Salt and Nutrient Management Plan for the Upper Temescal Valley

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Submitted by:

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Acronyms, Abbreviations, and Initialisms

µg/L	micrograms per liter
acre-ft	acre feet
acre-ft/yr	acre feet per year
Basin Plan	Water Quality Control Plan for the Santa Ana River Basin
bgs	below ground surface
CDFM	cumulative departure from mean
CDPH	California Department of Public Health
cfs	cubic feet per second
CRA	Colorado River Aqueduct
CSRM	constantly stirred reactor model
DIPAW	deep infiltration of precipitation and applied water
DWR	California Department of Water Resources
Eastern	Eastern Municipal Water District
EC	electrical conductivity
Elsinore Valley	Elsinore Valley Municipal Water District
ET	evapotranspiration
ft-bgs	feet below ground surface

Acronyms, Abbreviations, and Initialisms

ft-msl	feet above mean sea level
GMZ	groundwater management zone
HSA	hydrologic simulation area
MCL	maximum contaminant level
mg/L	milligrams per liter
MS4	Municipal Separate Storm Sewer System
MWDSC	Metropolitan Water District of Southern California
nitrate	nitrate as nitrogen
QA/QC	quality assurance/quality control
RCFC&WCD	Riverside County Flood Control and Water Conservation District
Regional Board	Regional Water Quality Control Board, Santa Ana Region
RWRF	regional water reclamation facilities
SGAG	Southern California Association of Governments
SNMP	salt and nutrient management plan
SWP	State Water Project
Task Force	Basin Monitoring Program Task Force
TDS	total dissolved solids
TIN	total inorganic nitrogen
TVWD	Temescal Valley Water District
USGS	United States Geological Survey
WLAM	Wasteload Allocation Model
WRF	Water Reclamation Facility

Section 1 – Introduction and Background

This Upper Temescal Valley Salt and Nutrient Management Plan (SNMP) is a joint management plan, prepared by the Elsinore Valley Municipal Water District (Elsinore Valley) and the Eastern Municipal Water District (Eastern). Elsinore Valley and Eastern are public agencies and are responsible for municipal water supply and wastewater services. Wastewater services include the treatment of wastewater generated in their respective service areas and the subsequent discharge and reuse of treated wastewater, hereafter referred to as recycled water. The ultimate goal of the SNMP is to define the management activities that Elsinore Valley and Eastern will implement to comply with the total dissolved solids (TDS) and nitrate as nitrogen (hereafter, nitrate) concentration objectives of the groundwater management zones (GMZs) and surface water bodies that are impacted by recycled water discharge and reuse in the Upper Temescal Valley Watershed.

The Upper Temescal Valley GMZ is a proposed GMZ boundary that combines the existing Warm Springs, Lee Lake, and Bedford GMZs into one management unit. Prior to defining the SNMP management activities, technical work was required to establish defensible, scientifically based numerical groundwater quality objectives for the Upper Temescal Valley GMZ, based on historical ambient TDS and nitrate concentrations. The technical work is documented herein. The work performed to develop this SNMP represents the most comprehensive modern effort to collect and summarize historical and current data and information on the water resources of the Upper Temescal Valley area.

This report describes the regulatory framework requiring the development of this SNMP; the data collected and used to characterize the Upper Temescal Valley Watershed and GMZ; the methodologies used to characterize historical, current, and future TDS and nitrate concentrations in groundwater; and the resultant management activities required for the discharge and reuse of recycled waters in the Upper Temescal Valley Watershed.

1.1 General Study Area Setting

Figure 1-1 is a location map of the Upper Temescal Valley, which is located in the western portion of Riverside County, California. The Upper Temescal Valley GMZ, delineated by the red outline on Figure 1-1, is an approximately 20-mile long, narrow alluvial groundwater basin that is drained by the Temescal Wash, which is an unlined stream channel through almost the entire GMZ. The Upper Temescal Valley Watershed, delineated by the yellow outline, is the watershed tributary to the Temescal Wash, which originates just downstream of Lake Elsinore and terminates at the All-American Aggregate Pit in the Temescal GMZ within the City of Corona. There are three water supply agencies that overly and provide water supply services to residences and businesses within the Upper Temescal Valley GMZ: The City of Corona, the Temescal Valley Water District (TVWD; formerly known as the Lee Lake Water District), and Elsinore Valley. All three agencies also own and operate water reclamation facilities to treat wastewater generated in their service areas to tertiary standards before the water is either discharged to Temescal Creek or percolation ponds or reused for irrigation. Figure 1-1 also shows the service area boundaries, treatment plant locations, and discharge points in the Upper Temescal Valley. Eastern also discharges tertiary treated wastewater generated in its service area to the Temescal Wash just downstream of the Lake Elsinore outlet channel, as shown in Figure 1-1.

1.2 Regulatory Setting

The Santa Ana Regional Water Quality Control Board (Regional Board) manages salinity in the Santa Ana River Basin, in part, by regulating the discharge and reuse of recycled water. TDS and nitrate concentration limitations for recycled water discharge and reuse are set by the Regional Board based on the Wasteload Allocation for surface waters in the Santa Ana River Watershed and the antidegradation objectives and ambient TDS and nitrate concentrations of the receiving GMZs, as defined in the Water Quality Control Plan for the Santa Ana River Basin (Basin Plan).

In the case of surface water, the combined recycled water discharge plans of all dischargers in the Santa Ana River Watershed are evaluated simultaneously to assess the discharge and associated TDS and nitrogen concentration impacts from storm, recycled water, and other discharges to the Santa Ana River and its tributaries. The Wasteload Allocation Model (WLAM) is the Regional Board's current planning tool of record for these evaluations. The WLAM, developed by Wildermuth Environmental Inc. (WEI), was used for the 2004 Basin Plan amendment and the pending Basin Plan amendment related to the current recycled water management plans in the region.[1] The WLAM is also used from time to time by various dischargers to review proposed recycled water discharge alternatives.

In the case of groundwater, the TDS and nitrate antidegradation objectives of a GMZ (set based on the historical ambient water quality for the period 1954-1973) are compared to the current ambient concentrations (recomputed every three years) to determine if recycled water limitations need to be changed to protect against groundwater quality degradation in the receiving GMZ. The standard methodology for computing ambient water quality in GMZs requires a minimum spatial coverage of wells with *sufficient data* across the GMZ, where *sufficient data* from a well is defined as a minimum of three TDS and nitrate concentration determinations in three different years over a 20-year contiguous period (WEI, 2000). For the most current ambient water quality time period (1993-2012), there is an insufficient spatial distribution of data to compute ambient water quality for the Bedford, Lee Lake, and Warm Springs Valley GMZs. Furthermore, historical data were insufficient both spatially and temporally to define the aquifer storage properties or compute an antidegradation objective for the 1954-1973 period or to compute ambient quality for the periods of 1978-1997, 1984-2003, 1987-2006, and 1990-2009 (WEI, 2014a). Thus, the technical information needed by the Regional Board to regulate waste discharges in the Upper Temescal Valley Watershed pursuant to the Basin Plan is not available.

1.2.1 Elsinore Valley Municipal Water District Problem Statement

Elsinore Valley owns and operates three wastewater treatment plants within its service area: the Railroad Canyon Water Reclamation Facility (WRF), the Regional WRF, and the Horsethief WRF. Recycled water from the Railroad Canyon WRF is discharged or reused in the watershed tributary to the Elsinore GMZ. Recycled water from the Regional WRF is discharged to Lake Elsinore (in the Elsinore GMZ) or to the Temescal Wash in the Upper Temescal Valley. And,

[1] See the *2008 Santa Ana River Wasteload Allocation Model Report*, prepared for the Basin Monitoring Program Task Force by WEI (May 2009), for a model description and how the model is used in the wasteload allocation process.

recycled water from the Horsethief WRF is reused for irrigation or discharged to percolation ponds in the Upper Temescal Valley.

In 2011, the Regional Board assessed mandatory minimum penalties on Elsinore Valley for discharging recycled water from the Regional WRF with TDS concentrations in excess of the discharge limitation of 700 milligrams per liter (mg/L), as measured by the 12-month running average concentration, to the Temescal Wash. The discharge limitations for the Regional WRF are specified in Order No. R8-2013-0017 (NPDES Permit No. CA8000027). As part of the process to renew its prior Order (R8-2005-0003), the Regional Board required Elsinore Valley to prepare a salt offset plan to: (1) quantify the impact of its recycled water discharges in excess of 700 mg/L on the water quality of Reach 2 of the Santa Ana River (at Below Prado Dam) and the GMZs underlying the natural-bottom reach of the Temescal Wash, which include the Warm Springs, Lee Lake, and Bedford GMZs (e.g. the Upper Temescal Valley GMZ), and (2) propose a salt offset program to mitigate the mass of TDS discharged to the Temescal Wash that was in excess of the discharge limitations.

Elsinore Valley submitted a draft offset plan to the Regional Board on October 30, 2012 (MWH, 2012). The following are some of the conclusions of the draft report:

- The total offset required for recycled water discharges to the Temescal Wash with TDS concentrations in excess of 700 mg/L between 2005 and 2011 is 446.5 tons of TDS.
- Recycled water discharges in excess of 700 mg/L resulted in no impact to the TDS concentration of the Santa Ana River at Below Prado Dam, as modeled by the WLAM.
- The impact of recycled water discharges in excess of 700 mg/L on the water quality of the Warm Springs, Lee Lake, and Bedford GMZs could not be determined due to insufficient data: there are no historical or current ambient water quality concentrations for these GMZs to compare to the recycled water discharge concentrations.
- There are no cost-effective, beneficial mitigation facilities to remove 446.5 tons of TDS from the Warm Springs, Lee Lake, and Bedford GMZs.

The Regional Board proposed using "best professional judgment" as the means for setting a new TDS concentration discharge limitation for the Regional WRF in the absence of historical and current ambient water quality determinations for the impacted GMZs. Generally, in the absence of antidegradation objectives, the Regional Board will either set discharge limitations that are protective of municipal drinking water quality standards or use recent water quality sample results to set antidegradation thresholds. The Basin Plan states that a TDS concentration of 1,000 mg/L is the beneficial use threshold and that 500 mg/L is preferable for drinking water supply.[2] Either approach could result in arbitrarily low TDS compliance

[2] The 500 mg/L desired threshold is really a goal based on consumer preference. In certain areas of the Santa Ana River Watershed the TDS concentration in municipal supplies exceeds 500 mg/L, including the Elsinore Valley and Eastern services areas. In areas that use extensive amounts of Colorado River water or a blend of Colorado River and State Water Project water, the TDS concentration can exceed 500 mg/L. For example, the TDS concentration of water provided to Elsinore Valley and Eastern from the Metropolitan Water District of Southern California's Skinner treatment plant exceeds 500 mg/L about 60 percent of the time and has historically exceeded 700 mg/L when the supply to the plant is dominated by Colorado River water.

metrics and subsequently high compliance costs with no substantive benefit to the water quality of the Upper Temescal GMZ or the Elsinore Valley's rate payers.

