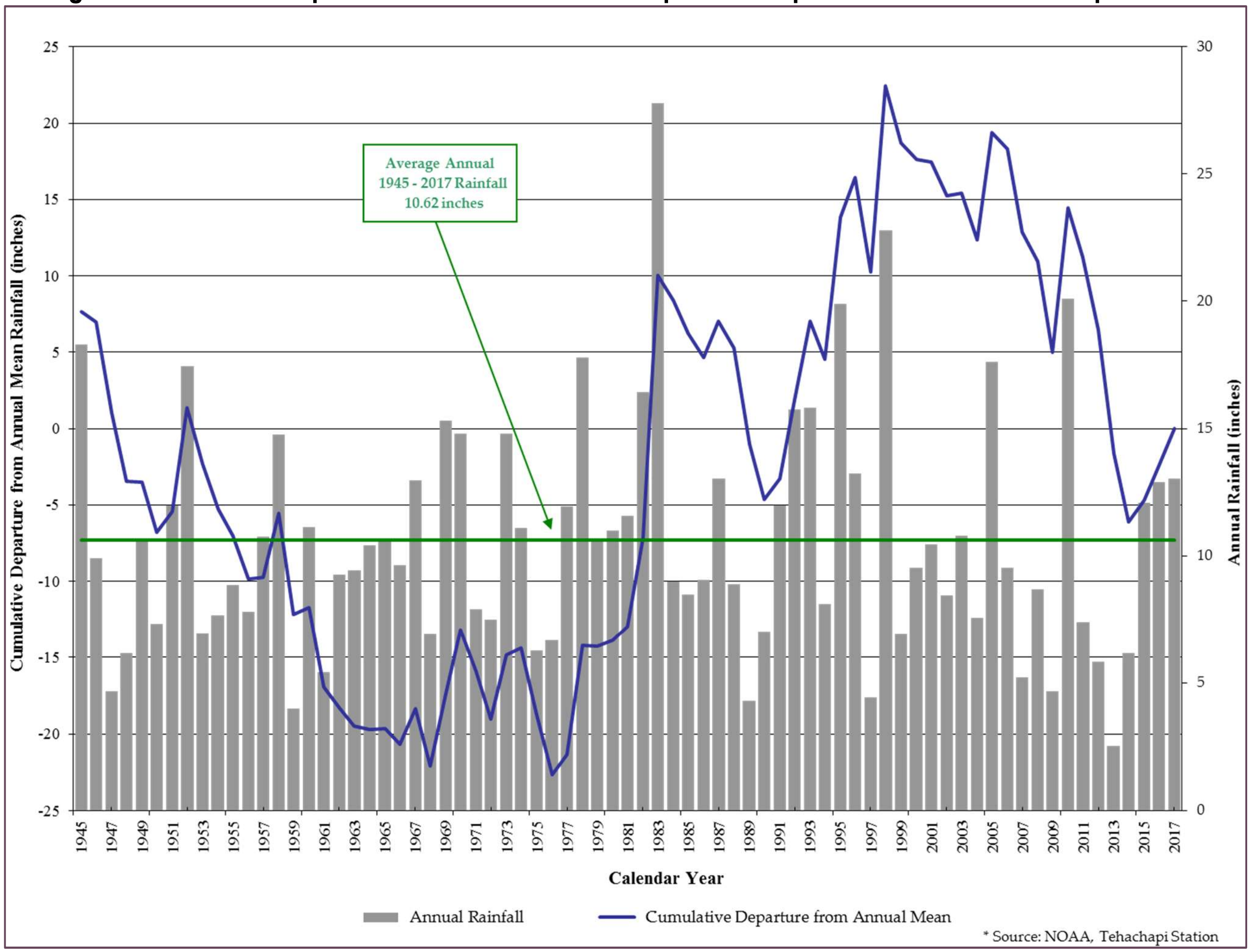


Figure 7: Annual Precipitation and Cumulative Precipitation Departure Curve at Mojave Station



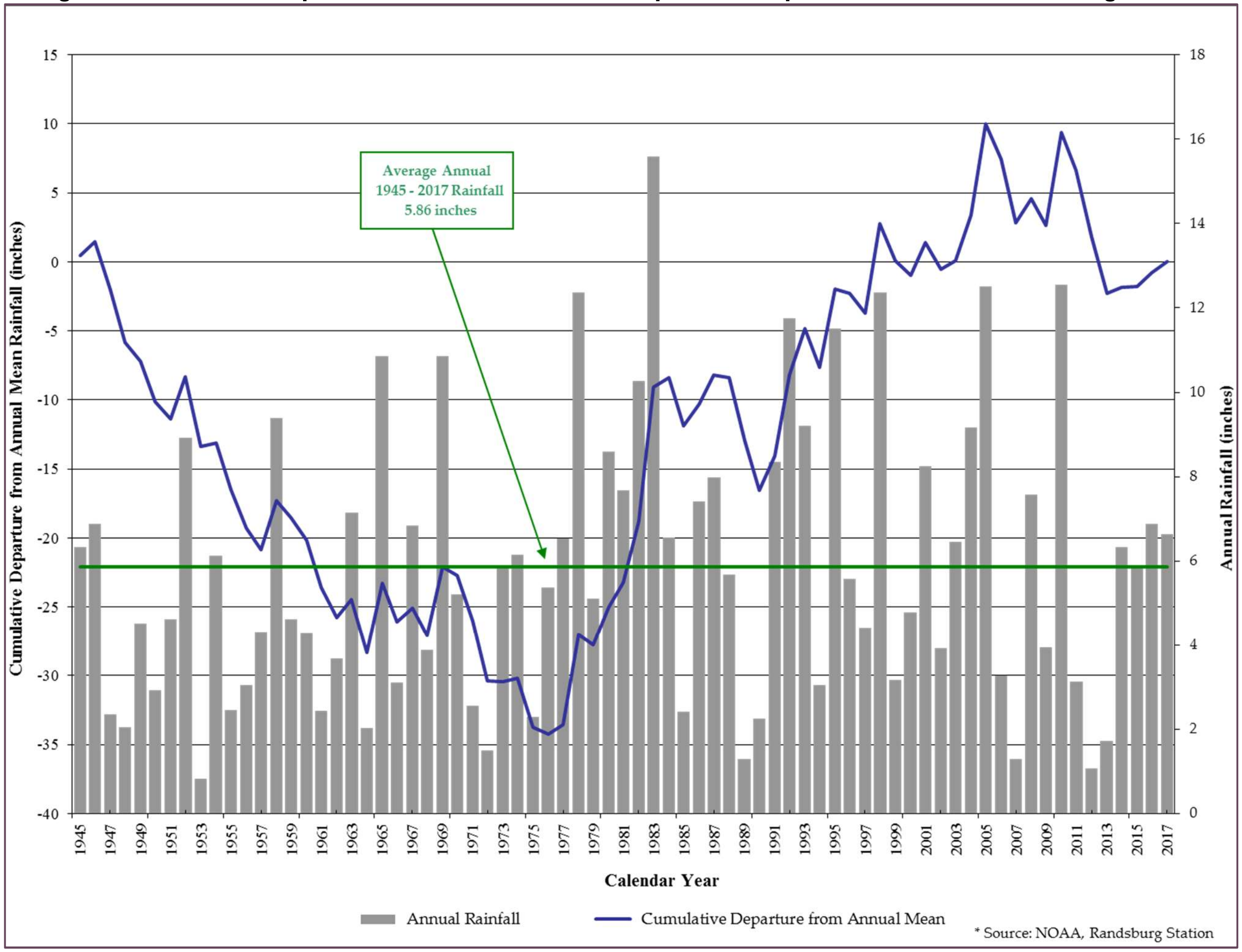
Notes: (1) Precipitation data for 2011 and the majority of the year 2012 were missing; data presented in the figure were estimated for these missing time periods based on the long-term average of a similar hydrologic year type. (2) Cumulative departure curves are plotted relative to the long-term average precipitation at the station.

Figure 8: Annual Precipitation and Cumulative Precipitation Departure Curve at Tehachapi Station



Notes: (1) Precipitation data for 2008 were missing; data presented in the figure were estimated for these missing time periods based on the long-term average of a similar hydrologic year type. (2) Cumulative departure curves are plotted relative to the long-term average precipitation at the station.

Figure 9: Annual Precipitation and Cumulative Precipitation Departure Curve at Randsburg Station



Note: Cumulative departure curves are plotted relative to the long-term average precipitation at the station.

3.3.2 Land Use

Land use in the FVGB is predominantly comprised of undeveloped lands, urban lands, and a small percentage of developed agricultural lands. Current land uses within the Plan area are depicted in Figure 10 and are based on Kern County assessor data and aerial review. The largest urban area is within the City's boundary. A breakdown of each major land use category in the Plan area is defined as follows:

- Residential category uses include a mix of housing developed at varying densities. Residential densities in the Plan area range from "estate" (i.e., large lot parcels) to low, medium low, medium, and high densities. Single-family, multiple-family, condominium, mobile home, and senior housing are included within these categories.
- Commercial category includes commercial uses that offer goods for sale to the public (retail) and service and professional businesses housed in offices (doctors, accountants, architects, etc.). Neighborhood commercial includes retail businesses that serve local needs in a neighborhood area, such as restaurants, neighborhood markets, and dry cleaners. Community commercial businesses are those that serve community or regional needs, such as entertainment complexes, auto dealers, and furniture stores.
- Industrial category includes heavy industrial areas which are lands designated for intensive manufacturing, processing, and storing of materials. Light industrial and research is also included within this category. These non-intensive manufacturing processes are found in research and office park developments and areas adjacent to residential lands. Light industrial activities include some types of assembly work, utility infrastructure and work yards, solar energy production, wholesaling, and warehousing.
- Resources category encompasses land used for private and public recreational open spaces, and local and regional parks. Recreational use areas also include golf courses, cemeteries, water bodies and water storage. Also included in this category are conservation and restoration areas, as well as mineral exploration.
- Agriculture category includes areas devoted to the production of irrigated crops, including alfalfa and pistachio production in recent years, and in some cases goats and cattle.
- Public Facilities category includes facilities used for public or semi-public services including airports, treatment plants, and water spreading areas.
- Vacant lands are undeveloped lands that are not preserved in perpetuity as open space or for other public purposes.

The General Plan for the City designates 22,000 acres of land intended for future development in the central core of the City (Figure 11). While development in the northeastern portion of the City can still occur, as evidenced by the construction of the California City Correctional Facility, future development plans are expected to promote housing and open spaces, jobs, accommodate transportation needs, and reduce air and noise pollution (City of California City 2009). The major future development planned currently is the expansion of the CoreCivic Correctional Facility.

One notable impact to future land use in the Plan area is cannabis production. In 2016, California voters legalized cannabis in the State of California for recreational use. The City was one of the first municipalities in Kern County to permit cannabis cultivation, and land designation for agricultural land uses is underway. A municipal ordinance in 2017 increased the maximum number of each type of marijuana business that may operate at the same time within the City. The City expects a land use designation increase for indoor cultivation facilities, hemp outdoor cultivation facilities, processing and packaging facilities, distribution and transport facilities, and retail cannabis stores (City of California City N.D.b).

Figure 10: Existing Land Use in the Fremont Valley Groundwater Basin Area

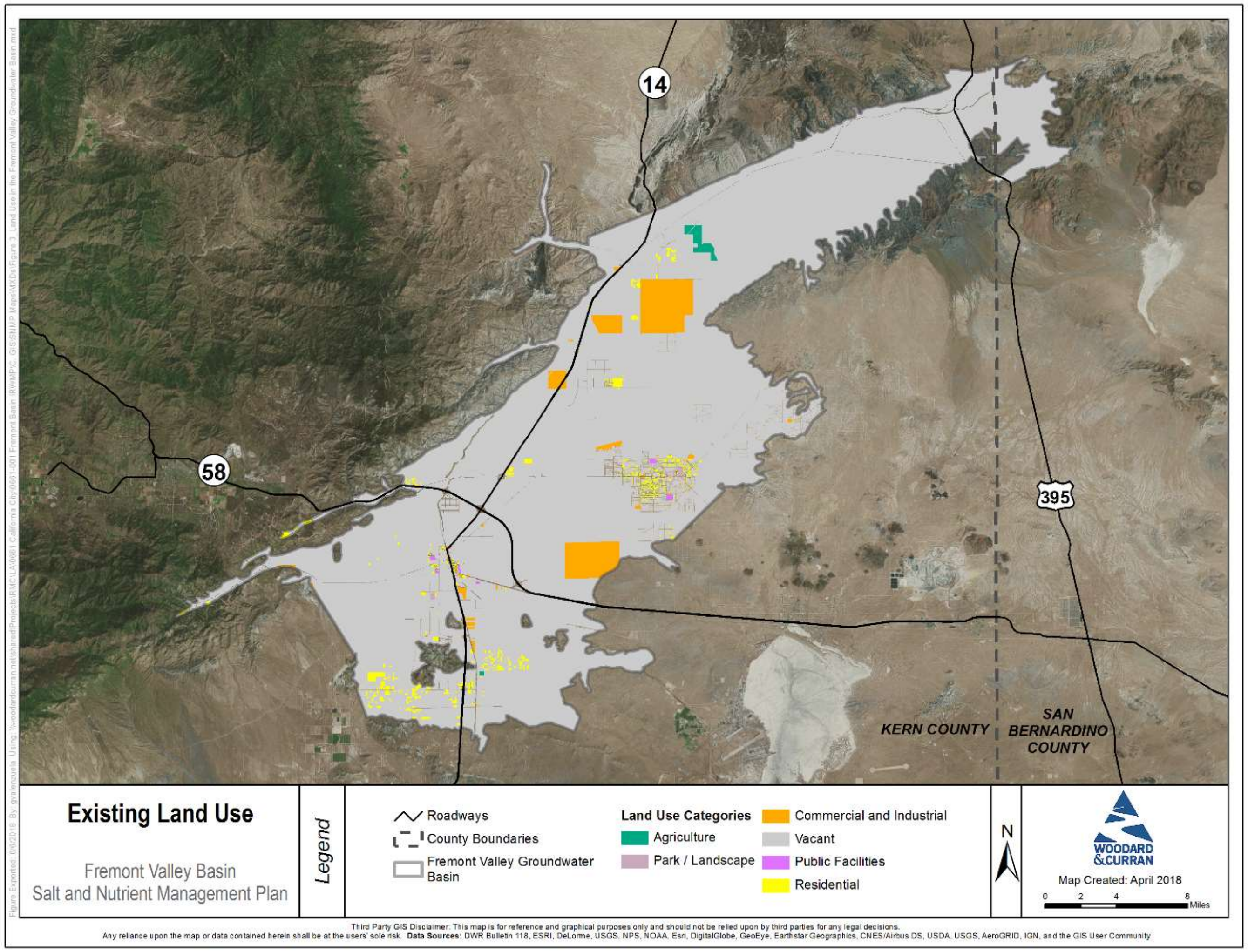
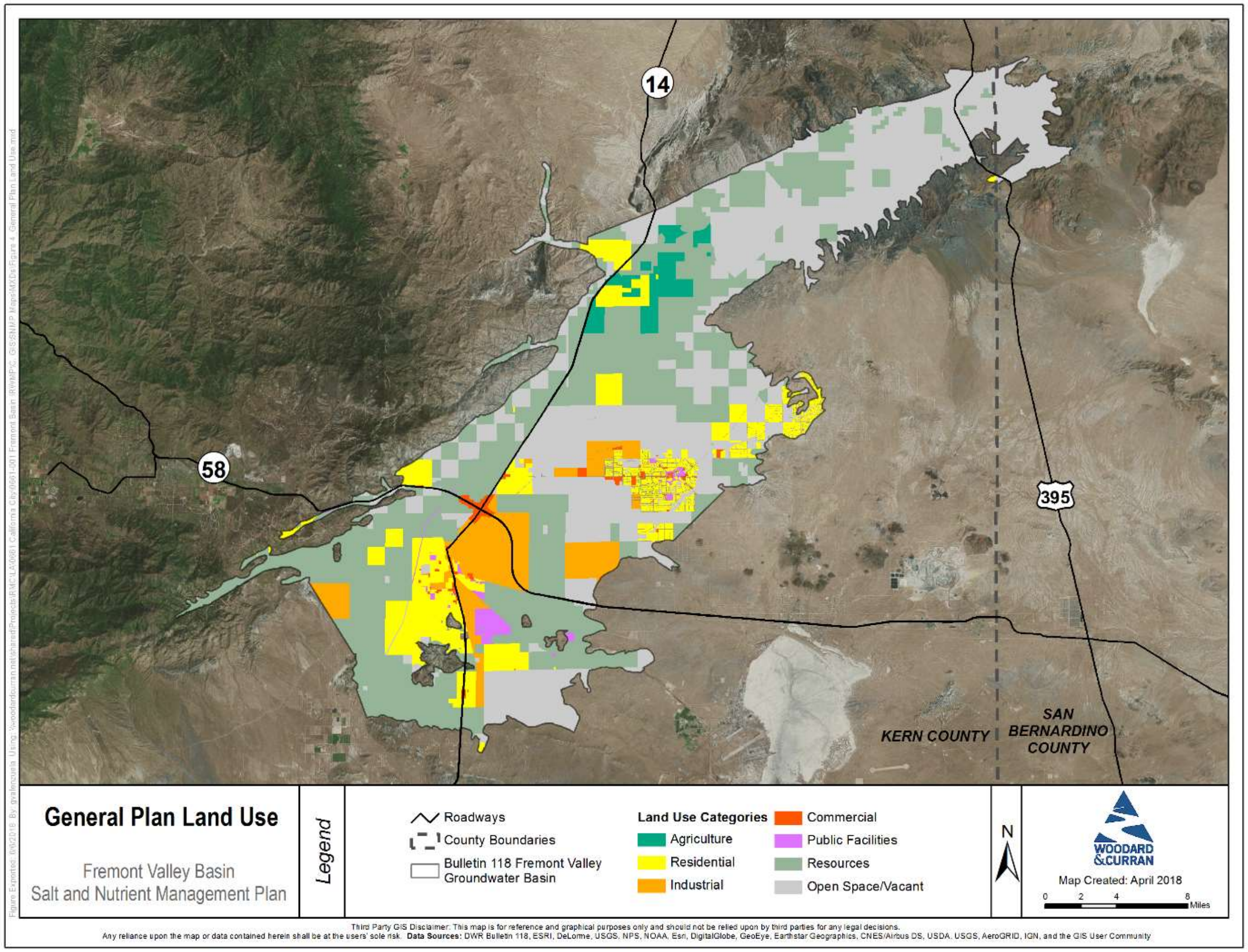


Figure 11: General Plan Land Use in the Fremont Valley Basin Area by 2028



3.4 Water Resources

The Fremont Valley Basin SNMP area utilizes a combination of water sources to meet water demand, including groundwater, imported water, and some recycled water. Supplies are used to meet urban, agricultural, and domestic water demands and are delivered by water agencies as well as private wells. The following sections provide an overview of each supply source used within the Plan area. A more detailed discussion of the current and future projected water demand and supply conditions in the Plan area is presented in Section 5.

3.4.1 Groundwater

The FVGB has been historically used as the primary water supply source in the Plan area. There are five water agencies that supply residential water from the FVGB in the Plan area: the City, MPUD, California Water Service Company (Cal Water), Rand Communities Water District (RCWD), and Rancho Seco Inc. The City supplies water to the southeastern portion of Kern County within the Plan area. MPUD serves unincorporated residential, commercial, industrial, and undeveloped land overlaying the southern part of the FVGB. Cal Water has a small district north of the City. RCWD covers the north east portion of the Plan area. Rancho Seco Inc. serves a small portion of the Plan area in the Cantil area. Users not served by these water purveyors rely on private wells to meet domestic water demands.

Historically, the City and MPUD depended entirely on groundwater until AVEK started delivering surface water in 1980. Based on available pumping data provided by the City for the years 2010 through 2016, the City's annual average pumping was approximately 3,000 acre-feet per year (AFY). Based on available data provided by MPUD for the years 2012 through 2016, MPUD's pumping ranged from 980 acre-feet (AF) in 2016 to 1,340 AF in 2013. Combined pumping by small water suppliers (Cal Water, RCWD, and Rancho Seco, Inc.) is estimated to be approximately 75 AFY, based on limited pumping data provided by the water suppliers. Pumping by private well owners is difficult to estimate as it is unmetered and unreported.

The FVGB also supports the production of irrigated crops, including alfalfa and pistachio production, in unincorporated areas of the Plan area. Historically, agricultural activities have occurred in the northern portion of the FVGB and peaked in the 1970s with estimated groundwater extractions reaching up to approximately 60,000 AFY in 1976 (Stetson 2009). Agricultural activities significantly decreased thereafter; and as of 2010, only 1 percent of lands cultivated in 1976 were still in production according to aerial imagery (USGS 1977; USDA 2017). In 2015, approximately 207 acres of land in the Plan area were cultivated for pistachios (approximately 50 percent of the total cultivated lands) and alfalfa (approximately 50 percent of the total cultivated lands) with an estimated demand of approximately 650 AF. In 2017, approximately 159 acres of alfalfa (approximately 40 percent of the total cultivated lands) and pistachios (approximately 60 percent of the total cultivated lands) were grown with estimated demand of approximately 410 AF. Groundwater is anticipated to be a significant supply for future agriculture demand.

3.4.2 Imported Water Supplies

AVEK, the State Water Project (SWP) contractor in the Plan area, delivers imported SWP water to both the City and MPUD. According to AVEK's imported water record, historical imported water deliveries to the City averaged 669 AFY since 1980 and to MPUD averaged 208 AFY since 1979. Based on the 2015 Urban Water Management Plan (UWMP) for AVEK, approximately 653 AF was delivered to the Plan area in 2015, including 651 AF to the City and 2 AF to MPUD.

3.4.3 Surface Water

Imported water purchased from the SWP is the only surface water used to meet regional demands. Local surface waters are not reliable sources because most are ephemeral streams that are extremely limited by drought conditions. Much of the surface water in the Plan area percolates into the FVGB. Additionally, high desert conditions cause water that does not percolate into the groundwater basin to evaporate (AVEK 2015; California City Water Department 2017).

3.4.4 Recycled Water

There are two WWTPs in the Plan area, owned and operated by MPUD and California City. MPUD provides wastewater services to communities west of California City. Between 2012 and 2016, the average annual wastewater inflow to the plant was 435 AF (121.9 million gallons (MG)) and average annual effluent discharge to the percolation ponds was approximately 121 AF (33.8 MG). Most of the treated effluent remains on-site to evaporate from several evaporation ponds. Any solids remaining is sent to a specialized treatment facility off-site.

The WWTP owned and operated by the City is the only source of recycled water that is reused in the Plan area. The collection system in these communities is gravity fed and only conveys domestic wastewater, not stormwater runoff. California City's WWTP is capable of producing secondary and tertiary treated recycled water. Currently, the only permitted sites for use of the secondary and tertiary treated effluent are the City's eight existing percolation ponds, the Central Park Lake (used as recreational non-contact water) and the Tierra Del Sol Golf course (used for landscape and course irrigation). The Central Park Lake is primarily a holding transfer point of tertiary treated effluent for the irrigation systems at Tierra Del Sol Golf Course (California City Water Department 2017).

Recycled water use in the Plan area ranged from 405 AFY in 2010 to 518 AFY in 2015, based on the City's 2015 UWMP. Recycled water use is anticipated to increase in the future, as further described in Section 5.2.4.

In 2002, the capacity of the City's WWTP was expanded from 3 AF per day (1 million gallons per day (MGD)) to 4.6 AF per day (1.5 MGD) to accommodate population growth. When storage basins are full during the winter season, approximately 1 percent of the recycled water produced, is diverted to percolation ponds to offset groundwater extractions.

3.5 Water Demand

Water demand in the Plan area is comprised of urban and agricultural water demands. Urban demands can be further classified into residential water uses and industrial activities, assuming residential demand includes water delivered by water purveyor systems (including commercial and water losses for the purpose of this analysis) as well as private pumping for residences. An estimated 19,400 people reside within the Plan area boundaries, and the population is expected to grow more than 35 percent by 2040. The FVGB also supports an existing solar industry and emerging cannabis industry, both of which are expected to grow significantly in the next two decades.

The total water demand in the Plan area is currently estimated at approximately 6,000 AFY. Historically, agriculture has been a significant source of water demand in the Plan area. The FVGB experienced large groundwater extractions for agricultural use in the 1960s, 1970s and 1980s, leading to severe drops in groundwater elevation in portions of the basin. As of 2015, only 207 acres, less than one percent of all land cultivated in 1976, was still in production for alfalfa and pistachio cultivation. A more detailed water demand analysis for the Plan area is included in Section 5.

3.6 Description of Other Plans

The SNMP was developed in coordination with two other key planning efforts within the FVGB, including the Fremont Basin IRWM Plan and the Fremont Valley Basin GWMP. In addition, the City and AVEK prepared their 2015 UWMPs as the major urban water suppliers serving over 3,000 AFY. These planning efforts inform and support each other to ensure reliable water supplies are available to meet future regional demand, to promote the sustainable use of water supplies, and to facilitate groundwater resources management in the Plan area. This section provides an overview of these planning efforts led by the City in close coordination with MPUD and AVEK in the Plan area.

3.6.1 Fremont Basin IRWM Plan

IRWM planning is a collaborative effort to manage all aspects of water resources in a region. IRWM crosses jurisdictional, water, and political boundaries; involves multiple agencies, stakeholders, individuals, and groups; and it attempts to address the issues and differing perspectives of all entities involved through mutually beneficial solutions. The IRWM process involves identifying and implementing water management solutions on a regional scale to increase regional self-reliance, reduce conflict, and manage water in a way that concurrently achieves social, environmental, and economic objectives.

An integral part of the IRWM program is developing an IRWM Plan, which is a comprehensive document of the outcome of IRWM planning efforts. The IRWM Plan reflects efforts and objectives of all stakeholders within a defined region and documents the development and implementation of effective strategies that promote sustainable water use, guarantees a reliable water supply, improves water quality, and endorses environmental stewardship within the Region. IRWM Plans also describe the water supply portfolio and demands in the region, as well as describe the existing and projected water management challenges with respect to climate change impacts and population changes.

The IRWM Region was approved by the DWR in September 2011 through the IRWM Region Acceptance Process. The IRWM Region encompasses 992 square miles in eastern Kern County and in western San Bernardino County in the western edge of the Mojave Desert (Figure 1). The only incorporated city in the IRWM Region is the City. The primary defining feature of the Fremont Basin IRWM Region is its position overlying the entirety of the FVGB. The first IRWM Plan for the Region was developed concurrently with this SNMP and is anticipated to be completed in 2018.

3.6.2 Fremont Valley Groundwater Management Plan (GWMP)

As previously noted, the FVGB is currently designated as a low priority groundwater basin under SGMA; thus, the agencies within the Plan area are not subject to SGMA requirements at this time. However, the City, AVEK, and MPUD have initiated efforts to prepare the Plan area for development of a GSP through the development of the GWMP for the FVGB. The Fremont Valley Basin GWMP was developed in coordination with the development of the SNMP and is intended to act as a “pre-GSP” document. The City, AVEK, and MPUD, as well as other key stakeholders in the Region, may form a GSA in the future and continue the GSP development process to help plan the sustainable use of the FVGB. The City and Plan area stakeholders recognize that cooperation across agencies involved in the basin management is essential to long-term groundwater basin sustainability, and to supporting the new GWMP goals and objectives and streamlining data collection and reporting efforts from agencies involved. Therefore, the SNMP could be potentially combined and managed with future efforts implemented under a larger GSP effort with a goal to develop a consistent and cost-effective basin-wide monitoring program that is managed under the same governance structure.

3.6.3 Urban Water Management Plans (UWMPs)

UWMPs are prepared by urban water suppliers to support long-term resource planning and ensure adequate water supplies are available to meet current and future water demands in their service areas. Preparation of an UWMP is a requirement of the Urban Water Management Planning Act for urban water suppliers with more than 3,000 connections or supplying more than 3,000 AF of water annually. These plans must be updated and submitted to DWR every five years to comply with the Urban Water Management Planning Act and be eligible for State funding.

In the Plan area, the City submitted its 2015 UWMP to DWR in 2017 (California City Water Department 2017). AVEK also published its 2015 UWMP in 2016 (AVEK 2016). The most recent UWMP prepared by MPUD was submitted to DWR in 2004 (MPUD 2004). Since that time, they have not been required to complete an UWMP because they have less than 3,000 connections and supply less than 3,000 AF of water annually. The UWMPs for the urban water suppliers in the Plan area were used to help describe and calculate the water supplies and demands in the Plan area, as further described in Section 5.

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4. BASIN CHARACTERIZATION

The purpose of this section is to present a summary description of the hydrogeology of the FVGB, geologic setting and groundwater conditions for levels, flow, storage, and water quality. This section relies on available data collected from public sources, data provided by the stakeholders, and review of information from previous investigations.

4.1 Geologic Setting

The geologic setting in the FVGB is described below and is based principally from previous work (USGS 1977; Richard C. Slade & Associates 1995; Layne Geosciences/Colog Group 2005; Stetson 2009). The geologic formations of the FVGB are divided into two main units: consolidated rocks of Tertiary and pre-Tertiary age, and unconsolidated deposits of Quaternary age. The consolidated rocks form the mountains and hills surrounding the valley area, and the basement complex underlying the unconsolidated deposits make up the sides and bottom of the FVGB.

Unconsolidated deposits form the FVGB and consist primarily of Recent Quaternary alluvium in the valley floor and Pleistocene Quaternary non-marine deposits in the alluvial fans along the low hills of the eastern boundary, FVGB northern tip, and the alluvial fans between the Oak Creek and the Cache Creek along the western boundary. Quaternary lake deposits are also present in low-lying areas (lower than the elevation of 2,000 feet msl). The thickness of the unconsolidated deposits southwest of Koehn Lake varies from 400 feet to 900 feet (USGS, 1977). In the area northwest of Koehn Lake, the thickness of the unconsolidated deposits is unknown, but wells drilled to depths of 800 feet below land surface did not encounter consolidated rocks.

Older alluvium of Pleistocene age underlies most of the valley floor. It consists of poorly to moderately consolidated alluvial fan and stream channel deposits characterized by moderately to poorly sorted gravel, sand, and silt of Pleistocene (Quaternary) geologic age. The older alluvium is oxidized and generally unconsolidated, but in some places, it is slightly cemented. This formation is permeable, extends below the water table, yields water freely to wells, and is the most important water-bearing unit in the area. According to available drillers' logs, these unconsolidated materials are interbedded with layers of shale at various thickness in many places, especially in the central portion of the FVGB. The older alluvium appears to have a maximum thickness of about 550 feet to 650 feet in the southern portion of the FVGB, and does not appear to extend to a depth greater than about 800 feet. Water wells in this area produce from older alluvium and Pliocene sediments (Richard C. Slade & Associates 1995).

The thickness of the unconsolidated deposits was estimated in several previous reports. DWR reports the alluvium is about 1,190 feet thick (Bader 1969; DWR 1964) along the margin of the basin and thins toward the middle of the basin, where it is interbedded with thick layers of lacustrine silt and clay near Koehn Lake. The most recent report, based on well data from Koehler (1977), showed an alluvial thickness that ranges from 400 feet to 800 feet near Koehn Lake. Information from completed water supply wells suggests that the thickness reported by Koehler (1977) of 800 feet may be low, as the total depths of the wells on the site vary from about 800 feet to 1,700 feet below the ground surface (bgs). If the wells were completed in alluvial materials, these depths suggest that unconsolidated materials may be thicker than previously reported. MPUD wells, located in the southern portion of the FVGB, have depths ranging from approximately 350 feet to 800 feet. The City's wells, located further north, have depths ranging from approximately 550 feet to 810 feet.

4.2 Structural Features

Several named and unnamed faults in the FVGB are identified on California geologic maps, as shown on Figure 12. Four major faults transverse the FVGB in a northeast-trending direction. The longest ones are the Garlock fault and El Paso fault system that run along the north and west sides of the basin, along the foothills of the Sierra Nevada and El Paso Mountains, and separates the consolidated rocks of the Tehachapi, Piute, and El Paso Mountains from the FVGB.

The Garlock fault zone is traceable for some 150 miles and has a left-lateral displacement of unknown magnitude However, earlier studies suggest a displacement of about 6 miles near Randsburg to a displacement of 40 miles based on offset of a dike swarm west of Searles Lake north of the fault from a similar dike swarm south of the fault about 40 miles east (Dibble 1967). These faults from restrictive groundwater barriers on the west and northwest sides of the FVGB (Layne Geosciences/Colog Group 2005, Stetson 2009). The Garlock fault appears to act as a barrier to downslope movement of groundwater where groundwater on the upslope side apparently backs up against the fault, which acts as an “underground dam” and the overflow reaches the surface to seep out as one of more springs, as reported by Dibble (1977).

The Cantil Valley fault, which appears to be a branch of the Garlock fault, runs from the Garlock fault near the town of Cantil, bisects the FVGB through Koehn Lake, and rejoins the Garlock fault approximately nine miles east of US 395. According to the DWR, the effects of the Cantil Valley fault on groundwater flow are not known; but the USGS and recent studies indicate that it is a partial barrier to groundwater flow (USGS 1977). The USGS 1977 study notes different hydraulic characteristics on the two sides of the Cantil fault.

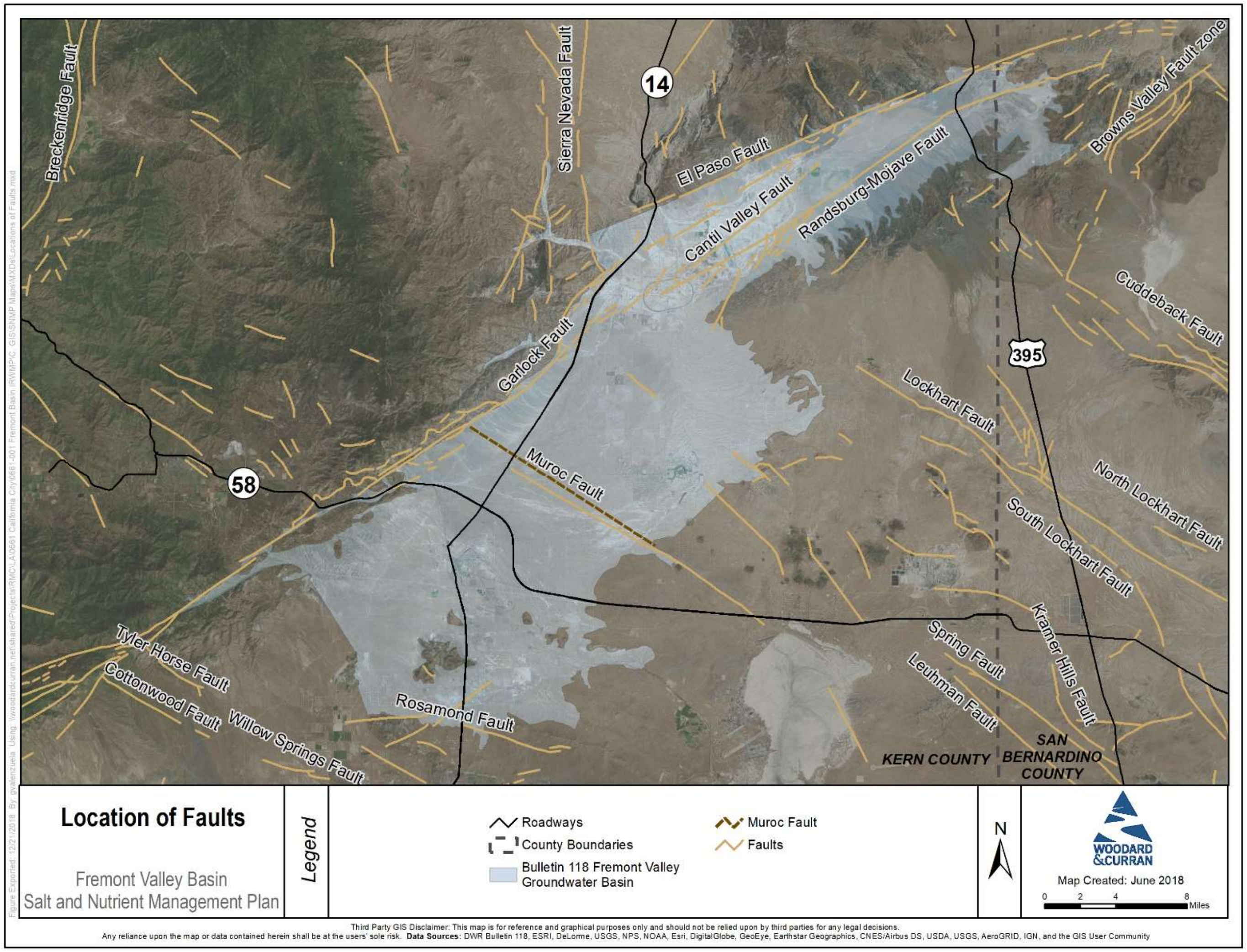
The Randsburg-Mojave fault runs along the northeastern side of the basin and separates the consolidated rocks of the Rand Mountains from the FVGB. The southern FVGB is bounded on the south by the east-west trending Rosamond fault. These faults form restrictive groundwater barriers on the west and northwest sides of the FVGB (Dibblee 1967). The Randsburg-Mojave fault and the Muroc fault extension have been inferred by the USGS based on apparent barriers to groundwater flow, as reported by Richard C. Slade & Associates 1995.