1.2.2 Eastern Municipal Water District Problem Statement

Eastern owns and operates four active regional water reclamation facilities (RWRF) for the treatment of wastewater generated in its service area: the San Jacinto Valley RWRF, the Moreno Valley RWRF, the Perris Valley RWRF, and the Temecula Valley RWRF. Recycled water from the RWRFs is reused in Eastern's service area for a variety of non-potable uses, including agriculture, landscape irrigation, and industrial use. During peak outdoor water demand months (the warmer summer months), when recycled water demand exceeds recycled water production, recycled water production is supplemented from storage facilities. During the cooler, wetter times of year when recycled water demands decrease, surplus recycled water is stored in recycled water storage ponds, either on-site at the RWRFs or off-site throughout Eastern's service area. When the volume of recycled water generated is in excess of Eastern's recycled water demand and storage capacity, recycled water is conveyed via pipeline to the Upper Temescal Valley and discharged to the Temescal Wash. The discharge to the Temescal Wash is typically a blend of recycled water from multiple RWRFs.

Eastern also faces TDS compliance issues for its recycled water discharges to the Temescal Wash, which are regulated under Regional Board Order No. R8-2009-0014. The TDS concentration limitation specified in R8-2009-0014 is 650 mg/L, as measured by the 12-month running average concentration. Eastern's discharges to the Temescal Wash are out of compliance with this limitation due to the high TDS concentrations of the source water supplies available in Eastern's service area (WEI, 2013a). Between 2008 and 2013, the annual volume-weighted TDS concentration of discharges to Temescal Wash ranged between 670 mg/L and 770 mg/L. In 2014 through 2016 (to date), Eastern reused 100 percent of its recycled water and has not discharged to Temescal Wash. However, if discharges are required, the TDS concentrations will exceed the discharge limitation due to high-TDS source water supplies.

Eastern had requested that the Regional Board raise the TDS limitation for its discharge to the Temescal Wash for R8-2009-0014. To support this action, Eastern hired WEI to run the WLAM to evaluate the impact of its recycled water discharges on Reach 2 of the Santa Ana River (at Below Prado Dam) for: (1) historical discharges in excess of 650 mg/L and (2) future discharges at limitations of 700 mg/L and 750 mg/L. The results of the WLAM runs showed that historical recycled water discharges in excess of 650 mg/L resulted in no impact to the TDS concentration of Reach 2 of Santa Ana River. The results also showed that future discharges at 700 mg/L or 750 mg/L would result in no measurable impact to the TDS concentration of Reach 2 (WEI, 2013b).

As was the case for Elsinore Valley's WLAM study, the impact of recycled water discharges on the water quality of the Warm Springs, Lee Lake, and Bedford GMZs could not be determined. Accordingly, the use of "best professional judgment" by the Regional Board to set objectives for these management zones could be problematic for Eastern if the objectives are proposed to be less than the existing discharge limitation of 650 mg/L or any future proposed discharge limitation that is greater than 650 mg/L.

1.3 Alternative Compliance Proposal for Recycled Water Discharge and Reuse in the Upper Temescal Valley

As previously noted, the Regional Board's proposed approach to setting discharge limitations in the Upper Temescal Valley could result in arbitrarily low TDS compliance metrics and subsequently high compliance costs for Elsinore Valley and Eastern with no benefit to the water quality of the Upper Temescal Valley GMZ. Based on knowledge of the hydrology, geology, and historical land and water use in the Temescal Valley region, and extensive experience computing ambient water quality, WEI hypothesized that the historical ambient (1954-1973) TDS and nitrate concentrations of the Warm Springs, Lee Lake, and Bedford GMZs would likely be greater than 700 mg/L. Elsinore Valley and Eastern hired WEI to develop an alternative regulatory compliance strategy that would resolve historical TDS violations and ensure the long-term protection of the beneficial uses of surface and groundwater in the Upper Temescal Valley.

In October 2012, WEI met with Regional Board staff to review a draft outline of an alternative compliance strategy that included the following proposed actions:

- Develop an alternative, scientifically based methodology to calculate the historical ambient water quality for a newly delineated Upper Temescal Valley GMZ, combining the Warm Springs, Lee Lake, and Bedford GMZs into one single GMZ.[3]
- Prepare an SNMP report that will document the technical work performed, include recommendations for setting antidegradation objectives for TDS and nitrate, define a monitoring program to collect the data needed to compute ambient water quality on an ongoing basis in the future, and include management actions to address any regulatory issues that arise as a result of the current and future recycled water plans of the agencies discharging and reusing recycled water in the Upper Temescal Valley.
- Elsinore Valley and Eastern will present the work to local and regional stakeholders throughout the process of developing the SNMP.
- The Regional Board will allow the Elsinore Valley and Eastern efforts to develop the SNMP to offset the historical TDS-related violations of permit conditions and any TDS-related violations of permit conditions that occur during the period in which the SNMP is being developed.

Regional Board staff was supportive of WEI's proposal and asked that a write-up of the plan be developed for approval. A formal scope of work was submitted to the Regional Board on May 13, 2013 (WEI, 2013c) and approved in July 2013. The scope of work was expanded in December 2014 based on additional work required by the Regional Board. The final scope of work to develop the Upper Temescal Valley SNMP includes the following tasks:

1. develop, apply, and document an alternative methodology to compute historical ambient TDS and nitrate concentrations for the Upper Temescal Valley GMZ;

[3] A written rationale for combining the three GMZs into one single GMZ was formally requested by the Regional Board in July 2014. This rationale was submitted to the Regional Board on September 8, 2014. The letter report documenting the *Rationale for Creating the Upper Temescal Valley Groundwater Management Zone* (WEI, 2014b) is included with this report as Appendix A. The Regional Board verbally approved the creation of the Upper Temescal Valley GMZ as the unit of study at a progress meeting held on September 30, 2014.

2. modify as appropriate, apply, and document the alternative methodology to estimate current ambient TDS and nitrate concentrations for the Upper Temescal Valley GMZ;
3. apply and document the alternative methodology to project future ambient TDS and nitrate in the Upper Temescal Valley GMZ, based on the range of possible recycled water discharge and reuse plans in the watershed; and
4. identify the regulatory challenges that arise from the implementation of recycled water discharge and reuse plans, and define an SNMP (including a monitoring plan) that addresses current and future TDS and nitrogen challenges, including recommendations for setting the Basin Plan antidegradation objectives for TDS and nitrate in the Upper Temescal Valley GMZ.

1.4 Process to Develop and Refine the Upper Temescal Valley SNMP

1.4.1 Regulator and Stakeholder Collaboration

To ensure that the technical work and final recommendations of the Upper Temescal Valley SNMP would meet the requirements of the Regional Board, Elsinore Valley and Eastern implemented a process to meet with the Regional Board to present interim results, discuss comments and concerns, and subsequently refine the scope of work, methods and/or proposed management actions, as appropriate. Since the approval of the scope of work in July 2013, eight project progress meetings were held at the Regional Board on the following dates:

- November 18, 2013
- January 16, 2014
- March 12, 2014
- June 11, 2014
- September 30, 2014
- July 28, 2015
- May 22, 2017
- August 28, 2017

Additionally, Elsinore Valley and Eastern conducted stakeholder outreach to present the goals, results, and recommendations of the SNMP as they were being developed. One meeting was held with other POTW dischargers in the Upper Temescal Valley Watershed on March 30, 2015. The invitees included the City of Corona and the Temescal Valley Water District. These agencies were not required by the Regional Board to participate in the development of the SNMP, but provided data for inclusion in the analyses and were invited to learn about the project and how the outcomes could impact the agencies. Two presentations were made to the Santa Ana Region Basin Monitoring Program Task Force on November 17, 2014 and October 27, 2015. These presentations focused on the results of the technical work and the draft recommended SNMP action items. A final regional stakeholder outreach meeting will be held upon Regional Board approval of the SNMP as part of a CEQA scoping meeting to support the incorporation of the SNMP into the Basin Plan.

1.4.2 Refinement of the Technical Methodology to Estimate Ambient Water Quality

The approved scope-of-work for the *Development of an Upper Temescal Valley Salt and Nutrient Management Plan* (WEI, 2013c) included a "flux"-based method as a surrogate for the

traditional methodology for computing historical ambient water quality. The proposal was based on the observation that the groundwater system underlying Temescal Wash is shallow, narrow, and primarily confined to the sediments underlying the Wash. The proposed flux method assumes that the ambient TDS and nitrate concentrations in the Upper Temescal Valley GMZ for a specific year (e.g. 1973) are equal to the volume-weighted average recharge TDS and nitrate concentrations for a representative preceding period (e.g. 1954-1973). This is a valid assumption if it can be demonstrated that the total recharge volume over that period is significantly greater than the storage volume of the management zone, where "significantly" means that the basin turn-over time (e.g. the number of years it takes for recharge to completely replace the volume of water in storage) is less than or equal to half the number of years in the representative period. For example, for this study, the representative period of interest is 20 years and so the turn-over time must be 10 years or less. Section 2.4.3 of this report demonstrates that the turn-over time is estimated to be less than 7 years.

The flux-based method should produce a reasonably accurate estimate of the ambient TDS and nitrate concentrations if sufficient information is available to compute the recharge volumes and their associated TDS and nitrate concentrations. As discussed in Section 2 of this report, numerous source water supplies, with varied levels of salinity, were available in the Upper Temescal Valley during the historical period of interest. However, there was insufficient information available to develop reliable estimates of TDS and nitrate concentrations for the deep infiltration of applied water. Specifically, it was not possible to determine for any given year where and how much of each supply source was used in the watershed in order to calculate the volume-weighted average recharge quality. Fortunately, other comprehensive datasets collected in support of this study allowed for the extension of the flux method to a constantly stirred reactor model (CSRM) methodology. A CSRM can be used to evaluate the range of reasonable TDS and nitrate concentration estimates for the deep infiltration of applied water recharge in a calibration process and subsequently to estimate historical ambient water quality. The revised CSRM methodology was presented to the Regional Board as part of the project technical review process (presented on June 11, 2014). The Regional Board approved the CSRM methodology in July 2014. As part of the approval, the Regional Board also requested that Elsinore Valley and Eastern expand the scope of work to include an estimation of current ambient water quality and projections of future ambient water quality, as noted previously in Section 1.3 of this Report.

1.5 Report Organization

The remainder of this report is organized into the following sections:

Section 2 – Study Area Setting: Section 2 describes the general study area setting, the datasets collected and complied to support the work, and how the data were used to characterize the hydrology and hydrogeology of the Upper Temescal Valley.

Section 3 – Computation of Historical Ambient Water Quality: Section 3 describes the methodology and results of the approach used to estimate historical ambient water quality in the Upper Temescal Valley GMZ.

Section 4 – Computation of Current Ambient Water Quality: Section 4 describes the methodology and results of the approach used to estimate current ambient water quality in the Upper Temescal Valley GMZ.

Section 5 – Projection of Future Ambient Water Quality: Section 5 describes the methodology and results of the approach used to estimate future ambient water quality in the Upper Temescal Valley GMZ.

Section 6 – Salt and Nutrient Management Plan: Section 6 defines the anticipated regulatory challenges associated with recycled water discharge and reuse and describes the schedule of actions that will be implemented by Elsinore Valley and Eastern to manage salinity in the Upper Temescal Valley GMZ.

Section 7 – References: Section 7 provides the references consulted in developing the Upper Temescal Valley SNMP.