The Muroc fault traverses the southern portion of the FVGB and forms a partial barrier to groundwater flow (DWR 1964). Previous studies by Stetson (2009) considered the Muroc fault as an intrabasin boundary dividing the basin into two subbasins: the California City subbasin on the north and the Mojave City subbasin on the south. The subsurface flow across the Muroc fault is reported to occur only when groundwater levels south of the Muroc fault is high enough to allow groundwater to overflow the groundwater barrier created by the fault. The subsurface flow appears to stop when groundwater levels south of the Muroc fault is lower than the barrier crest, which is estimated at an elevation of approximately 2,420 feet msl based on historical water levels near the Muroc fault. As further described in Section 4.8.2, review of historical and recent water levels at the wells within the FVGB do not appear to confirm the hydrogeologic effects of the faults in the area, except for the Muroc fault. The significant difference in the water levels in 1958 for two wells that are located approximately 1.3 miles across the Muroc fault confirm the hydrogeologic effects of this fault, as also reported by Stetson 2009.

The unnamed faults include a fault running parallel to the Muroc fault across the narrows between the Castle Butte and the Twin Buttes, and a southeast-northwest fault running from the Castle Butte to the vicinity of the Pine Tree Canyon mouth. The effects of these unnamed faults on groundwater in the FVGB are not known.

Because the Muroc fault is the only fault that has been documented as creating a barrier to groundwater flow and that has well data that support the fault as creating a partial barrier to flow, this fault was included in the groundwater modeling analysis described in Section 4.3 and 4.6.4. Groundwater conditions within the FVGB and across the Muroc fault are described using groundwater contour elevation maps generated based on the information available. See Section 4.6.1 and 4.6.2 for additional details on groundwater flow and elevations in the FVGB as well as the estimated groundwater contours.

Figure 12: Location of Faults



4.3 Groundwater Subbasins and Subunits

This SNMP uses the DWR Bulletin 118 groundwater basin boundary, as shown in Figure 13, for the basin characterization and groundwater quality analyses for TDS and nitrate. Different nomenclature has been used to define subdivisions of the FVGB by DWR, USGS, and previous investigators. DWR and USGS definitions differ substantially on the division of the groundwater basin into subunits[1]. The subunit and subbasin boundaries and names identified by the USGS and previous investigators are summarized here. The findings from previous studies conducted for the FVGB were referenced for describing the basin geology and hydrogeology (Krieger and Stewart 1971; USGS 1977; Stetson 2009).

The USGS defined six subunits in the FVGB: Koehn, California City, Chafee, Oak Creek, Gloster, and Willow Springs Subunits. Figure 13 shows the general areas of these subunits as defined by the USGS. The Koehn and Oak Creek subunits are narrow elongated units bounded by the Garlock fault on the west and the Randsburg-Mojave fault on the east. The boundary between the two subunits appears to be located just south of a surface water divide. East of the Randsburg-Mojave inferred fault, the USGS defines the California City Subunit as north of the Muroc fault and the inferred extension of the fault, and defines the Chaffee Subunit as south of the Muroc fault. The Gloster Subunit is defined as south of the Chafee Subunit and the Willow Springs Subunit (not shown on Figure 13) south of the Gloster Subunit. Previous investigation by Stetson (2009) also described the Muroc Fault acting as a groundwater barrier and dividing the basin into two subbasins, defined as the “California City Subbasin” north of the Muroc fault and the “Mojave City Subbasin” south of the Muroc fault. Figure 13 shows the boundaries used by Stetson; these boundaries do not conform with the DWR Bulletin 118 boundary for the FVGB.

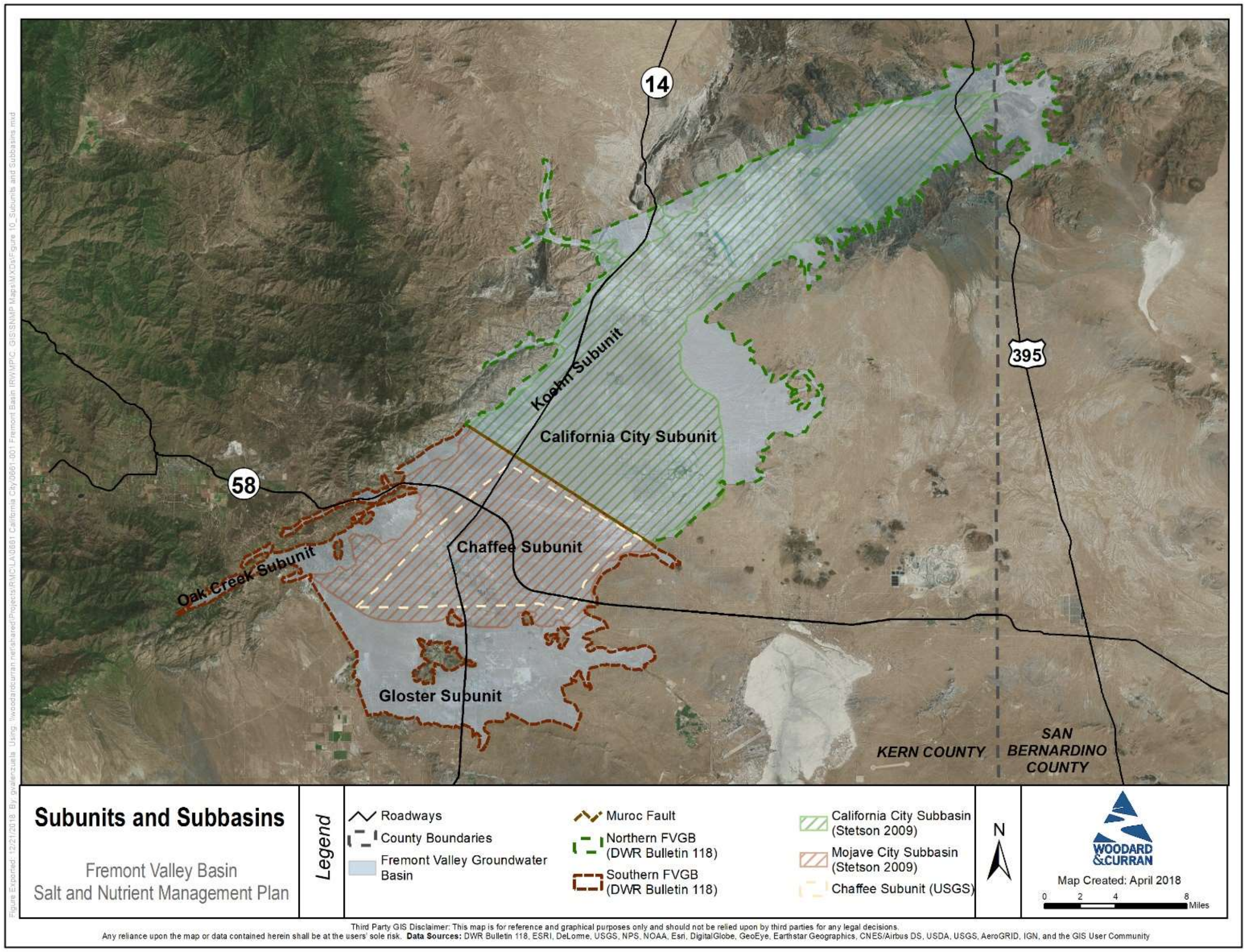
In contrast to the USGS, DWR Bulletin 118 does not define any subunits in the FVGB. While the SNMP uses the Bulletin 118 boundary for the FVGB, the basin is represented as two subareas with the Muroc fault as a divider. In this way, it is similar to the USGS and other previous studies. These subareas were defined for the purpose of the SNMP and allow for the assessment of spatial variability and different trends that may potentially exist in groundwater conditions. In this SNMP, the portion of the FVGB north of the Muroc fault is referred to as the “Northern FVGB” and the portion south of the Muroc fault is referred to as the “Southern FVGB”. This terminology was introduced to differentiate the two subareas defined in the FVGB boundaries for the SNMP from the areas and naming conventions used by the USGS and previous Stetson study (2009). It is important to note that the geographic areas covered by these SNMP terms are unique. The proposed approach for dividing the FVGB into two subareas across the Muroc fault for the purpose of the SNMP was discussed with the LRWQCB in April 2018. Figure 13 shows the subdivisions used in this SNMP, the Northern FVGB and Southern FVGB.

4.4 Aquifer Systems

Data and information on the characteristics of the FVGB aquifer system, such as conditions (confined or unconfined), transmissivities, hydraulic conductivities, and coefficients of storage, are very limited. According to DWR, groundwater in the alluvium is generally unconfined, although locally confined conditions occur near Koehn Lake (DWR 2004c). This is consistent with interpretations in a previous investigation stating confined layers of sand and gravel, which thin or lens out downslope to impervious clay near playas such as Koehn Lake, produce the largest yields. Historical water level data also indicate a portion of the aquifer system in the FVGB, particularly in the vicinity of Koehn Lake, is under confined conditions. Results of a pump test, which was conducted in the Cinco area, suggest that the aquifer in that area is limited to semi-confined conditions.

[1] Subdivisions of groundwater basins are generally referred to as “subbasins”; whereas in hydrologic studies, the term “subunits” is typically used to define subdivisions.

Figure 13: Subunits and Subbasins



4.5 Water Bearing Formations

Water bearing formations in the Southern FVGB at the surface of the Chafee Subunit consist primarily of older and younger alluvium (Richard C. Slade & Associates 1995). Most of the younger alluvium is above the water table and has a reported maximum thickness of 150 feet to 200 feet. Younger alluvium consists of alluvium, playa clay, and windblown sand of Holocene (Quaternary) geologic age. It is commonly described as yellow to brown clay, sandy clay, or silt with gravel lenses.

Older alluvium constitutes the principal aquifer and consists of poorly to moderately consolidated alluvial fan and stream channel deposits characterized by moderately to poorly sorted gravel, sand, and silt of Pleistocene (Quaternary) geologic age. The older alluvium appears to have a maximum thickness of about 550 feet - 650 feet in the Chaffee subunit. Older alluvium does not appear to extend to a depth greater than about 800 feet in the Chafee Subunit. Water wells in this area produce from the older alluvium and Pliocene sediments. North of the Muroc fault in the California City Subunit, a tertiary geologic unit also appears to yield groundwater.

Previous investigations indicated the depth to water in the Southern FVGB varied from over 300 feet bgs in the alluvial fan areas along the Tehachapi Mountains to less than 150 feet bgs along the low hills between the Soledad Mountains and the Radio Tower Hills. The depth to water in the Northern FVGB varied more drastically from near or above the ground surface in the vicinity of Koehn Lake to over 600 feet bgs near the Muroc fault (Stetson 2009).

4.6 Groundwater Conditions

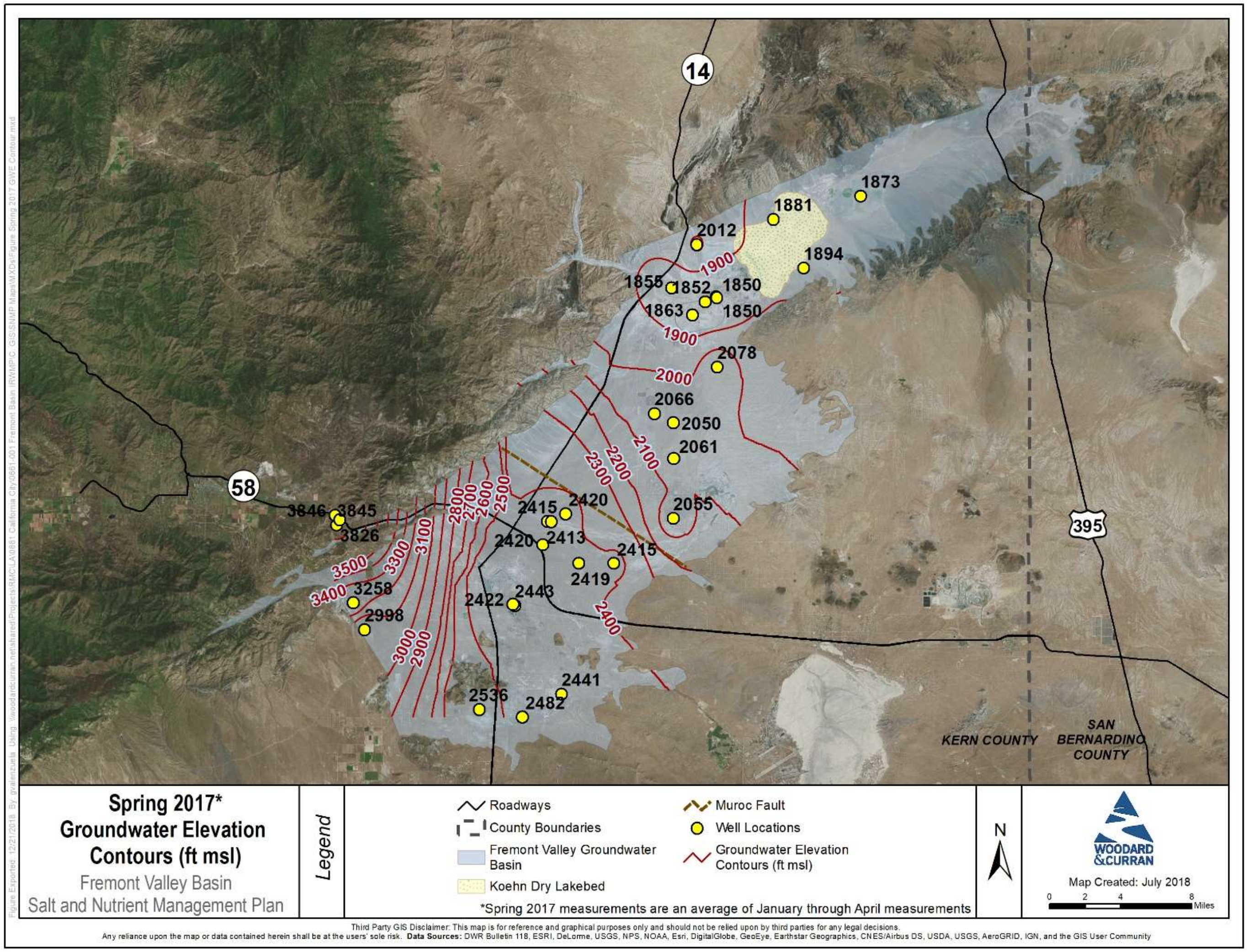
Historical and current groundwater conditions for general groundwater flow directions, groundwater levels, and storage are described in the following sections.

4.6.1 Groundwater Flow

There are two distinct directions of groundwater flow within the FVGB that have been reported by DWR Bulletin 118. In the southwestern part of the basin, groundwater flows from near Oak Creek northward toward the town of Mojave and continues under the surface drainage divide toward Koehn Lake (located in the northwestern part of the basin). The FVGB internally drains to the area below Koehn Lake. The Muroc fault acts as a partial groundwater barrier, which impedes but does not prevent the northerly movement of groundwater toward Koehn Lake. As mentioned above, the subsurface flow across the Muroc fault is reported to occur only when groundwater levels in the south of Muroc fault is higher than an elevation of approximately 2,420 ft msl, based on historical water levels near the Muroc fault, to allow groundwater to overflow the groundwater barrier created by the fault. Figure 14 shows a groundwater elevation contour map generated for Spring 2017, representing the current conditions. The general direction of groundwater flow is consistent with the DWR description.

As reported in the 1977 USGS study on the Koehn Lake area, groundwater moved from all directions toward Koehn Lake in 1958. A small pumping depression was reported five miles southeast of Koehn Lake because of increased agricultural pumping. Near Koehn Lake, irrigated acres increased from 4,100 acres in 1965 to 9,900 acres in 1976 for growing alfalfa. As pumping for irrigation increased in this area in 1976, the groundwater gradient from Koehn Lake toward a pumping depression increased. This condition caused concern about the possibility of saline water from under Koehn Lake migrating to the less saline areas. This condition has not occurred as there was a sharp decline in groundwater pumping as a result of reduction in agriculture after 1976. The 2017 groundwater elevation contour map in Figure 14 shows that the lowest groundwater levels are observed near Koehn Lake, topographically the lowest point in the FVGB.

Figure 14: Spring 2017 Groundwater Elevation Contours



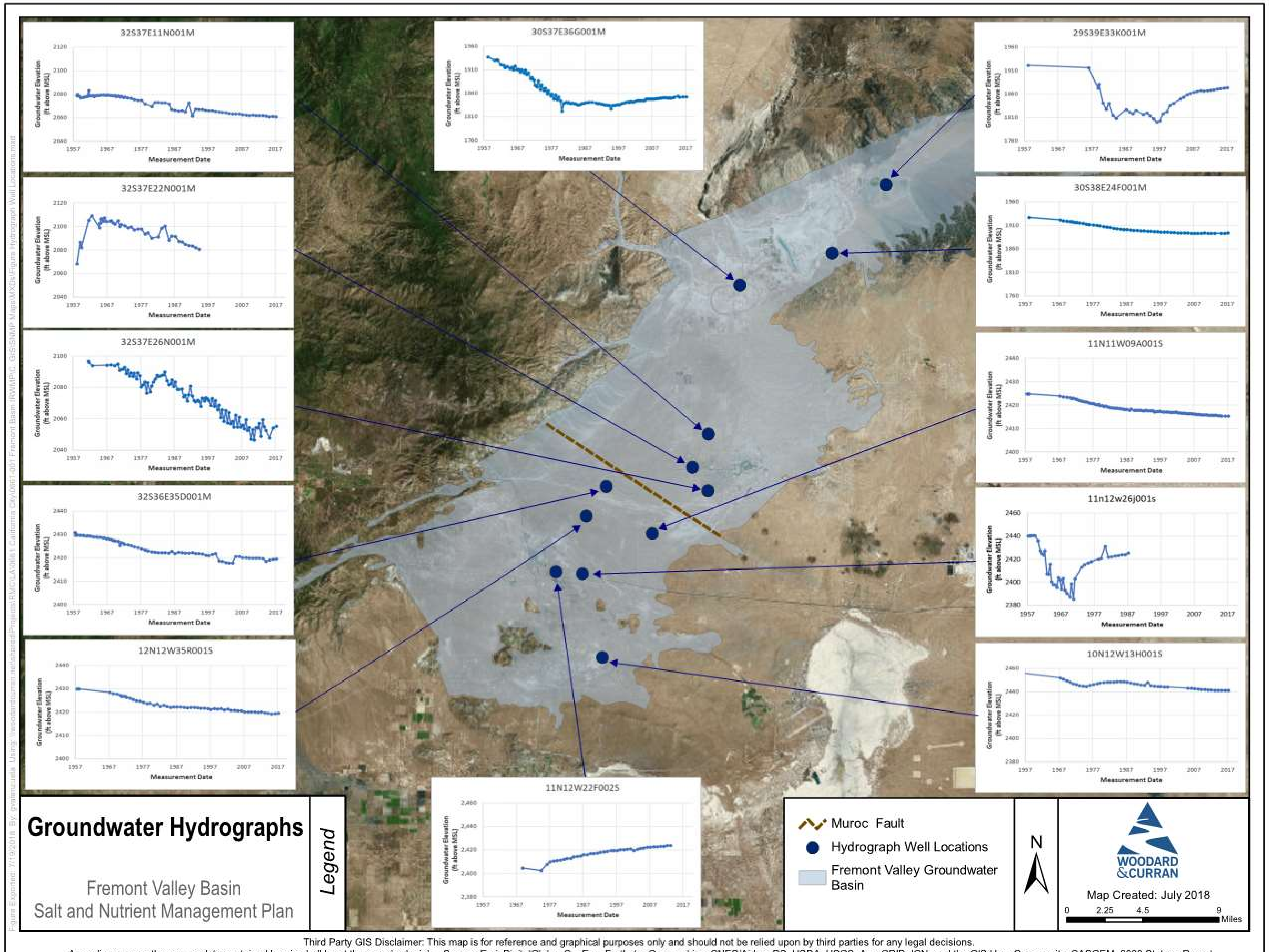
4.6.2 Groundwater Levels

Long-term groundwater level data indicate that the groundwater levels in the FVGB have declined significantly since 1955, probably due to the prolonged drought period from 1945 to 1964 and increased groundwater extractions in the late 1950s through the 1970s. Twelve groundwater hydrographs are presented in Figure 15 as representative examples of trends seen in the basin based on available historical water level data. Data collection for groundwater elevation analysis included the publicly-available CASGEM Program and USGS databases. Additional data were acquired from MPUD and Kern County agencies and from a 2009 Evaluation of Groundwater Resources report conducted by Stetson for the City.

In the Southern FVGB, hydrographs generally show the highest levels in the late 1950s, prior to the start of pumping by MPUD in 1960. Representative groundwater hydrographs showing similar trends include wells 12N12W35R001S, 11N11W09A001S, and 32S36E35D001M. Groundwater levels declined gradually until approximately 1968, when water levels began to decline at a greater rate. This appears to coincide with MPUD production increasing from about 200 AFY - 300 AFY prior to 1968 to between 500 AFY and 900 AFY through 1980. Around 1980, water levels continued to decline but at a much lower rate. This decrease in rate of decline appears to coincide with decreased pumping by MPUD when AVEK imported water deliveries became available in 1980. Groundwater level increases in this area after 1974, possibly due to a reduction in irrigation pumping in the area (10N12W13H001S). Hydrographs for the wells in the northern portion of the Southern FVGB show no obvious responses to significant precipitation events, such as the above-average rainfall from 1977 to 1984. Historical water level trends are quite different further south in the Southern FVGB where water levels showed increasing trends after 1975, as shown in the hydrographs for wells 11N12W26J001S and 11N12W22F002S. Well 11NR12W26J001S is located on or adjacent to the former Jameson Ranch and its hydrograph indicates sharp declines from 1960 through 1970. Following the apparent cessation of Jameson Ranch pumping at the end of 1970, water levels rose sharply between 1971 and 1974 and then gradually after 1974. While the USGS discontinued monitoring this well after 1987, hydrographs for 11N12W22F002S (near unused MPUD well No. 31) shows that water levels are still rising slowly in the vicinity of the former ranch. This rising trend is inconsistent with the declining trends in the majority of the Southern FVGB and could be due to a slow recovery from the cessation of agricultural pumping and/or due to the local effects of recharging wastewater treatment plant effluent.

Groundwater levels in the Northern FVGB have been declining since approximately 1965 or 1970, and trends have varied more drastically compared to the Southern FVGB. Similar to the Southern FVGB, there is an apparent trend of rising groundwater levels after AVEK deliveries began in 1980. Groundwater levels at the City's Well No.2 (32S37E22N001M, destroyed in 1994) declined over 100 feet by the mid-1950s, reportedly due to irrigation pumping (Richard C. Slade & Associates, 1995). By the mid-1960s, water levels had risen over 100 feet to near their pre-pumping levels. Water level increases observed from 1980 to1984 appear to correlate to AVEK deliveries beginning in 1980 and could be also attributed to the recharge effects of the 1977-1984 period of above-average precipitation. After 1984, water levels continued to decline, which was coincident with a reduction in AVEK deliveries (approximately 890 AFY - 1900 AFY for 1980-1984 reduced to approximately 50 AFY - 250 AFY for 1985-1990) and with a six-year period of below average precipitation in Mojave between 1985 and 1991.

Figure 15: Groundwater Hydrographs



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The hydrograph for Well 29S39E33K001M, which is located north of Koehn Lake, indicates a decline in groundwater levels of about 110 feet between 1976 and 1984. The water level in this well stabilized between 1985 and 1996 and has recovered about 70 feet since 1996, as shown on Figure 15. The hydrograph for well 30S38E24F001M, located near Koehn Lake, has been historically showing gradual decrease in groundwater levels but water levels appear to stabilize since early 2000. The hydrograph for well 30S37E36G001M, which is located in the central portion of the FVGB just south of the Koehn Lake, indicates a decline of approximately 105 feet between 1953 and 1985. The water level in this well appeared to stabilize between 1985 and 1995 and recovered approximately 17 feet since 1996. The hydrograph for well 31S37E35N001M, which is located in the south-central portion of the FVGB, just north of the California City, indicates a decline of approximately 28 feet between 1953 and 1980. The water level in this well appeared to stabilize between 1980 and 1991; then it recovered slightly and has been relatively stable in recent years. The hydrograph for Well 32S37E26N001M (California City's Well No.1) indicates a decline of approximately 20 feet between 1961 and 1978. The water level in this well recovered approximately 14 feet between 1978 and 1984 and then declined approximately 35 feet after 1984.

Review of the historical water levels and the recent water levels at the wells within the FVGB do not appear to confirm the hydrogeologic effects of the faults in the area, except for the Muroc fault. The significant difference in the water levels in wells 32S36E22C001M (reported as 2,110 feet msl in January 1958) and 32S36E21Q001M (reported as 2,429 feet msl in January 1958), which are located approximately 1.3 miles across the Muroc Fault, confirm the hydrogeologic effects of this fault.

4.6.3 Groundwater Storage

Different estimates of groundwater storage are reported for the FVGB or portions of the basin. DWR reports a storage capacity of 4.8 million acre-feet (MAF), though the amount of groundwater in storage is currently unknown. Groundwater storage was reported to be 4.1 MAF in 1976 based on a USGS study (USGS 1977). A recent investigation by Stetson (2009) estimated the groundwater storage for the Mojave City and California City Subbasins at approximately 5.66 MAF and 2.62 MAF, respectively. Groundwater storage under Koehn Lake, above the 500 feet depth, was estimated to be approximately 2 MAF by USGS (1977). The Fremont Valley Basin GWMP conducted a 2018 analysis to estimate the change in groundwater storage for the FVGB as briefly described below.

4.6.3.1 Change in Groundwater Storage

As part of the Fremont Valley Basin GWMP, groundwater elevations were contoured for selected years between 1958 and 2017 and contour maps were compared to calculate the change in groundwater elevations and resulting change in groundwater storage. Total storage change was estimated as -738,100 AF for the FVGB, including -608,300 AF for the Northern FVGB and -129,800 AF for the Southern FVGB. The negative change indicates a decline in groundwater storage, and this trend is consistent with the generally declining trends seen in groundwater levels as described above.

A network of wells was chosen north of the Muroc fault and south of the Muroc fault to calculate the change in storage for the Northern FVGB and the Southern FVGB separately. Twenty representative years were selected based on the availability of sufficient groundwater level data; the years were also selected such that both dry and wet hydrologic periods were included. Table 6 presents the years selected for groundwater contouring and the storage analysis; it identifies the hydrologic condition of each year with respect to the long-term average precipitation. Each year, an average of January, February, March, and April groundwater elevation measurements were used to represent spring groundwater elevations, when available (to capture conditions that occur, generally, after the rainy season). Representative wells were also selected from the available data. For wells with missing data, groundwater elevation values were interpolated based on adjacent years or nearby wells, as appropriate.

Table 6: Years Selected for Groundwater Elevation Contours

Year	Precipitation Above or Below Average	Year	Precipitation Above or Below Average
1958	Above	1990	Below
1969	Above	1993	Above
1972	Below	1995	Above
1975	Below	1998	Above
1978	Above	2005	Above
1980	Below	2007	Below
1981	Below	2010	Below
1983	Above	2013	Below
1985	Below	2015	Below
1987	Below	2017	Below

The Natural Neighbors tool for raster[1] interpolation in Geographic Information System (GIS) software was used to develop groundwater contours for the Northern and Southern FVGB separately. Appendix A presents the groundwater contours generated for each of the selected years using the locations of the selected wells. The change in groundwater elevation between each of the selected years was then calculated using raster math in GIS. This approach estimates the volume of dewatered sediments and multiplies that by the specific yield of the sediments for each consecutive year contoured. The change in storage was calculated by multiplying the change in groundwater elevation for each cell of a raster by the area covered by the raster, using a specific yield value of 0.098[2]. The value assumed for the specific yield was based on the previous investigation by Stetson (2009) for the unconsolidated deposits. The USGS study had an average specific yield of 1.1 percent (0.011) for the Koehn Lake area. Since Stetson's estimate covers much of the FVGB, this value was considered appropriate and used for the estimate of groundwater storage changes.

Some portions of the basin were not contoured because data were sparse or lacking. To calculate the change in storage outside of the raster areas for a given time period, the average change in groundwater elevation inside the raster areas was used.

For the purposes of the SNMP loading analysis, the groundwater storage volume was established by using the DWR estimate of 4.8 MAF of groundwater storage capacity as the initial condition. Then, declines in storage volume estimated between 1958 and 2017 were deducted from this initial value. The storage capacities assumed for north and south of the Muroc fault were set proportional to the overlying acreages south and north of the Muroc fault. This resulted in approximately 2.84 MAF of groundwater storage for the Northern FVGB and 1.96 MAF for the Southern FVGB. The calculated declines in storage volume were subtracted from these initial 1958 values, resulting in 2.24 MAF for the Northern FVGB and 1.83 MAF for the Southern FVGB in 2017 (current groundwater storage volume).

[1] A raster is "a spatial data model that defines space as an array of equally sized cells arranged in rows and columns, and composed of single or multiple bands. Each cell contains an attribute value and location coordinates. Unlike a vector structure, which stores coordinates explicitly, raster coordinates are contained in the ordering of the matrix. Groups of cells that share the same value represent the same type of geographic feature."

[2] Specific yield is defined as the percentage by volume of drainable pore spaces.

4.6.4 Groundwater Recharge

Recharge to the FVGB has two sources: recharge from precipitation to the valley floor and percolation of runoff from mountains and neighboring watersheds. As the runoff migrates over the valley floor, losses occur by evaporation and transpiration. When runoff is intense, some of the water reaches Koehn Lake. Because the lake bed is nearly impermeable, most of the water is ponded and lost to evaporation (USGS 1977). Recharge also occurs from underflow in the creek channels that emanate from the mountains. The Fremont Valley Basin GWMP developed a simplified, spreadsheet-based groundwater balance model and estimated an annual average recharge to the FVGB as summarized below.

4.6.4.1 Groundwater Balance Model

As part of the Fremont Valley Basin GWMP, a spreadsheet-based groundwater balance model was developed to estimate inflows, outflows, and resulting changes in groundwater storage in the FVGB. Due to distinct trends in groundwater levels north and south of the Muroc Fault, a separate groundwater balance analysis was performed for each of the two subareas. Overall, inflows include recharge to the valley floor and runoff recharge from the neighboring watersheds. The Northern FVGB is also assumed to receive a small amount of underflow from the Antelope Valley Groundwater Basin and from the Southern FVGB across the Muroc Fault (only occurred historically through 1958). Recharge from WWTP effluent is not considered significant from a water balance perspective because evaporation at the California City ponds significantly reduce percolation and the MPUD ponds are lined. Therefore, WWTP effluent is not included in the water balance accounting, though all of the nitrate and TDS from the California City ponds is assumed to be available for the groundwater basin. Outflows include pumping for urban and agricultural demands.

Change in storage estimated from the water balance was calibrated against the change in storage estimated from the groundwater elevation contour maps, as discussed above. The calibration was performed to minimize the difference between the change in storage from the water balance and the change in storage estimated from the groundwater elevation contour maps. Precipitation coefficients[1] were used as calibration parameters to achieve a good match between the two datasets. The root-mean-square-error (RMSE)[2] was used to evaluate the difference (or residuals) between two datasets during calibration. The water balance analysis was conducted for the years 1945 to 2017, but the groundwater contouring analysis begins in 1958 as groundwater elevation data prior to 1958 were sparse or lacking. For the Southern FVGB, pumping in unincorporated areas is unknown and was estimated as part of the calibration process to minimize the difference between the change in storage from the water balance and the change in storage estimated from the groundwater elevation contour maps. Historical agricultural pumping in the Northern FVGB was based on limited available historical data and a methodology for estimating demands was further described in Section 5.

Based on the calibrated groundwater balance analysis, the average groundwater recharge was estimated as 13,800 AFY[3] for the FVGB, with 11,300 AFY in the Northern FVGB (approximately 80 percent of total) and 2,500 AFY in the Southern FVGB (approximately 20 percent of total). The last 20 years of data (1998-2017) were selected to calculate the average annual recharge as this period reflects a reduction in urban groundwater pumping. The reduction is probably a reflection of AVEK deliveries starting in 1980 and the significant reduction in agricultural pumping after 1976. This period also includes more complete groundwater elevation records and encompasses both hydrologically wet and dry periods, including the most recent years with below average precipitation.

[1] Precipitation coefficient is a dimensionless coefficient used to estimate the amount of runoff from the amount of precipitation, i.e., the percentage of precipitation that is assumed to infiltrate into the basin.
[2] RMSE is the square root of the average of squared residuals between two datasets.
[3] This recharge estimate is higher than the 1977 USGS recharge estimate which noted a local groundwater recharge of 10,200 AFY. The difference in the recharge estimates is primarily due to the different basin footprint used in the USGS analysis.

4.6.5 Groundwater Quality for Salt and Nutrients

Determining the groundwater quality conditions with respect to TDS and nitrate is a critical step in the SNMP analysis and supports the loading analysis that is discussed in Section 7, as discussed below.

4.6.5.1 Indicators for Salts and Nutrients

TDS and nitrate (measured as nitrogen or N) are the salt and nutrient indicator constituents selected for this SNMP. Other chemicals of concern are described within the Fremont Valley Basin GWMP. TDS is a measure of all dissolved constituents in water, including organic and suspended solids smaller than 2 micrometers, primarily from rocks and sediments with which the water comes in contact. While TDS can occur naturally in groundwater, high levels of TDS can be a sign of anthropogenic impacts such as agriculture and waste disposal practices. Because of the wide variety of activities that contribute TDS and could lead to water quality degradation, it is considered a good initial indicator of overall water quality. In SNMP analyses, concentration trends are often used as a long-term indicator of basin health.

Nitrate is a widespread contaminant in California groundwater. Elevated concentrations of nitrate in groundwater are often associated with human activities such as wastewater treatment discharges, fertilizer application and land application of animal wastes.

4.6.5.2 Water Quality Objectives

Water quality objectives for TDS and nitrate provide references for assessing groundwater quality in the FVGB. While no MCL exists for TDS, the recommended SMCL for TDS is 500 mg/L for taste and odor thresholds with upper limit SMLC of 1,000 mg/L, and short-term limit SMCL of 1,500 mg/L. Although SMCLs address aesthetic issues rather than health effects, elevated TDS concentrations in water can damage crops, affect plant growth, and damage municipal and industrial equipment.

As a regulated drinking water contaminant, the Basin Plan has established a water quality objective of 10 mg/L MCL for “nitrate as nitrogen” (as N) or 45 mg/L as “nitrate” (NO_3) for groundwater designated as municipal and domestic supply. Nitrate-N was selected for the assessment in this SNMP.

4.6.5.3 Data Sources

Available groundwater quality data for TDS and nitrate-N were collected from various sources, including the following publicly-available databases: Geotracker Groundwater Ambient Monitoring and Assessment Program (Geotracker GAMA), USGS, records collected by the City, Kern County Public Health Department (Kern County), MPUD, and RCWD. TDS and nitrate-N were analyzed to develop a representative single estimate for the Northern FVGB and the Southern FVGB. The resulting concentrations were used in the loading analysis described in Section 7.

A summary of the collected data for TDS and nitrate-N is presented in Table 7. Datasets from different sources were compared and wells were matched by their USGS identification numbers; duplicate reports were identified and omitted to the extent possible. The reported number of wells is greater than the unique number of wells because, in some cases, duplicate information was reported from different agencies. The unique number of wells with data is estimated to be 166 for TDS and 236 for nitrate-N. Data collected for other chemicals of concern (chloride, boron, arsenic, and hexavalent chromium (chromium-6)) were analyzed as part of the Fremont Valley Basin GWMP.

Table 7: Groundwater Quality Data Summary

Reporting Agency	Number of Wells[1]	
	Total Dissolved Solids (TDS)	Nitrate (as N)
California City	4	7
Geotracker GAMA	162	151
Kern County	N/A	76
MPUD	6	6
RCWD	1	3
USGS	8	7

Note: (1) Reported number of wells is greater than unique number of wells because in some cases duplicate information was reported from different agencies. The unique number of wells with data is estimated to be 166 for TDS and 236 for nitrate-N.

4.6.5.4 Total Dissolved Solids

Generally, relatively low TDS concentrations (less than 500 mg/L) are observed throughout most of the basin. Figure 16 presents average TDS concentrations of wells based on the historical data available. Of the 166 wells analyzed, 86 (52 percent) reported average TDS concentrations above the recommended SMCL of 500 mg/L and 24 wells (14 percent) above the upper limit SMCL of 1,000 mg/L. Elevated concentrations above 1,000 mg/L were generally observed around and north of Koehn Lake. Elevated levels of TDS near Koehn Lake were also noted by DWR as an impairment to groundwater quality. Overall, the percentage of wells exceeding the upper limit SMCL of 1,000 mg/L is low (14 percent of total number of wells). High concentrations of TDS from the 1950s and 1960s were reported near Koehn Lake, but there are no recent data available for the area.

Figure 17 shows time-concentration plots for TDS within the FVGB from selected wells. Eight wells with available data were selected to represent trends across the basin. Two wells show concentrations that are stable and consistently lower than the 500 mg/L SMCL. Two wells observed concentrations that are near or just below the 500 mg/L SMCL. Four wells show concentrations that exceed the 500 mg/L but generally fall between 500 and 600 mg/L.

4.6.5.5 Nitrate

Nitrate-N concentrations are generally low across the basin with most of the wells at concentrations of nitrate-N below the 10 mg/L MCL. Figure 18 shows average nitrate-N concentrations for wells with available historical data. Of the 236 wells analyzed, five wells (2 percent) reported average nitrate-N concentrations above the 10 mg/L MCL.

Figure 19 shows time-concentration plots for nitrate-N trends within the FVGB. Eight wells with the most consistent data and spatial distribution were chosen to assess nitrate-N trends. One well shows fluctuations and concentrations exceeding the 10 mg/L MCL. The rest of the wells appear to show concentrations that are generally stable and less than 2 mg/L. Overall, the percentage of wells exceeding the water quality objective of 10 mg/L MCL is very low (2 percent). This small number of exceedances is likely reflective of localized conditions and not a regional, widespread nitrate issue.

4.6.5.6 Groundwater Quality Averaging

Data availability and trends were analyzed for both for TDS and nitrate to develop a dataset representative of the groundwater quality conditions for the Northern and Southern FVGB. The approach used in this SNMP to analyze the water quality for south and north of the Muroc fault was shared with the LRWQCB in April 2018.

Data available for the last 5, 10, 15, and 20 years were analyzed. Figure 20 shows the number of wells with data available for TDS and nitrate for the time periods analyzed for the Northern and Southern FVGB. As shown in the figure, the last 20 years have the highest number of wells with data available, including 28 wells in the Northern FVGB and 20 wells in the Southern FVGB for TDS, and 32 wells in the Northern FVGB and 42 wells in the Southern FVGB for nitrate. The last 20 years of data (1998-2017) were utilized for the SNMP analysis to best reflect the basin conditions both spatially and temporally.

For the purposes of the SNMP, median groundwater concentrations for samples collected from wells were used for TDS and nitrate-N to reflect variability observed in the datasets. For TDS, the median concentration over the 20-year averaging period was approximately 484 mg/L for the Northern FVGB, which is below the recommended SMCL of 500 mg/L. The median concentration for the Southern FVGB was 503 mg/L, which was slightly above the SMCL of 500 mg/L and well below the upper limit SMCL of 1,000 mg/L for TDS. Based on the data utilized for this analysis, the vast majority of the wells exhibited low TDS concentrations. Basin-wide, 19 wells (40 percent) utilized for the TDS analysis exceeded the recommended SMCL of 500 mg/L and only three wells (6 percent) exceeded the upper limit SMCL of 1,000 mg/L.

Similar to the approach used for TDS, median concentrations were calculated for nitrate-N for the last 20 years. Nitrate datasets included four records reported as non-detects that were replaced with half of the reporting limit of 0.4 mg/L for nitrate-N. The median concentration for the last 20 years was calculated to be 0.68 mg/L for the Northern FVGB and 2 mg/L for the Southern FVGB. Overall, the vast majority of the wells exhibited low nitrate concentrations. Basin wide, only one well (1 percent) utilized for nitrate-N exceeded the 10 mg/L MCL.

In Section 7, the average TDS and nitrate-N concentrations are compared to the Basin Plan water quality objectives to determine the currently-available assimilative capacity in the FVGB.

Figure 16: TDS Concentrations

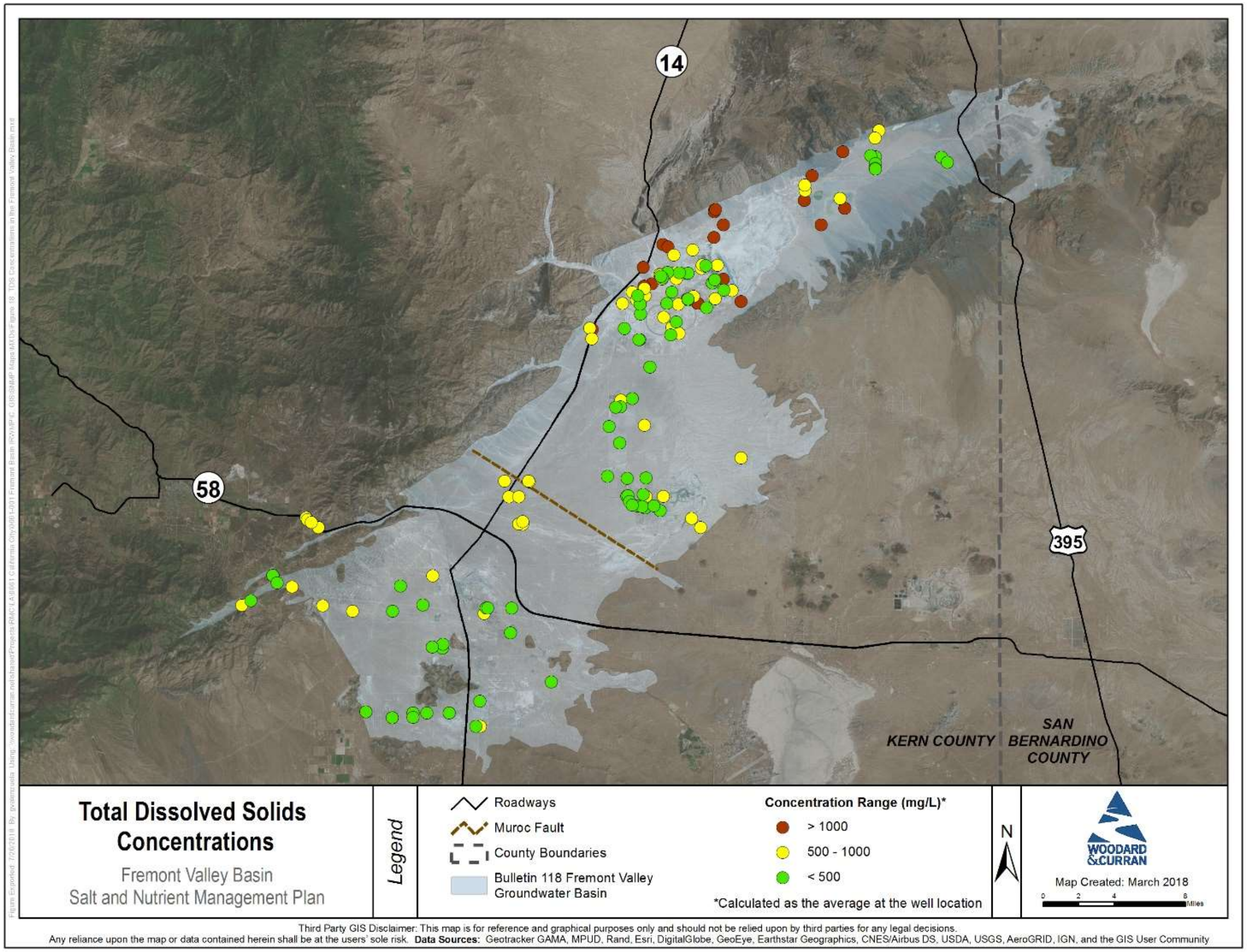

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Figure 17: TDS Concentration Trends

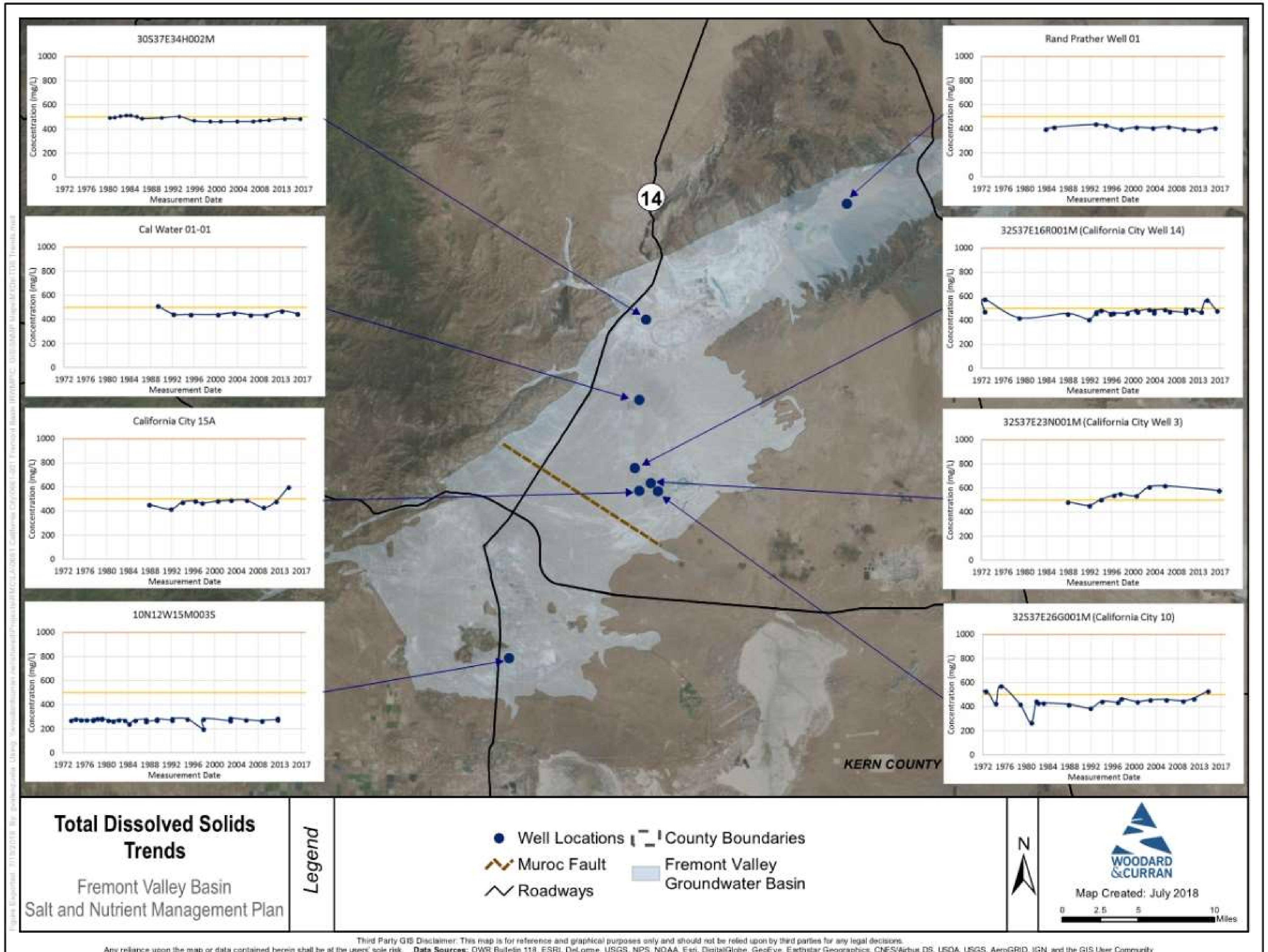

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Figure 18: Nitrate (as N) Concentrations

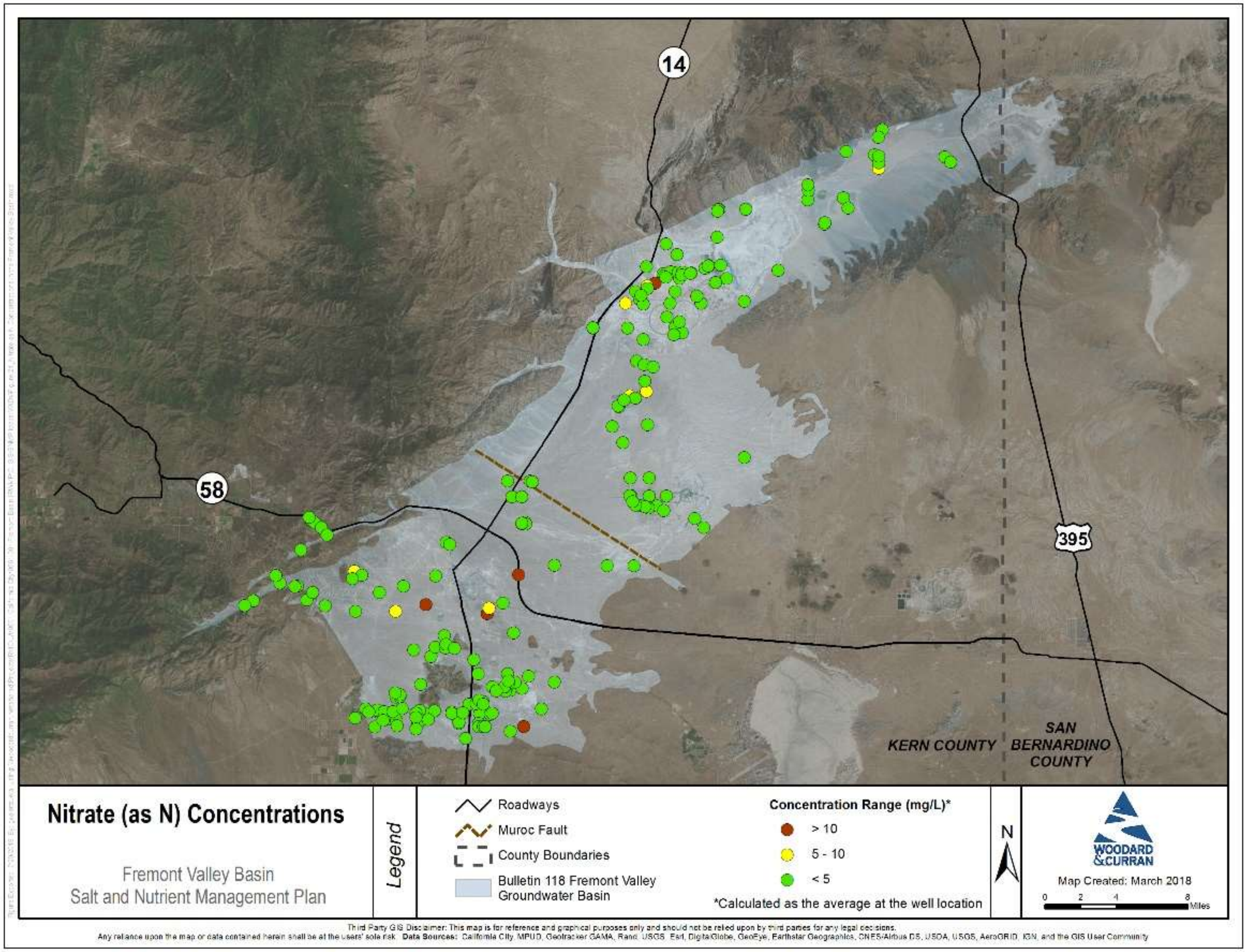

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Figure 19: Nitrate (as N) Concentration Trends

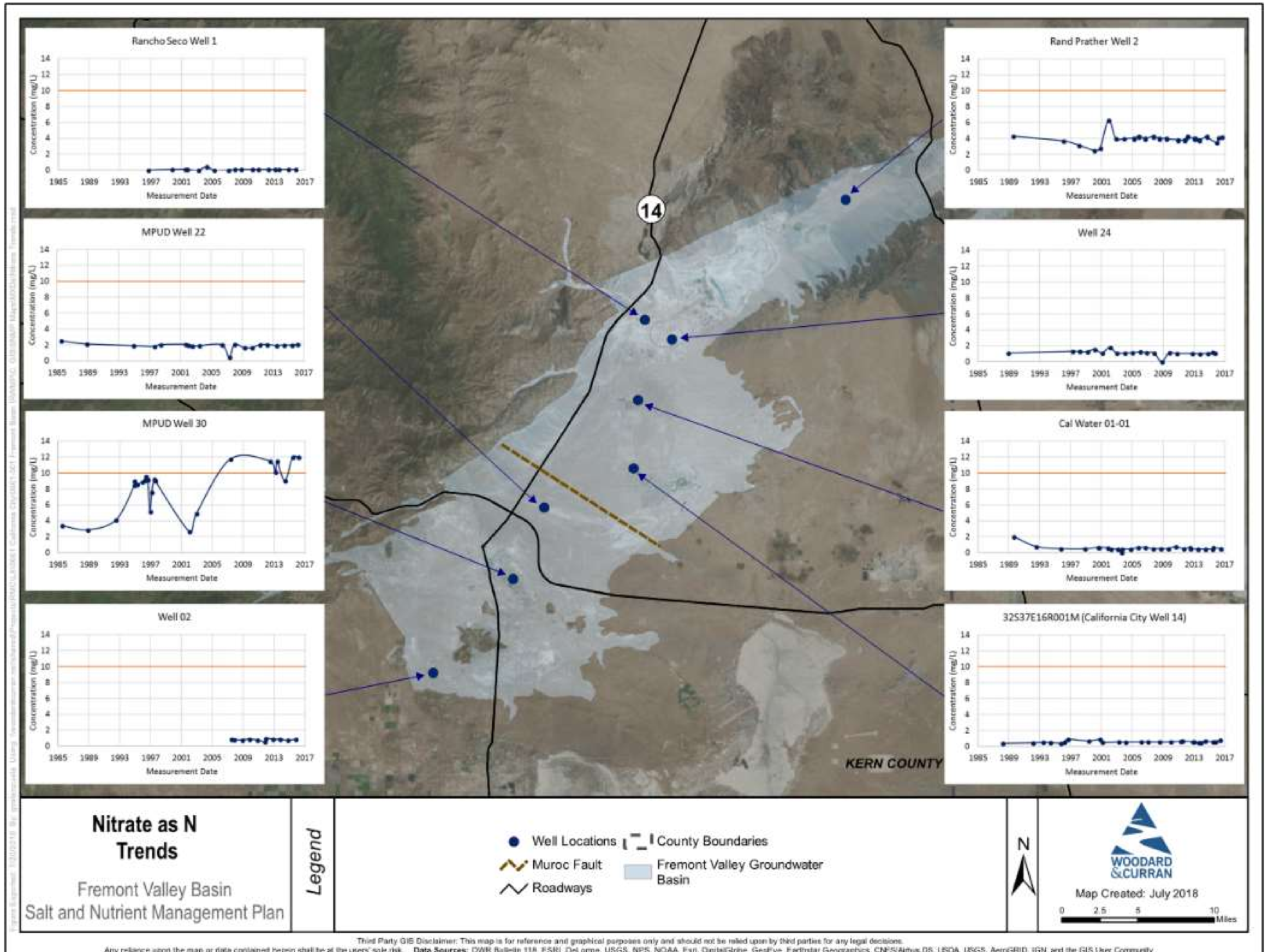

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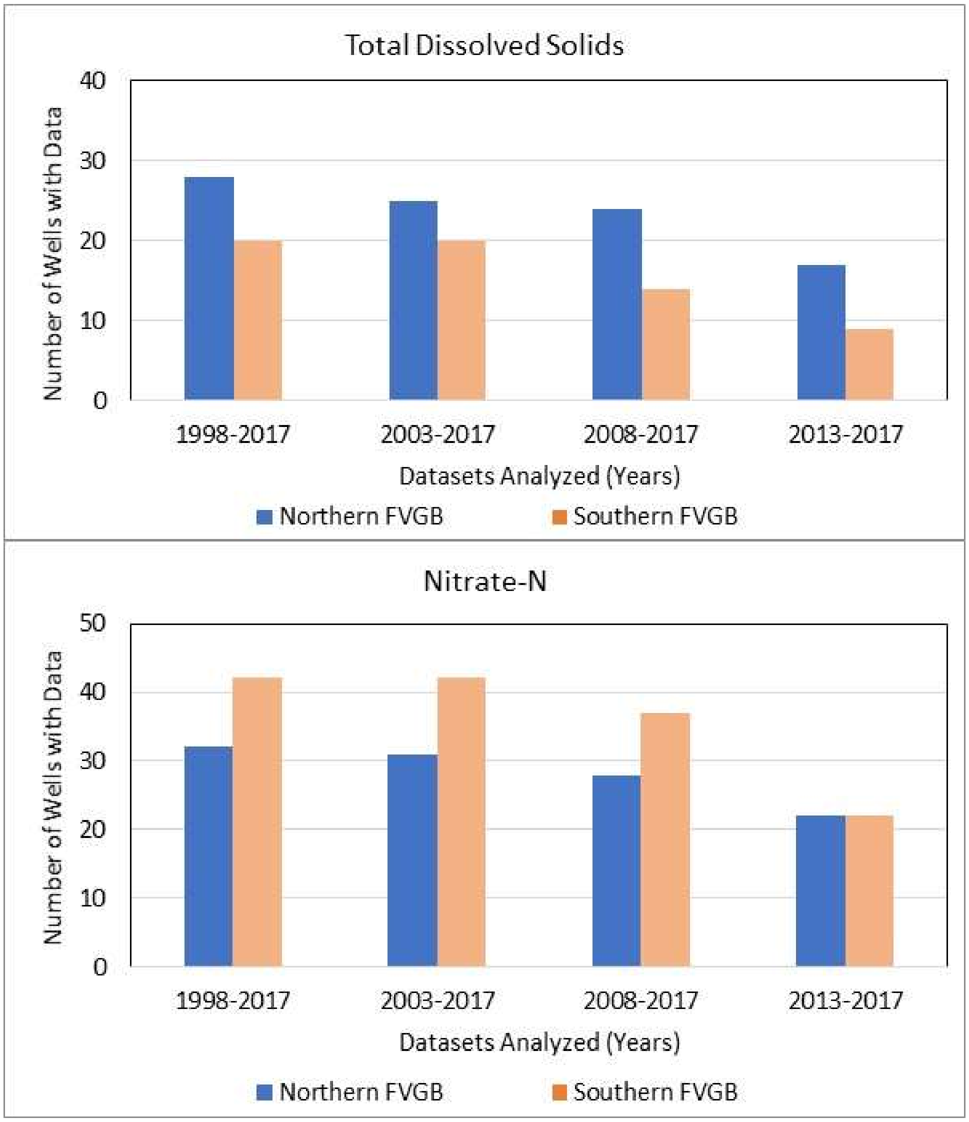
Figure 20: Summary of Available TDS and Nitrate-N Data



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5. WATER DEMAND AND SUPPLIES

This section describes the historical, current and future projected water demand and supply conditions in the Plan area.

5.1 Water Demand

The basin-wide water demand described in the following sections is based on demands from individual sectors, including residential, agricultural, and industrial.

5.1.1 Historical Water Demands

In the Plan area, water demands have historically been for urban and agricultural uses. Urban demand, comprised of residential users served by the City, MPUD, Cal Water, Rancho Seco Inc., RCWD, and private pumping, has increased over time as presented in Table 8. For the purpose of this plan, these demands include any commercial users served by the water purveyors and any associated distribution system water losses. Agricultural activities increased through the 1960s and 1970s and peaked in 1976, with groundwater extractions reaching a maximum of approximately 60,000 AFY according to previous USGS investigations (USGS 1977). Increased groundwater production led to significant groundwater declines in the FVGB that persisted through the mid-1980's. Agricultural activities significantly decreased thereafter; when comparing cultivated acreage from USGS 1977 to 2010 aerial imagery, as of 2010, only one percent of lands cultivated in 1976 were still in production. Aerial maps were used to estimate the areas cultivated historically and were used to verify that most agricultural activities were performed in the northern FVGB. It was not possible to confirm the types of crops produced in the Plan area based on visual inspections of aerial maps. Since alfalfa has been historically grown throughout the Plan area, agricultural demand estimates assume that alfalfa is the only crop cultivated in the Plan area. Historical agricultural demands were estimated by applying a specific crop coefficient to the acres of land cultivated.

Historical urban water demands in the Plan area are based on estimated groundwater pumping data and imported water data provided by the City, MPUD, and AVEK. For years with missing water records, demands were extrapolated using:

- The population overlaying the FVGB (provided by U.S. Census data)
- Historical growth rates in Kern County (provided by the Department of Finance (DOF))
- Average assumed gallons per capita per day (GPCD) for the City and MPUD (obtained from UWMPs).

For urban demand estimates in the Southern FVGB (south of Muroc fault), it was assumed that the population consists of the MPUD service area and approximately 30 percent of the population in unincorporated Kern County that overlies the basin. The 30 percent value is assumed because 30 percent of the current unincorporated Kern County population overlaying the basin resides south of the Muroc fault. All remaining population overlying the basin was assumed to be located in the Northern FVGB (north of Muroc fault).

Table 8: Estimated Historical Urban Demand in the Plan Area (AFY)

	1960	1970	1976[1]	1980	1990	2000	2010
Agricultural Demand[2]	17,500	34,000	60,000	39,600	10,200	2,700	700
Urban Demand[3]	2,800	3,200	3,600	3,900	5,100	5,100	5,700
Total Demand	**20,300**	**37,200**	**63,600**	**43,500**	**15,300**	**7,800**	**6,400**

Note: Data rounded to nearest hundred.
Source: (1) Values for 1976 are included because it was the peak year for agricultural demands; urban demands for 1976 were interpolated from 1970 and 1980 values; (2) Estimated from Cooperative Extension University of California Division of Agriculture and Natural Resources N.D.a. and N.D.b. and aerial maps; (3) Estimated from Department of Finance growth rates for Kern County for the years 1960 through 2010 and U.S. Census data for 1990, 2000, and 2010.

5.1.2 Current and Projected Water Demand

Total water demand in the Plan area is projected to increase more than 60 percent by 2040. Residential water use accounts for the biggest portion of current demand, making up approximately 70 percent. Residential demand will continue to be the largest component of total water demand through 2040. Industrial activities account for the second largest component of current water demand, making up approximately 20 percent. In comparison, agricultural activities account for less than 10 percent of all demand. Water loss associated with water purveyor distribution systems are not separated from the residential category for the purpose of this analysis but, it is important to note, are significant issues for many distribution systems in the Plan area. Water demand projections in this section do not consider climate change, natural disasters, or other events that may affect water demand. Potential future scenarios for demands in the FVGB are discussed in Section 8. Potential impacts of climate change on demands are discussed qualitatively in Sections 5.3 and 8.4.

A summary of water demand by land use is provided in Table 9 and described in detail in Sections 5.1.2.1 through 5.1.2.3. Residential demands include water purveyor potable system demands (including commercial and water loss), recycled water demands, and the estimated unincorporated Kern County private pumping demands. For the purpose of the demand analysis, 2015 was assumed to represent current conditions. Table 9 reflects a "Baseline Condition" that assumes residential and industrial demands steadily increase according to planned development documented in UWMPs or cited by City planning officials, whereas agricultural demands remain static at 2015 levels. The Baseline Condition does not reflect an increase in agricultural demands as there are currently no specific plans to increase or decrease agriculture in the planning area. Because an increase in agriculture is possible in the planning area, three future agricultural growth scenarios ("light", "medium", and "heavy") were developed and compared to the Baseline Condition, as described in Section 5.1.2.2. Other future scenarios involving increased stormwater capture and septic to sewer conversions are discussed in Section 8.

Table 9: Current and Projected Water Demand in the Plan Area (AF) – Baseline Condition

	2015	2020	2025	2030	2035	2040
Residential[1]	5,278	7,339	7,686	8,045	8,408	9,328
Agricultural	647	647	647	647	647	647
Industrial	1,442	1,501	1,707	1,914	2,120	2,326
Plan Area Total	**7,367**	**9,487**	**10,040**	**10,606**	**11,175**	**12,301**

Note: 1) Residential water demands include recycled water and unincorporated Kern County private pumping

5.1.2.1 Current and Projected Residential Water Demand

The total current residential demand for 2015 in the Plan area is estimated to be 5,278 AFY for a total population of approximately 19,000. The water demand projections for the City are based on the 2015 UWMP (California City Water Department 2017) and include demands for recycled water. Demands in the City service area are projected to increase by approximately 90 percent by 2040, primarily due to the planned expansion of a correctional center (California City Water Department 2017).

Current and future demands for MPUD, Cal Water, RCWD, and private pumping in unincorporated Kern County were calculated by applying estimated DOF Kern County population growth rates to each agency's 2015 water deliveries in the Plan area (DOF 2017; California Water Service 2016). Private pumping demand in unincorporated Kern County was estimated to be 98 AF[1], based on population in the areas outside of established service areas (U.S. Census 2010) and an average per capita water use value for the Plan area. Approximately 70 percent of these residential water demands are expected to occur in the Northern FVGB based on the current population distribution estimated relative to the Muroc fault. A summary of the projected residential water demands is shown in Table 10.

Table 10: Current and Projected Residential Water Demand (AF)

	2015	2020	2025	2030	2035	2040
California City[1]	4,124	6,125	6,386	6,650	6,917	7,743
Cal Water[2]	14	15	16	17	18	19
MPUD[2]	986	1,038	1,111	1,192	1,274	1,355
Rancho Seco[2]	9	9	10	11	12	12
RCWD[2]	47	49	53	57	61	65
Unincorporated Kern County Private Pumping[2]	98	103	110	118	126	134
Plan Area Total	**5,278**	**7,339**	**7,686**	**8,045**	**8,408**	**9,328**

Note: Water demands shown in the table above include current and projected recycled water demands.
Sources: (1) Projections based on DOF growth rates for the City; (2) Projections based on DOF growth rates for the unincorporated Kern County.

5.1.2.2 Current and Projected Agricultural Water Demand

Agriculture is an important component of the water demand for the Plan area and it is anticipated to be a source of significant demand in the Northern FVGB in the future. Though it is assumed that only alfalfa has been historically cultivated in the Plan area, both the Sustainable Groundwater Management tool provided by DWR and aerial maps confirmed that pistachios are currently cultivated in the Plan area in addition to alfalfa. To estimate current agriculture demands, approximately 207 acres of land in the Plan area were assumed to be cultivated, and for the purposes of estimating current and projected future agricultural water use, it is assumed that approximately half of the area was cultivated with alfalfa and the other half of the area was cultivated with pistachios in 2015. Agricultural water demand for these two crops was estimated based on the calculated monthly gross water requirements (ETc) as the product of the reference evapotranspiration (ETo) from the Palmdale CIMIS Station and a unique crop factor (Kc). Kc values

[1] The population estimate in unincorporated Kern County is based on discussions with the Fremont Basin RWMG and their knowledge of communities outside of existing service areas.

account for specific daily evapotranspiration variations due to growth and development in different crops. Alfalfa has an annual gross water requirement more than eight times greater than that of pistachios, which results in a significant difference in agricultural water demand for a given acreage (Cooperative Extension University of California Division of Agriculture and Natural Resources N.D.a. and ND.b.). Assuming an irrigation system efficiency of 75 percent under normal conditions (USDA 2013), crop ETc is estimated at approximately 60.1 inches for alfalfa and 7.3 inches for pistachios, resulting in water demand estimates of 630 AF for alfalfa and 17 AF for pistachios in 2015. Alfalfa is a very water-intensive crop, and though it was assumed to be cultivated only on an estimated 50 percent of all farm lands in the Northern FVGB in 2015, it accounts for more than 97 percent of the total agricultural water demand.

To estimate future agricultural demands, a different approach was used. The viability of agricultural operations would depend on several factors, including but not limited to available zoned land, the price of water, market prices for various crop types, and local community support. The Kern County General Plan zoning and descriptions were reviewed for land use designations noted as a potential use of irrigated cropland. Though there are no formal plans to increase agriculture beyond 2015 levels, available documents indicate that agricultural demands in the FVGB have been as high as 60,000 AFY in the 1970s, with cultivated acreage covering a much larger area than today. To plan for potential future agricultural activity and estimate the water demands, the Baseline Condition plus three agricultural "growth scenarios" were developed and analyzed using the historical maximum of 60,000 AFY water demand as a basis.

The Baseline Condition assumes that 2015 demands for agriculture remain unchanged at 647 AFY in future years (about one percent of the historical maximum of 60,000 AFY). Building on the Baseline Condition, each of the three growth scenarios assumes agricultural demand in the Plan area would increase to approximately 5, 10, and 15 percent of the historical maximum by 2040. These are referenced as the "light growth", "medium growth", and "heavy growth" agricultural scenarios, respectively. While pistachio farming may increase in the Plan area due to their low water use requirements, the FVGB demand analysis was designed to assess potential future demand scenarios and is not intended to represent precise future crop profiles. Because alfalfa requires significantly more water than pistachios, the projections assume that pistachio cultivation will remain constant through 2040 and all future agricultural demand growth would be from increased alfalfa cultivation. Alfalfa cultivation is also assumed to increase linearly from 2015 to 2040. The total acres cultivated in the Plan area under the Baseline Condition and each of the three growth scenarios are shown in Table 11. It should be noted that other crop combinations could be cultivated and that actual agricultural demands could remain constant or decrease. It is also possible that agricultural expansion could occur more rapidly, given historical cultivation levels; but the following future scenarios are considered to be reasonable projections for the purposes of this SNMP by the RWMG and IRWM stakeholders.

Given these parameters and assumptions, alfalfa production in the FVGB has the potential to increase by approximately five times by 2040 in Scenario 1 (light growth), approximately 10 times by 2040 in Scenario 2 (medium growth), and approximately 14 times by 2040 in Scenario 3 (heavy growth) (Table 12).

To estimate the breakdown of agricultural demand projections between the Northern the Southern FVGB, findings from a groundwater balance analysis conducted as part of the Fremont Valley Basin GWMP were used. The groundwater balance analysis described in Section 4.6.4.1 estimated an average annual recharge rate of approximately 13,800 AFY, with about 80 percent of the recharge assumed to occur in the Northern FVGB and approximately 20 percent assumed to occur in the Southern FVGB. The breakdown of 80 and 20 percent for the Northern and Southern FVGB, respectively, was used for estimating agricultural demand based on the proportion of estimated annual natural recharge for the Northern and Southern FVGB in the Fremont Valley Basin GWMP.

Table 13 summarizes the current and projected agricultural water demands, separated into values for the Northern and Southern FVGB. Agricultural demand by 2040 is projected to be 3,000 AF for Scenario 1 (light growth), 6,000 AF for Scenario 2 (medium growth), and 9,000 AF for Scenario 3 (heavy growth). These projections are incorporated into the salt and nutrient loading and anti-degradation analysis in Sections 7 and 8 of this Plan to quantify potential impacts to groundwater quality from the future agricultural growth scenarios.

Table 11: Total Acres Cultivated in the Plan Area (acres)

	Scenario	2015	2020	2025	2030	2035	2040
Northern FVGB	Baseline Condition	207	207	207	207	207	207
	Scenario 1: Light Growth	207	265	322	380	437	495
	Scenario 2: Medium Growth	207	343	480	616	753	889
	Scenario 3: Heavy Growth	207	422	638	853	1,068	1,283
Southern FVGB	Baseline Condition	0	0	0	0	0	0
	Scenario 1: Light Growth	0	20	39	59	79	99
	Scenario 2: Medium Growth	0	39	79	118	158	197
	Scenario 3: Heavy Growth	0	59	118	177	237	296

Assumptions: 80 percent of agricultural activities will occur in the Northern FVGB and 20 percent in the Southern FVGB to reflect proportion of the total recharge assumed to occur in the Northern and Southern FVGB. Each of the three growth scenarios assumes linear agricultural demand increase to approximately 5, 10, and 15 percent of the historical maximum by 2040. Pistachio cultivation is assumed to remain constant through 2040, and all future agricultural demand growth is assumed to be from increased alfalfa cultivation. Projections assume an irrigation system efficiency of 75 percent under normal conditions.