117°20'0"W

All American Aggregate Pit

Temescal GMZ

Lake Mathews

Corona No. 3 WRF

Bedford Wash

Temescal Valley Water District WRF

Upper Temescal Valley Watershed

Riverside County

Orange County

Bedford GMZ

El Sobrante de San Jacinto

Coldwater GMZ

15

Lee Lake

Temescal Wash

Lee Lake GMZ

Horsethief WRF

Santa Ana Mountains

Warm Springs GMZ

Elsinore Valley Regional WRF

Railroad Canyon Reservoir

Elsinore GMZ

Eastern Combined RWRF Discharge

Lake Elsinore

33°40'0"N

117°20'0"W

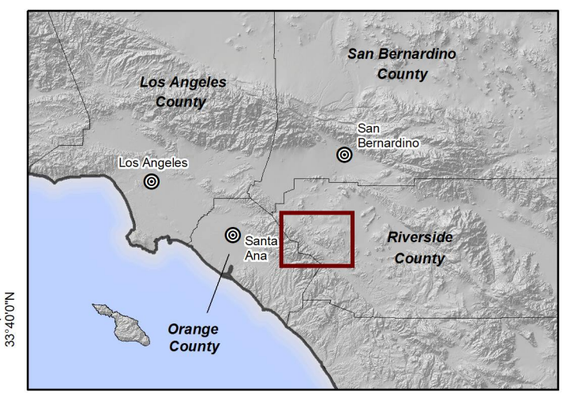
33°40'0"N

Main Features

- Upper Temescal Valley Groundwater Management Zone (GMZ)
- Other GMZs
- Water Reclamation Facilities (WRF)
- Active WRF Discharge Points to Temescal Wash
- Inactive WRF Discharge Points to Temescal Wash
- Streams and Flood Control Channels
- Lakes and Flood Control Basins

Agency Service Areas in the UTV

- City of Corona
- Temescal Valley Water Disctrict
- Elsinore Valley Municipal Water District



Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: GAR
Date: 9/15/2017
Document Name: Fig_1-1_Watershed_2017

0 2 4 Miles

0 2 4 KM

EVMWD

emwd Eastern Municipal Water District

Upper Temescal Valley
Salt and Nutrient Management Plan

Upper Temescal Valley SNMP Study Area

Figure 1-1

Section 2 – Data Collection and Study Area Characterization

In order to develop a scientifically based, defensible alternative methodology to estimate historical and current ambient TDS and nitrate concentrations, it was first necessary to determine that sufficient historical information was available to characterize the hydrogeologic system. The data and information needed to make these estimations includes: land use; water supply sources and associated TDS and nitrate concentrations; precipitation; surface water discharge and TDS and nitrate concentrations; groundwater well construction; groundwater production, levels, and TDS and nitrate concentrations; and wastewater discharge and associated TDS and nitrate concentrations.

The objectives of this section are to describe the datasets collected and compiled for the development of the SNMP, to characterize the development of land use and water supplies in the Upper Temescal Valley from 1930s to present, and to characterize the general hydrology and hydrogeology of the Upper Temescal Valley based on the data collected.

2.1 Data Collection and Management

A significant source of data and information used in the study was collected from the archives of the Temescal Water Company, which is maintained and provided by Elsinore Valley. A comprehensive summary of the published reports and datasets utilized follows.

The published reports and documents that were collected and reviewed include:

- United States Geological Survey. (1919). *Groundwater in the San Jacinto and Temecula Basins, California*. Water-Supply Paper 429. By Gerald A. Waring.
- California Department of Public Works, Division of Water Resources (1933), *Bulletin No. 40-A – South Coastal Basin Investigation – Detailed Analyses Showing Quality of Irrigation Waters*. (Supplemental to Bulletin No. 40).
- California Department of Public Works, Division of Water Resources (1947), *Bulletin No. 53 – South Coastal Basin Investigation – Overdraft on Ground Water Basins*.
- California Department of Water Resources (1959), *Bulletin No. 15 – Santa Ana River Investigation*.
- California Division of Mines (1959). *Geology and Mineral Deposits of the Lake Elsinore Quadrangle*. Bulletin 146.
- California Division of Mines and Geology. (1961). *Geology and Mineral Resources of the Corona South Quadrangle*. Bulletin 178.
- Water Resources Engineers, Inc. (1970). *Watershed Climate, Geohydrology, and Water Quality*. Prepared for the Santa Ana Watershed Planning Agency.
- Water Resources Engineers, Inc. (1970). *Unit Water Requirements and Waste Increments, a Final Report on Task VI-6, August 1970*. Prepared for the Santa Ana Watershed Project Authority.
- Iris Hayward and Bud Wood. (1973; updated 1989). *A History of the Temescal Water Company*.

- California Department of Water Resources. (1975). *Bulletin No. 113-3 - Vegetative Water Use in California, 1974*.
- United States Geological Survey. (1977). *Development of Water Facilities in the Santa Ana River Basin California, 1810-1968*. Open-File Report 77-398.

The data sets collected, compiled, and analyzed include:

- Land use maps from the DWR and Southern California Association of Governments (SGAG)
- Land use and irrigation maps of California from the archives of the Temescal Water Company
- Water Well Driller's Reports obtained from the California Department of Water Resources (DWR), Elsinore Valley, and City of Corona, and the archives of the Temescal Water Company
- Groundwater level data for the period of 1930 to 1980 from the archives of the Temescal Water Company
- Groundwater quality data for the period of 1954 to 1980, provided by the DWR.
- Groundwater level and water quality data for the period of 1954 to 2012 from the Basin Monitoring Program Task Force's Ambient Water Quality Database, maintained by WEI
- Groundwater quality data for the period of 2013 to 2014, provided by Elsinore Valley and the City of Corona
- Groundwater production records for the period of 1947 through 2013 from State Recordation filings, provided by Steve Mains of Watermaster Support Services, Inc.
- Precipitation station data, provided by the RCFC&WCD
- Precipitation for 800-meter square grid cells distributed over the watershed published by the PRISM[4] Climate Group at Oregon State University, provided by WEI
- Stream discharge data for Temescal Wash, provided by the United States Geological Survey (USGS)
- Surface water quality monitoring data for the Elsinore, Upper Temescal Valley, and Temescal GMZs, provided by the Riverside County Flood Control and Water Conservation District (RCFC&WCD)
- Wastewater discharge and water-quality data, provided by Elsinore Valley, Eastern, and the City of Corona, and available through the State of California's CIWIQS database

The groundwater wells, elevation, water quality, and production data, and the surface and recycled water discharge and water quality data were processed into electronic formats, checked for QA/QC, and loaded in to HydroDaVE℠.[5] These datasets are included with this report, on compact disc, as Appendix B.

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[4] http://www.prism.oregonstate.edu/

[5] HydroDaVE℠ is a software system with a centralized database and graphical user interface that allows the visualization of data through a variety of sophisticated data-analysis tools.

2.2 Land Use and Water Supply Development in the Upper Temescal Valley

Understanding the history of land and water supply development in the Upper Temescal Valley provides critical insight into the analysis and characterization of water quality and how it has changed over time.

Groundwater recharge is directly related to land use in the Upper Temescal Valley in two ways. First, when combined with knowledge of local soil types, land use can be used to characterize the fate of precipitation that falls on the land surface. With few exceptions, as land is converted from natural undeveloped conditions to human uses, it becomes more impervious and produces more storm-water runoff and less deep infiltration of precipitation. Historically, when land use has been converted from natural and agricultural uses to urban land uses, the imperviousness can increase from near zero to as high as 60 to 70 percent, depending on the specific land use (WEI, 2014c). Numerical surface-water models rely on land use characterizations to route precipitation to its various potential end-points within a watershed.

Second, land use can be used to estimate irrigation water use requirements and the resulting deep infiltration of the irrigation water. Each irrigated land use type can be assigned a water duty (or demand) based on crop-specific water evapotranspiration requirements and irrigation practices. The resultant calculation of irrigation demand is used to estimate how much of the applied water returns to the groundwater basin by deep infiltration past the root zone. With respect to irrigated land use types, as irrigation efficiency improves (e.g. increases) over time with modern irrigation techniques, the amount of water that returns to the groundwater basin through deep infiltration decreases. For example, the typical efficiency of flood irrigation is 60 percent or less; whereas modern irrigation methods, such as drip irrigation, can achieve 90 percent efficiency (PIER, 2006).

Knowledge of the water supply sources available to the irrigated land use types is important for characterizing the constituent mass and concentration of the deep infiltration of applied water.

2.2.1 Land Use and Development

Figures 2-1a and 2-1b summarize the land use of the Upper Temescal Valley for the years 1933 1957, 1963, 1975, 1990, 2005, 2014, and at build-out in the future (estimated to occur in 2100). Table 2-1 summarizes the total acres of each land use type in the Upper Temescal Valley for each of the time periods shown in Figures 2-1a and 2-1b. Table 2-1 also shows the percent imperviousness of each land use type, which ranges from two percent to 95 percent. Figure 2-2 summarizes the land uses into three main categories—native and undeveloped, agricultural, and urban—and shows how the imperviousness of the Upper Temescal Valley has increased over time as a result of land use changes.

The land use characterizations prior to and including 1975 are based on land use maps prepared by the DWR and its predecessors. The land use characterizations from 1990 to 2014 are based on land use maps prepared by SCAG. The land use characterization for 2014 is based on the 2005 SGAG land use and updated using Google Earth Imagery from 2014. The land use characterization for future build-out conditions was developed from the general plan maps provided by the various City and County development agencies in the region. These land use

characterizations are representative of the historical, current, and future time periods of interest that will be evaluated throughout the report.

The land was developed slowly through the 1930s, primarily for non-irrigated field crops. By the 1960s, agricultural was shifted primarily to irrigated citrus and some truck crops, and the acreage of irrigated citrus continued to grow through 1990. Urban development accelerated after 1975. Although a significant portion of the Watershed remained undeveloped in 2014, urban land uses dominated the developed parts of the watershed, and the remaining irrigated land uses were urban in character: homes, golf course, and parks. While the primary changes in the development of the watershed over time have been concentrated on the valley floor (the land overlying the GMZ), future build-out plans show that much of the previously undeveloped lands comprised of native vegetation will be developed for urban uses. Figure 2-2 shows that the total imperviousness of the Watershed increased from about two percent in 1933 to nine percent by 2014 and is projected to reach 24 percent at buildout. However, recall that currently the valley floor overlying the alluvial basin is covered predominantly by urban land uses and is about 60 percent impervious compared to about one to three percent impervious when the valley floor was dominated by agricultural and native land use types from 1933 through 1975.

2.2.2 Development of Water Supply Sources: 1886 to 1973

In 1886, the South Riverside Land and Water Company was formed to develop a water supply for the land owned by the company; much of the original land holdings of the Company are now within the modern City of Corona, which overlies the Temescal GMZ and the northwest portion of the Upper Temescal Valley GMZ. The South Riverside Land and Water Company began developing water supplies from the Upper Temescal Valley and Coldwater Canyon by drilling wells to pump the then-artesian groundwater supply and transporting it through a newly constructed pipeline that extended from the location of the modern Lee Lake Dam to the City of Corona, where about 6,000 acres of land was being irrigated. An additional 5,000 acres of land upstream of the pipeline had the potential for agricultural development, but the Company lacked additional water supplies and facilities to develop it.

As the South Riverside Land and Water Company was expanding its land holdings and irrigated area into the Upper Temescal Valley, it formed the Temescal Water Company in 1887 to further develop water supplies and facilities. In 1892, the first Lee Lake Dam was constructed to store water developed and deliver it through the pipeline to the Corona area. That same year, property rights to Lake Elsinore and surrounding lands were acquired by the South Riverside Land and Water Company so that water from Lake Elsinore could be pumped to the Lee Lake Dam and then delivered to the Corona area. These lands were eventually transferred to the Temescal Water Company. However, Lake Elsinore's water quality was poor, and the citrus trees irrigated with Lake Elsinore water were seriously affected by the high saline water. As the citrus trees began to die off, the use of Lake Elsinore for irrigation was abandoned in 1898. To replace this water source, the Temescal Water Company began looking for water supplies outside of the Temescal Valley.

In 1902, the Temescal Water Company developed a groundwater supply from the San Jacinto River Basin, which was transported through 40 miles of ditch and pipeline to the Upper Temescal Valley. The wells were located in the modern day Perris South GMZ. By 1920, the use of these wells was discontinued due to high salinity.

During the 1920s and 30s, the Temescal Water Company purchased shares from numerous water companies in the Upper Santa Ana River Basin, including the Meeks and Daley Water Company, the Agua Mansa Water Company, and the Riverside Water Company. The Gage Canal was constructed to transport groundwater pumped from Riverside and Bunker Hill Groundwater Basins southwest to the Temescal Valley. And, the Riverside Canal transported water from the Colton Basin to the Corona area. The Temescal Water Company also focused on developing its local water supplies during this time period, building wells in the Bedford Basin (the Flagler Wells), upstream of Lee Lake Dam (the Barney Lee Wells), and developing groundwater and surface water supplies from Coldwater Canyon. And, in 1929, the Company completed the construction of the Railroad Canyon Dam to create a 12,000 acre-ft reservoir to capture the flood waters of the San Jacinto River. The water was delivered through a combination of pipelines and open canals. Historical documents note that, for periods of time, landowners in the Temescal Valley only had access to local water supplies. The Coldwater Canyon supply was primarily used for domestic purposes due to its "near-perfect" quality, but in the dry summer months, the "higher salinity water" pumped from the low-lying valley floor had to be used as a supplement, reducing the amount of water available for irrigators, who would truck in water from where ever they could find it.

By the 1950s, much of the land in the City of Corona was being urbanized, but the irrigated areas in the Upper Temescal Valley were growing faster than the development of water supply, so in 1955, the Temescal Water Company teamed with the Elsinore Valley Municipal Water District to bring Colorado River water to the Upper Temescal and Elsinore Valleys. Colorado River water was initially released to the San Jacinto River and stored in Railroad Canyon for delivery throughout the Valleys as needed.

In 1973, the Temescal Water Company was serving 4,000 acres of land, 1,500 of which were in the Upper Temescal Valley. Total annual water use was about 14,000 af and was delivered through 100 miles of pipeline and four miles of open canal which were fed by 16 groundwater wells and surface water from the Upper Temescal Valley, San Jacinto River, and Colorado River.

Table 2-2 summarizes the estimated TDS and nitrate concentrations of the source waters used in the Upper Temescal Valley from 1900 to 1975, based on available historical documents. The TDS concentration of these sources ranged from as low as 100 mg/L for local surface-water runoff to greater than 1,000 mg/L for Lake Elsinore and San Jacinto River Basin groundwater. The nitrate concentration ranged from zero to ten mg/L. Given that the highest-quality water sources (local surface and storm waters) were not available year-round and were insufficient to meet demands in most years, especially as urban development began, it is reasonable to assume that the average TDS of the irrigation supply in any given year ranged between 300 and 900 mg/L, depending on the mix of sources being used and assuming that irrigators would manage the irrigation to have a TDS concentration of less than 1,000 mg/L to protect the citrus trees. Based on this source water quality, and assuming that irrigated crops do not assimilate the TDS and that flood irrigation practices had an efficiency of 50 percent, the TDS concentration of the deep infiltration of applied water likely ranged between 600 and 1,800 mg/L. Given that crops do assimilate nitrogen, the nitrate concentration of the deep infiltration of applied water is a function of fertilizer practices.

The high-TDS historical ambient water quality of the Temescal and Arlington GMZs for the 1954-1973 period, which were 770 and 980 mg/L respectively (WEI, 2000), can be explained, in part, by the abundant use of poor quality source waters developed, used, and abandoned by the Temescal Water Company and its predecessors from the 1880s through 1930.

2.2.3 Current Water Supply Sources: 1975 to the Present

The Temescal Water Company was ultimately purchased by Elsinore Valley in 1989 with some of its water assets also divided amongst the City of Corona and the TVWD. These three water supply agencies serve the major municipal and agricultural demands within and adjacent to the Upper Temescal Valley. The primary sources of water supply served by these agencies to meet potable demands in the Upper Temescal Valley include imported water from Northern California through the State Water Project (SWP) and the Colorado River Aqueduct (CRA), potable groundwater from the Coldwater and Elsinore GMZs, and desalinated brackish groundwater from the Temescal GMZ. Non-potable demands are served with groundwater from the Upper Temescal Valley GMZ and recycled water. The agencies are also beginning to evaluate the use of groundwater from the Upper Temescal Valley GMZ to meet potable municipal demands. In addition to these water service agencies, there are a few land owners throughout the Valley who provide their own water supply through use of private groundwater wells.

Table 2-3 summarizes the TDS and nitrate concentrations of the current water supply sources used in the Upper Temescal Valley. The TDS concentrations of the potable water sources range between 270 and 530 mg/L. Dedicated non-potable outdoor irrigation supply sources range between 500 and 1,500 mg/L. Based on the mix of supplies used for outdoor irrigation, and assuming that irrigated vegetation does not assimilate the TDS and an irrigation efficiency of 75%, the concentration of the deep infiltration of applied water likely ranges between 1,500 and 2,500 mg/L. The nitrate concentrations of the potable water sources range between 0.2 and 2.8 mg/L and the non-potable sources from 3.6 to 45 mg/L. As with the historical period, the nitrate concentration of the deep infiltration of applied water is a function of fertilizer practices.

2.3 Surface Water Hydrology

Figure 2-3 shows the delineation of the Upper Temescal Valley Watershed, which for the purposes of this study is the area that is tributary to the unlined reach of the Temescal Wash. The Temescal Wash originates within the Upper Temescal Valley Watershed, just downstream of Lake Elsinore, and flows northwest parallel to the Santa Ana Mountains into Lee Lake reservoir. Water released at the Lee Lake Dam continues down Temescal Wash towards the All-American Aggregate Pit in the Temescal GMZ. Temescal Wash is an unlined, natural stream channel from the Lake Elsinore Spillway Channel to its point of discharge into the All-American Aggregate Pit. Tributaries to the Temescal Wash consist primarily of smaller, unlined stream channels that drain the adjacent mountain slopes and valleys.

Surface-water discharge in the Temescal Wash and its tributaries originates from various sources, including storm-water runoff, dry-weather runoff, rising groundwater, and since the 1980s, discharge of tertiary-treated recycled water. Additionally, in very wet years, Lake Elsinore can overflow into the Temescal Wash. Storm-water runoff is the largest source of natural recharge to the Upper Temescal Valley GMZ.

The data collected and analyzed to characterize the surface water hydrology of the Upper Temescal Valley, including precipitation and surface water discharge and quality, are described in the following subsections.

2.3.1 Precipitation

Long-term precipitation records from two sources were analyzed:

- Elsinore Station D067 with a period of record running from 1898 to 2014
- PRISM[6] 800 square-meter grid coverage of the Upper Temescal Valley Watershed for the period of record running from 1885 to 2013

These records showed the same temporal pattern of precipitation. The location of Elsinore Station D067 is shown in Figure 2-3. Figure 2-4 shows the annual precipitation at this station as a bar-chart and the cumulative departure from mean (CDFM) precipitation curve for the period of October 1898 through September 2014. From water year 1899 to 2014, precipitation ranged from a minimum of 1.97 inches (2007) to a maximum of 33.6 inches (2005) and averaged 12.1 inches per year. The CDFM curve illustrates the consecutive and cumulative relationship of each year's precipitation to the long-term mean. When the slope of the curve trends downward from left to right, the annual precipitation is less than the average precipitation; when the slope continues downward for two or more years, the CDFM indicates a dry period. When the slope of the curve trends upward from left to right, the annual precipitation is greater than the average precipitation; when the slope of the curve trends upward from left to right for two or more years, the CDFM indicates a wet period. Generally, dry periods contain one or more wet years, and wet periods contain some dry years.

The precipitation record for the Upper Temescal Valley demonstrates that the climate of the region is subject to prolonged dry periods and short wet periods. As the CDFM curve shows, the Upper Temescal Valley experienced the following wet and dry periods:

Table 2-A
Characterization of Wet and Dry Periods in the Upper Temescal Valley Watershed 1899 - 2014

Dry Periods	Wet Periods
6-year dry period from 1899 through 1904	
	13-year wet period from 1905 through 1917
19-year dry period from 1918 through 1936	
	8-year wet period from 1937 through 1944
33-year dry period from 1945 through 1977	
	6-year wet period from 1978 through 1983
7-year dry period from 1984 through 1990	
	8-year wet period from 1991 through 1998
16-year dry period from 1999 through 2014*	

*The last (current) dry period continued through 2016

The average duration of a dry period is about sixteen years, and the average duration of a wet period is about nine years. The ratio of dry years to wet years is about seven to three. That is, for every ten years, about seven years experienced below-average precipitation (dry), and three years experienced above-average precipitation (wet).

[6] http://www.prism.oregonstate.edu/

2.3.2 Surface Water Discharge and Quality

Stream-gages are used to characterize the amount of surface water discharge at any point in a stream system. Measuring surface-water discharge at points across a GMZ or groundwater basin can provide the data needed to estimate the in-stream recharge of storm-water runoff, dry-weather discharge, and recycled water discharge.

For the historical period, surface water discharge data from USGS stream-gage 11072000 were available to characterize surface water outflows from the Upper Temescal Valley GMZ for the station's period of record, ranging from 1927 to 1980. The stream-gage was located just downstream of the northwest GMZ boundary, as shown in Figure 2-3. Figure 2-5 shows the daily discharge hydrograph for the 11072000 gage. Review of the data indicates that the discharge is generally zero and positive for relatively short storm-water discharges. The USGS considers the records from this gage to be "poor" due to the irrigation diversions that were located upstream of the gage during its operation. That said, the "poor" characterization doesn't mean that the gage measurements were poor, but rather, due to upstream diversions, the gage measurements do not represent the expected runoff that would have occurred without the upstream diversions.

Two historical water quality data points were found to characterize the TDS and nitrate concentrations of surface water discharge at station 11072000 (Water Resources Engineers, Inc. 1970b), as shown in Table 2-B below.