Table 12: Current and Projected Agricultural Water Demand (AF)

	2015	2020	2025	2030	2035	2040
Baseline						
Alfalfa	630	630	630	630	630	630
Pistachios	17	17	17	17	17	17
Total	**647**	**647**	**647**	**647**	**647**	**647**
Scenario 1 (Light Growth): 5% of Historical Agricultural Maximum						
Alfalfa	630	1,101	1,571	2,042	2,512	2,983
Pistachios	17	17	17	17	17	17
Total	**647**	**1,118**	**1,588**	**2,059**	**2,529**	**3,000**
Scenario 2 (Medium Growth): 10% of Historical Agricultural Maximum						
Alfalfa	630	1,701	2,771	3,842	4,912	5,983
Pistachios	17	17	17	17	17	17
Total	**647**	**1,718**	**2,788**	**3,859**	**4,929**	**6,000**
Scenario 3 (Heavy Growth): 15% of Historical Agricultural Maximum						
Alfalfa	630	2,301	3,971	5,642	7,312	8,983
Pistachios	17	17	17	17	17	17
Total	**647**	**2,318**	**3,988**	**5,659**	**7,329**	**9,000**

Assumptions: Each of the three growth scenarios assumes linear agricultural demand increase to approximately 5, 10, and 15 percent of the historical maximum by 2040. Pistachio cultivation is assumed to remain constant through 2040, and all future agricultural demand growth is assumed to be from increased alfalfa cultivation. Projections assume an irrigation system efficiency of 75 percent under normal conditions.

Table 13: Current and Projected Agricultural Water Demand for Northern and Southern FVGB (AF)

	Scenario	2015	2020	2025	2030	2035	2040
Northern FVGB	Baseline Condition	647	647	647	647	647	647
	Scenario 1: Light Growth	647	998	1,348	1,699	2,049	2,400
	Scenario 2: Medium Growth	647	1,478	2,308	3,139	3,969	4,800
	Scenario 3: Heavy Growth	647	1,958	3,268	4,579	5,889	7,200
Southern FVGB	Baseline Condition	0	0	0	0	0	0
	Scenario 1: Light Growth	0	120	240	360	480	600
	Scenario 2: Medium Growth	0	240	480	720	960	1,200
	Scenario 3: Heavy Growth	0	360	720	1,080	1,440	1,800

Assumptions: 80 percent of agricultural activities will occur in the Northern FVGB and 20 percent in the Southern FVGB to reflect proportion of the total recharge assumed to occur in the Northern and Southern FVGB. Each of the three growth scenarios assumes linear agricultural demand increase to approximately 5, 10, and 15% of the historical maximum by 2040. Pistachio cultivation is assumed to remain constant through 2040, and all future agricultural demand growth is assumed to be from increased alfalfa cultivation. Projections assume an irrigation system efficiency of 75 percent under normal conditions.

5.1.2.3 Current and Projected Industrial Water Demand

In addition to agriculture, industrial processes are also an important component of the water demand in the Region. The four largest industrial water user categories are the solar, cannabis, mining and manufacturing industries. The cannabis industry, while traditionally thought of as an agricultural water use, is currently being regulated under the LRWQCB as an industrial water use for waste discharge requirements. Because of this, cannabis cultivation, specifically indoor cannabis cultivation, is being described in this Plan under the industrial water uses. Other types of industrial demands in the Region are assumed to be negligible, though small manufacturers may be included in future updates to the SNMP.

5.1.2.3.1 Solar Energy Production

The Beacon Photovoltaic solar plant is the largest solar facility in the Plan area. Water use by all other solar power plants is assumed to be negligible due to their relative sizes. Previous studies have estimated the Beacon Photovoltaic solar plant uses an average of 6 AFY for panel cleaning (Frisvold & Marquez 2013). Demand projections assume that solar demand will remain relatively constant through 2040, as shown in Table 14.

5.1.2.3.2 Cannabis Cultivation

Cannabis is a new industry being developed in the Plan area. The City expects continued development of this industry over the next few years. The City expects to approve roughly 20 permits for 20,000 square-foot indoor cannabis grow houses by 2020 and as many as approximately 300 permits by 2040. According to the California City Public Works Director, the facilities are anticipated to operate within municipal boundaries using approximately 2.2 AFY to 2.9 AFY of potable water per facility. This water use assumes that each facility will also reuse 70 to 80 percent of its irrigation wastewater internally. Demand projections for cannabis cultivation through 2040 conservatively assume a demand of 2.9 AFY per facility (Table 14).

5.1.2.3.3 Mining and Manufacturing

Golden Queen Mining Company uses open pit mining methods to extract gold and silver at the Soledad Mountain Mine near Mojave. The mining operations utilize water pumped from 5 production wells and 9 domestic wells to support operations. CalPortland operates a plant in Mojave for cement production. The plant uses water pumped from a private well. Like the solar industry, water demands for mining and manufacturing are assumed to remain constant through 2040, and water use by all other manufacturing operations are assumed to be negligible. Future updates to the GWMP may include additional demand estimates for small manufacturers pumping from the FVGB. General water demand estimates determined from communication with CalPortland Company management and Golden Queen Mining Company management are shown in Table 14.

Table 14: Total Current and Projected Industrial Water Demand (AF)

	2015	2020	2025	2030	2035	2040
Solar[1]	6	6	6	6	6	6
Cannabis[2]	0	59	265	472	678	884
Mining[3]	1,105	1,105	1,105	1,105	1,105	1,105
Manufacturing[4]	331	331	331	331	331	331
Total	**1,442**	**1,501**	**1,707**	**1,914**	**2,120**	**2,326**

Sources: (1) Frisvold, G., & Marquez, T. 2013; (2) Communication with California City Staff 2018; (3) Communication with Golden Queen Mining Company Management 2018; (4) Communication with CalPortland Company management 2018.
Assumptions: Energy production will remain constant through 2040. Cannabis cultivation will grow to 20 facilities by 2020 and approximately 300 facilities by 2040; each facility is projected to use approximately 2.9 AFY of potable water with 70 to 80 percent wastewater reuse.

5.2 Water Supplies

Water demand in the Plan area is met with local groundwater supplies, imported water from the SWP, and recycled water generated by the City's WWTP. Stormwater is not currently being captured for beneficial use in the Plan area. There are no planned stormwater capture projects at this time; therefore, stormwater was not included in the supply analysis. The following is an analysis of the projected groundwater, imported water, and recycled water supplies in the Plan area through 2040 under normal conditions. The projected supplies are for an average year and do not account for climate change impacts, catastrophes, changes in legislation, and other events that can disrupt supply deliveries. Potential future scenarios for supplies in the FVGB area are discussed in Section 8. Potential impacts of climate change on supplies are discussed qualitatively in Sections 5.3 and 8.4.

5.2.1 Total Current and Projected Water Supplies

Total water supplied within the Plan area is expected to increase by more than 60 percent by 2040 to match demand under the heavy agricultural growth scenario, as shown in Table 15. These projections assume agricultural demands will increase to 9,000 AFY by 2040 which represents 15 percent of the historical maximum of 60,000 AFY based on the heavy agricultural growth projection.

Table 15: Total Current and Projected Water Supplies (AF)

	2015	2020	2025	2030	2035	2040
Baseline						
Groundwater	6,197	7,516	7,985	8,456	8,931	9,893
Imported Water	653	1,190	1,240	1,300	1,360	1,420
Recycled Water	518	783	816	850	884	988
Total	**7,368**	**9,489**	**10,041**	**10,606**	**11,175**	**12,301**
Scenario 1 (Light Growth): 5% of Historical Agricultural Maximum						
Groundwater	6,197	7,986	8,926	9,867	10,813	12,246
Imported Water	653	1,190	1,240	1,300	1,360	1,420
Recycled Water	518	783	816	850	884	988
Total	**7,368**	**9,959**	**10,982**	**12,017**	**13,057**	**14,654**
Scenario 2 (Medium Growth): 10% of Historical Agricultural Maximum						
Groundwater	6,197	8,586	10,126	11,667	13,213	15,246
Imported Water	653	1,190	1,240	1,300	1,360	1,420
Recycled Water	518	783	816	850	884	988
Total	**7,368**	**10,559**	**12,182**	**13,817**	**15,457**	**17,654**
Scenario 3 (Heavy Growth): 15% of Historical Agricultural Maximum						
Groundwater	6,197	9,186	11,326	13,467	15,613	18,246
Imported Water	653	1,190	1,240	1,300	1,360	1,420
Recycled Water	518	783	816	850	884	988
Total	**7,368**	**11,159**	**13,382**	**15,617**	**17,857**	**20,654**

Assumptions: For these supply/demand calculations, it is assumed that future stormwater is negligible. The projected supplies are for an average year and do not account for climate change impacts, catastrophes, changes in legislation, and other events that can disrupt local and imported supply deliveries. Future stormwater capture scenarios are discussed separately from this supply/demand analysis in Section 8.

5.2.2 Groundwater

Groundwater volumes pumped and distributed within the City for the year 2015 were documented in the City's 2015 UWMP. Because almost the entire population of the City is within the Plan area, all groundwater extractions occur from the FVGB and almost all are consumed within the FVGB boundary. Cal Water pumping data for the year 2015 reflects the groundwater supplies that were distributed solely to the Fremont Valley System. MPUD and RCWD provided groundwater pumping data for 2015. Demand estimated for the portions of unincorporated Kern County not served by the City, MPUD, Cal Water, Rancho Seco Inc., or RCWD is assumed to be met by groundwater pumping.

Groundwater pumping is projected to increase over the next two decades due to population growth, cannabis cultivation, and agricultural activities, as shown in Table 16 through Table 19. The projected groundwater pumping is assumed to be the variable for supplies and is set to be equal to the total projected demand minus projected recycled and imported water supplies. Projected imported water supply deliveries were calculated based on historic delivery records. The calculations are based on the following key assumptions:

- Agricultural demands assume the Baseline Condition (Table 16); light agricultural growth (Table 17); medium agricultural growth (Table 18), and heavy agricultural growth (Table 19) by 2040.
- Groundwater is the only available water supply outside of the City and MPUD service areas.
- Groundwater pumping is used to make up supply shortfalls.

Table 16: Current and Projected Groundwater Extractions in the Plan Area (AF) – Baseline Condition

Source	2015	2020	2025	2030	2035	2040
California City[1]	2,955	4,273	4,450	4,620	4,793	5,455
Cal Water[2]	14	15	16	17	18	19
MPUD[3]	985	918	991	1,072	1,154	1,235
Rancho Seco[4]	9	9	10	11	12	12
RCWD[5]	47	49	53	57	61	65
Unincorporated Kern County Private Pumping[6]	2,187	2,251	2,465	2,679	2,893	3,108
Total	**6,197**	**7,515**	**7,985**	**8,456**	**8,931**	**9,894**

Note: Unincorporated Kern County Private Pumping captures private groundwater pumping for agricultural, industrial, and residential demands outside any given service area within the FVGB.
Sources: (1) California City Water Department 2017; (2) Cal Water pumping data for the Fremont Valley System; (3) MPUD pumping data; (4) Rancho Seco Inc. pumping data; (5) RCWD pumping data; (6) Estimated from supply shortfall
Assumptions: 2015 demands for agriculture remain unchanged at 647 AFY in future years (about 1 percent of the historical maximum of 60,000 AFY).

Table 17: Current and Projected Groundwater Extractions in the Plan Area (AF) – Light Agricultural Growth

Source	2015	2020	2025	2030	2035	2040
California City[1]	2,955	4,273	4,450	4,620	4,793	5,455
Cal Water[2]	14	15	16	17	18	19
MPUD[3]	985	918	991	1,072	1,154	1,235
Rancho Seco[4]	9	9	10	11	12	12
RCWD[5]	47	49	53	57	61	65
Unincorporated Kern County Private Pumping[6]	2,187	2,722	3,406	4,091	4,776	5,461
Total	**6,197**	**7,986**	**8,926**	**9,868**	**10,814**	**12,247**

Note: Unincorporated Kern County Private Pumping captures private groundwater pumping for agricultural, industrial, and residential demands outside any given service area within the FVGB.
Sources: (1) California City Water Department 2017; (2) Cal Water pumping data for the Fremont Valley System; (3) MPUD pumping data; (4) Rancho Seco, Inc. pumping data; (5) RCWD pumping data; (6) Estimated from supply shortfall.
Assumptions: Agricultural demand will increase to approximately 5 percent of the historical maximum by 2040; projections assume that pistachio cultivation will remain constant through 2040 and all future agricultural demand growth would be from increased alfalfa cultivation.

Table 18: Current and Projected Groundwater Extractions in the Plan Area (AF) – Medium Agricultural Growth

Source	2015	2020	2025	2030	2035	2040
California City[1]	2,955	4,273	4,450	4,620	4,793	5,455
Cal Water[2]	14	15	16	17	18	19
MPUD[3]	985	918	991	1,072	1,154	1,235
Rancho Seco[4]	9	9	10	11	12	12
RCWD[5]	47	49	53	57	61	65
Unincorporated Kern County Private Pumping[6]	2,187	3,322	4,606	5,891	7,176	8,461
Total	**6,197**	**8,586**	**10,126**	**11,668**	**13,214**	**15,247**

Note: Unincorporated Kern County Private Pumping captures private groundwater pumping for agricultural, industrial, and residential demands outside any given service area within the FVGB.
Sources: (1) California City Water Department 2017; (2) Cal Water pumping data for the Fremont Valley System; (3) MPUD pumping data; (4) Rancho Seco, Inc. pumping data; (5) RCWD pumping data; (6) Estimated from supply shortfall
Assumptions: Agricultural demand will increase to approximately 10 percent of the historical maximum by 2040; projections assume that pistachio cultivation will remain constant through 2040 and all future agricultural demand growth would be from increased alfalfa cultivation.

Table 19: Current and Projected Groundwater Extractions in the Plan Area (AF) – Heavy Agricultural Growth

Source	2015	2020	2025	2030	2035	2040
California City[1]	2,955	4,273	4,450	4,620	4,793	5,455
Cal Water[2]	14	15	16	17	18	19
MPUD[3]	985	918	991	1,072	1,154	1,235
Rancho Seco[4]	9	9	10	11	12	12
RCWD[5]	47	49	53	57	61	65
Unincorporated Kern County Private Pumping[6]	2,187	3,922	5,806	7,691	9,576	11,461
Total	**6,197**	**9,186**	**11,326**	**13,468**	**15,614**	**18,247**

Note: Unincorporated Kern County Private Pumping captures private groundwater pumping for agricultural, industrial, and residential demands outside any given service area within the FVGB.
Sources: (1) California City Water Department 2017; (2) Cal Water pumping data for the Fremont Valley System; (3) MPUD pumping data; (4) Rancho Seco, Inc. pumping data; (5) RCWD pumping data; (6) Estimated from supply shortfall
Assumptions: Agricultural demand will increase to approximately 15 percent of the historical maximum by 2040; projections assume that pistachio cultivation will remain constant through 2040 and all future agricultural demand growth would be from increased alfalfa cultivation

5.2.3 Imported Water

AVEK delivers imported SWP water to both the City and MPUD. The 2015 imported water supplies and future projections for the City and MPUD were obtained from the City's and AVEK's 2015 UWMPs. The City's 2015 UWMP projects that imported water supplies will nearly double within the next two decades, whereas MPUD's imported water supplies are expected to remain constant through 2040 as shown in Table 20.

Table 20: Current and Projected Imported Water Supplies (AF)

	2015	2020	2025	2030	2035	2040
California City[1]	651	1,070	1,120	1,180	1,240	1,300
MPUD[2]	2	120	120	120	120	120
Total	**653**	**1,190**	**1,240**	**1,300**	**1,360**	**1,420**

Sources: (1) 2015 data from California City Water Department 2017; 2020-2040 data from AVEK 2016; (2) 2015 data from AVEK 2016; 2020-2040 projections per communication with MPUD General Manager at January 18, 2018 Working Group Meeting.
Assumptions: For an average water year; does not account for climate change impacts, catastrophes, changes in legislation, and other events that can disrupt imported supply deliveries.

5.2.4 Recycled Water

Recycled water generated by the City is utilized within the Plan area to irrigate the Tierra Del Sol Golf Course and as makeup water for Central Park Lake. Recycled water supply is projected to increase 90 percent by 2040 as shown in Table 21. As described in the City's 2015 UWMP, the increase is based on population growth that will increase potable water demand and produce higher wastewater flows to the WWTP. The City currently manages all available recycled water at eight percolation ponds, the Central Park Lake, and the Tierra Del Sol Golf Course. To increase recycled water supply and use, the City would need to expand the WWTP so that additional flows can be accepted and treated. While there are no specific plans to expand recycled water use at this time, the City is exploring the feasibility of using recycled water on green belts, parks, and other facilities, including the Par 3 Golf Course. (California City Water Department 2017).

In 2002, the capacity of the WWTP was expanded from 3 AF per day (1 MGD) to 4.6 AF per day (1.5 MGD) to accommodate population growth. Currently, the plant can treat an average flow of 4.6 AF per day (1.5 MGD) and a peak flow of 9.2 AF per day (3.0 MGD), though the average influent currently averages 2.5 AF per day (0.8 MGD). Biosolids are dewatered, dried, and disposed of at a landfill (California City Water Department 2017). During a normal year, the City collects approximately 19 percent of total potable water production as wastewater (or 675 AF); 75 percent of this water, or approximately 500 AF, is recycled and used for irrigation at the Tierra Del Sol Golf Course. When storage basins are full during the winter season, approximately 10 AF, or 1 percent of the recycled water produced, is diverted to percolation ponds to offset groundwater extractions.

Table 21: Current and Projected Recycled Water Supplies (AF)

	2015	2020	2025	2030	2035	2040
Recycled Water	518	783	816	850	884	988

Source: California City Water Department 2017.

5.3 Potential Climate Change Impacts

Climate change could impact the water supplies and demands in the Plan area. Sea level rise is expected to reduce SWP supply deliveries by up to 21 to 25 percent. However, the average annual precipitation is expected to remain relatively unchanged through 2100 (California Energy Commission 2017). Despite the minimal impact on total annual precipitation, climate change is expected to result in a larger proportion of precipitation coming in the form of intense single-day events, which would increase the difficulty of retaining stormwater for groundwater recharge and could contribute to declining groundwater levels (EPA 2017; California Emergency Management & Natural Resources Agency 2012). Longer drought periods could strain water supplies in the Plan area, as water demands are expected to increase while supplies decrease. Increased temperatures due to climate change, combined with decreased rainfall, could increase water demands in an already water-limited area.

6. BASIN MANAGEMENT GOALS

This chapter presents the goals for the use of recycled water and stormwater in the FVGB. These goals were developed based on stakeholder input during the development of the SNMP, information contained in the City's 2015 UWMP, and regional goals and objectives from the Fremont Basin IRWM Plan.

6.1 Recycled Water Goals

Recycled water goals are based on information provided in the City's 2015 UWMP and from direct communication with IRWM stakeholders. The goals incorporate recycled water use projections up to the year 2040.

As described in Section 5, there are two WWTPs in the Plan area, owned and operated by MPUD and the City. MPUD does not have plans to generate and use recycled water from its WWTP in near future. The WWTP owned and operated by the City is the only current source of recycled water in the Plan area. In 2002, the capacity of the City's WWTP was expanded from 3 AF per day (1 MGD) to 4.6 AF per day (1.5 MGD) to accommodate population growth. Recycled water generated by the City is utilized within the Plan area to irrigate the Tierra Del Sol Golf Course and as makeup water for Central Park Lake. The amount of recycled water used in the Plan area ranged from 405 AF in 2010 to 518 AF in 2015, based on the City's 2015 UWMP. Recycled water supply is projected to increase to 988 AFY by 2040 (90 percent increase compared to 2015), based on population growth that will increase indoor potable water demands and produce higher wastewater flows to the WWTP. As discussed in Section 5, the City is currently exploring the feasibility of using recycled water on green belts, parks, and other facilities, including the Par 3 Golf Course. The future estimates of the recycled water goals for the FVGB are utilized in the groundwater quality analysis described in Sections 7 and 8.

The Fremont Basin IRWM Objectives and Targets that are relevant to recycled water goals in this SNMP are shown in Table 22.

6.2 Stormwater Goals

Historically in the region, stormwater has been viewed as a flood management problem and an issue of protecting public safety and property. Stormwater control is of particular concern in the Cantil area where high flows from Cache Creek and Jawbone Canyon can cause severe flooding during storm events. Lately, as drought has put more pressure on water supplies at the State level and groundwater basins become depleted, stormwater is increasingly seen and promoted as a potential option to recharge groundwater basins and augment local water supplies. In the FVGB, stormwater capture and reuse/recharge projects could be beneficial to groundwater by potentially decreasing TDS and nitrate concentrations in the basin as stormwater is likely to contain very low concentrations of these constituents.

It is anticipated that future projects for stormwater capture and recharge will be implemented using newer techniques for urban development utilize low impact development (LID) and green infrastructure projects to manage stormwater on-site. LID techniques can improve water quality and augment water supplies either by harvesting the water for other uses or by allowing water to infiltrate into groundwater aquifers.

Stormwater capture and recharge projects are being considered in the Plan area conceptually as a viable option to augment water supplies and improve water quality conditions with respect to TDS and nitrate, while providing flood management benefits. In this SNMP, an analysis was performed, as described in Section 8, to evaluate the potential stormwater recharge amount that would be needed to maintain the 2015 TDS levels under the Baseline Condition and three future agricultural growth scenarios (light, medium, and heavy). This analysis suggested stormwater recharge amounts ranging from approximately 3,200 AFY for the Baseline to up to over 11,000 AFY for the heavy agricultural growth scenario. These values do not represent stormwater "goals", per se; however, as further discussed in Section 9, the Plan area will consider stormwater recharge projects that could be potentially implemented to accomplish the

IRWM stormwater-related objectives in the context of the SNMP. The Fremont Basin IRWM Objectives and Targets that are relevant to stormwater goals in this SNMP are shown in Table 22. Future updates to the Plan will include stormwater recharge projects as they continue to be developed.

Table 22: Fremont Basin IRWM Region Objectives and Targets that are Relevant to SNMP Goals for Recycled Water and Stormwater

Objective	Target
Water Supply	
Increase regional water supply reliability to meet demands	Increase recycled water use by 2025 compared to 2017
	Increase stormwater capture by 2025 compared to 2017
	Adapt to climate change impacts on runoff and recharge, and from sea level rise
Water Quality	
Protect water quality in groundwater basins in the Region	Prevent degradation of groundwater basins according to Basin Plan
	Map contaminant sites and constituent movement in the Fremont Valley Groundwater Basin by 2027
Flood Management	
Reduce negative impacts of stormwater	Identify areas of highest flood risk in the Region by 2018
	Implement projects to provide flood protection to existing and future planned properties where benefits exceed costs
	Implement integrated, multi-benefit flood management projects, when feasible

7. SALT AND NUTRIENT LOADING ANALYSIS

Salt and nutrient loading to FVGB is due to various surface activities, including:

- Irrigation water (privately produced groundwater, municipal water supplies, and reclaimed wastewater)
- Agricultural inputs (fertilizer)
- Urban inputs (septic systems, wastewater treatment plants, fertilizer, and applied water)

Most of these sources, or “inputs,” are associated with rural and agricultural areas. Within the City and the town of Mojave, urban area salt and nutrient loads due to indoor water use are primarily routed to the municipal wastewater system for reclamation or discharge. Percolation of these loadings to groundwater only occurs to the extent that recycled water is reused for landscape irrigation. Discharges and percolation from wastewater treatment plants are considered and calculated separately. Outside the urban centers, groundwater serves as the primary source of water, supplying both urban and agriculture use. Other surface inputs of salts and nutrients, such as atmospheric loading, are not considered a significant net contributing source of salts and nutrients and are not captured in the loading analysis.

7.1 Loading Analysis Methodology

A GIS-based loading model was developed to better understand the significance of various loading factors. The loading model is a spatially-based mass balance tool that represents TDS and nitrogen loading on an annual-average basis. Primary inputs to the model are land use, irrigation water source and quality, and WWTP and septic system loading.

Salt and nutrient loadings were determined using the general methodology outlined below:

- Identify the analysis units to be used in the model: Parcels from Kern County and San Bernardino County served as the analysis units.
- Categorize land use categories into discrete groups: These land use groups represent land uses that have similar water demand as well as salt and nutrient loading and uptake characteristics. Each land use group is assigned characteristics including: percent irrigated, applied water rates, and applied fertilizer application rates.
- Identify concentrations of TDS and nitrogen for private groundwater and municipal water supplies: Concentrations of TDS and nitrogen within a water supplier’s service area are assumed to be uniform as they come from the same water supply. Concentrations of TDS and nitrogen in groundwater are based on the findings discussed in Section 4.
- Apply the irrigation water source to the analysis units: Each water source is assigned concentrations of TDS and nitrogen.
- Estimate the water demand for the parcel: Water demand is based on the irrigated area of the parcel and varies with the crop type and the source water quality as described in Section 7.2.3.
- Estimate the TDS load applied to each parcel: TDS load is based on the land use practices, irrigation water source and quantity, septic load, and wastewater infrastructure load. The loading model makes the conservative assumption that no salt is removed from the system once it enters the system.
- Estimate the nitrogen load applied to each parcel: Nitrogen load is based on the land use practices, irrigation water source and quantity, and septic load. The loading model assumes that a portion of the applied nitrogen is taken up by plants and (in some cases) removed from the system (through harvest of plant material). Additional nitrogen is converted to gaseous forms and lost to the atmosphere. A 10 percent volatilization rate is applied, based on the average pH of soils, the relatively coarse texture of

soils and a semi-arid climate. Remaining nitrogen is assumed to convert to nitrate and to be subject to leaching.

- Estimate TDS and nitrogen loads from point sources (WWTPs).

7.2 Data Sources for Salt and Nitrate Loading

Data sources for the model include land use (spatial distribution and associated loading), irrigation water (sources and associated quality and loading), septic inputs, and wastewater discharge loads. These inputs are discussed below.

7.2.1 Existing Land Use

Section 3.2.2 describes the general land use categories in the Plan area; existing land uses are shown in Figure 10. For the purposes of this loading analysis, a land use database was developed at a parcel-level basis, using Kern County assessor data[1] and aerial review for parcels in San Bernardino County. Parcels identified as agriculture were further refined based on aerial review and US Department of Agriculture's (USDA) Cropland Data Layer[2] to determine the type of agriculture and the acreage. Finally, an aerial review of the land use categories was performed to estimate the typical percentage of the category that is irrigated. For urban categories, the irrigated area is generally turfgrass. The acreages and estimated irrigation percentages are summarized in Table 23.

Table 23: Land Use Categories

Land Use Category	Total Area (acres)	Percent Irrigated[1]
Alfalfa	64	100%
Pistachio	95	100%
Urban Commercial and Industrial (CI)	11,897	5%
Urban CI Low Impervious Surface[2]	313	30%
Urban Residential	4,215	15%
Rural Residential	579	10%
Urban Landscape (e.g. Park or Golf Course)	117	75%
Vacant/Undeveloped	308,548	0%

Notes: (1) Percent of the parcel area that is irrigated, based on aerial review; (2) Includes schools and churches.

7.2.2 Water Supply Sources

The irrigation water source data input within the FVGB is derived from a combination of several sources, including local municipal water agencies, private groundwater wells, and treated wastewater. Imported water purchased from the SWP is the only surface water used to meet demands. Within the Fremont Basin IRWM Region, AVEK delivers imported water to MPUD and the City.

[1] Kern County Assessor – GIS Parcel Data, 2015 Final Edition
[2] USDA, National 2017 Cropland Data Layer, https://www.nass.usda.gov/Research_and_Science/Cropland/Release/index.php

Most of the Fremont Basin IRWM Region's water supply comes from groundwater. Established urban areas within the FVGB meet their water demands through MPUD and the California City Water Department. Water demands outside these population centers fall under several smaller water districts or utilize private groundwater sources. Water quality parameters for each water district are based on sampling results from Annual Drinking Water Quality reports (also known as Consumer Confidence Reports) for the past five-year period. For areas outside water district boundaries, the water quality parameters were generated using the median of measured TDS and nitrate concentrations for the previous 20 years for the Northern FVGB and Southern FVGB, as described in Section 4[1]. The median TDS and nitrate values are used to calculate the loads from applied water.

The Tierra Del Sol Golf Course in the City uses reclaimed wastewater from the City's only WWTP. TDS and nitrate values are taken as the effluent water quality values from the WWTP. The WWTP in the City is the only source of recycled water in the Plan area.

Sources of water supply for all parcels within the groundwater basin are summarized in Figure 21. Table 24 summarizes the water quality inputs used for each irrigation water source.

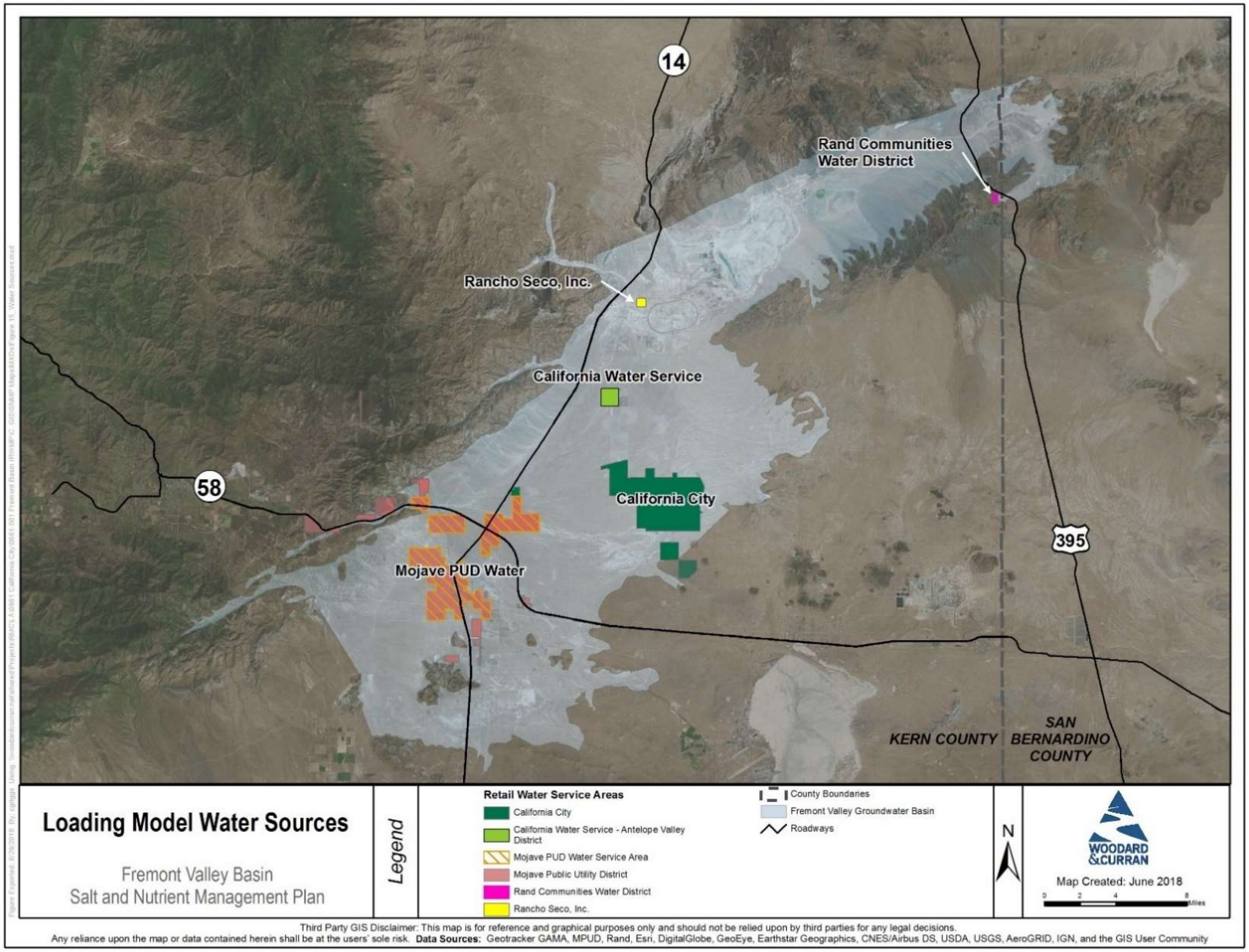
Table 24: Water Quality Parameters for Loading Model Water Sources

Source	TDS (mg/L)	Nitrate as N (mg/L)
California City	536	1.0
MPUD	669	2.9
Cal Water	452	0.5
Rancho Seco Inc.	495	ND
RCWD	420	4.9
Groundwater – Northern FVGB	485	0.7
Groundwater – Southern FVGB	503	2.0
Reclaimed wastewater (California City)	637	3.9

Note: ND = non-detect.

[1] The portion of the FVGB north of the Muroc fault is referred to as California City Subunit by USGS and the California City Subbasin by Stetson (2009); the portion of the FVGB south of the Muroc fault is referred to as the Chafee Subunit by USGS and the Mojave City Subbasin by Stetson (2009). However, the boundaries of the California City Subbasin, Mojave City Subbasin and Chafee Subunits are different than the FVGB per DWR's Bulletin 118.

Figure 21: Loading Model Water Sources



7.2.3 Irrigation Loading

There are three typical plant types that receive irrigation water in the FVGB: alfalfa, pistachios, and turfgrass. These three crop types were evaluated to estimate overall irrigation water use as well as water quality of the water assumed for leaching. Crop water use is calculated using monthly average ETo for the Plan area, the corresponding crop coefficients, and assumed leaching requirements as summarized below.

Salts can accumulate in the root zone if allowed to remain in the soil due to insufficient leaching. Leaching is the process of applying more water to the field than can be retained by the soil such that the excess water drains below the root system, carrying salts with it. The more water that is applied in excess of the crop water requirement, the less salinity remains in the root zone, despite the fact that more salt loading has actually been added to the field. The objective of leaching is to maintain or reduce soil salinity in the root zone to levels that are equal to or less than the threshold for the particular crops selected. Some crops are very sensitive to salts, while others can tolerate much higher concentrations. Table 25 shows the salt tolerance threshold (EC_{ct}) for each of the three crop types, above which yield reductions are likely to occur.

Table 25: Salt Tolerance of Representative Fremont Valley Crops

Crop	Salt Tolerance Threshold EC_{ct}	Source
Alfalfa	2	Sanden B. and B. Sheesley. 2007
Pistachios	8.4	Ferguson et al. 2010
Turfgrass	6.9	Tanji, K. and N. Keilen, 2002

Notes: Units in milliMhos/cm.

These crop tolerances, along with irrigation efficiency, are used to estimate the leaching fraction. The leaching fraction is the minimum fraction of the applied water that must pass through the crop root zone to prevent a reduction in yield from excessive accumulation of salts. Irrigation efficiency, considered when calculating the gross irrigation requirement, varies by crop type. For instance, turfgrass is irrigated through conventional irrigation methods while high frequency irrigation is more commonly used for tree crops (e.g., pistachios).

This analysis assumes that the proper irrigation methods, tailored to the water, crop, and site conditions, and a high level of management are available to accomplish the efficiencies anticipated in this study for golf courses, sports fields, and other larger landscaping projects. Residential irrigation systems, on the other hand, are anticipated to have a lower application efficiency. Conveyance efficiency is assumed to be 95 percent while irrigation efficiency varies with the irrigation system. Conveyance efficiency refers to losses during the delivery of water to the irrigation system. Micro-spray systems are assumed to operate at 90 percent efficiency while sprinkler systems are assumed to operate at 80 percent efficiency.

With trickle irrigation, very little of the fertilizer spread over the soil surface moves into the root zone. Therefore, much of the required fertilizer, especially nitrogen, must be added directly in the water through fertigation. From an agricultural perspective, the nitrogen content in the irrigation water can be viewed as a resource. Most of the nitrogen salts and urea dissolve readily in water and may be incorporated with no side effects to the water or irrigation system. Urea (44-0-0) is a soluble nitrogen fertilizer that is common in combination with trickle irrigation systems. It is a neutral molecule that does not react with water to form ions. Urea and ammonium nitrate are mixed in water to give a concentrated liquid mixture marketed as 32-0-0 Urea Ammonium Nitrate Solution (UAN) ammonium form. For the purposes of this Plan, it is assumed that nitrogen loss through ammonia volatilization is limited to 10 percent for high frequency UAN applications.