Table 2-B
Historical Surface Water Measurements on Temescal Wash

Year	Climate	TDS (mg/L)	Nitrate-N (mg/L)
1932	Dry	300	--
1946	Dry	150	5.6

The values reported by Water Resources Engineers, Inc. represent the average of measurements taken during the year if more than one measurement was available, however the raw data were not reported. The TDS and nitrate concentrations of storm-water runoff generated by precipitation are generally very low. In a 2006 study performed for the Chino Basin Watermaster, it was estimated that the TDS and nitrate-N concentrations of storm water diverted for recharge were about 100 mg/L and 1.0 mg/L, respectively (DDB and WEI, 2006). Thus, while storm-water runoff generated by precipitation is the largest source of natural recharge to the Upper Temescal Valley, the discharge and precipitation patterns suggest that large influxes of high-quality storm-water runoff were occurring infrequently in about three out of ten years.

Currently, there are no active stream gages or surface-water monitoring programs to measure discharge or surface-water quality within the Upper Temescal Valley. The nearest gaging station on Temescal Creek is located in the Temescal GMZ at Main Street in Corona, a location that includes surface water discharges contributed by the watersheds tributary to the Upper Temescal Valley GMZ and the Arlington GMZ and is therefore not representative of the Upper Temescal Valley alone.

As part of the RCFC&WCD's former Municipal Separate Storm Sewer System (MS4) monitoring program, water quality samples were collected at the outlet of the All-American Aggregate Pit during dry weather conditions from 1994-2004. As the terminus of the unlined section of Temescal Wash, the water quality of All-American Aggregate Pit outflows can be considered representative of the water quality of the combined surface, subsurface, and rising groundwater outflows at the boundary of the Upper Temescal Valley and Temescal GMZs. Figure 2-6 is a time history plot of the TDS and nitrate concentrations measured during this time period. Table 2-C summarizes the TDS and nitrate sample result statistics for this time period.

Table 2-C
TDS and Nitrate Concentration Summary Statistics for Surface-Water Outflow from the All-American Aggregate Pit

Statistics for 1994-2004	TDS	Nitrate-N
Number of Samples Collected	34	35
Minimum Concentration (mg/L)	480	< 0.1
Maximum Concentration (mg/L)	960	9.0
Average Concentration (mg/L)	744	1.9*

*Represents the average concentration of detected values only

The RCFC&WCD's current MS4 monitoring program no longer includes the All-American Aggregate Pit outlet.

2.3.3 Recycled Water Discharge and Quality

As previously noted, four agencies discharge tertiary-treated recycled water to the Temescal Wash, including: the City of Corona (from Corona Plant No. 3), TVWD (from the TVWD WRF), Elsinore Valley (from the Regional WRF), and Eastern (combined discharge from multiple RWRFs in Eastern's service area). Elsinore Valley also discharges tertiary treated recycled water from the Horsethief WRF to ponds located adjacent to the treatment plant. In 2013, the TVWD discontinued discharges to Temescal Wash and now discharges to percolation ponds adjacent to its WRF. Figure 2-3 shows the locations of the recycled water treatment plants and discharge points to Temescal Wash. Table 2-4a summarizes the annual discharges to the Temescal Wash by each agency since 1991, based on a fiscal year.[7] Between 1991 and 2014, annual recycled water discharge to the Temescal Wash ranged from a minimum of 1,007 acre-ft/yr (2014) to a maximum of 22,815 acre-ft/yr (2006) and averaged 6,933 acre-ft/yr. Discharges increased from 1991 through 2007 and then rapidly began to decline after 2007. From 2012 to 2014, the average annual discharge was only about 3,200 acre-ft/yr. This decline in recycled water discharge to the Temescal Wash is primarily due to the use of all but 0.5 million gallons per day (mgd) of effluent flows from the Elsinore Valley's Regional WRF for the enhancement of lake levels in Lake Elsinore (which began in 2008) and to the increased reuse of recycled water within Eastern's service area. Additionally, Eastern discharges less in dry years when limited precipitation reduces the need to drain the recycled water storage ponds

[7] The fiscal year is from July 1 through June 30. So, fiscal year 1991 is July 1, 1990 through June 30, 1991.

during rain events. Both the TVWD and Corona have also increased recycled water reuse, leading to less discharge.

All of the discharges to the Temescal Wash (or ponds) are regulated pursuant to waste discharge requirements issued by the Regional Board. Table 2-4a shows the 12-month, volume-weighted TDS and total inorganic nitrogen (TIN)[8] concentrations of each recycled water discharge to Temescal Wash and totals for all discharges combined. The combined volume-weighted TDS concentrations of the discharges to Temescal Wash ranged from 582 to 873 mg/L and averaged about 720 mg/L. The combined volume-weighted TIN concentrations ranged from 1.2 to 23 mg/L and averaged about 5.6 mg/L. Values at the high end of this range no longer occur due to treatment improvements made by Elsinore Valley at the Regional WRF. Figure 2-7 is a graphical representation of the data presented in Table 2-4a. Note that the volume-weighted TDS and TIN concentrations of discharges to the Temescal Wash have generally been decreasing over the time period shown.

Table 2-4b summarizes the annual discharges, and the associated TDS and nitrate[9] concentrations, to percolation ponds in the Upper Temescal Valley GMZ by Elsinore Valley[10] and the TVWD. Between 1991 and 2014, annual recycled water discharge to percolation ponds ranged from a minimum of 14 acre-ft/yr (1999) to a maximum of 575 acre-ft/yr (2014), and averaged 175 acre-ft/yr. The discharges increased over time as the portion of the Elsinore Valley service area tributary to the Horsethief WRF was developed. Discharges by Elsinore Valley were lower than usual in 2013 and 2014 due to high irrigation demands during the dry period. The increase in total discharge to ponds in 2014 and 2015 was driven by the TVWD. The TDS concentration of the combined discharges to percolation ponds in the Upper Temescal Valley ranged from 559 to 792 mg/L and averaged 689 mg/L. Nitrate-N concentrations ranged from 9.2 to 37 mg/L and averaged 24 mg/L.

2.4 Hydrogeology

2.4.1 Geologic Setting and Stratigraphy

The Upper Temescal Valley GMZ is located in the northern part of the Peninsular Ranges along the Elsinore Fault Zone within the Upper Temescal Valley. The active Elsinore Fault Zone separates the Santa Ana Mountains to the west from the Perris Block to the east (Morton and Weber, 2003). The El Sobrante de San Jacinto is a bedrock plateau that forms the western edge of the Perris Block. The structure of the Upper Temescal Valley is a complex graben formed by a system of northwest trending high-angle faults (Engel, 1959). During Plio-Pleistocene time, uplift and tilting along the Elsinore Fault Zone likely provided the initial course for the Temescal Creek to begin eroding the adjacent mountain and hill sediments (Gray, 1961).

[8] TIN is used for the recycled water discharges to Temescal Wash because for most of the period of record, only TIN data was available, as opposed to nitrate-N. In some cases, only nitrate-N values were available – this is noted on Table 2-4a. For the purpose of this study, it is assumed that TIN is made up entirely of nitrate-N.

[9] In the case of the Horsethief plan, only nitrate data were available.

[10] Values were estimated based on total effluent production and deliveries of recycled water for irrigation.

Sediments eroded from the adjacent mountains have filled the valley to form shallow groundwater reservoirs.

Figure 2-8 shows the general surface geology in the vicinity of the Upper Temescal Valley GMZ. The stratigraphy of this area is divided into two natural divisions: (1) the pervious formations that comprise the groundwater reservoir are termed the "water-bearing sediments," and (2) the impermeable formations that enclose the groundwater reservoirs are termed "consolidated bedrock." The water-bearing sediments overlie the consolidated bedrock with the bedrock formations exposed at the surface as the surrounding hills and mountains. The terms used in this report to describe bedrock, such as "consolidated," "non-water-bearing," and "impermeable," are used in a relative sense. The water content and permeability of these bedrock formations is not zero. However, the primary point is that the permeability of the bedrock formations flanking and underlying the groundwater basin is much less than the aquifer sediments within the basin.

The water-bearing sediments consist of Quaternary[11] younger, older, and very old alluvium. The alluvium is composed of interbedded and unconsolidated layers of gravel, sand, silt, and clay. The younger alluvium is considered to be the primary groundwater reservoir in the Upper Temescal Valley GMZ. As seen in Figure 2-8, the younger alluvium is concentrated along the current floodplain of the Temescal Wash and its tributaries.

The consolidated bedrock formations consist primarily of Tertiary[12] sedimentary units and Cretaceous[13] and pre-Cretaceous[14] volcanic, intrusive, and metamorphic units. The consolidated bedrock formations outcrop as the surrounding hills and mountains. The consolidated bedrock formations occur at depth underlying the water-bearing sediments of the Bedford Basin and act as the effective base of the freshwater aquifer, or the "bottom of the aquifer."

2.4.2 Groundwater Recharge and Discharge

Tables 2-5a and 2-5b summarize the annual recharges and discharges to the Upper Temescal Valley GMZ for the two periods of interest in this study: 1954 to 1973 (historical) and 1991 to 2014 (current). The derivation of the recharge and discharge components is described in the following sections.

2.4.2.1 Recharge

Groundwater recharge to the Upper Temescal Valley GMZ primarily occurs by streambed recharge, the deep infiltration of precipitation and applied water, and subsurface inflow. These recharge components and their associated TDS and nitrate concentrations are described below.

Infiltration of surface-water discharge from the Temescal Wash and its tributaries (hereafter, streambed recharge). Sources of surface water discharge include: storm-water

[11] Approximately 2 million to 12,000 years ago.

[12] Approximately 66 to 2.6 million years ago.

[13] Approximately 145 to 66 million years ago.

[14] Older than approximately 145 million years.

runoff, POTW discharge, and dry-weather runoff. The infiltration of surface-water runoff in the Upper Temescal Valley GMZ is highly variable and is a function of climate conditions. The magnitude of streambed recharge was estimated for two time periods, 1954 to 1973 and 1991 to 2014, using the WLAM (a detailed description of the use of the WLAM to estimate historical and current streambed recharge is provided in Sections 3 and 4 of this report). For 1954 to 1973, the estimated streambed recharge ranged from about 500 to 22,000 acre-ft/yr and averaged about 4,700 acre-ft/yr. As Figure 2-4 shows, 1954 to 1973 falls within the 33-year dry period from 1945 to 1977.

For 1991 to 2014, streambed recharge ranged from about 2,500 to 25,000 acre-ft/yr and averaged 11,400 acre-ft/yr. The increase in surface-water infiltration during the modern time period is due to the introduction of recycled water discharges to the Temescal Wash and an increase in the impervious surfaces in the watershed, which results in more storm-water runoff. And, as shown in Figure 2-4, the first 8 years of this more recent period were within a wet period.

The TDS and nitrate concentrations of the streambed recharge are a function of the relative volumes of the surface-water runoff sources, which range from about 100 to 300 mg/L and 0 to 6 mg/l, respectively, for storm-water runoff (see Section 2.3.2), and from about 580 to 870 mg/L and 2 to 23 mg/L, respectively, for recycled water discharges (see Section 2.3.3).

Deep infiltration of precipitation and applied water (DIPAW). The amount of water that can infiltrate through the soil zone is dependent on the properties of the soil, the overlying vegetation, evapotranspiration (ET), and the timing and amount of precipitation and applied water that enters the soil. DIPAW occurs when the sum of the water applied and stored in the soil water exceeds field capacity and ET.

The deep infiltration of precipitation was assumed to be negligible and was not estimated as part of this study. Thus, in this study, DIPAW is made up entirely of the deep infiltration of applied water. Table 2-6 summarizes the annual deep infiltration of applied water in the Upper Temescal Valley Watershed by land use type for 1933, 1949, 1957, 1963, 1975, 1990, 1993, 2001, 2005, 2014, and future buildout (estimated to be 2100). The magnitude of the deep infiltration of applied water was estimated based on the water requirements of each irrigated land use type and the time-period appropriate irrigation efficiency.

For the historical period, applied water requirements and irrigation efficiencies for agricultural land use types were based on the California Department of Water Resources' *Bulletin No. 113-3 - Vegetative Water Use in California, 1974*. For irrigated urban land uses, values were based on *Unit Water Requirements and Waste Increments, a Final Report on Task VI-6, August 1970* (Water Resources Engineers, Inc. 1970a). During this time period, the annual deep infiltration of applied water increased from about 4,000 acre-ft/year to about 8,600 acre-ft/yr and averaged about 6,900 acre-ft/yr. As discussed in Section 2.2.2, the TDS concentration of the deep infiltration of applied water likely ranged between 600 and 1,800 mg/L. Nitrate concentrations are a function of historical fertilization practices

For the period of 1991 through buildout, applied water requirements and irrigation efficiencies were based on those assumed for the Chino Basin in the *2013 Chino Basin Groundwater Model Update and Recalculation of Safe Yield Pursuant to the Peace Agreement* (WEI, 2015a). A significant decrease in the deep infiltration of applied water occurred after agricultural land use types were replaced with urban land use types and with improvements

in irrigation efficiencies. By 1991, the deep infiltration of applied water had decreased to about 3,600 acre-ft/yr and continued to decrease through 2014 to about 2,200 acre-ft/yr, averaging about 2,500 acre-ft/yr over this period. The deep infiltration of applied water will increase as the watershed is built out and natural vegetation is converted to irrigated land uses associated with urban development. At build-out, the deep infiltration of applied water is estimated to be about 4,900 acre-ft/yr if modern irrigation practices continue in the future. As discussed in Section 2.2.3, the TDS concentration of the deep infiltration of applied water likely ranges between 1,500 and 2,500 mg/L. Again, nitrate concentrations are a function of modern fertilization practices.

Recycled Water Discharges to Ponds. As described in Section 2.3.3., the annual recycled water discharge to percolation ponds ranged from a minimum of 14 acre-ft/yr (1999) to a maximum of 575 acre-ft/yr (2014) and averaged 175 acre-ft/yr. The TDS concentration of the combined discharges ranged from 555 to 792 mg/L and averaged 689 mg/L. Nitrate-N concentrations ranged from 8.0 to 37 mg/L and averaged 24 mg/L.

Sub-surface inflow from the saturated alluvium and fractures within the consolidated bedrock in the bordering hills and mountains. This recharge term was assumed to be negligible and was not estimated as part of this study.

Sub-surface inflow across the North Glen Ivy Fault from the Coldwater Basin. This fault is an effective groundwater barrier, and sub-surface underflow across this fault may only occur after extensive recharge has filled the Coldwater Basin (John S. Murk Engineers, 1987). This recharge term was assumed to be negligible and was not estimated as part of this study.

Total Recharge. Total recharge is summarized in Tables 2-5a and 2-5b. The total recharge for the historical period ranged from about 4,900 to 30,000 acre-ft/yr and averaged about 11,700 acre-ft/yr. For the current period, total recharge ranged from about 5,300 to 28,000 acre-ft/yr and averaged about 14,100 acre-ft/yr. Note that the range in recharge volumes in both periods is about the same, but in the current period, the average recharge is higher. This is largely due to the introduction of recycled water discharges to the Temescal Wash and an increase in impervious surfaces in the watershed that result in more storm-water runoff.

2.4.2.2 Discharge

Groundwater discharge from the Upper Temescal Valley GMZ primarily occurs by groundwater production, ET by riparian vegetation, and subsurface outflow. These discharge components are described below.

Production. Groundwater production data were available from State Recordation filings for 39 wells located throughout the Upper Temescal Valley for 1947 to 2014. During this historical time period, production ranged from about 2,700 to 5,400 acre-ft/yr and averaged about 4,000 acre-ft/yr. Groundwater production is much lower in the current period, averaging only 2,600 acre-ft/yr from 1991 to 2014 and ranging from about 700 to 4,400 acre-ft/yr. The reduction in groundwater production since the 1970s is largely attributable to the transition from irrigated land use types to urban land use types, which are being served with potable sources of water as opposed to groundwater from the Upper Temescal Valley GMZ. For the purposes of the analysis performed for this study, the TDS and nitrate concentrations of produced groundwater are assumed to equal the basin-wide volume-weighted concentration of the groundwater basin, which is estimated in part based on actual measured groundwater quality at wells. The groundwater quality data is discussed in Section 2.4.5 of this report.

Evapotranspiration (ET). ET is defined as the water lost to the atmosphere from the ground surface, evaporation from the capillary fringe of the groundwater table, and the transpiration of groundwater by plants. Within the Upper Temescal Valley GMZ, riparian vegetation is primarily confined to the alluvial floodplain sediments along the Temescal Wash where groundwater water levels have remained persistently high. The dense riparian vegetation visible along the Temescal Wash indicates that ET is an active process within the Upper Temescal Valley GMZ. The areal extent and density of riparian vegetation was estimated using a series of aerial photographs. It was noted that the extent and density of the vegetation varied over wet and dry climate conditions. Immediately following a very wet year, the extent and density was the smallest due to large storms uprooting and washing away vegetation. The vegetation would then expand over a wet period and thin-out over dry periods. Based on these observations, each year was assigned an area and density of riparian vegetation to calculate ET. ET was then estimated assuming an ET rate of 3 ft/yr (DWR, 1942). Total ET in the Upper Temescal Valley GMZ ranged from about 1,000 to 1,800 acre-ft/yr and averaged about 1,400 acre-ft/yr over both the historical and current time periods.

There is no assignment of TDS concentration for this discharge term. ET removes water from the groundwater basin but not its associated mass of TDS (e.g. the salt stays in the groundwater), thus increasing the TDS concentration in the GMZ. Conversely, riparian vegetation assimilate nitrogen, thereby reducing nitrate concentrations. For the purpose of this study, it was assumed that the process of ET will reduce the nitrate concentration of recycled water discharges by 25 percent, per the Basin Plan accepted nitrogen-loss rate.

Rising Groundwater. Within the Upper Temescal Valley GMZ, shallow groundwater occurs in a number of places along the Temescal Wash, resulting in rising groundwater. And, sub-surface outflow occurs at the northwest boundary with the Temescal GMZ. The volume of rising groundwater and subsurface outflow varies as a function of groundwater levels and recharge. Because of the paucity of groundwater level data and stream discharge data, a rising groundwater estimate cannot be directly made. Rising groundwater estimates were developed with the WLAM and from other modeling work, discussed in Sections 3, 4, and 5 of this report.

During the historical time period of 1954 to 1973, rising groundwater ranged from about 0 to 25,000 acre-ft/yr and averaged about 6,400 acre-ft/yr. For the current period, rising groundwater ranged from about 2,000 to 25,000 acre-ft/yr and averaged about 10,000 acre-ft/yr. Note that the variability of the annual estimates of rising groundwater are correlated with the annual estimates of streambed recharge. For example, when streambed recharge is at its maximum in 1969, so is the rising groundwater. And, because the annual average recharge is higher and the production is lower for the current period compared to the historical period, the average rising groundwater volume is higher for the current period.

Subsurface Outflow. Subsurface outflow can only occur at one location: the downstream end of the Upper Temescal Valley GMZ. The groundwater basin narrows, and bedrock rises up to form an almost impermeable boundary, forcing groundwater to rise and exit the basin as surface water discharge. This subsurface outflow was assumed to be negligible and was not estimated for this study.

Total Discharge. Total discharge is summarized in Tables 2-5a and 2-5b. The total discharge for the historical period ranged from about 5,700 to 30,000 acre-ft/yr and averaged about 11,900 acre-ft/yr. For the current period, total discharge ranged from about 5,200 to 28,000 acre-ft/yr and averaged about 14,000 acre-ft/yr. Note that the range in discharge volumes in

both periods is about the same, but in the current period, the average discharge is higher; this is driven by the increase in rising groundwater.

2.4.3 Groundwater Storage Capacity

Figure 2-8 shows the locations of wells in the Upper Temescal Valley GMZ where bedrock was encountered during well construction, as described in the lithologic descriptions recorded on well driller's reports obtained from the DWR, the Temescal Water Company, and Elsinore Valley. The depth to bedrock is annotated at each well, and the alluvial sediments along Temescal Wash generally range between 40 to 120 feet deep. The wash thalweg (the deepest point of the channel) provides a vertical control on the effective width and depth of the groundwater system. Figure 2-9 is a representative cross section of the Upper Temescal Valley alluvial aquifer along the Temescal Wash at Elsinore Valley's Flagler 2A well in the northwest end of the GMZ (see cross section A on Figure 2-7). Also shown in Figure 2-9 is a simplification of the cross section that allows for the estimation of groundwater storage capacity. The simplification depicts the aquifer as a prism where storage capacity can be calculated as:

$$Storage\ Capacity = \left(\frac{1}{2}\begin{matrix} Average\ Width \\ of\ Valley\ Floor \end{matrix} * \begin{matrix} Maximum \\ Aquifer\ Thickness \end{matrix}\right) * \begin{matrix} Total\ Length\ of \\ Alluvial\ Aquifer \end{matrix} * Specific\ Yield$$

The valley floor ranges in width from 50 to 12,000 feet, averaging about 1,400 feet. On average, the aquifer thickness at the thalweg is no more than 100 feet. The total length of the alluvial aquifer is about 30 miles. Based on the aquifer sediments described in Section 2.4.1, the specific yield is estimated to range between 0.10 and 0.20. These values yield a total storage capacity estimate for the Upper Temescal Valley GMZ ranging from about 25,000 to 75,000 acre-ft.

Based on the recharge estimates described in Section 2.4.2, which predict streambed recharge in the Temescal Wash to be as high as 25,000 acre-ft in the wettest years, it is likely that the storage capacity is closer to the 75,000 acre-ft. Due to the small storage capacity of the basin, during large recharge events, an increase in rising groundwater outflow will occur as groundwater levels rise and exceed the thalweg elevation, ultimately discharging groundwater to the Wash.

Based on the average annual recharge estimates described in Section 2.4.2, the following table summarizes the estimated turnover time of storage in the basin for a range of storage capacities. The turnover time is the number of years it takes for recharge to completely replace the volume of water in storage.

Table 2-D
Estimated Turnover Time of the Upper Temescal Valley GMZ for a Range of Storage Capacities in Historical and Modern Time Periods
(acre-ft/yr)

Time Period	Turnover Time (years)		
	25,000 acre-ft	50,000 acre-ft	75,000 acre-ft
Historical: 1953 to 1975	2.2	4.4	6.6
Current: 1990 to 2014	1.5	3	4.5

At a storage capacity of 75,000 acre-ft, groundwater in storage would be replaced three to four times during a 20-year time period. Based on this range of turnover times, it is reasonable to assume that for any given 20-year time period, the long-term average TDS and nitrate concentration of the recharge sources will be reasonably representative of the ambient water quality. Ambient TDS concentrations should be higher than the volume weighted recharge if due to the concentrating effect of ET by riparian vegetation.