Given the following bulleted conditions in the FVGB, an average regional Nitrogen Update Efficiency (NUE) between the California average and the practical upper limit of 80 percent can be reasonably expected at the individual parcel level. Thus, for the purposes of this Plan, it is assumed that the NUE for all crops is 70 percent because of:

- Hot, dry climate;
- High irrigation efficiencies for pistachios;
- High percentage of groundcover and root coverage for alfalfa and turfgrass, and;
- Controlled nitrogen fertilizer applications coupled with modest leaching (salinity) requirements.

Historical and recommended nitrogen fertilizer application rates in pounds per acre (lbs/acre) per year and assumed NUE for the three key crops are shown in Table 26. In this SNMP, the statewide guidelines were used and guidelines from the University of California are provided as reference.

Table 26: Nitrogen Fertilizer Application Rates (lbs. N/acre – year)

Crop	Application Rates in California	Published University of California Guidelines		This SNMP	Crop Utilization Rate
	2005	Min	Max		
Alfalfa	10	20	60	10	70%
Pistachios	155	40	240	155	70%
Turfgrass	N/A	174	261	45[1]	70%

Notes: (1) The value of 45 lbs/acre is based on Technical Report 2: Nitrogen Sources and Loading to Groundwater, page 166 which notes this value as an overall national average.

7.2.3.1 Irrigation Related Loading Factors

Based on the land use characterization and the irrigation and fertigation assumptions described above, loading factors were associated with each land use type. These loading factors are summarized in Table 27.

Table 27: Crop Loading Factors

Crop Type Category	Water Source	Applied Water (inches/yr)[1]	Leachable TDS (lbs/acre-year)	Leachable Nitrogen (lbs/acre-year)
Alfalfa	Private Groundwater (Northern FVGB)	92.5	10,200	4.4
Pistachio	Private Groundwater (Southern FVGB)	58.0	6,400	42.1
Turfgrass	California City	70.6	8,600	12.6
	MPUD	70.8	10,700	17.7
	Cal Water	70.4	7,200	12.4
	Rancho Seco Inc.	70.5	7,900	12.2
	RCWD	70.4	6,700	23.5
	Private Groundwater (Northern FVGB)	70.5	7,700	12.5
	Private Groundwater (Southern FVGB)	70.5	8,000	13.1
	Reclaimed Wastewater (California City)	70.8	10,200	12.3

Notes: (1) Applied water values are calculated based on crop evapotranspiration (ETc), reference evapotranspiration (ETo), leaching fraction for salinity control, and irrigation efficiency.

7.2.4 Wastewater Treatment Plants

The Plan area has two WWTPs, operated by MPUD and the City. The WWTP operated by MPUD discharges to lined evaporation ponds; after drying, the sediment is offhauled to a landfill outside of the groundwater basin. The City's WWTP sends most of its treated wastewater to the Central Park Lake, where it is stored for irrigation use at Tierra Del Sol Golf Course. Excess wastewater effluent is percolated at the treatment plant's irrigation ponds. As summarized in Section 5, approximately 675 AFY is available for recycled water use. For the loading analysis, it is assumed that approximately 90 percent of the wastewater effluent not used for irrigation evaporates; all salt and nutrient loads are concentrated in the remaining 10 percent and percolate to groundwater. An assumed nitrogen volatization rate of 25 percent is used for these calculations. Based on wastewater effluent testing from 2012 - 2017, average TDS levels are 640 mg/L, and average nitrate-N levels are 3.9 mg/L. The WWTP locations and service areas are shown in Figure 22.

7.2.5 Septic Systems

While a septic system dataset was not available, data from the City's Local Agency Management Program[1] indicates that there are 3,540 permitted septic systems within the City's sewer service area as of 2017. All other parcels within the City's sewer service area are assumed to be treated at the City's WWTP. Parcels within the MPUD's sewer service area are assumed to be treated at the MPUD's WWTP. Parcels outside the City's and MPUD's sewer service areas are assumed to have a septic system if the land use was designated as urban residential or urban commercial.

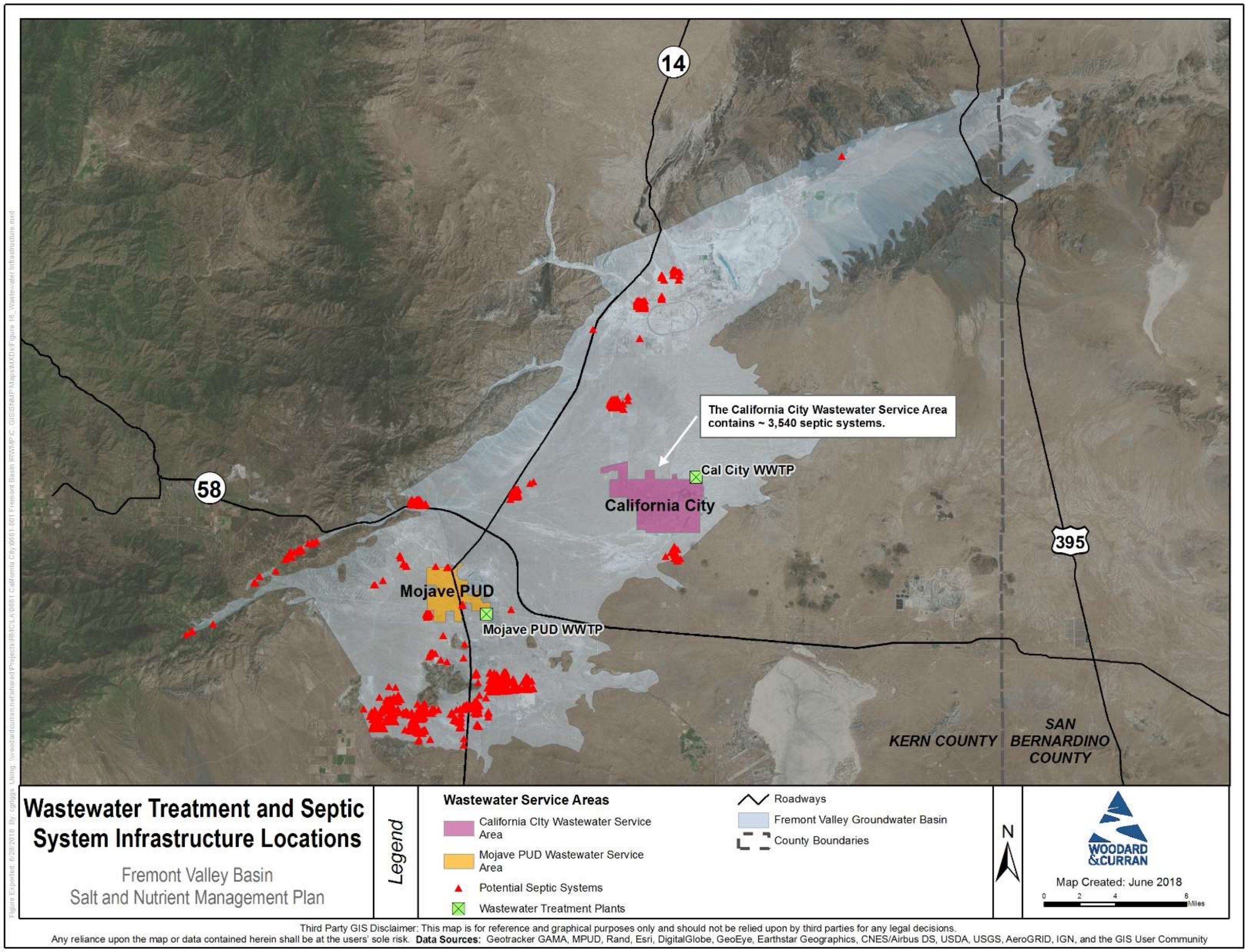
Each parcel with a septic system is assumed to leach 263 gallons per day (gpd), based on 75 gpd per person with an average of 3.5 people per system. The 75 gpd per person estimate is based domestic use quantity estimates contained

[1] City of California City, Local Agency Management Program for Onsite Wastewater Treatment System (Figure 4 and Table 2), January 2018

in the CCR, Title 23, Section 697. An estimate of 3.5 persons per household is a conservative estimate which assumes that the average household size for homes with septic systems is larger than that that of average homes within the City[1]. TDS concentrations in septic system effluent are assumed to be 640 mg/L across the basin, based on the reported effluent concentration from the City's WWTP. Nitrate-N concentrations were assumed to be 30 mg/L, based on typical wastewater concentrations for medium strength wastewater of 40 mg/L minus an assumed volatilization rate of 25 percent within the septic system (Metcalf & Eddy, 2003). Potential septic system locations are also shown in Figure 22.

[1] Persons per household for 2010-2014 is 3.2 in Kern County, with 2.7 people per household in the City of California City and Mojave. (United States Census Bureau, 2014)

Figure 22: Wastewater Treatment and Septic System Infrastructure Locations



7.3 Summary of Loading Analysis Results

Based on the loading parameters and methodology described above, the loading model was used to estimate TDS and nitrate-N loading rates across the basin under existing conditions. Results indicate that most of the TDS loading originates from urban irrigation activities, while most of the nitrate loading originates from septic systems. Results are summarized in Table 28 .

Table 28: TDS and Nitrate-N Loading Results

Land Use Category	Total Area (acres)	TDS (lbs/year)	Percent of Total TDS Loading	Nitrogen (lbs/year)	Percent of Total Nitrate-N Loading
Alfalfa	64	649,728	3%	138	0%
Pistachio	95	604,960	3%	1,967	2%
Urban CI	11,897	4,698,717	21%	3,725	3%
Urban CI Low Impervious Surface	313	888,366	4%	614	1%
Urban Residential	4,215	10,159,150	47%	7,549	6%
Rural Residential	579	465,401	2%	360	0%
Urban Landscape (e.g. Park or Golf Course)	117	1,213,667	6%	785	1%
Vacant/Undeveloped	308,548	0	0%	0	0%
Septic	N/A	363,577	10%	102,016	84%
WWTP	N/A	844,299	4%	3,919	3%

7.4 Future Land Use and Population Changes

The loading analysis also incorporated estimates on future changes to the Plan area based on population growth and potential agricultural expansion.

Future population is based on Kern County and the City's annual growth rate, as summarized in Table 29 below; note that it is expected that most population growth is expected to occur within the City and Mojave. As population density increases in the City, septic to sewer conversion will be planned, but for the purposes of the loading analysis, it is assumed that no change in septic systems will occur (a conservative assumption). Return flows (indoor sewer to the local WWTP and outdoor irrigation) are estimated on a per capita basis[1]. Salt and nutrient loads to the City's WWTP are assumed to percolate into the groundwater basin while salt and nutrient loads to the MPUD WWTP are assumed to be offhauled from the basin. Future population growth is summarized in Table 29 .

As alfalfa has historically been the most common crop in the Plan area, future agricultural growth scenarios are based on the assumption that additional acreage will be cultivated with alfalfa. Three potential expansion scenarios have been considered, ranging from 5 percent up to 15 percent of the maximum historical agricultural coverage (8,420 acres). For

[1] 75 gpd per person indoor sewer returns, 2.7 persons per dwelling unit and 0.7 acres per dwelling unit, with percent irrigated as summarized in Table 28 for urban residential.

loading purposes, alfalfa expansion has been allocated as 80 percent to the Northern FVGB, and 20 percent to the Southern FVGB. This is based on historical agricultural patterns and annual groundwater recharge. The resulting expansion scenarios are summarized in Table 30 and are derived from the total agricultural acreages presented in Section 5.1.2.2**.**

Table 29: Estimated Population in Northern FVGB and Southern FVGB

	2015	2020	2025	2030	2035	2040
Northern FVGB[1]	15,139	16,287	17,539	18,890	20,340	23,492
Southern FVGB[2]	4,313	4,540	4,860	5,213	5,572	5,926

Notes: (1) Based on California City's annual growth rate for population with California City, and Kern County annual growth rate for population outside of California City; (2) Based on Kern County's annual growth rate.
Sources: (1) California City Water Department 2017.; California Department of Finance (DOF). 2017. County Population Projections (2010-2060). Available at: http://www.dof.ca.gov/Forecasting/Demographics/projections/; (2) California Department of Finance (DOF). 2017. County Population Projections (2010-2060). Available at: http://www.dof.ca.gov/Forecasting/Demographics/projections/

Table 30: Agricultural Expansion Scenarios (Net Increase from Current) (acres)

	Scenario	2020	2025	2030	2035	2040
Northern FVGB	Heavy[1]	215	430	645	861	1,076
	Medium[2]	136	272	409	545	682
	Light[3]	57	115	172	230	287
	Baseline (No Expansion)	0	0	0	0	0
Southern FVGB	Heavy[1]	59	118	177	237	296
	Medium[2]	39	79	118	158	197
	Light[3]	20	39	59	79	99
	Baseline (No Expansion)	0	0	0	0	0

Notes: (1) Based on 15 percent of historical alfalfa maximum coverage; (2) Based on 10 percent of historical maximum coverage; (3) Based on 5 percent of historical maximum coverage.

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8. ANTIDEGREDATION ANALYSIS

SWRCB Resolution No. 68-16 is the State of California's antidegradation policy which, in summary, establishes the requirement that discharges to waters of the State be regulated to achieve the "highest water quality constituent to the maximum benefit to the people of the State." This resolution essentially establishes a two-step process for compliance. First, if a discharge will degrade high quality water, the discharge may be allowed if any change in water quality (1) will be consistent with the maximum benefit to the people of the State, (2) will not unreasonably affect present and anticipated beneficial uses of such water (as defined in the Basin Plan), and (3) will not result in water quality less than that prescribed in State policies. These requirements are demonstrated in an antidegradation analysis. The second step requires the use of BPTC of the discharge necessary to avoid a pollution or nuisance and to maintain the highest water quality consistent with the maximum benefit to the people of the State. Resolution No. 68-16 was incorporated into the SWRCB's Recycled Water Policy in Section 9, Antidegradation, which sets forth the parameters under which recycled water may be used. Specifically, the Recycled Water Policy states that in cases where more than 10 percent of a basin's assimilative capacity will be used by a project (or more than 20 percent of a basin's assimilative capacity will be used by multiple projects), an antidegradation analysis consistent with Resolution No. 68-16 must be performed to provide sufficient information to the RWQCB to make a determination that the proposed projects will provide the maximum benefit to the people of the State.

The groundwater quality trend analysis presented herein uses data collected and analyzed as part of this SNMP to address the requirements of the Recycled Water Policy and Resolution No. 68-16. These data were used in a mass balance model to perform the groundwater quality trend analysis.

8.1 Mass Balance Model

A mass balance model was developed to evaluate constituent trends in groundwater concentrations over a 25-year planning horizon within the Northern and Southern FVGB, considering two scenarios – present land and water uses (reflecting baseline or present-day conditions) and future conditions (including agricultural land use supplied by groundwater). This model considered the volume of groundwater in storage and water qualities in the Northern and Southern FVGB, and it evaluated the impact of the basin inflows and outflows on groundwater quality.

Inflows to the model include the following components:

- Deep percolation includes deep percolation of precipitation, agricultural irrigation return flows, municipal wastewater discharge, and septic discharges
- Subsurface inflows from other basins

Based on the basin characterization presented in Section 4, available information for subsurface flow between the Northern and Southern FVGB is limited and it is considered small and has not been included. Outflows in the model include groundwater pumping. Based on the basin characterization presented in Section 4, no subsurface outflows or groundwater discharge to rivers and creeks have been included.

As previously discussed, existing water quality of the basin has been evaluated as part of this Plan. Average constituent concentrations and groundwater storage volumes for the Plan area are summarized in Section 4.

Groundwater quality concentrations for TDS and nitrate-N were simulated using a spreadsheet-based mass balance model. To simulate the effect of current and future loading on groundwater quality, the spreadsheet model dynamically calculated the loading factors of each component based on the conditions at the simulated time step. Under this model, each flow component listed in the groundwater budget was combined with its respective concentration of either TDS or nitrate-N to determine loading from the constituent's mass. These transfers of mass were then assumed to completely mix with groundwater in the aquifer system on an annual time-step to determine the resulting concentrations in the Northern and Southern FVGB separately. As available surface and subsurface water quality data is limited, future revisions of this Plan should confirm or revise constituent concentrations based on any additional available data.

The surface and aquifer loading, used to determine water quality, was calculated utilizing the following equations:

Surface Loading:

$$X_t = X_{t-1} + \sum_{j=1}^{m} Q_{t_j} C_{t-1_j}$$

Aquifer Loading:

$$M_t = M_{t-1} + \sum_{i=1}^{n} Q_{t_i} C_{t-1_i}$$

$$C_t = M_t / S_t$$

Where: $\mathbf{X_t}$ is the mass of the constituent in the root zone available for deep percolation.

$\mathbf{M_t}$ is the mass of the constituent in the aquifer at timestep t.

m is the total number of budgetary flow components (j) experienced by the root zone (applied water, fertilizers, septic systems, and waste water facility discharge).

n is the total number of budgetary flow components (i) experienced by the groundwater system (deep percolation, subsurface boundary flows, and groundwater pumping).

$\mathbf{Q_t}$ is the flow into, out of, or between adjacent basins at timestep t.

$\mathbf{C_t}$ is the concentration of the constituent at timestep t.

$\mathbf{S_t}$ is the end-of-year storage in the groundwater system at timestep t.

8.1.1 Mass Balance Model Inputs

The inputs to the mass balance model are summarized in Table 31 and Table 32 for the Northern FVGB and Southern FVGB, respectively.

Table 31: Estimated Volume and Concentration of Inflows and Outflows for Groundwater Quality Trend Analysis – Northern FVGB

Item	Volume in Storage or Flow (AF or AFY)	TDS (mg/L)	Nitrogen (mg/L)	Basis
Initial Conditions	2,200,000	485	0.7	See Section 4.
Inflows				
Deep Percolation	10,300	530	3.7	Deep percolation volume based on recharge determined in Section 4. TDS and Nitrogen loads are calculated based on loading analysis described in Section 7.
Subsurface Inflow	2,600	404	1.8	Subsurface inflow volume based on subsurface flow from Antelope Valley determined in Section 4.
Future Inflows				
Alfalfa Return Flows	0 – 2,200	1,711	0.9	Volume varies by scenario and year
Urban Return Flows	0 – 1,800	3,200	9.3	Includes both California City WWTP percolation and turfgrass return. Volume varies by year
Outflows				
Groundwater Production	4,500	483	0.70	Groundwater production volume based on average of past 20 years of production, as described in Section 4. Concentrations are based on basin conditions.
Future Groundwater Production				
Additional Urban Pumping	0 – 2,400	483	0.70	Volume varies by year
Additional Agricultural Pumping	0 – 7,500	483	0.70	Volume varies by scenario and year

Table 32: Estimated Volume and Concentration of Inflows and Outflows for Groundwater Quality Trend Analysis – Southern FVGB

Item	Volume in Storage or Flow (AF or AFY)	TDS (mg/L)	Nitrogen (mg/L)	Basis
Initial Conditions	1,800,000	503	2.0	See Section 4.
Inflows				
Deep Percolation	2,500	1,002	2.7	Deep percolation volume based on recharge determined in Section 4. TDS and Nitrogen loads are calculated based on loading analysis described in Section 7.
Subsurface Inflow	0	--	-	No subsurface inflow into the southern FVGB, as described in Section 4.
Future Inflows				
Alfalfa Return Flows	0 - 560	1,818	2.0	Volume varies by scenario and year
Urban Return Flows	0 – 80	2,175	3.5	Includes turfgrass return. Volume varies by year
Outflows				
Groundwater Production	4,800	530	2.0	Groundwater production volume based on past 20 years of production, as described in Section 4. Concentrations are based on initial basin conditions.
Future Groundwater Production				
Additional Urban Pumping	0 - 300	530	2.0	Volume varies by year
Additional Agricultural Pumping	0 – 1,900	530	2.0	Volume varies by scenario and year

8.2 Groundwater Trend Analysis Results

Results from the mass balance model are summarized in Table 33, Table 34, and Figure 23. Analysis of existing basin-wide groundwater quality conditions indicates that the existing groundwater quality is generally better than the water quality objectives set forth in the Basin Plan. However, such a comparison is hampered by disparity in the Plan area definitions as generally used to describe the groundwater basin relative to those used in the Basin Plan. If drinking water standards (MCLs) are used for this analysis, there is assimilative capacity remaining in the groundwater basin for nitrates. If the recommended SMCL for TDS is used (500 mg/L), then assimilative capacity exists only in the Northern FVGB. Assimilative capacity is available throughout the groundwater basin for the upper limit SMCL of TDS (1,000 mg/L).

In such situations, Resolution 68-16 states that "such existing high-quality water will be maintained until it has been demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial use of such water and will not result in water quality less than that prescribed in the policies." The results of the groundwater quality trend and loading analyses, based on a series of conservative assumptions and over a 25-year planning horizon, indicate that basin-wide average TDS concentrations would increase slightly over time if significant agricultural activities return, but will not exceed the water quality objectives in those areas where the water quality objectives are presently met. Nitrate concentrations are anticipated to be relative stable basin-wide.

Given the following, the qualitative cost-benefit analysis concludes that increases in the indicator constituents (TDS and nitrate) in the groundwater basin with anticipated future uses are consistent with the maximum benefit to the people of the State of California:

- Current groundwater elevation trends (the basin moving towards overdraft conditions);
- The economic importance of the existing water supplies that contribute to salt and nutrient loading in the basin;
- Current state mandates to increase recycled water use; and
- The projected continued ability of groundwater to meet present and anticipated beneficial uses.

Table 33: Groundwater Trend Analysis Results – TDS

Basin	Initial Conditions (mg/L)	Basis	2040 No Growth Scenario	2040 Light Growth Scenario	2040 Medium Growth Scenario	2040 Heavy Growth Scenario
Northern FVGB	485	Change in Concentration	+4	+11	+21	+33
	--	% AC Used – 500 mg/L WQO	--	68%	137%	214%
	--	% AC Used – 1,000 mg/L SMCL	1%	2%	4%	6%
Southern FVGB	503	Change in Concentration	16	19	23	27
	--	% AC Used – 500 mg/L WQO	NAC	NAC	NAC	NAC
	--	% AC Used – 1,000 mg/L SMCL	3%	4%	5%	5%

Notes: WQO = Water Quality Objective; AC = Assimilative Capacity; NAC = No Assimilative Capacity.

Table 34: Groundwater Trend Analysis Results – Nitrate (as N)

Basin	Initial Conditions (mg/L)	Basis	2040 No Growth Scenario	2040 Light Growth Scenario	2040 Medium Growth Scenario	2040 Heavy Growth Scenario
Northern FVGB	0.70	Change in Concentration	+0.27	+0.29	+0.30	+0.31
	--	% AC Used – WQO/MCL	3%	3%	3%	3%
Southern FVGB	2.00	Change in Concentration	+0.02	+0.03	+0.04	+0.05
	--	% AC Used – WQO/MCL	0%	0%	0%	1%

Notes: WQO = Water Quality Objective; AC = Assimilative Capacity; NAC = No Assimilative Capacity.

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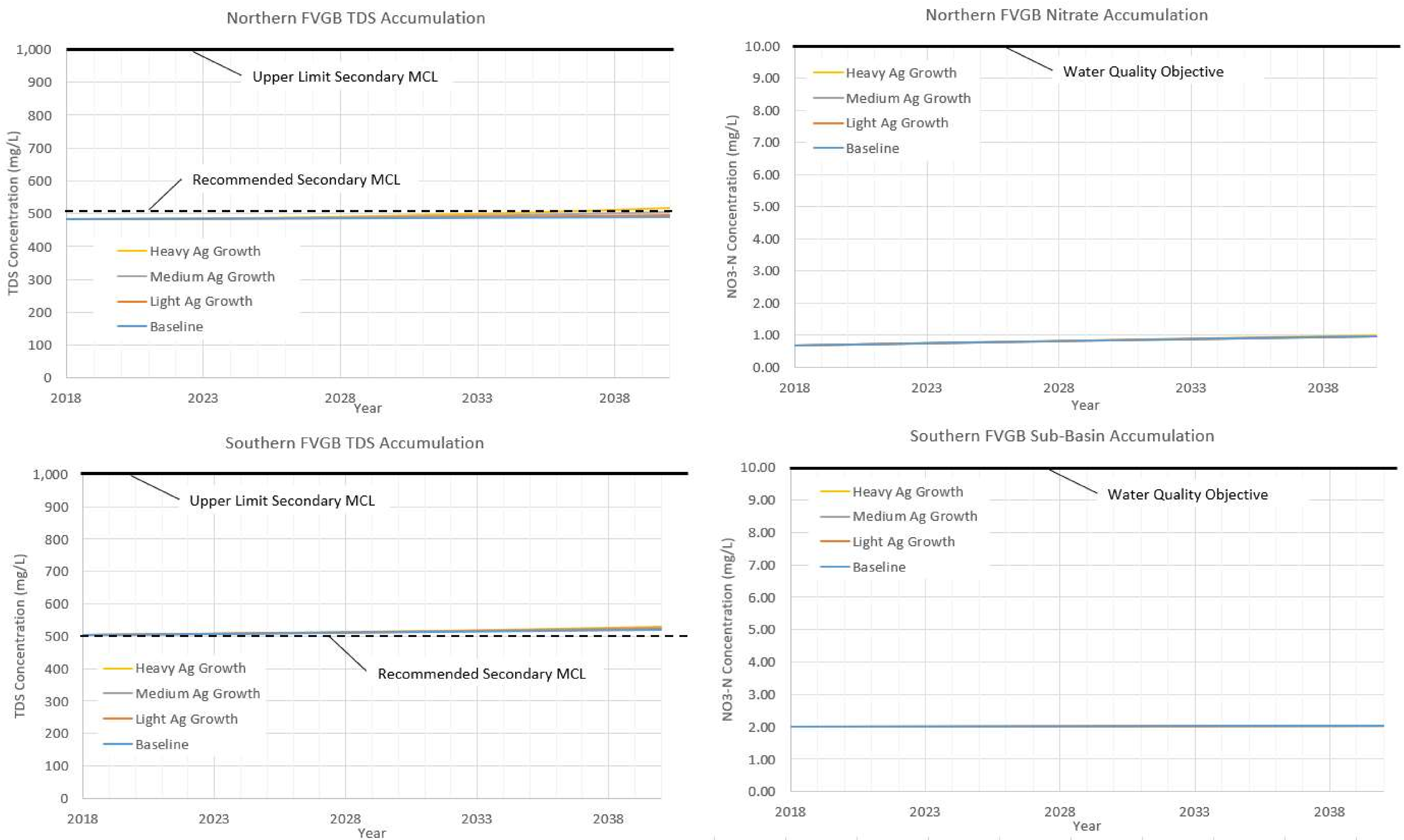
Figure 23: Groundwater Trend Analysis Results



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8.3 Impact of Stormwater Recharge and Septic Tank Conversions

As summarized above, a slight increase in both TDS and nitrogen may occur during the period considered for the SNMP. Two projects are being considered that may reduce TDS and nitrogen concentrations: a stormwater recharge project to increase the volume of water percolating to the aquifer and septic to sewer conversions which would remove the septic system contributions. While it is expected that both TDS and nitrogen levels would be reduced by either project, an analysis has been performed to evaluate the potential stormwater recharge project size needed to maintain current TDS levels. A similar analysis has been performed to evaluate the septic conversion necessary to maintain current nitrogen levels (for simplicity of analysis, it was assumed that the converted septic systems would result in negligible nitrogen percolation through the California City WWTP). The results of these analyses are summarized in Table 35 and Table 36.

Table 35: Stormwater Recharge Project Size to Maintain Current TDS Levels (acres)

	Baseline Condition (No Growth Scenario)	Scenario 1: Light Growth	Scenario 2: Medium Growth	Scenario 3: Heavy Growth
Northern FVGB	800	2,500	4,800	7,500
Southern FVGB	2,400	2,800	3,400	3,900

Table 36: Septic Conversion Necessary to Maintain Current N Levels (No. of Septic Systems)

	Baseline Condition (No Growth Scenario)	Scenario 1: Light Growth	Scenario 2: Medium Growth	Scenario 3: Heavy Growth
Northern FVGB	3,400	3,500	3,600	3,700
Southern FVGB	200	250	300	400

8.4 Potential Climate Change Impacts

Potential impacts of climate change on water supplies and demands in the Plan area are being evaluated qualitatively in the context of the Fremont Basin IRWM and discussed here briefly. Climate change could potentially result in decrease in surface water and groundwater supplies in the Plan area. As discussed in Section 5, the Plan area receives SWP water from the Delta, a climate-sensitive watershed. The Sacramento and San Joaquin Rivers are the primary sources to the Delta, and both are supplied by snowmelt from the Sierra Nevada Mountains. The FVGB that supplies water to the Plan area are also recharged from seasonal streams that originate in the Sierra Nevada Mountains. Climate change is expected to reduce the Sierra Nevada spring snowpack by 70 to 80 percent State-wide (California Energy Commission 2017). As a result, imported water supply deliveries from the SWP are projected to decrease by 21 to 25 percent at the State-wide level (Climate Change Center 2009). These anticipated changes from climate change, along with anticipated flashier storm events, could also make it difficult for retaining stormwater for groundwater recharge and could contribute to declining groundwater levels (California Energy Commission 2017; EPA 2017; California Emergency Management & Natural Resources Agency 2012).

In addition to precipitation and groundwater recharge changes, water demand in the Plan area is likely to increase with climate change. Longer drought periods, coupled with increased temperatures and increased evaporation and evapotranspiration rates due to climate change, could increase water demands, lead to greater agricultural and landscape irrigation demands and further strain water supplies in the Plan area.

Changes to supplies and demands due to climate change are not yet quantified, but an increase in demands and decrease in recharge are anticipated, as discussed in Section 2.9 of the Fremont Basin IRWM Plan (2019). Potential climate change impacts, including increased temperatures and precipitation changes, were considered during the development of the SNMP and in modeling efforts. At this time, it is anticipated that increased demands resulting from climate change will have minimal impacts on the modeled FVGB salt and nutrient balance. It should be noted that increased demands due to climate change are "simulated" to some extent by the increased agricultural demand scenarios modeled for the SNMP.

As the Region further develops climate change scenarios and its effects on water supply and demand, future updates to the Plan will include a more quantitative evaluation of resulting anticipated changes on groundwater quality conditions with respect to TDS and nitrate.

9. MONITORING PLAN

Groundwater monitoring is a required element of SNMPs under the State's Recycled Water Policy and a key component of meeting water quality objectives within the FVGB. A framework for the SNMP monitoring plan is described in this section as the next step toward implementation of the SNMP.

Groundwater quality is currently monitored by various public water purveyors in the FVGB (the City, MPUD, RCWD, Rancho Seco Inc, and Cal Water) to meet regulatory requirements, including drinking water regulations enforced by the California Department of Public Health (CDPH), and SWRCB Division of Drinking Water (DDW). Some of these public water purveyors will be assigned the responsibility of providing monitoring data for SNMP purposes. To this end, locations of existing wells monitored for groundwater levels and/or water quality are presented as potential monitoring locations, and a preliminary subset of specific wells are recommended to reflect geographic coverage for both the northern and southern portions of the FVGB. The responsible parties, frequency of monitoring, parameters to be monitored and documentation of monitoring protocols and monitoring results are presented in this section. The monitoring plan presented for this SNMP may be incorporated into future SGMA efforts should the FVGB decide to form a GSA.

9.1 Monitoring Plan Objectives

Monitoring the groundwater basin is necessary to understanding how constituent concentrations are changing over time and to confirm whether the Plan area is continuing to meet Basin Plan WQOs. The overall objectives of monitoring are to obtain sufficient data to track spatial and temporal changes in salt and nutrient concentrations in the aquifer. The groundwater level and water quality monitoring plan for this SNMP will be designed to accomplish the following:

- Document groundwater level and groundwater quality trends through time;
- Monitor and evaluate salt and nutrient constituents of concern;
- Identify potential sources of salts and nutrients; and
- Identify existing monitoring well locations that will be used to track potential changes in water quality over time.

9.2 Monitoring Network

This section describes the primary parameters to include in the SNMP monitoring efforts, the selection of appropriate wells, and the sampling frequency. It defines the preliminary monitoring network that will be used for SNMP purposes.

9.2.1 Primary Parameters

The recommended primary parameters to be monitored for the SNMP monitoring plan include electrical conductivity (EC), pH, temperature, TDS and nitrate-N, in addition to general minerals and physical constituents. The general mineral constituents to be analyzed may include calcium, magnesium, potassium, sodium, copper, iron, manganese, zinc, chloride, sulfate, alkalinity and hardness. The primary constituents and monitoring methods are presented in Table 37. Additional parameters may be monitored in the future if they are determined to be appropriate.

Table 37: Primary Parameters for Sampling and Sampling Methods

Parameters	Units	Analysis	Analytical Method	Frequency
EC	µmohs/cm	Field	Not applicable	Annually
pH	units	Field	Not applicable	Annually
Temperature	°C	Field	Not applicable	Annually
TDS	mg/L	Laboratory	SM 2540C or EPA Method 160.1	Annually
Nitrate-N	mg/L	Laboratory	EPA Method 300.0 or 300.1	Annually
Calcium	mg/L	Laboratory	EPA Method 200.7	Annually
Magnesium	mg/L	Laboratory	EPA Method 200.7 or 200.8	Annually
Potassium	mg/L	Laboratory	EPA Method 200.7	Annually
Sodium	mg/L	Laboratory	EPA Method 200.7	Annually
Copper	mg/L	Laboratory	EPA Method 220.2, 200.7 or 200.8	Annually
Iron	mg/L	Laboratory	EPA Method 200.7 or 200.8	Annually
Manganese	mg/L	Laboratory	EPA Method 200.7 or 200.8	Annually
Zinc	mg/L	Laboratory	EPA Method 200.7 or 200.8	Annually
Chloride	mg/L	Laboratory	EPA Method 300.0	Annually
Sulfate	mg/L	Laboratory	EPA Method 300.0	Annually
Alkalinity	mg/L	Laboratory	EPA 310.1	Annually
Hardness, total (as CaCO3)	mg/L	Laboratory	SM 2320B	Annually

9.2.2 Other Constituents of Concern

Other constituents of concern in the FVGB include boron, arsenic, chloride, and hexavalent chromium (chromium-6) as the basin has, at times, had observed concentrations exceeding the MCLs, SMLCs, or notification levels (NLs) for these constituents. Boron concentrations exceeding the NLs of 1,000 micrograms per liter (µg/L) were commonly observed in the vicinity of Koehn Lake and near the Muroc fault. Arsenic has been measured in concentrations above the MCL of 10 µg/L in the Randsburg area and within the Southern FVGB. Chloride concentrations have exceeded the recommended SMCL of 250 mg/L near Koehn Lake. Chloride concentrations have not exceeded the recommended SMCL in the Southern FVGB. Although recently regulated and actively monitored, hexavalent chromium concentrations are still below MCLs throughout the FVGB, except at the City's wells showing localized elevated concentrations above the 10 µg/L[1]. Hexavalent chromium will continue to be monitored at wells as part of the monitoring plan.

[1] Chromium-6 is currently regulated with the MCL of 50 µg/L for total chromium. A previously established California MCL of 10 µg/L was invalidated by the Superior Court of Sacramento County on May 31, 2017.

The SNMP monitoring plan will focus on the groundwater conditions with respect to TDS and nitrate-N. along with the other primary parameters. Other constituents of concerns briefly discussed herein are monitored by the public water supply purveyors as part of the drinking water regulations and not included in the SNMP monitoring plan. Water quality conditions for these constituents are analyzed and further discussed in the Fremont Valley Basin GWMP.

9.2.3 Constituents of Emerging Concern

CEC is a term used to describe a broad range of unregulated chemical components, including pharmaceuticals and personal care products, that are being found at trace levels in many water supplies. A "blue ribbon" science advisory panel, convened by the State Water Board, prepared a report titled, "Monitoring Strategies for Chemicals of Emerging Concern in Recycled Water" which presented recommendations for monitoring CECs in municipal recycled water used for groundwater recharge. The Recycled Water Policy Attachment A states that "Monitoring of health-based CECs or performance indicator CECs is not required for recycled water used for landscape irrigation due to the low risk for ingestion of the water."