2.4.4 Groundwater Levels

In general, groundwater flow mimics surface-water drainage patterns: from the flanks of the surrounding bedrock hills and mountains toward the Temescal Wash and then northwestward, following the downstream course of the Temescal Wash. Along these general flow paths, groundwater encounters bedrock ridges and bedrock constrictions that restrict groundwater flow to narrow flow paths and can create localized areas of shallow or rising groundwater.

Groundwater level data for wells in the Upper Temescal Valley GMZ were available from Corona, Elsinore Valley, the Temescal Water Company, and the TVWD. The locations of wells with data available during the 1935 to 2014 period are shown in Figure 2-10. Also shown in Figure 2-10 are time-history charts of static (non-pumping) groundwater level measurements for selected wells across the Upper Temescal Valley GMZ, some of which have data for the entire period of 1935 to 2014. The groundwater level data are plotted together with the CDFM precipitation curve.

Figure 2-10 shows that groundwater levels respond to the stresses of precipitation, especially during periods of high groundwater production. Compare the decline in water levels at the Flagler 2/2A and Barney Lee 1 wells in the dry period from 1945 to 1968—a period of high groundwater production—to the decline in the current dry period from 2006 to 2014—a period of low groundwater production. During wet years (see 1937, 1969, and 1978 for example), groundwater levels increased rapidly in response to the recharge of storm-water in Temescal Wash and its tributaries. Since about 1993, when production was decreasing and recycled water discharge was increasing, groundwater levels have remained shallow and relatively stable.

Note that all of the groundwater level time histories shown in Figure 2-10 contain evidence of vertical control caused by the elevation of the stream thalweg adjacent to the wells. This can be seen by the appearance of approximately flat groundwater level time series segments during wet periods.

2.4.5 Groundwater Quality

As discussed in Section 1.2 of this report, historical data were insufficient both spatially and temporally to compute TDS and nitrate antidegradation objectives for the Upper Temescal Valley GMZs. As part of the data collection efforts of this study, new historical water quality data were obtained from the DWR for the period of 1954 to 1980. Although the datasets are still insufficient to compute antidegradation objectives per the Basin Plan adopted methodology, the newly identified water quality data provide valuable insight into historical water quality concentrations and spatial and temporal trends and enable computation of antidegradation objectives using the alternative methodology described in Section 3 of this report.

Figure 2-11 is a time-history of all available TDS and nitrate measurements from all wells in the Upper Temescal Valley GMZ from 1954 to 2014, symbolized by the location where the sample was collected within the original GMZ assignments from the 2004 Basin Plan amendment (Bedford, Lee Lake, or Warm Springs). The TDS concentrations are highly variable across space and time, ranging from a low of 240 mg/L to a high of 1,500 mg/L, and there is no significant long-term trend of water quality degradation or improvement. That said, from 1954-1975, the TDS concentration at wells in the Bedford and Lee Lake subareas averaged about 1,100 mg/L and ranged from 240 to 1,340 mg/L. Since 1995, the average TDS concentration has declined to about 790 mg/L, ranging from 340 to 1,130 mg/L. In comparing these periods, the average TDS declined by about 310 mg/L and the period variability declined by about 110 mg/L. This observed change could be attributable to multiple factors: a reduction in the number of wells with TDS concentration measurements, a change in the recharge sources and their respective TDS concentrations, and/or the fact that groundwater levels in the GMZ have been relatively high since 1990, meaning there is less space for large volumes of storm-water runoff to recharge in wet years.

Similar to TDS, nitrate concentrations are also highly variable; however, there does appear to be a decrease in concentrations over time, which are probably due to the reduction in irrigated agriculture land uses and hence a reduction in added nitrogen in the form of fertilizers.

Figure 2-11 demonstrated that the TDS concentration of groundwater in the Upper Temescal Valley GMZ is consistently variable over space and time. Figures 2-12 and 2-13 demonstrate that TDS concentrations are also highly variable at individual wells, both in historical and current periods. Figures 2-12 and 2-13 show the locations of wells with TDS data during the antidegradation objective setting period (1954 to 1973) and the current 20-year period (1995-2014), respectively. Each well is labeled with TDS measurement statistics for the 20-year period. The bold value represents a modified version of the ambient water quality statistic,[15] and the values in parentheses (in order) are: the number of annualized average values over the 20-year period, the mean of the annualized averages, the minimum annualized average, and the maximum annualized average. The statistic is shown as "N/A" for any well with less than three annualized average values.

For the antidegradation objective setting period (Figure 2-12), there are 25 wells in the Upper Temescal Valley GMZ with data. The number of years of available data at each well ranges from one year to 17 years. The statistic values range from about 440 to 1,200 mg/L. For the six wells with the longest time-histories of data (nine or more annualized average values), the TDS concentrations at the individual wells varied by 400 to 800 mg/L (i.e. the difference between the minimum and maximum statistic for the annualized average values).

For the current period (Figure 2-13), there are 19 wells with data. The number of years of available data at each well ranges from two to 15 years. The statistic values range from about 600 to 1,470 mg/L. For the eight wells with the longest time-histories of data (nine or more annualized average values), the TDS concentrations at the individual wells varied by 240 to

[15] See WEI, 2014. *Recomputation of Ambient Water Quality in the Santa Ana River Watershed for the Period 1993 to 2012.* Technical Memorandum. Prepared for the Santa Ana Watershed Project Authority Basin Monitoring Program Task Force. August 2014.

Note that a simplified method to compute the ambient water quality statistics was used for this data analysis: the data used to compute the statistics shown in Figures 2-13 and 2-14 were not subject to the Shapiro-Wilk test for normality and outliers.

440 mg/L (i.e. the difference between the minimum and maximum statistic for the annualized average values), demonstrating that the variability at individual wells has decreased over time.

Figures 2-14 and 2-15 are similar maps for nitrate. For the antidegradation objective setting period (Figure 2-14), there are 24 wells in the Upper Temescal Valley GMZ with data. The number of years of available data at each well ranges from one year to 17 years. The statistic values range from 1.7 to 18.6 mg/L. For the four wells with the longest time-histories of data (nine or more annualized average values), the nitrate concentrations at the individual wells varied by 6.7 to 17.6 mg/L (i.e. the difference between the minimum and maximum statistic for the annualized average values).

For the current period (Figure 2-15), there are 19 wells with data. The number of years of available data at each well ranges from two to 14 years. The statistic values range from about 2.9 to 9.4 mg/L, further demonstrating that nitrate concentrations may be improving over time. For the seven wells with the longest time-histories of data (nine or more annualized average values), the nitrate concentrations at the individual wells varied by 2.7 to 18.1 mg/L (e.g. the difference between the minimum and maximum statistic for the annualized average values), indicating there is no difference in the variability of nitrate at individual wells compared to the antidegradation period.

As shown in Figures 2-11 through 2-15, TDS and nitrate concentration trends in the Upper Temescal Valley are reflective of wet and dry climate cycles, the small effective storage relative to recharge, recycled water discharge trends, production trends, and the surface and groundwater interchange along the Temescal Wash.

Table 2-1
Land Use in the Upper Temescal Valley Watershed
acres

Land Use Type	Percent Impervious[1]	1933	1949	1957	1963	1975	1990	1993	2001	2005	2014*	Build-out
Non-Irrigated Field Crops, Pasture, Fruits, and Nuts	2	2,761	2,761	1,294	268	168	110	118	121	127	181	1
Irrigated and Non-Irrigated Citrus	2	1,537	1,325	1,452	2,388	2,423	4,443	3,964	1,949	1,029	377	576
Irrigated Field Crops, Pasture, Fruits, and Nuts	2	94	94	123	940	1,103	241	278	433	703	767	1,168
Irrigated Vineyards	2	0	0	10	0	0	0	0	0	0	0	0
Dairies and Feedlots	10	0	0	10	51	36	9	9	8	0	0	0
Medium to High Density Urban Residential	75	87	470	856	1,239	1,969	768	884	1,631	2,274	3,309	4,077
Low Density Urban Residential	30	11	11	13	220	243	2,738	2,877	2,982	3,360	3,460	19,589
Commercial	90	0	0	3	6	5	131	178	255	424	611	3,938
Industrial	90	3	3	2	165	165	462	488	517	634	806	2,648
Special Impervious	95	0	6	35	76	71	981	1,037	1,028	1,195	1,217	2,784
Native Vegetation	2	73,819	73,642	74,515	72,959	72,129	68,427	68,478	69,388	68,567	67,584	43,534
Totals		**78,312**	**78,312**	**78,312**	**78,312**	**78,312**	**78,312**	**78,312**	**78,312**	**78,312**	**78,312**	**78,312**

1 Source: *2013 Chino Basin Groundwater Model Update and Recalculation of Safe Yield Pursuant to the Peace Agreement* , Table 7-2. October 2015.
*Land use modified from 2005 SCAG land use maps and Google Earth Imagery

Table 2-2
Estimated TDS and Nitrate Concentrations of Source Waters Used in Upper Temescal Valley from 1900-1975

Water Supply Source	Estimated TDS *mg/L*	Estimated Nitrate (as Nitrogen) *mg/L*	References
San Jacinto River Basin Groundwater (Perris South GMZ)	1,260	2.5	Based on the historical ambient water quality for the 1954-1973 time period (WEI, 2000)
Coldwater GMZ	380	1.5	Based on the historical ambient water quality for the 1954-1973 time period (WEI, 2000)
Upper Temescal Valley GMZ	> 380		Hayward and Wood (1973; updated 1989) noted that the groundwater from the Valley was saltier than the Coldwater Canyon Supplies; no information available for nitrate
Surface Water Diversions from Tributaries to Temescal Wash	150 - 300	0 - 6	TDS: Water Resources Engineers, 1970; Nitrate: Water Resources Engineers, 1970; Bulletin 40-A DWR, 1933
Bunker Hill-B GMZ	330	7.3	Based on the historical ambient water quality for the 1954-1973 time period (WEI, 2000)
Riverside-A GMZ	560	6.2	Based on the historical ambient water quality for the 1954-1973 time period (WEI, 2000)
Riverside-F GMZ	660	9.5	Based on the historical ambient water quality for the 1954-1973 time period (WEI, 2000)
San Jacinto River Diversions		trace	TDS: No information available Nitrate: Bulletin 18 DWR, 1959
Colorado River Aqueduct	700	< 1	Annual Reports of the Metropolitan Water District, 1950-1970

Table 2-3
Estimated TDS and Nitrate Concentrations of Source Waters Currently Used in Upper Temescal Valley

Water Supply Source	Estimated TDS *mg/L*	Estimated Nitrate (as Nitrogen) *mg/L*	References
Imported Water from the State Water Project (SWP)	270	0.6	Average value of TDS measurements made by MWDSC at Silverwood Lake for the period of 1980 to 2014
Blend of SWP and Colorado River Water from the Skinner Treatment Plant	518	0.2	Average value of TDS measurements made by MWDSC at the Skinner Treatment Plan for the period of 1980 to 2014
Potable Groundwater from the Coldwater GMZ	440	2.8	2012 Ambient Water Quality (WEI, 2014a)
Potable Groundwater from the Elsinore GMZ	490	2.1	2012 Ambient Water Quality (WEI, 2014a)
City of Corona DWP Municipal Water Supply	530	1.8	City of Corona DWP 2014 Consumer Confidence Report
Brackish Groundwater from the UTV GMZ	400 - 1,500	ND* - 20	Based on water quality sample results at wells (see Section 2.4.6 for discussion on WQ data)
Recycled Water from TVWD WRF	500 - 550	5.3 - 8.9	Range of 12-month volume-weighted averages from 2010 to 2014, as reported in DMRs.
Recycled Water from Corona #3 WRF	650 - 690	3.6 - 6.4	Range of 12-month volume-weighted averages from 2010 to 2014, as reported in DMRs.
Recycled Water from Horsethief WRF	570 - 730	20 - 45	Range of 12-month volume-weighted averages from 2010 to 2014, as reported in DMRs.