Currently, recycled water is not directly used to recharge the groundwater basin in the FVGB. This preliminary SNMP monitoring plan does not include monitoring CECs. Future monitoring of CECs can be incorporated into future updates to the SNMP monitoring plan if the Plan area implements recycled water projects for recharging the basin.

9.2.4 Selection of Wells

Public supply wells and USGS monitoring wells are recommended elements of the SNMP monitoring plan. The City, as the lead agency for the SNMP, worked closely with MPUD, other water suppliers, and other stakeholders in the Plan area to identify potential wells for the SNMP monitoring plan.

Figure 24 shows the locations of the existing wells currently monitored by public agencies and the USGS in the FVGB. The wells in this figure represent a pool of potential SNMP monitoring wells; and from this pool, a preliminary subset has been identified and recommended for the SNMP monitoring plan. Four primary criteria are considered in identifying specific wells to recommend for the SNMP monitoring plan:

- Maintain existing monitoring locations, particularly those that were installed by public entities and have reasonably long periods of record (i.e., public supply wells).
- Provide coverage of areas of special interest, including monitoring of areas utilizing recycled water and monitoring of areas near surface water courses to better understand surface water/groundwater interactions.
- Provide adequate geographic coverage for both the Northern and Southern FVGB.
- Select wells owned and operated by members of the RWMG for SNMP monitoring, if possible.

Of the 71 wells shown in Figure 24, seven are recommended as selected wells for the SNMP monitoring plan. These seven wells meet all of the criteria described above. To select the appropriate number of wells to represent conditions in the FVGB, monitoring well density guidelines recommended by DWR under the CASGEM and SGMA programs were reviewed. Both CASGEM and SGMA use groundwater pumping estimates and basin geographic area as criteria for general and broad density guidelines. Per the guidelines under the Hopkins (1984) method listed by CASGEM and SGMA (Table 38), the recommended number of wells for the FVGB would range from approximately 5 to 10 wells, based on estimated pumping (approximately 4,800 AFY) and basin area (523 square miles. Based on a review of these guidelines, seven wells are recommended as an appropriate representative well density. More wells were selected in the Northern FVGB than the Southern FVGB (five wells versus two), considering the larger basin area and higher groundwater pumping in the Northern FVGB and areas with recycled water uses located in the Northern FVGB. Table 39 lists the seven selected wells and summarizes the well information available, with rationales for the selection of each well. Figure 25 shows the locations of the selected seven wells. While some wells were selected that had limited well log information available (i.e., two of the City's selected wells have an unknown distance to the perforated intervals), these wells were selected because they had long-term monitoring data available for TDS and nitrate. As new wells with monitoring data and complete bore-log information become available in the City's system, the selection of wells will be revisited and updated, and the new wells will be used to supplement the monitoring program as approved by California City and the RWQCB.

Table 38: Monitoring Well Density Guidelines

CASGEM Monitoring Well Density (wells per 100 miles^2)		SGMA, BMP 2 Monitoring Well Density (wells per 100 miles^2)	
Hopkins (1984)		**Hopkins (1984)**	
Basins pumping between 1,000 and 10,000 AFY per 100 mi^2	2.0	Basins with 1,000 – 10,000 AFY groundwater pumping per 100 mi^2 area	2.0
Basins pumping between 250 and 1,000 AFY per 100 mi^2	1.0	Basins with 1,000 – 10,000 AFY groundwater pumping per 100 mi^2 area	1.0

Figure 24: Potential Monitoring Well Locations

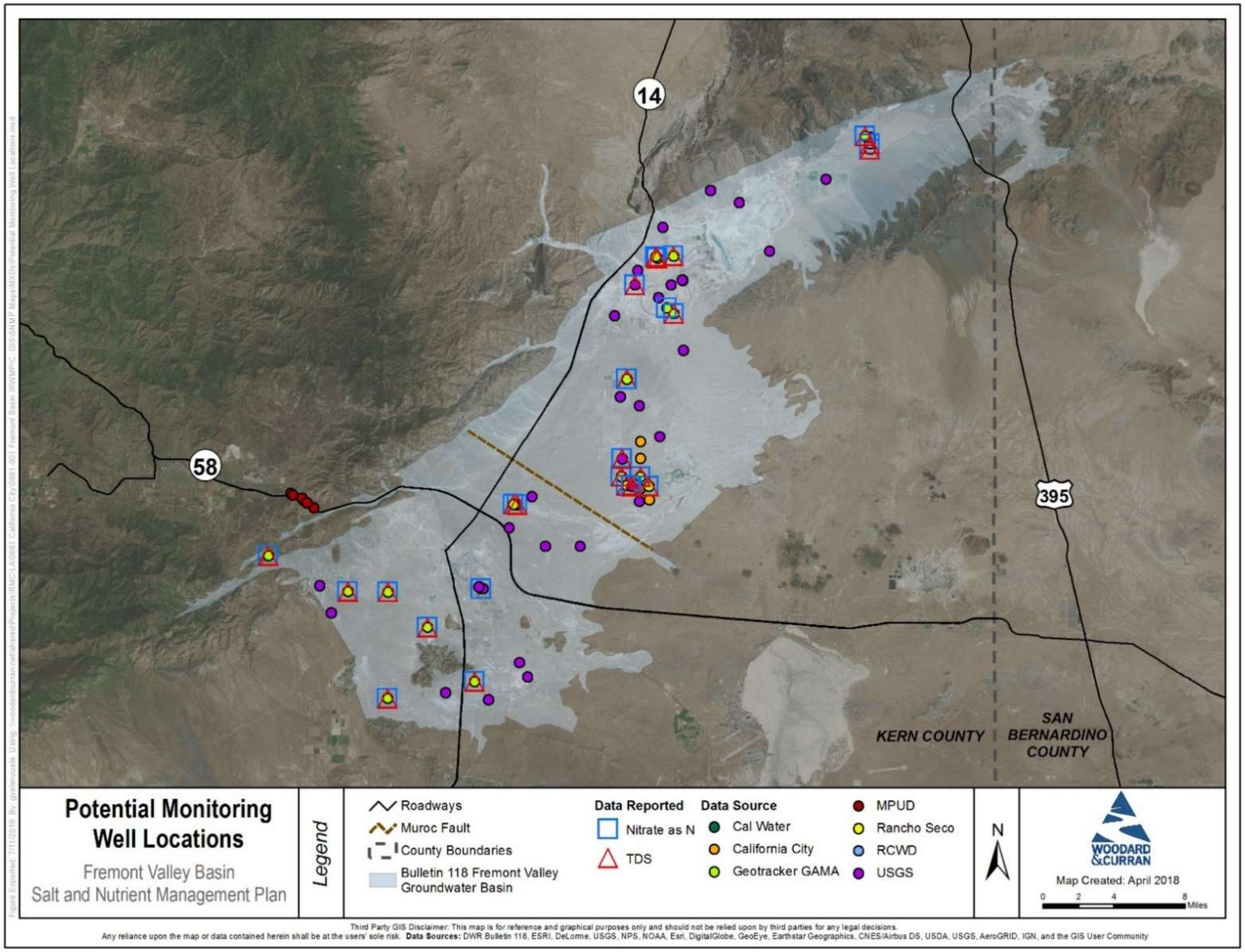

Figure 25: Preliminary Wells Selected for SNMP Monitoring Plan

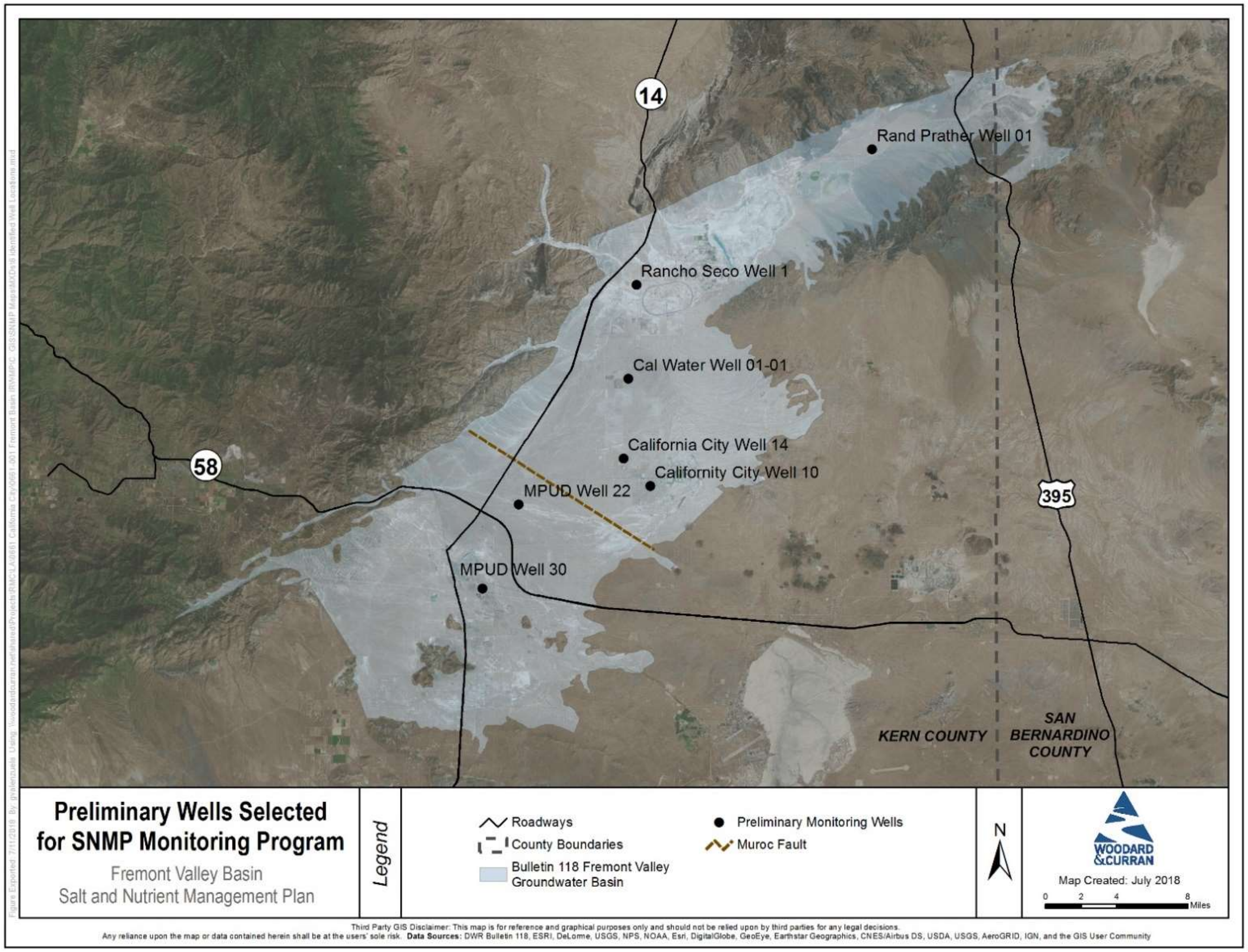

Table 39: Preliminary Subset of Wells Selected for SNMP Monitoring Plan

Well Name/ Number	Portion of FVGB	Owner	Well Type	Casing Diameter/ Material	Total Depth (feet bgs)	Perforated Interval(s) (feet bgs)	Constituents Monitored	Date Drilled	Pump Type	Rationales for Selection
California City Well 10	North	City of California City	Water Supply	16" / steel	553	NA	EC, pH, Temperature, TDS, nitrate-N	1952	DWT	Long period of records (1962-2014 for TDS and 1988-2017 for nitrate); located close to recycled water uses
California City Well 14	North	City of California City	Water Supply	16"/ steel	686	NA	EC, pH, Temperature, TDS, nitrate-N	1952	DWT	Long period of records (1972-2016 for TDS and 1988-2017 for nitrate)
Rand Prather Well 01	North	RCWD	Water Supply	14'' / steel	600	Start at 350	EC, pH, Temperature, TDS, nitrate-N	1976	25 horsepower Submersible	Long period of records (1984-2016 for TDS and 1984-2017 for nitrate)
Rancho Seco Well 1	North	Rancho Seco Inc.	Water Supply	8"	440	440	EC, pH, Temperature, TDS, nitrate-N	1960	6" Submersible	Long period of records (1980-2016 for TDS and 1993-2016 for nitrate)
Cal Water Well 01-01	North	Cal Water Service District	Water Supply	14'' / steel	635	98 - 554	EC, pH, Temperature, TDS, nitrate-N	Before 1959	DWT	Long period of records (1989-2016 for TDS and 1989-2017 for nitrate)
MPUD Well 30	South	MPUD	Water Supply	12'' / NA	395	Start at 205	EC, pH, Temperature, TDS, nitrate-N	1968	Turbine	Long period of records (1985-2017 for TDS and 1985-2003 for nitrate)
MPUD Well 22	South	MPUD	Water Supply	12'' / NA	591	Start at 300	EC, pH, Temperature, TDS, nitrate-N	1965	Turbine	Long period of records (1985-2014 for TDS and 1985-2017 for nitrate)

Note: NA: Not available; DWT: Deep Well Turbine

9.2.5 Sampling Frequency

The SNMP monitoring plan will include annual monitoring of the primary constituents for each well. Changes to the sampling frequency could be made if sufficient reasons exist to extend or reduce the sampling frequency. For example, if repeated monitoring results indicate that concentration levels are well below the MCL for a given constituent, it may be justified to decrease the sampling frequency. Similarly, if concentrations for a constituent are repeatedly shown to be approaching or exceeding the MCL, increased sampling frequency may be justified, particularly if the sampling events are in close proximity to public supply wells and/or domestic wells.

The City and other agencies participating in the monitoring plan will follow the same monitoring schedule for all wells in the SNMP monitoring plan to maintain a consistent sampling frequency and reporting timeline.

9.3 Monitoring Protocols

Groundwater samples collected as part of the SNMP monitoring plan will be collected using the following guidelines:

- Prior to sampling, a water level measurement will be obtained from each well using a sounder after pumping has been stopped at least a day.
- Wells with dedicated pumps will be purged using the dedicated pumps. Wells without dedicated pumps will be temporarily equipped with a submersible pump. Typically, three to five well casing volumes of water will be purged or until two consecutive measurements of conductivity, temperature, pH, and dissolved oxygen are within 10 percent of the previous two readings. At least five readings will be recorded during purging. Readings will be collected by passing water through a flow-through cell connected to a meter.
- Samples for water quality analysis will be collected in containers provided by the laboratory for the analysis intended.
- Each sample container will be labeled with the well number/location, date/time of sample collection, and sampler's name. The samples shall be delivered to the laboratory under chain-of-custody.
- Field notes will be taken during each monitoring event, including documentation of well purging and sampling.

9.4 Quality Assurance/Quality Control

Consistent procedures for Quality Assurance/Quality Control (QA/QC) are essential for successful implementation of the SNMP and for ensuring the accuracy of water quality data.

9.4.1 Data Reliability

Data obtained from wells will be scrutinized to determine if the data are representative of groundwater levels or water quality trends at each well. Anomalous results may be investigated by collecting confirmation water samples. Laboratory results will be validated with the laboratory's internal QA/QC procedures. Equipment used to purge and sample wells will be thoroughly cleaned between sampling locations to avoid cross contamination.

9.4.2 Field Equipment Calibration

Equipment used to measure field water quality parameters (EC, pH, and temperature) will be calibrated according to manufacturer specifications prior to each sampling.

9.4.3 Field Duplicate Samples

Field duplicate samples will be collected at a frequency of 10 percent of the number of samples to be collected during the sampling event. Each duplicate will be analyzed for the same parameters as the real sample. All duplicate samples will be collected, numbered, packaged, and sealed in the same manner as the real samples.

9.4.4 Reporting

A field log book will be kept to document all groundwater field monitoring activities. Field notes will document samples collected, analysis methods, how and when (date and time) the well was purged and sampled, the amount of water removed during the purging, and general field comments (such as site and/or weather conditions). If a well cannot be sampled, the reason will be documented. A Chain of Custody will be completed for each sampling event.

9.5 Agency Responsibilities

The overall implementation of the SNMP monitoring plan will be led by the City in coordination with MPUD. Stakeholders who are participating in the SNMP monitoring plan will also be responsible for monitoring and sampling data for their wells using the adopted monitoring protocol. The City and the participating agencies will collaborate and develop an understanding of respective roles and responsibilities for the joint data collection effort. Each agency will submit their data to the City. The City will be responsible for reporting the entire set of data collected to the SWRCB via the online Electronic Deliverable Format (EDF) as described below. The City will follow the reporting requirements in compliance with LRWQCB requirements.

9.6 Online Data Submittal

Data collected as part of the SNMP monitoring plan will be submitted online electronically into the SWRCB's GeoTracker GAMA online information system via EDF, as required by the SWRCB. The City will upload all EDFs for each sampling event.

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10. PLAN IMPLEMENTATION

This section describes the management strategies and projects identified to support the goals and objectives of the SNMP. Several programs and identified projects that will help manage groundwater supplies and quality are already underway in the Plan area. The projects included in this Plan inform and support the regional goals and objectives described in the Fremont Basin IRWM Plan.

10.1 Management Strategies

Best Management Practices (BMPs) are currently in place in the major land use sectors that are likely to be contributing salts and nutrients to the groundwater basin. BMPs for municipal wastewater management, agriculture, reclaimed wastewater irrigation, and septic systems are briefly described in the sections that follow.

10.1.1 Municipal Wastewater Management

The City and MPUD operate WWTPs within the FVGB and must implement a host of source control and industrial waste management measures to control salts and nutrients in influent waters.

10.1.2 Agricultural BMPs

While the current agricultural area is small relative to the total Plan area, there is potential for agriculture to expand in the future. Return flow from irrigation can contain significant amounts of salts and nutrients that may have significant impacts to groundwater quality. Land management practices within agricultural fields include various BMPs, including:

- Drip irrigation and focused application of fertilizer and soil amendments – Water application with drip irrigation (and the associated salt/nutrient loading) is minimized by focusing the amount and area applied. Application of salts and nutrients is limited to the area at the point of the irrigation drip emitter, rather than broadcast across a large area
- Soil and petiole testing – It is common practice for land managers to conduct annual soil testing to understand soil characteristics for crop production and flavor. Soil testing includes review of TDS and nitrate characteristics. Land managers also typically test petioles[1] to further refine crop nutrient needs.

10.1.3 Reclaimed Wastewater Irrigation BMPs

The implementation of recycled water is regulated by CCR Title 22. Numerous BMPs and operating procedures are required to be followed when using recycled water for irrigation; these BMPs ensure safety and effectively reduce the likelihood of over-application of fertilizers and soil amendments on grounds where recycled water is applied. The following BMPs are implemented as part of reclaimed wastewater operations:

- Water quality monitoring at the treatment plant to ensure regulatory compliance and to meet monitoring requirements for emerging contaminants as required by the Recycled Water Policy.
- Irrigation at agronomic rates – Irrigation is applied at a rate that does not exceed the demand of the plants, with some allowance for flushing salts below the root zone, and does not exceed the field capacity of the soil.
- Site supervision – A site supervisor, who is responsible for the system and for providing surveillance at all times to ensure compliance with regulations and permit requirements, is designated for each site. The site

[1] Petiole is a plant tissue sampling typically collected for analysis of nutrients in plants.

supervisor is trained to understand reclaimed wastewater and supervision duties. In addition to monitoring the reclaimed wastewater system, the site supervisor must also conduct an annual self-inspection of the system.

- Minimize runoff from irrigation – Irrigation is not allowed to occur at any time when uncontrolled runoff may occur, such as during times of rainfall or very low evapotranspiration; and any overspray must be controlled.

10.1.4 Onsite Wastewater Treatment System Management

There are permitted septic systems in the Plan area, each managed by individual property owners responsible for employing a variety of BMPs such as monitoring and frequent pumping to manage the operation of the system. Permits for septic systems can be obtained by application to the SWRCB. In June of 2012, the SWRCB adopted the Water Quality Control Policy for Siting, Design, Operation, and Maintenance of Onsite Wastewater Treatment Systems (OWTS). This policy was subsequently updated in April 2018. The intent of the policy is "to allow the continued use of OWTS, while protecting water quality and public health". BMPs required in the policy include site evaluations, setbacks, and percolation tests for new systems.

10.2 Projects and Management Actions

Water management planning efforts and projects related to the SNMP are presented in Table 40 and are described in the following sections. These projects will benefit the FVGB by supporting regional water supply reliability, promoting sustainable use of the FVGB, and providing drinking water that meets regulatory requirements. Projects are classified as either "conceptual" or "developed" in Table 40 based on the project's status, level of development, and readiness to proceed. Conceptual projects are those with minimal planning completed and that require further development to quantify project benefits, costs, and schedule. Conceptual projects are generally expected to evolve into developed projects as planning and design progress.

In addition to the management projects presented in Table 40, the Plan area identified various resource management strategies through the Fremont Basin IRWM Plan to help local agencies manage water and water-related resources. Resource management strategies that are pertinent to the SNMP and considered appropriate and valuable for the Plan area are as follows:

- Agricultural water use efficiency - Using and applying scientific processes to control agricultural water delivery and use to achieve a beneficial outcome.
- Urban water use efficiency - Implementing activities that reduce urban water use by increasing water use efficiency.
- Conjunctive management and groundwater storage - Coordinated and planned use and management of both surface water and groundwater resources to maximize the availability and reliability of water supplies to meet various management objectives.
- Groundwater/aquifer remediation - Improving the quality of degraded groundwater for beneficial use by removing constituents that affect its beneficial use.
- Pollution prevention - Reducing or eliminating waste at the source by modifying production processes, promoting the use of non-toxic or less toxic substances, reducing the generation and/or discharge of the pollutants, and preventing pollutants from entering the environment prior to treatment.
- Urban runoff management - Managing stormwater and dry-weather runoff by reducing pollutant loading and the volumes and velocities or urban runoff discharged to surface waters.
- Land use planning and management - Planning for the housing and economic development needs of a growing population, while providing for the efficient use of water, water quality, energy, and other resources.

- Recharge areas protection - Implementing activities that ensure areas suitable for recharge continue to be capable of adequate recharge and prevent pollutants from entering the groundwater to avoid expensive treatment that may be necessary prior to beneficial use.
- Public outreach and education - Using tools and practices to facilitate contributions by public individuals and groups toward good water management outcomes.

Table 40: Basin Water Management Projects

Project	Purpose	Implementing Agency	Stage	Impact to Salt and Nutrients Loadings
Central Park Lake Restoration	Restore lake lining where portions are failing and install water recirculation pumps to improve water quality	City of California City	Developed	Protects water quality and potentially reduces TDS and nitrate-N concentrations to the groundwater basin.
Wastewater Treatment Plant Upgrades	Upgrade the City's WWTP to be able to treat additional flows and produce more tertiary recycled water	City of California City	Developed	Supports the SNMP goals for recycled water use and protects groundwater quality
Fremont Valley Groundwater Basin GSP Development	Develop a GSP for the FVGB	City of California City	Conceptual	Could include measures to reduce both TDS and nitrate-N for protecting groundwater quality.
Septic to Sewer Conversion	Convert septic systems to sewer to improve groundwater quality	City of California City	Conceptual	Decreases nitrate-N loading to groundwater basin.
Stormwater Capture and Reuse/Recharge	Capture and use stormwater to recharge groundwater basin	City of California City	Conceptual	Decreases TDS and nitrate-N concentrations in groundwater basin.
Well Blending and Distribution System Enhancements	Blend groundwater from MPUD's Well 30 with groundwater from MPUD's other six wells to reduce nitrate-N in Well 30 below the 10 mg/L MCL	MPUD	Developed	None, but decreases nitrate-N concentrations in potable water supply.
New Water Meters	Replace water meters for 300 connections	RCWD	Conceptual	Accurately measure flow rates and promotes water conservation.

10.2.1 Well Blending and Distribution System Enhancements

This project will be implemented by MPUD and is currently at the developed stage. The project includes blending groundwater from MPUD's Well 30 with groundwater from MPUD's other six wells to reduce nitrate-N in Well 30 below the 10 mg/L MCL. The goal of the project is to provide drinking water that meets regulatory requirements with respect to nitrate. Currently, Well 30 is out of service due to high levels of nitrate exceeding the 10 mg/L MCL as nitrate-N. The blending system would be controlled by a Supervisory Control and Data Acquisition (SCADA) system that would allow preset amounts of water into the blending tank from both Well 30 and the distribution system. Continuous nitrate as N analyses would be performed on the effluent line from the tank. After the water is blended down to 80 percent of the nitrate-N MCL or lower, the blended water would be pumped back into the distribution system. The constructed project will include a new, higher head well pump, 500,000-gallon bolted steel blending tank, booster pump station, plant piping and valves, two continuous nitrate analyzers, connection to the MPUD SCADA system, and about 3/4th of a mile 8-inch diameter transmission pipeline.

Overall, this project does not change the TDS or nitrate-N loadings to the basin; but it will decrease nitrate-N concentrations in the potable water supply.

10.2.2 City of California WWTP Upgrades

The City is at the developed stage for a number of upgrades to its WWTP to accommodate increases in flow and to improve water quality. One major upgrade involves conversion from a chlorine to ultraviolet (UV) disinfection. The UV process will eliminate the need to generate, handle, transport, or store toxic, hazardous, or corrosive chemicals. This upgrade will improve the water quality to be recycled by removing some organic contaminants that might affect the FVGB.

Overall, the WWTP upgrades will improve the water quality collected to be recycled and used to irrigate the City's golf course; therefore, these upgrades will ultimately protect water quality of the FVGB.

10.2.3 Fremont Valley Groundwater Basin GSP Development

As discussed in Section 1, the FVGB is designated as a low priority groundwater basin and the agencies within the Plan area are not subject to SGMA's GSA and GSP requirements. However, the City, AVEK, and MPUD have initiated efforts to prepare the Plan area for SGMA compliance through the development of the Fremont Valley Basin GWMP. The City, AVEK, and MPUD, as well as other key stakeholders in the Region, may elect to form a GSA in the future and develop a GSP. This SNMP will support and inform the future development of a GSP for the FVGB with respect to basin management strategies, monitoring and implementation strategies related to water quality from recycled water use. The GSA for the FVGB will identify and prioritize projects and management actions to maintain the health of the groundwater basin. The GSP for the FVGB may include the following:

- Basin-wide groundwater level monitoring
- Groundwater quality monitoring
- Groundwater studies, including development of a robust, 3D groundwater model of water levels, salinity, geological features, and stratigraphy
- Water recycling projects to offset groundwater pumping
- Stormwater capture and reuse/recharge studies that can be conducted in conjunction with the Fremont Basin IRWM Plan
- Public Outreach Plan
- Surface water monitoring program

- Updating land cover maps for future agricultural expansion
- Encouraging conservation and BMPs for agriculture

Overall, the future GSP development will support the SNMP goals and objectives toward protecting groundwater quality (and preventing one of the undesirable results identified under SGMA) and ensuring the long-term sustainable management of groundwater resources. Over the long-term, active groundwater basin management could include measures to reduce TDS and nitrate-N in the FVGB.

10.2.4 Septic to Sewer Conversion

Septic tanks are one of the major sources of nutrients in the FVGB. Septic to sewer conversion is considered in the Plan are as a potential option to maintain nitrate levels in groundwater. Section 8 analyzed a future scenario to evaluate the septic conversion that would be necessary to maintain current nitrogen levels under the baseline and three future agricultural growth scenarios (light, medium, and heavy). The analysis suggested that almost all of the existing (approximately 3,700) septic systems would need to be removed to maintain the current nitrate levels. Future projects will likely include a combination of septic to sewer conversions in conjunction with stormwater recharge projects. Moreover, Section 8 demonstrated that the FVGB has sufficient assimilative capacity for nitrate-N. In situations where feasible, identified septic tanks may be abandoned and replaced by a centralized wastewater treatment facility as the Plan area develops further.

Septic to sewer conversion would decrease nitrate-N and TDS concentrations in the FVGB as septic tanks contribute nutrients and salts to the FVGB.

10.2.5 Stormwater Capture and Reuse/Recharge

Stormwater capture and reuse/recharge projects could be beneficial to the Plan area and they are being considered conceptually as part of the Fremont Basin IRWM Plan. Stormwater projects are considered viable options to potentially decrease TDS and nitrate concentrations in the basin, recharge the basin, and augment water supplies. Section 8 presented a future scenario with stormwater recharge to illustrate the potential stormwater recharge amount that would be needed to maintain the 2015 TDS conditions under the baseline and three future agricultural growth scenarios (light, medium, and heavy). Stormwater recharge amounts ranging from approximately 3,200 AFY for the baseline to over 11,000 AFY were needed to maintain 2015 levels for TDS. These values are not currently evaluated as quantitative goals; however, the Plan area stakeholders will consider stormwater recharge projects that could be potentially implemented to accomplish the IRWM stormwater-related objectives in the context of the SNMP. Future projects are intended to support the Fremont Basin IRWM Objectives and Targets that are relevant to stormwater goals as discussed in Section 6 (Table 22).

Stormwater projects could be beneficial to groundwater by potentially decreasing TDS and nitrate concentrations in the FVGB as stormwater is likely to contain very low concentrations of these constituents.

10.2.6 Central Park Lake Restoration

The City has found that some inside surface areas of the lake are failing. This project will fix these failing spots by installing lining on damage areas and install water recirculation pumps to improve water quality. The project is currently in the developed stage - water quality analyses were completed and visual inspection of the lake was performed. The lake is used to store recycled water before delivery to the golf course for irrigation. The lack of proper lining in the lake could cause recycled water seepage to groundwater basin and could cause water quality issues with TDS and nitrate.

This project will protect water quality of the FVGB and could reduce TDS and nitrate-N concentrations.

10.3 Performance Measures

Performance measures are used to assess whether the goals and objectives of the SNMP are being met. The Fremont Basin IRWM Plan identifies performance measures that can be utilized to ensure the RWMG is effectively addressing key regional issues by meeting objectives and planning targets. Led by the City of California City, the RWMG will collectively monitor progress towards meeting the IRWM objectives by reviewing the performance measures outlined in the IRWM Plan and Section 6 of the SNMP. The objectives, targets and performance measures that apply to the SNMP are summarized in Table 41. Each performance measure identifies at least one data source that can be used to track the targets described in Section 6.

Table 41: Plan Performance Measures

Target	Indicators	Data Source	Monitoring Responsibility
Water Supply Objective: Increase regional water supply reliability to meet demands			
Increase recycled water use by 2025 compared to 2017	Recycled water supply data	Recycled water customer meters	City of California City
Increase stormwater capture by 2025 compared to 2017	Stormwater capture data	Project Performance Monitoring Plans	Local water purveyors; project sponsors
Adapt to climate change impacts on runoff and recharge, and from sea level rise	Increase in local supply development projects	Project Performance Monitoring Plans, UWMPs	Local water purveyors; project sponsors; City of California City
Water Quality Objective: Protect water quality in groundwater basins in the Region			
Prevent degradation of groundwater basins according to Basin Plan	Prevent degradation of groundwater basins according to Basin Plan	Groundwater quality data	SNMP Monitoring Plans
Map contaminant sites and movement in the Fremont Valley Groundwater Basin by 2027	GeoTracker GAMA	RWMG	
Flood Management Objective: Reduce negative impacts of stormwater			
Identify areas of highest flood risk in the Region by 2018	Map of flood risk areas	FEMA maps	RWMG
Implement projects to provide flood protection to existing and future planned properties where benefits exceed costs	Projects implemented	IRWMP	RWMG
Implement integrated, multi-benefit flood management projects, when feasible	Projects implemented	IRWMP	RWMG

10.4 Adaptive Management

The SNMP and associated monitoring plan will be adaptively managed as a part of ongoing data review and SNMP updates. Data will be reviewed annually to evaluate whether the results are in the anticipated range based on the hydrogeologic conceptual model and predictive modeling of the FVGB. If analytical results are significantly different than anticipated, the need for reassessing the model assumptions and/or modifying the SNMP monitoring plan will be assessed. Adaptive management may also include assessing the potential need for additional BMPs, if warranted, to protect water quality objectives and to achieve the SNMP goals.

10.5 Plan Approval and Update Process

This Draft SNMP was submitted to the RWMG on July 12, 2018 and the Draft SNMP was presented at a public stakeholder meeting on September 20, 2018. Public comments on the Draft SNMP Report were considered and incorporated into a Draft Final SNMP Report. The Final SNMP was submitted to the LRWQCB on December 26, 2018 for their review and incorporation into their Basin Planning process and subsequent environmental documentation process. The Final SNMP Report (dated December 2018) will be posted online.

The timing of an update for the Plan is not tied to a scheduled reoccurrence interval; however, an update could be triggered by the following:

- Major changes in land use or land management practices
- Changes in basin management
- Implementation of future recycled water projects

Any future updates would be conducted utilizing a similar collaborative process as was utilized for development of this SNMP. The basin monitoring plan will be reviewed to determine the need for updates every five years. More frequent updates may occur if justifiable by basin conditions and data.

10.6 Conclusions

The average TDS and nitrate concentrations and the available assimilative capacity were discussed in Section 8. For TDS, the SNMP evaluated the assimilative capacity of the basin both for the recommended SMCL of 500 mg/L and the upper limit SMCL of 1,000 mg/L. For the purpose of this SNMP, the upper limit SMCL of 1,000 mg/L for TDS and the MCL of 10 mg/L for nitrate-N were considered as the water quality objectives for evaluating the assimilative capacity of the FVGB. As discussed in Section 8, the Northern FVGB and Southern FVGB are at or slightly below the recommended SMCL of 500 mg/L for TDS, but substantially below the upper limit SMCL of 1,000 mg/L. The antidegradation analysis determined that even under the heavy agricultural growth scenario, only 6 percent of the assimilative capacity of the basin would be used within the Plan period (2040) based on the 1,000 mg/L water quality objective for TDS, and only 1 percent would be used without any future agricultural growth. Both the Northern and Southern FVGB are substantially below the water quality objective for nitrate as N (10 mg/L), and nitrate-N levels are not expected to substantially increase within the Plan period (about 3 percent of the assimilative capacity).

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APPENDIX A: GROUNDWATER ELEVATION CONTOUR MAPS

Figure A-1: Spring 1958 Groundwater Elevation Contours

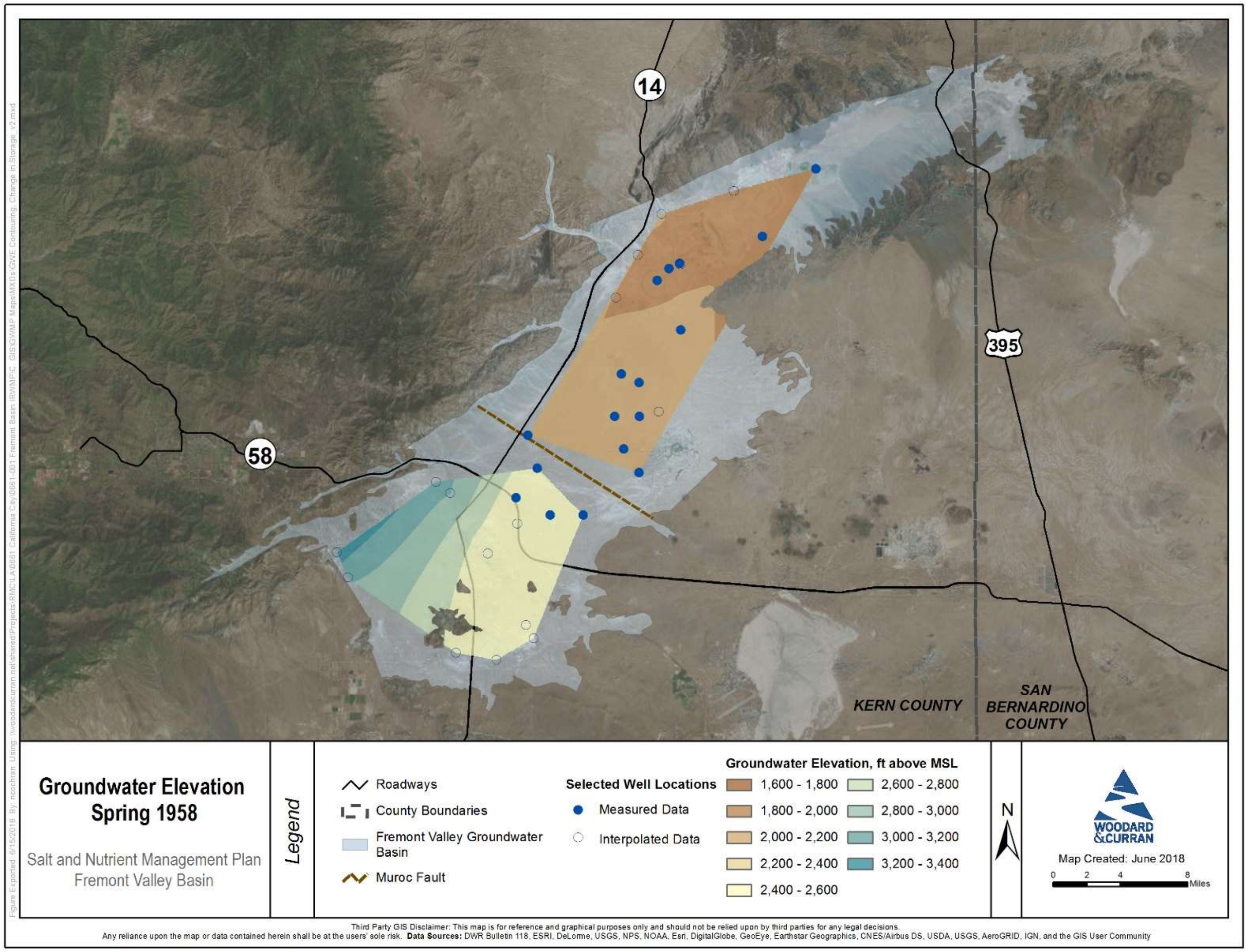


Figure A-2: Spring 1969 Groundwater Elevation Contours

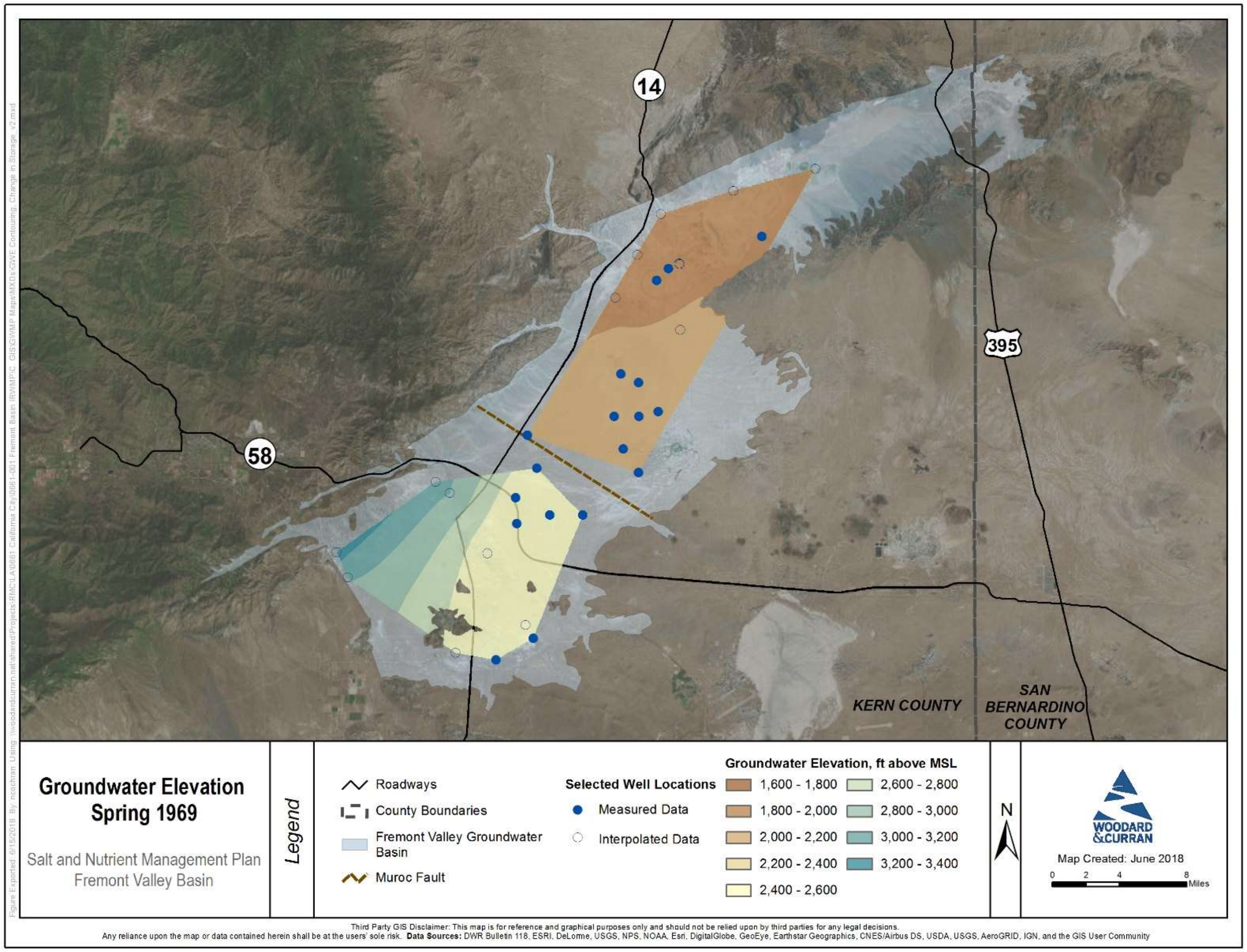


Figure A-3: Spring 1972 Groundwater Elevation Contours

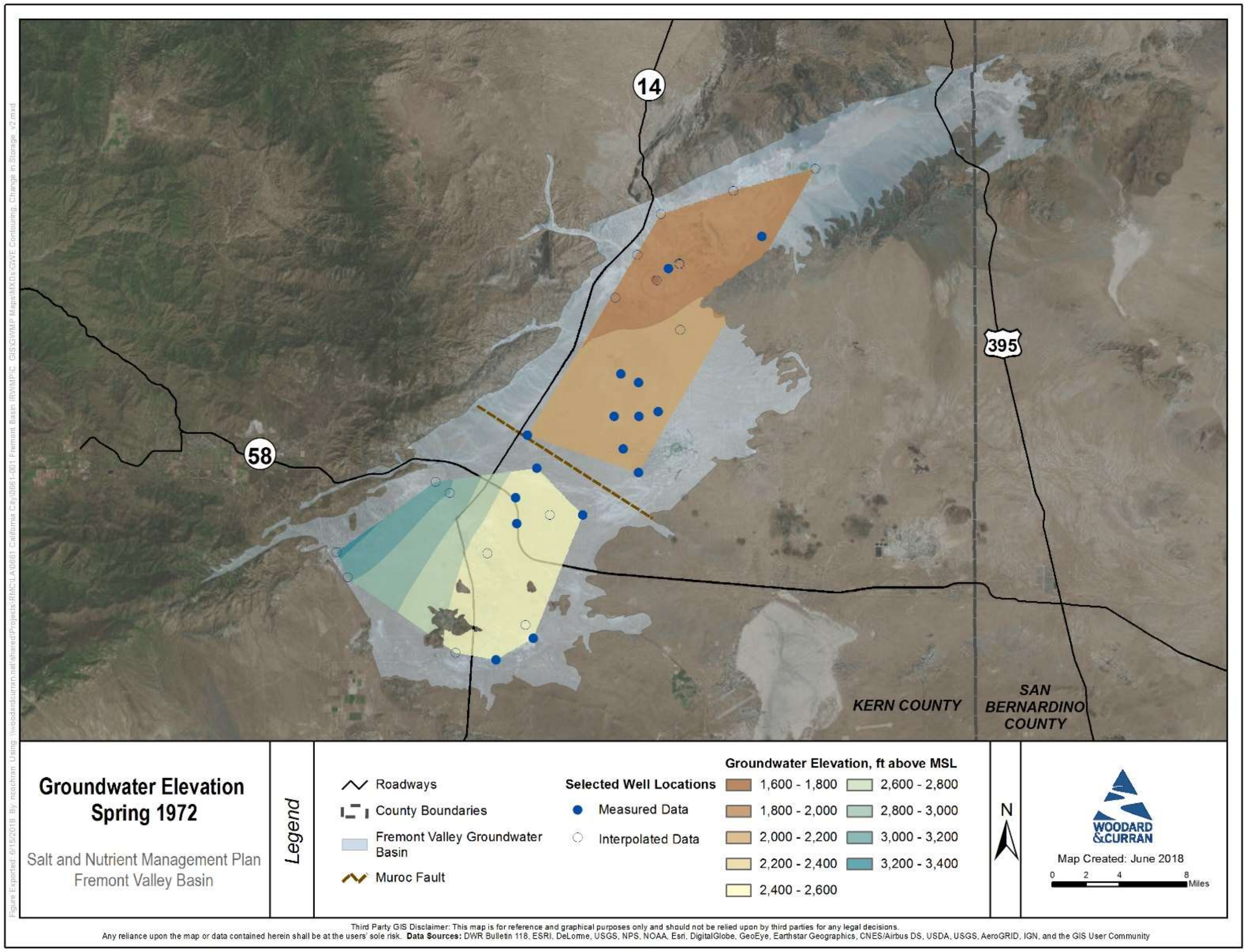


Figure A-4: Spring 1975 Groundwater Elevation Contours

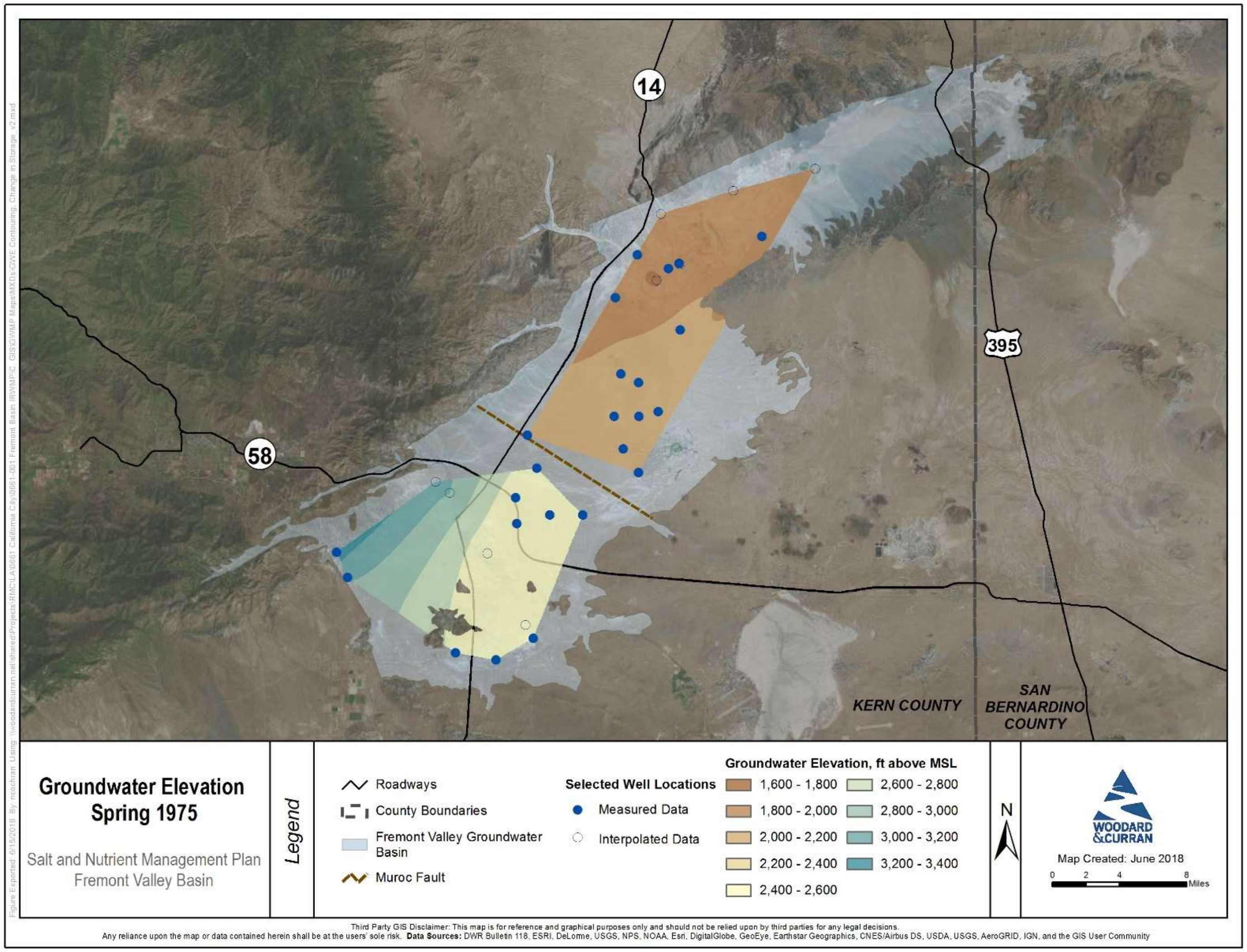


Figure A-5: Spring 1978 Groundwater Elevation Contours

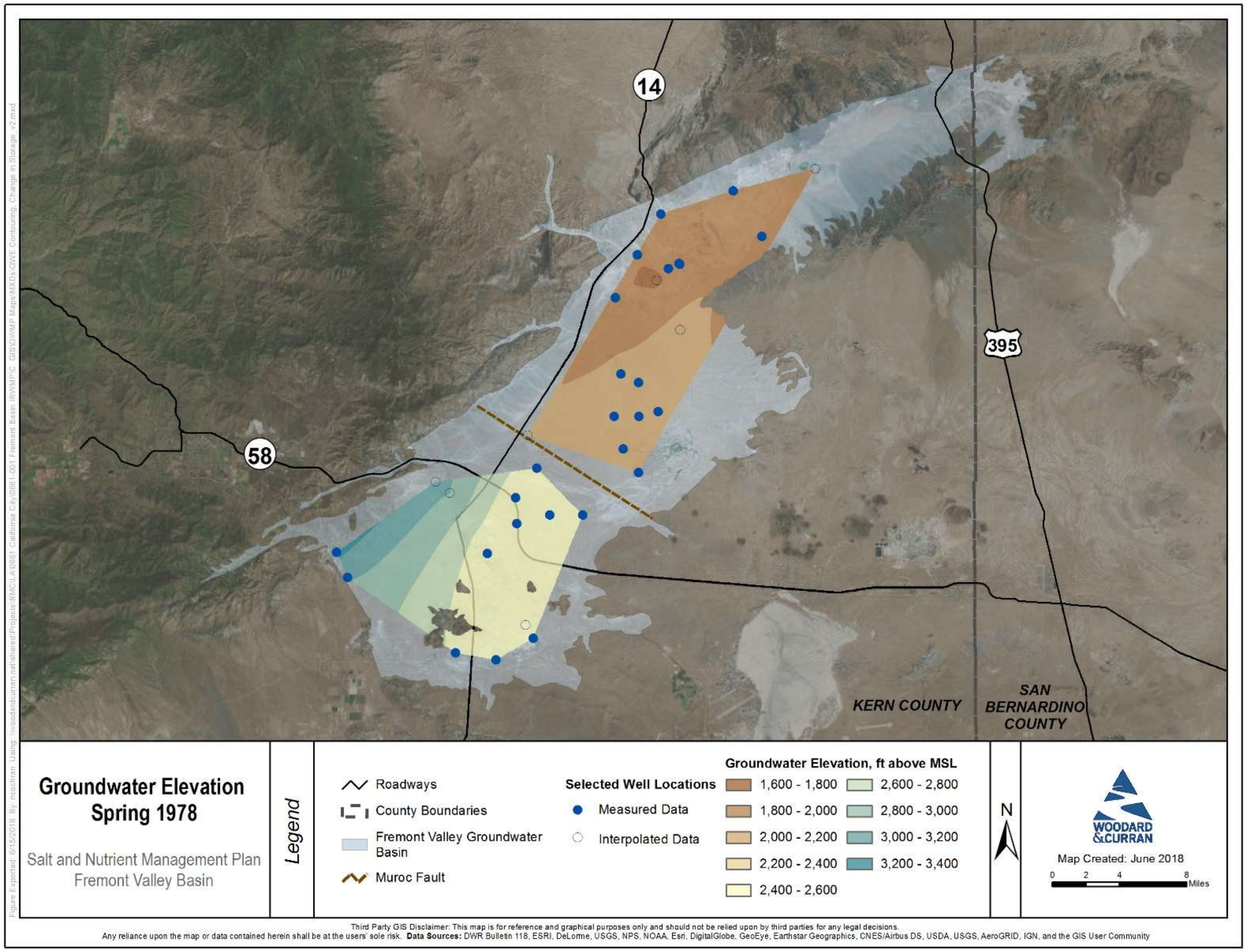


Figure A-6: Spring 1980 Groundwater Elevation Contours

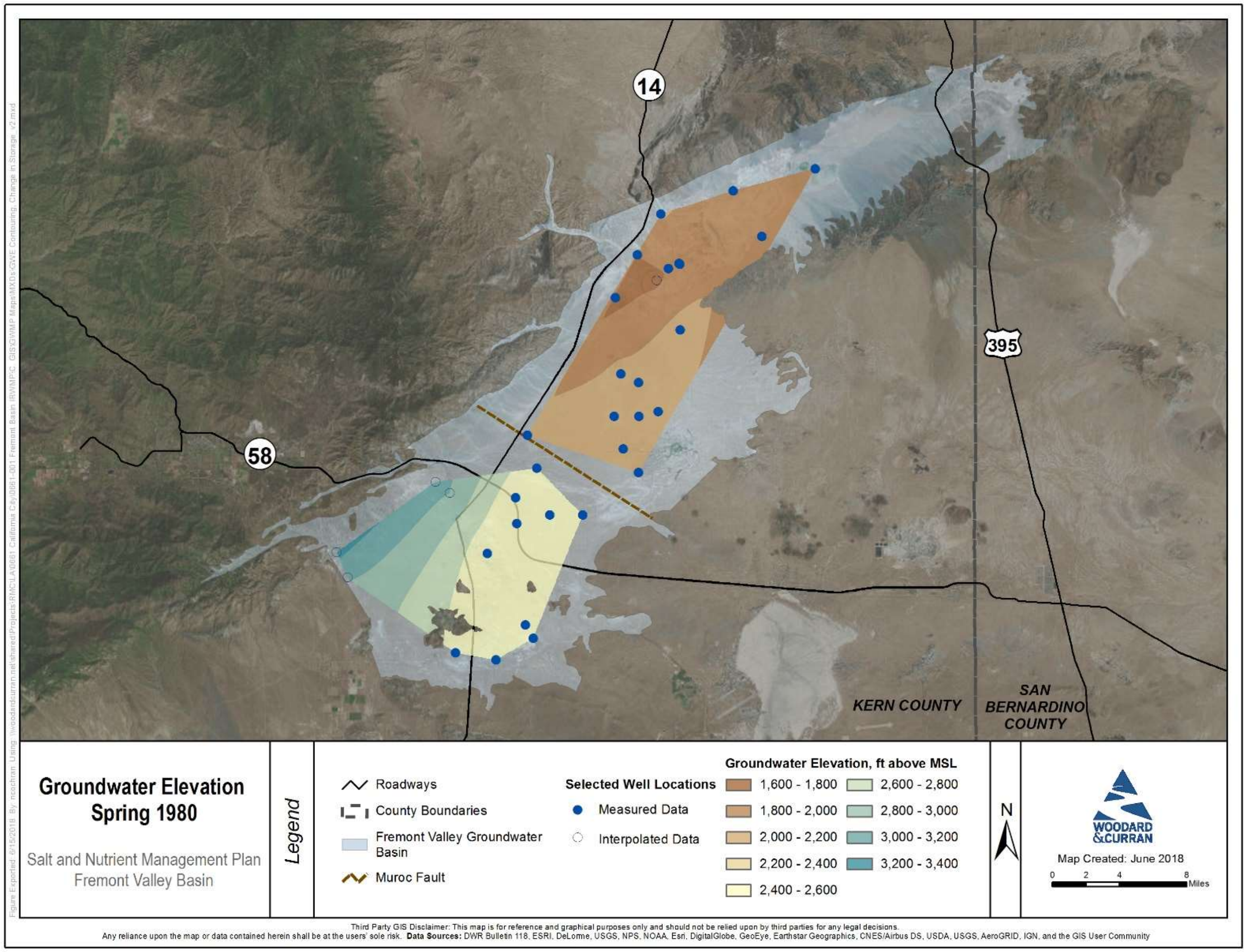


Figure A-7: Spring 1981 Groundwater Elevation Contours

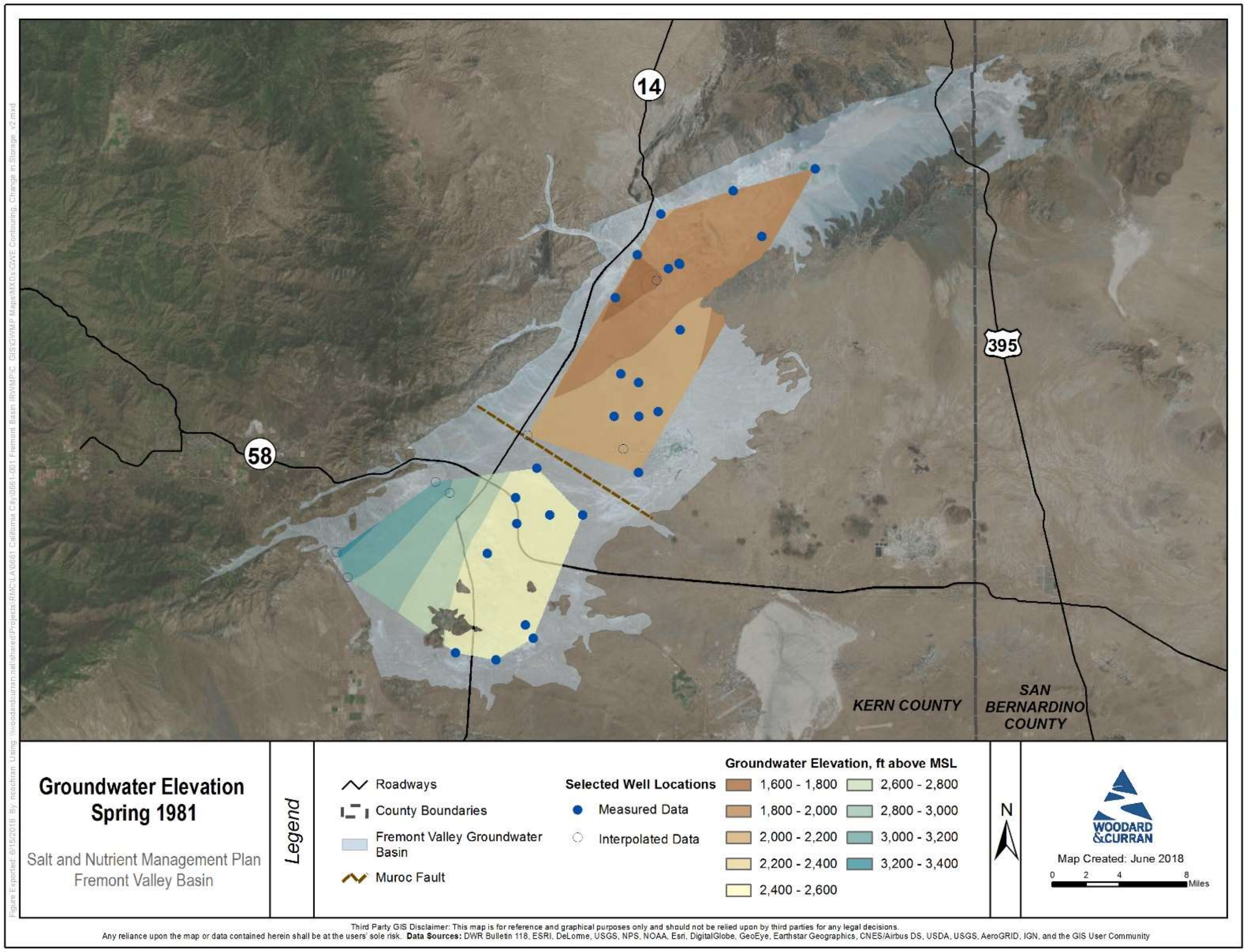


Figure A-8: Spring 1983 Groundwater Elevation Contours

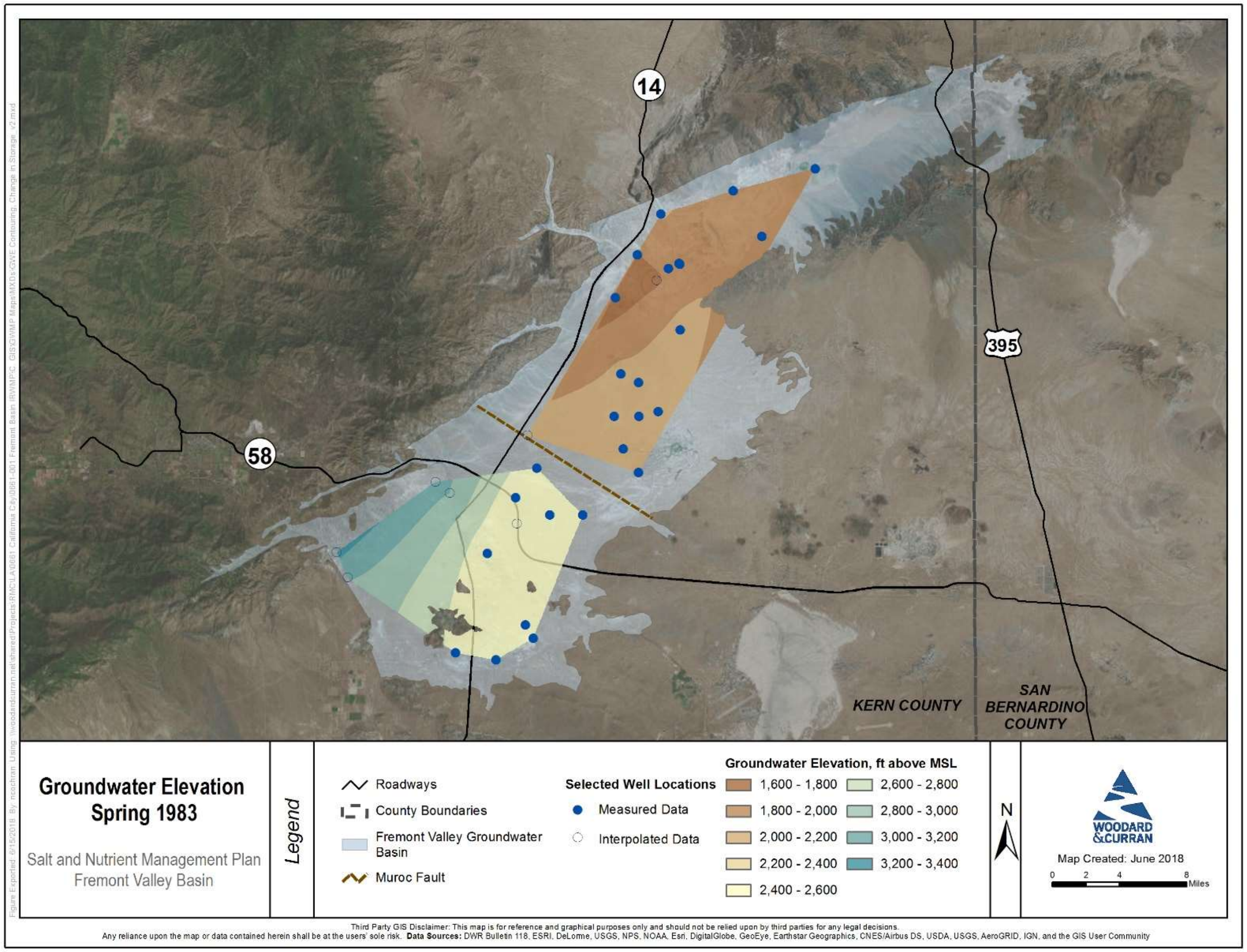


Figure A-9: Spring 1985 Groundwater Elevation Contours

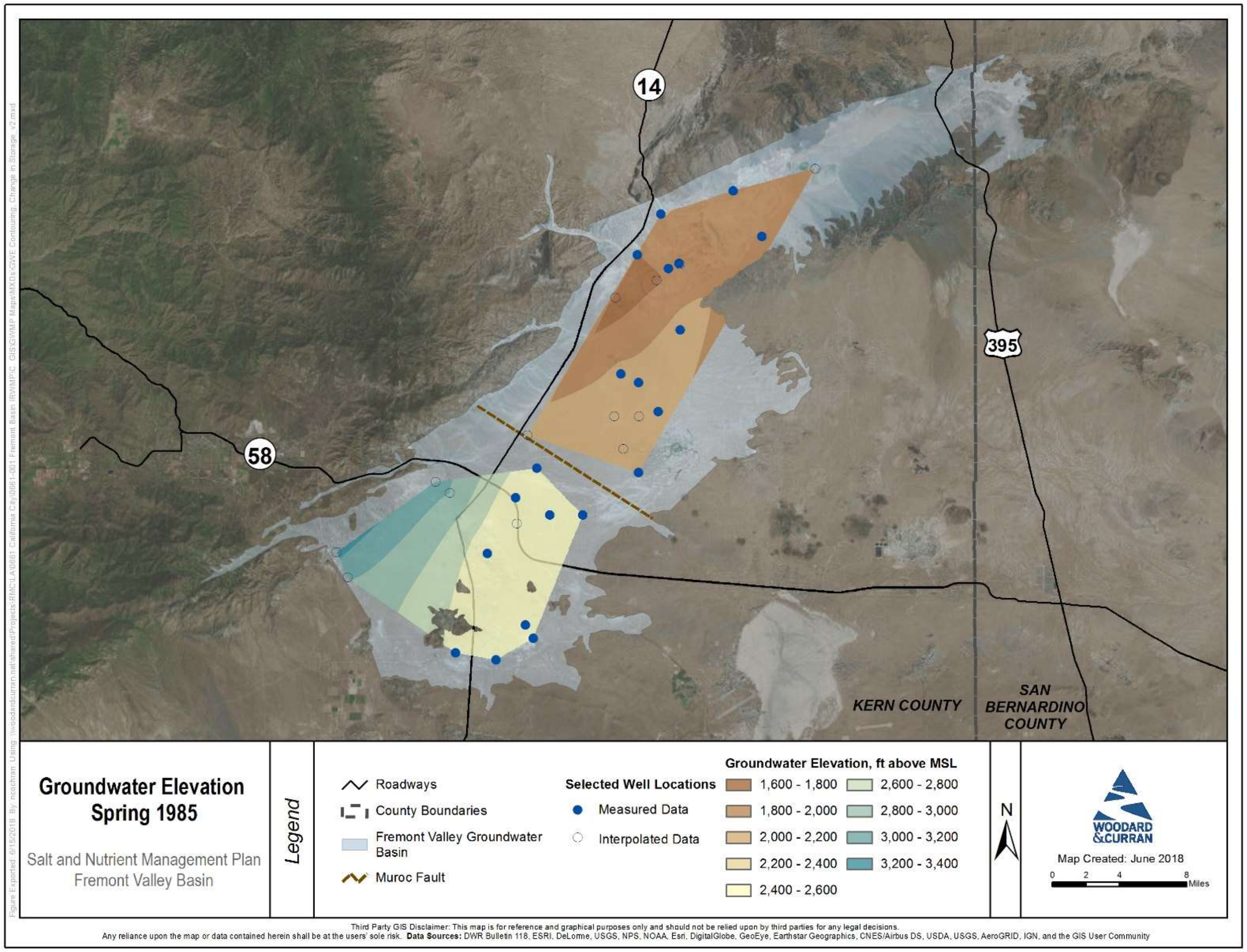


Figure A-10: Spring 1987 Groundwater Elevation Contours

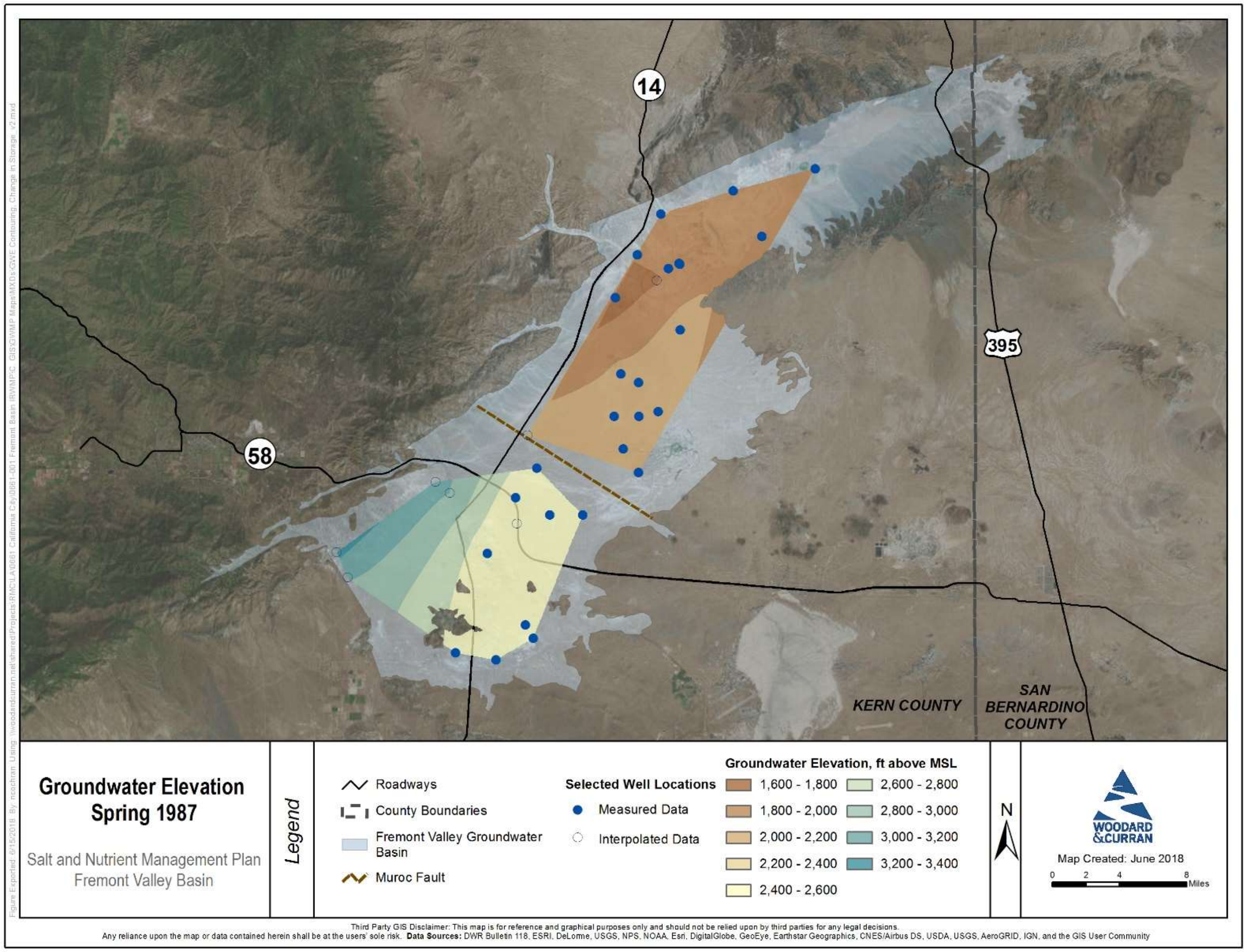


Figure A-11: Spring 1990 Groundwater Elevation Contours

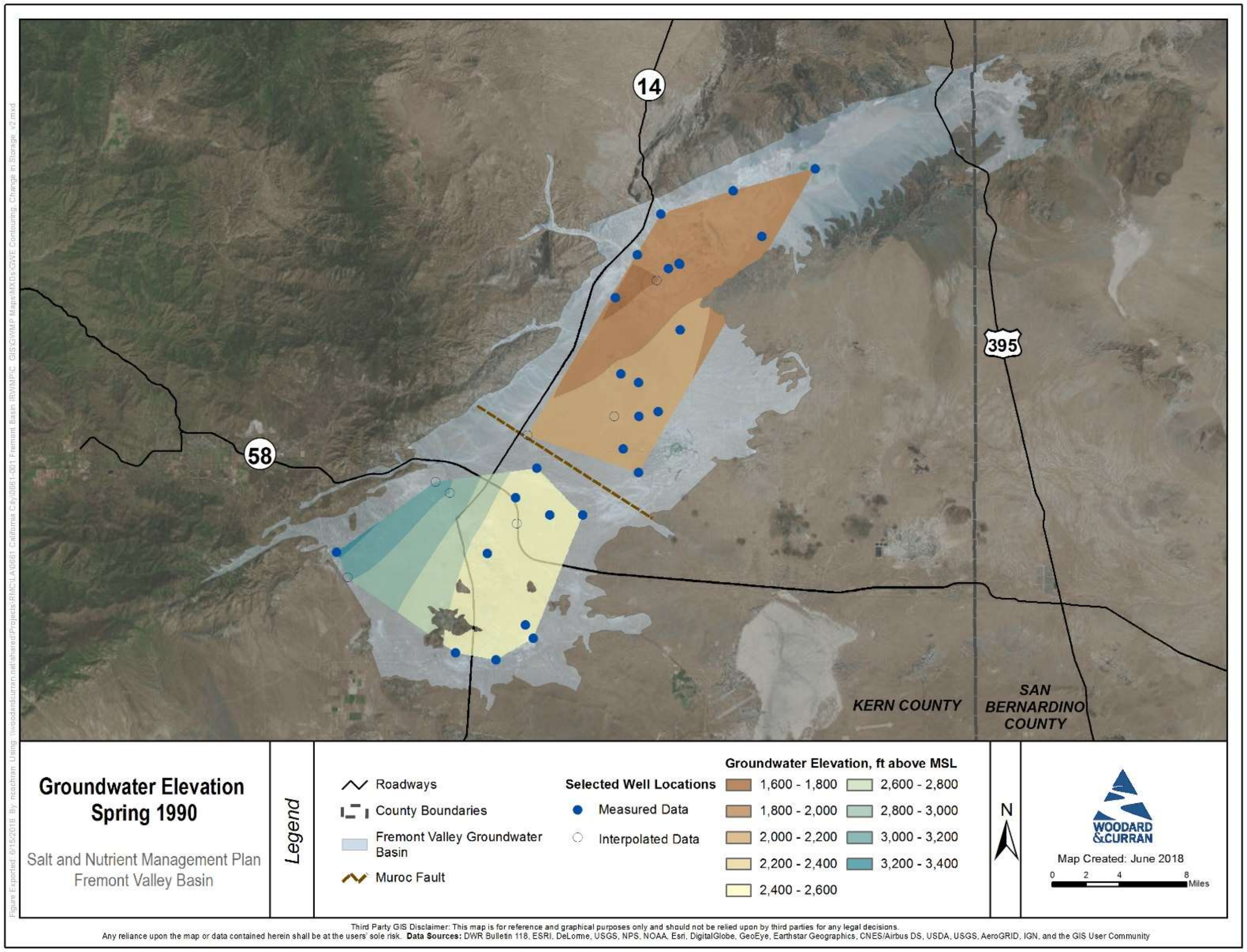


Figure A-12: Spring 1993 Groundwater Elevation Contours

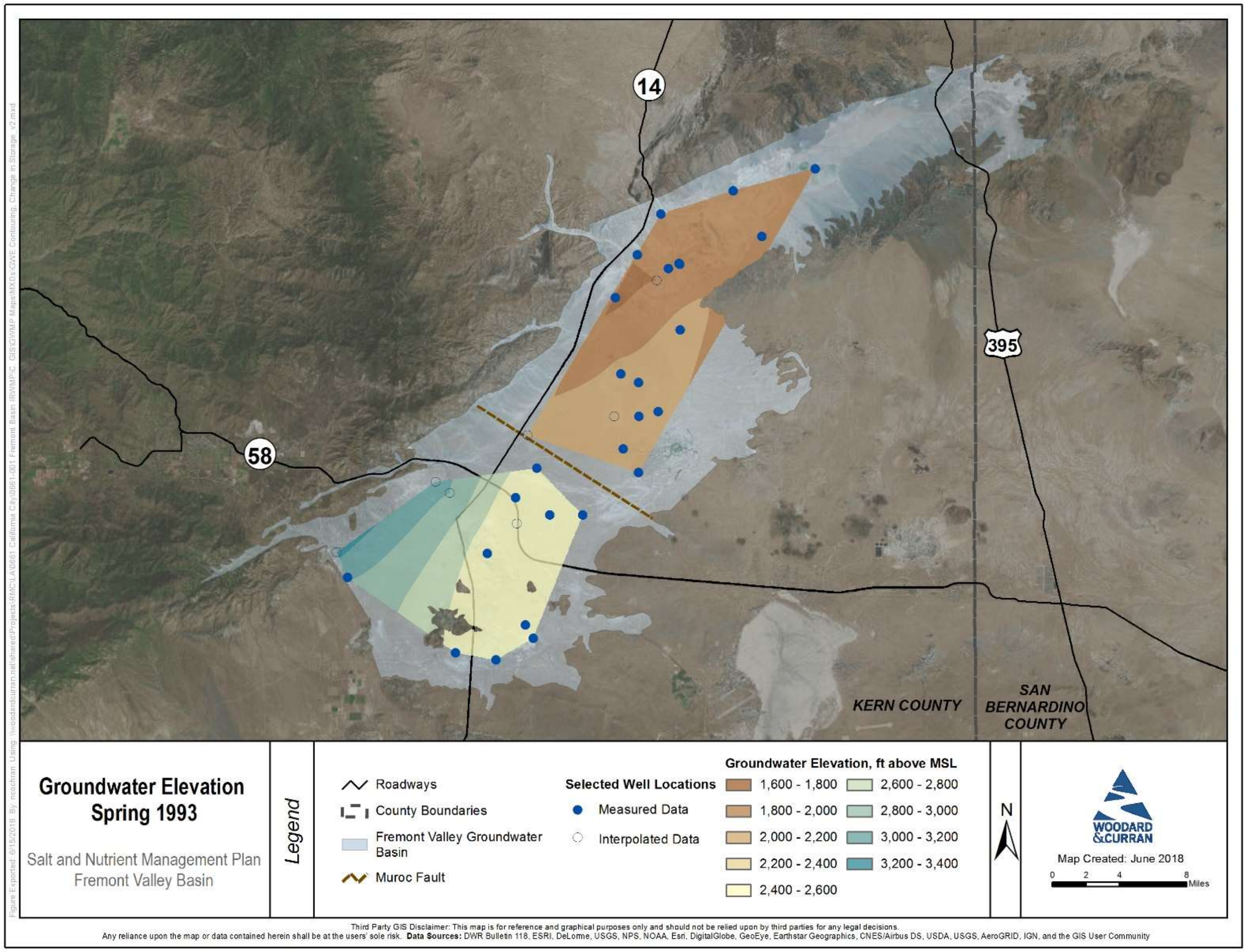


Figure A-13: Spring 1995 Groundwater Elevation Contours

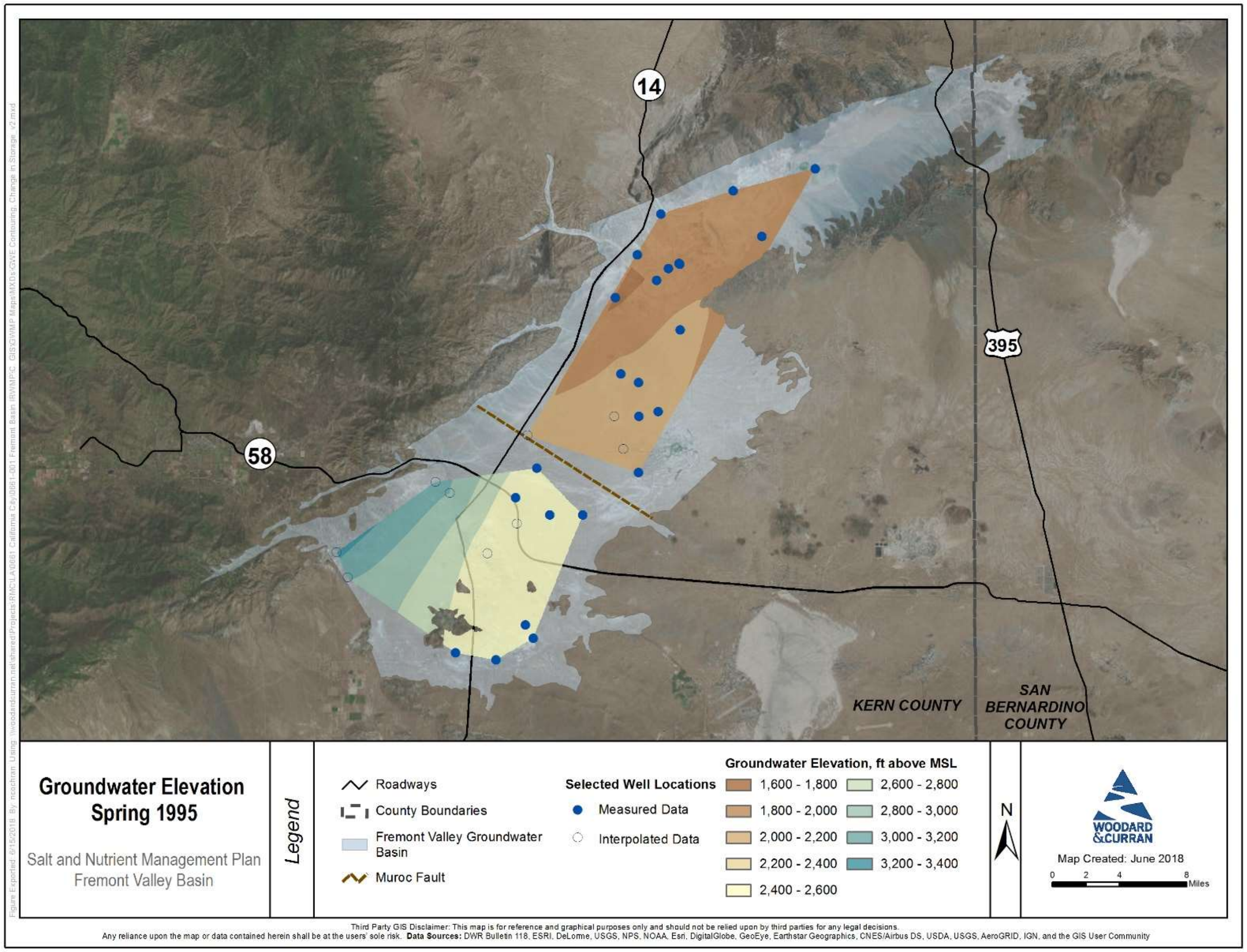


Figure A-14: Spring 1998 Groundwater Elevation Contours

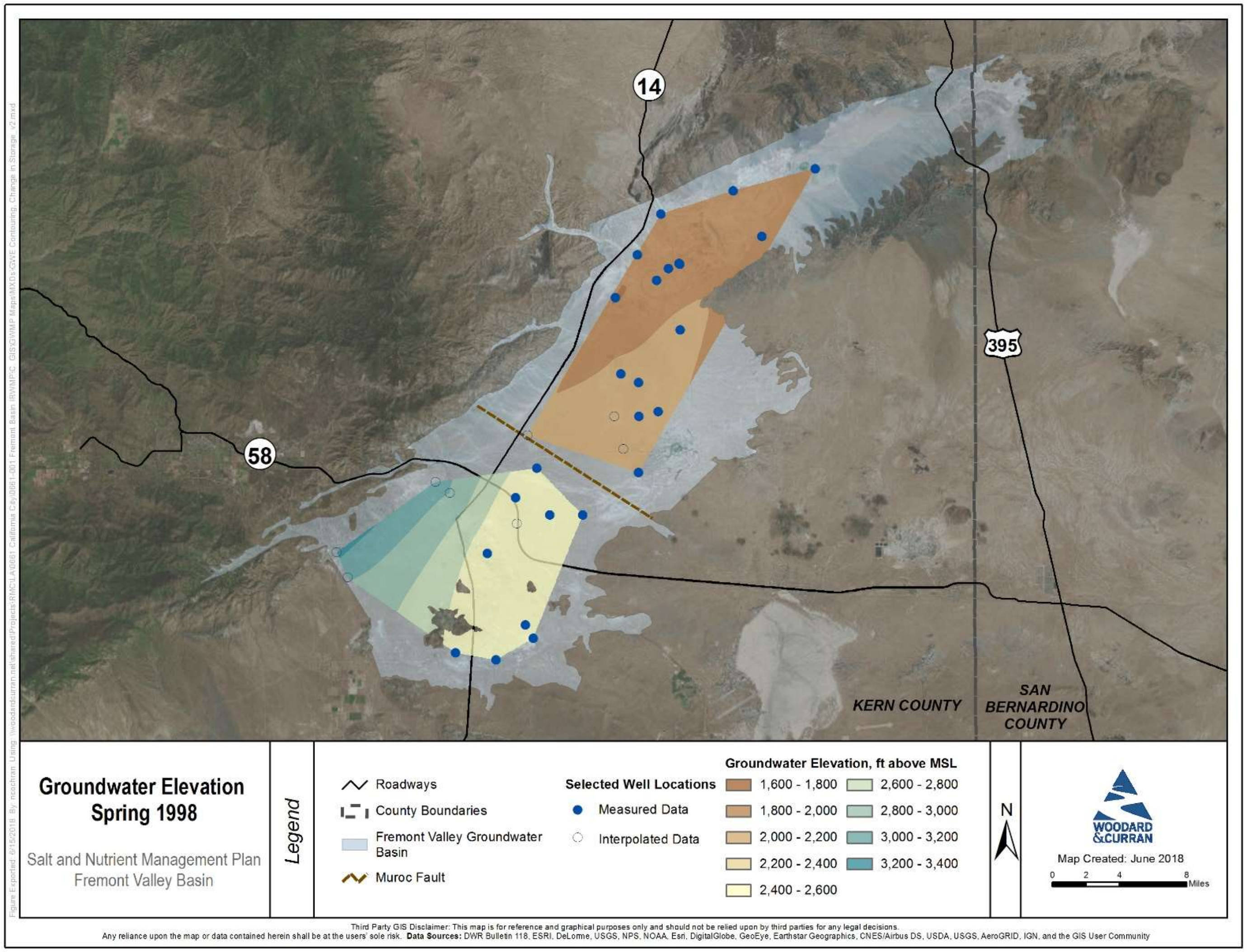


Figure A-15: Spring 2005 Groundwater Elevation Contours

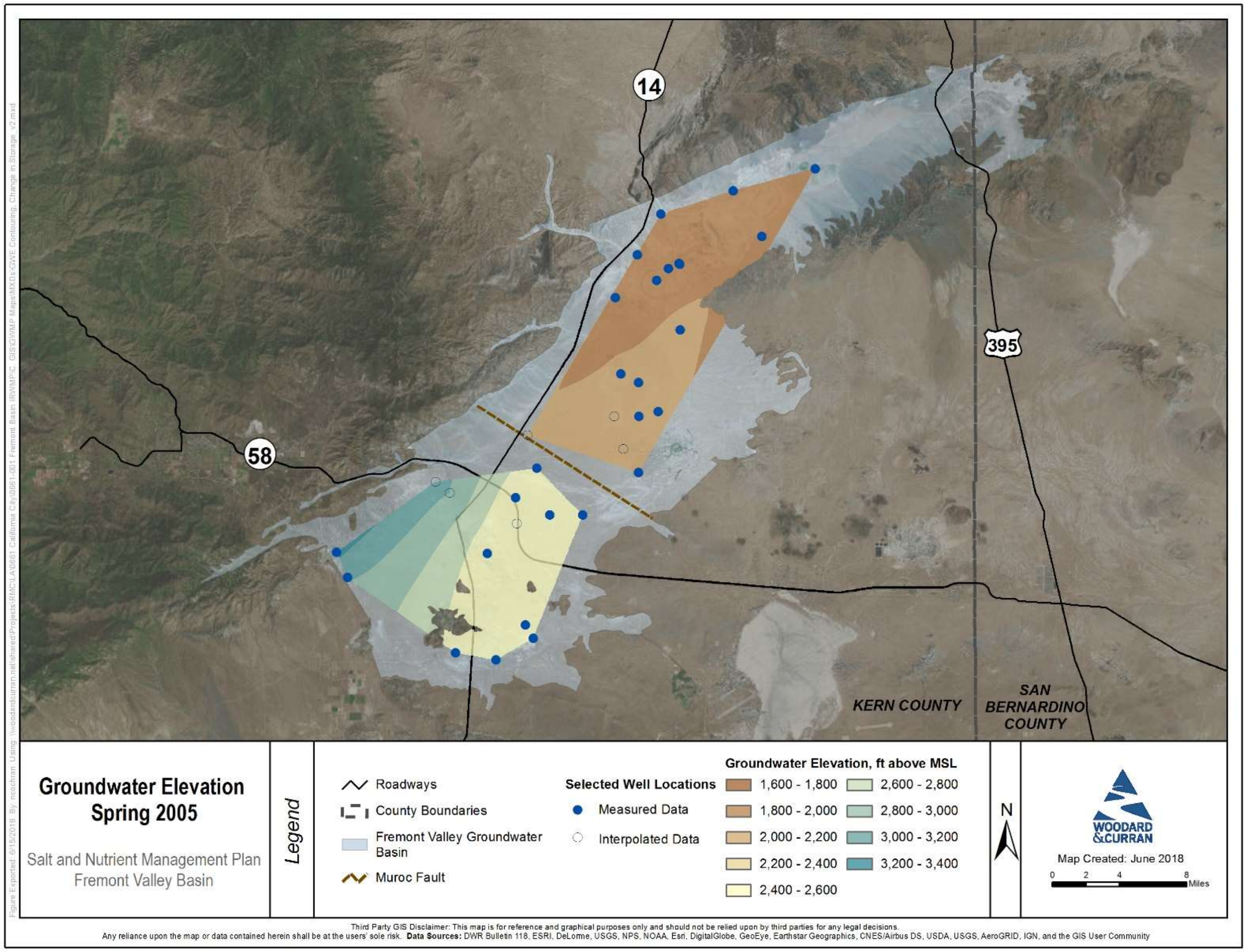


Figure A-16: Spring 2007 Groundwater Elevation Contours

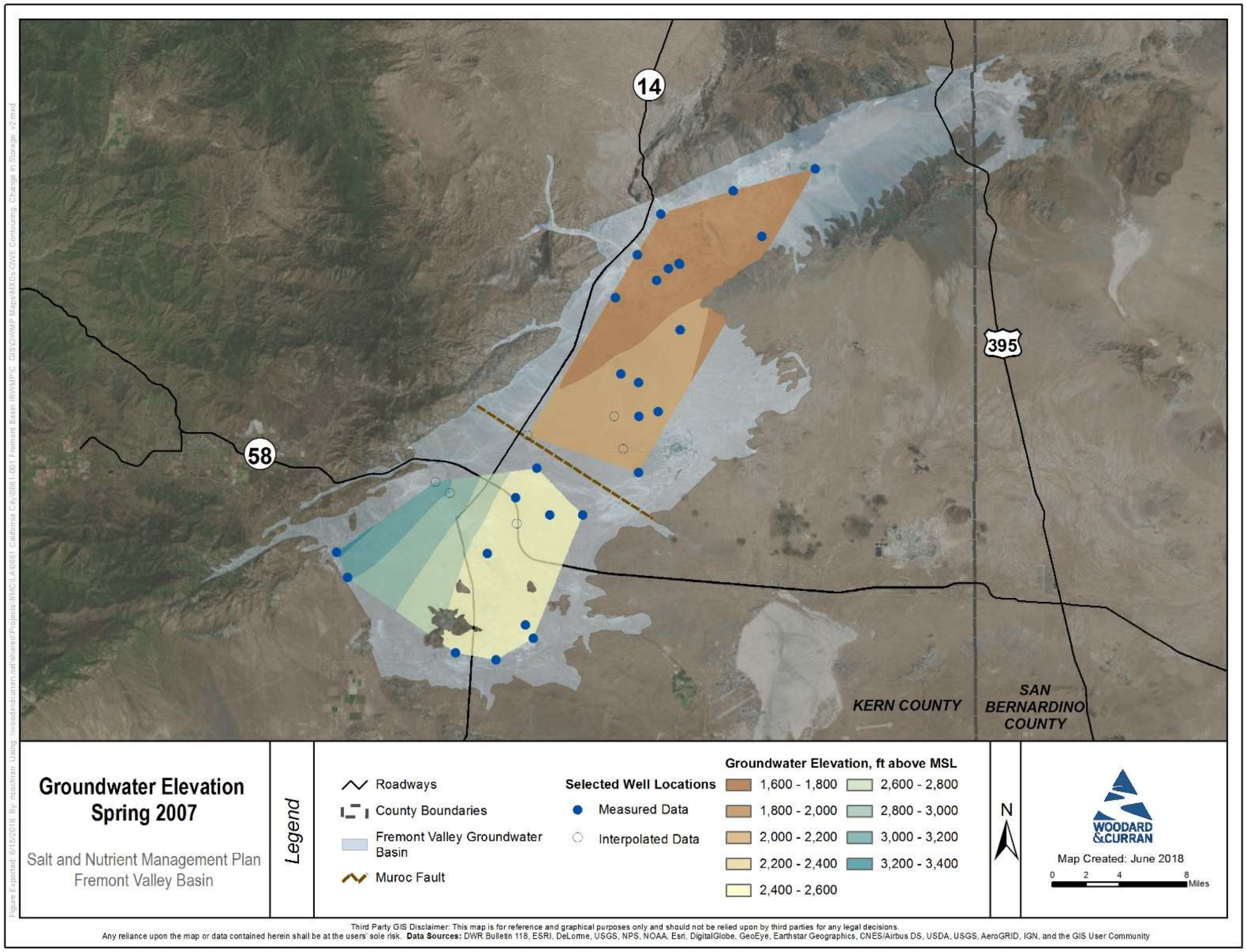


Figure A-17: Spring 2010 Groundwater Elevation Contours

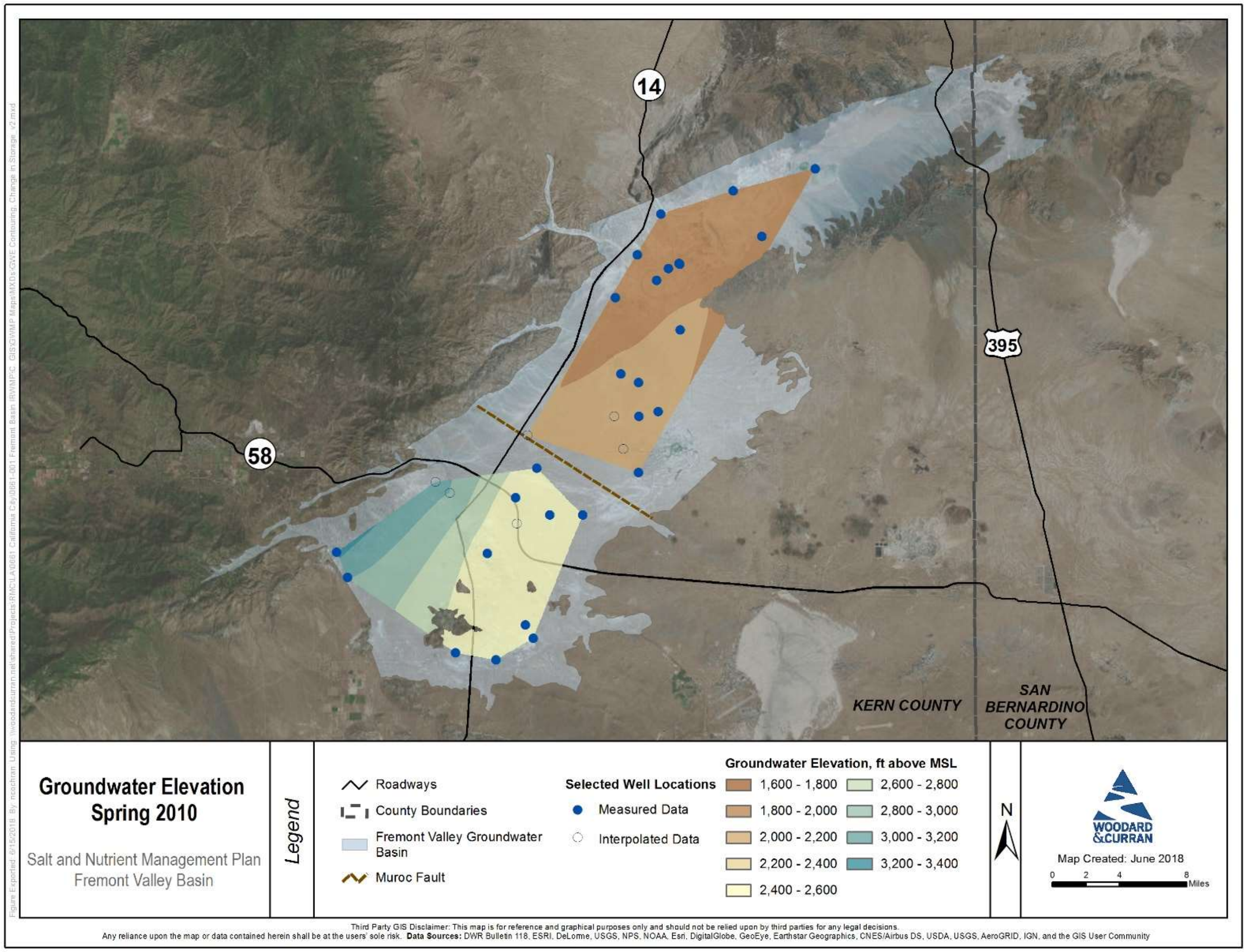


Figure A-18: Spring 2013 Groundwater Elevation Contours

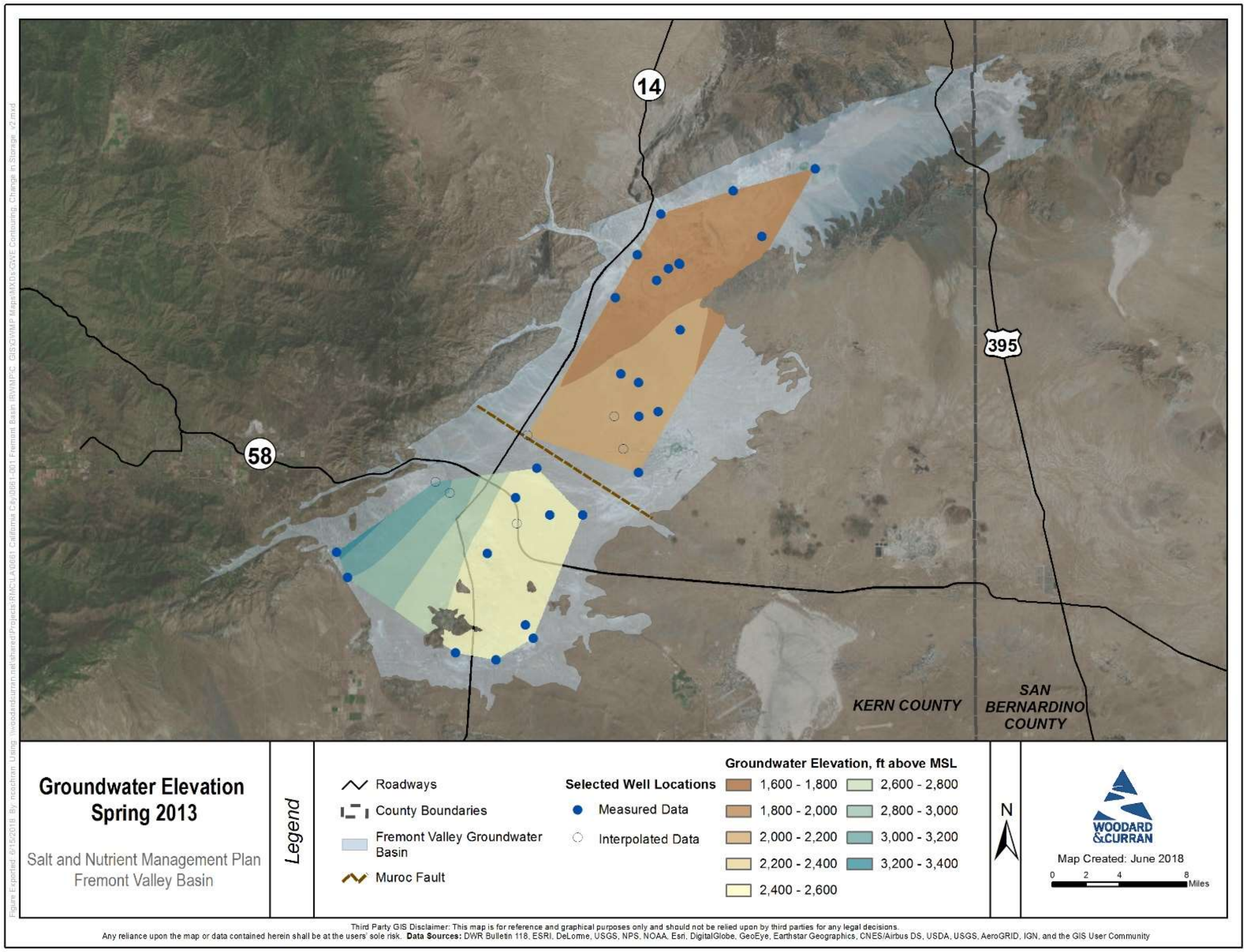


Figure A-19: Spring 2015 Groundwater Elevation Contours

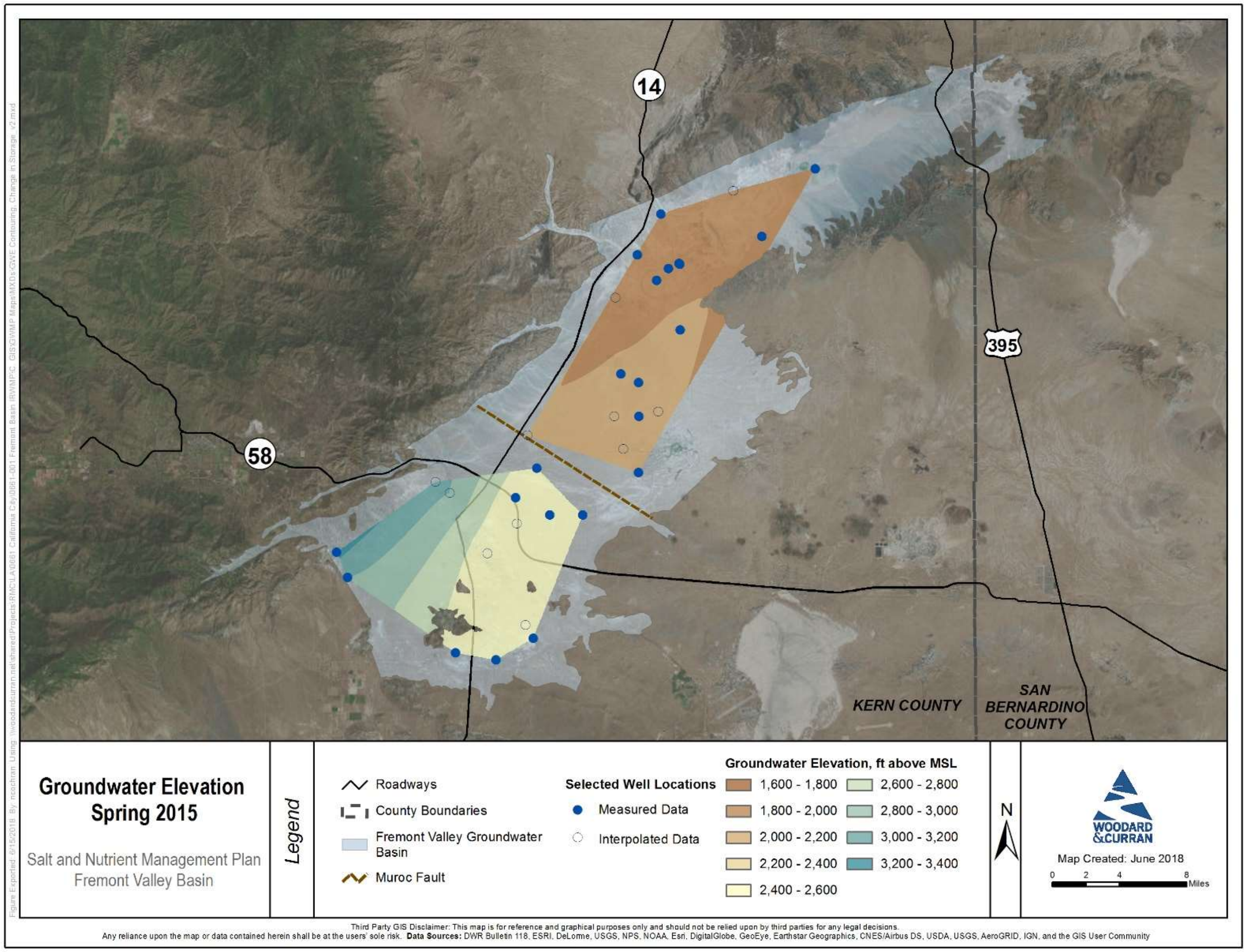
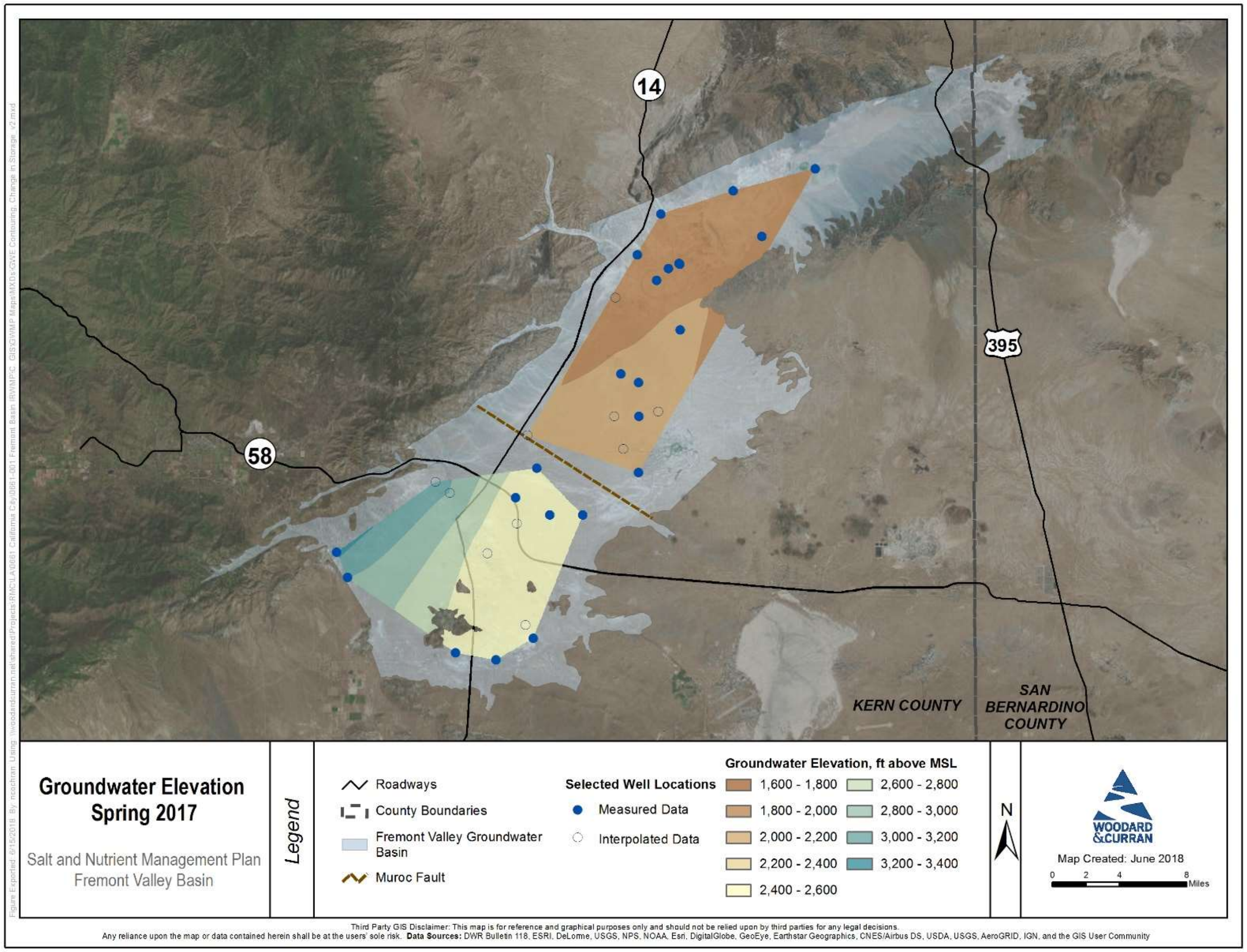


Figure A-20: Spring 2017 Groundwater Elevation Contours



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