Table 2-4a
Annual Discharges and Volume-Weighted TDS and TIN Concentrations for Recycled Water Discharges to Temescal Wash in the Upper Temescal Valley Since 1991

Fiscal Year	Eastern MWD			Elsinore Valley MWD			Temescal Valley WD			Corona 3A			Total		
	Volume Discharged *(acre-ft)*	Annual Volume-Weighted TIN[1] *(mg/L)*	Annual Volume-Weighted TDS *(mg/L)*	Discharge *(acre-ft)*	Annual Volume-Weighted TIN[1] *(mg/L)*	Annual Volume-Weighted TDS *(mg/L)*	Discharge *(acre-ft)*	Annual Volume-Weighted TIN[1] *(mg/L)*	Annual Volume-Weighted TDS *(mg/L)*	Discharge *(acre-ft)*	Annual Volume-Weighted TIN[1] *(mg/L)*	Annual Volume-Weighted TDS *(mg/L)*	Discharge *(acre-ft)*	Annual Volume-Weighted TIN[1] (mg/L)	Annual Volume-Weighted TDS (mg/L)
1991	0			2,745	23.23	778	0			0			2,745	23.23	778
1992	0			1,265	*11.73*	873	0			0			1,265	*11.73*	873
1993	0			3,495	*13.30*	748	0			0			3,495	*13.30*	748
1994	0			3,544	*8.14*	792	0			0			3,544	*8.14*	792
1995	0			3,776	*6.55*	791	70	2.80	595	0			3,846	*6.48*	788
1996	0			3,645	4.31	719	124	2.09	595	0			3,769	4.24	714
1997	0			3,738	*6.65*	707	129	3.05	595	0			3,867	*6.53*	703
1998	1,778	4.14	645	4,396	4.50	720	172	3.78	595	0			6,346	4.38	696
1999	0			4,152	9.24	744	234	4.20	595	0			4,386	8.97	736
2000	0			4,135	*3.87*	687	315	4.10	511	0			4,450	*3.89*	674
2001	0			4,248	4.69	687	347	3.84	531	0			4,595	4.63	675
2002	0			4,176	6.35	688	354	3.07	536	0			4,529	6.09	676
2003	0			2,845	3.71	714	438	3.57	505	0			3,283	3.69	686
2004	4,352	5.86	658	881	1.20	707	531	5.40	544	0			5,764	5.10	655
2005	14,191	6.03	723	3,487	1.42	706	633	5.44	640	0			18,312	5.13	717
2006	15,421	7.29	729	6,668	1.39	702	703	8.14	515	23	*3.28*	834	22,815	*5.59*	715
2007	13,159	8.56	641	6,397	*3.07*	682	693	5.19	484	150	*5.01*	950	20,399	*6.70*	651
2008	10,830	10.77	712	1,473	1.87	767	758	7.36	534	273	*7.61*	701	13,334	*9.53*	708
2009	6,677	10.11	749	903	*2.64*	783	932	6.07	565	264	4.91	749	8,776	*8.75*	733
2010	4,971	9.80	787	1,170	3.00	738	953	7.26	548	277	4.31	687	7,371	8.18	745
2011	5,692	8.15	683	3,059	*2.01*	644	911	5.31	503	308	3.95	662	9,971	*5.87*	654
2012	1,228	12.19	665	2,148	2.01	582	910	5.77	514	181	4.85	664	4,467	5.69	594
2013	2,701	10.00	668	618	1.92	631	466	8.86	553	274	6.41	648	4,059	8.40	648
2014	0			706	1.20	682	0			301	3.58	655	1,007	1.91	674
Min	0	4	641	618	1.20	582	0	2	484	0	3	648	1,007	1.91	594
Max	15,421	12	787	6,668	23.23	873	953	9	640	308	7.61	950	22,815	23.23	873
Average	3,375	8	696	3,070	5.33	720	403	5	550	85	4.88	728	6,933	7.34	710

[1] TIN values in italics indicate that the value is nitrate as nitrogen because TIN data was not available. Thus, the nitrate value was used in development of the summary statistics.

Table 2-4b

Annual Discharges and Volume-Weighted TDS and Nitrate Concentrations for Recycled Water Discharge to Percolation Ponds in the Upper Temescal Valley Since 1991

FY	Elsinore Valley MWD Horsethief WRF			Temescal Valley WD			Total		
	Discharge *(acre-ft)*	Annual Volume-Weighted Nitrate-N *(mg/L)*	Annual Volume-Weighted TDS *(mg/L)*	Discharge *(acre-ft)*	Annual Volume-Weighted Nitrate-N *(mg/L)*	Annual Volume-Weighted TDS *(mg/L)*	Discharge *(acre-ft)*	Annual Volume-Weighted Nitrate-N (mg/L)	Annual Volume-Weighted TDS (mg/L)
1991	14	NA	680	0			14	NA	680
1992	35	NA	688	0			35	NA	688
1993	64	NA	676	0			64	NA	676
1994	53	NA	709	0			53	NA	709
1995	70	NA	696	0			70	NA	696
1996	64	NA	749	0			64	NA	749
1997	58	NA	748	0			58	NA	748
1998	90	NA	748	0			90	NA	748
1999	144	NA	725	0			144	NA	725
2000	257	28	792	0			257	28	792
2001	169	31	759	0			169	31	759
2002	186	26	780	0			186	26	780
2003	205	27	763	0			205	27	763
2004	213	27	728	0			213	27	728
2005	217	18	706	0			217	18	706
2006	226	13	610	0			226	13	610
2007	222	20	604	0			222	20	604
2008	212	20	653	0			212	20	653
2009	211	28	758	0			211	28	758
2010	207	31	688	0			207	31	688
2011	221	32	571	0			221	32	571
2012	202	37	575	0			202	37	575
2013	24	34	725	250	8.9	553	274	11	568
2014	25	35	658	550	8.0	555	575	9.2	559
Min	14	13	571	0	8.0	553	14	9.2	559
Max	257	37	792	550	8.9	555	575	37	792
Average	141	27	699	33	8.4	554	175	24	689

[1] "NA" indicates that the data was not available for this year

Table 2-5a
Recharge and Discharge to the Upper Temescal Valley Groundwater Management Zone
1954 - 1973

Year	Recharge			Discharge			
	Streambed Recharge	Deep Infiltration of Applied Water	Total	Groundwater Production	Evapotranspiration	Rising Groundwater Outflow	Total
1954	7,280	3,990	11,270	4,121	1,790	9,109	15,020
1955	858	4,058	4,916	4,349	1,397	0	5,746
1956	4,380	4,125	8,505	4,272	1,397	2,005	7,674
1957	3,560	4,192	7,752	3,447	1,397	2,908	7,752
1958	10,798	4,841	15,639	3,721	1,017	10,901	15,639
1959	907	5,490	6,397	4,319	1,594	484	6,397
1960	1,057	6,138	7,195	3,130	1,790	2,275	7,195
1961	506	6,787	7,292	3,246	1,397	2,649	7,292
1962	4,094	7,435	11,529	2,988	1,397	7,144	11,529
1963	3,682	8,084	11,766	2,988	1,397	7,380	11,766
1964	657	8,137	8,795	3,105	1,397	4,292	8,795
1965	10,299	8,191	18,489	2,716	1,397	14,376	18,489
1966	7,160	8,244	15,404	3,983	1,397	10,024	15,404
1967	3,985	8,297	12,282	4,910	1,017	6,356	12,282
1968	1,460	8,351	9,811	5,395	1,594	2,822	9,811
1969	21,861	8,404	30,265	4,349	1,017	24,899	30,265
1970	4,155	8,458	12,612	5,070	1,594	5,948	12,612
1971	2,022	8,511	10,533	5,380	1,790	3,363	10,533
1972	1,663	8,564	10,227	4,634	1,397	4,196	10,227
1973	4,221	8,618	12,839	4,443	1,397	6,998	12,839
Min	506	3,990	4,916	2,716	1,017	0	5,746
Max	21,861	8,618	30,265	5,395	1,790	24,899	30,265
Average	4,730	6,946	11,676	4,028	1,429	6,406	11,863

Table 2-5b
Recharge and Discharge to the Upper Temescal Valley Groundwater Management Zone
1991 - 2014

Year	Recharge				Discharge			
	Streambed Recharge	Deep Infiltration of Applied Water	Recycled Water Discharge to Ponds	Total	Groundwater Production	Evapotranspiration	Rising Groundwater Outflow	Total
1991	9,001	3,570	14	12,585	4,176	1,789	5,370	11,335
1992	8,597	3,491	35	12,123	4,415	1,399	6,309	12,123
1993	13,181	3,412	64	16,657	3,577	1,016	12,063	16,657
1994	6,971	3,287	53	10,310	3,074	1,789	5,448	10,310
1995	22,876	2,593	70	25,538	3,149	1,016	21,373	25,538
1996	7,773	2,563	64	10,400	2,795	1,596	6,010	10,400
1997	8,602	2,532	58	11,192	3,510	1,397	6,286	11,192
1998	16,689	2,502	90	19,281	2,968	1,016	15,297	19,281
1999	5,019	2,472	144	7,635	2,146	1,593	3,896	7,635
2000	7,380	2,441	257	10,079	3,503	1,399	5,176	10,079
2001	7,747	2,411	169	10,328	3,867	1,397	5,063	10,328
2002	4,823	2,370	186	7,379	4,033	1,397	1,949	7,379
2003	10,644	2,330	205	13,179	4,076	1,397	7,706	13,179
2004	9,551	2,289	213	12,053	2,924	1,399	7,730	12,053
2005	25,307	2,248	217	27,772	1,837	1,016	24,918	27,772
2006	24,065	2,239	226	26,531	747	1,593	24,190	26,531
2007	20,522	2,278	222	23,022	1,418	1,397	20,207	23,022
2008	14,893	2,317	212	17,423	2,157	1,399	13,866	17,423
2009	13,274	2,125	211	15,610	2,044	1,397	12,169	15,610
2010	10,230	2,133	207	12,570	1,549	1,397	9,624	12,570
2011	14,897	2,194	221	17,312	868	1,397	15,047	17,312
2012	5,525	2,185	202	7,912	716	1,399	5,796	7,912
2013	4,539	2,176	274	6,990	1,653	1,397	3,940	6,990
2014	2,523	2,167	575	5,265	1,981	1,397	1,887	5,265
Min	2,523	2,125	14	5,265	716	1,016	1,887	5,265
Max	25,307	3,570	575	27,772	4,415	1,789	24,918	27,772
Average	11,443	2,514	175	14,131	2,633	1,391	10,055	14,079

Table 2-6

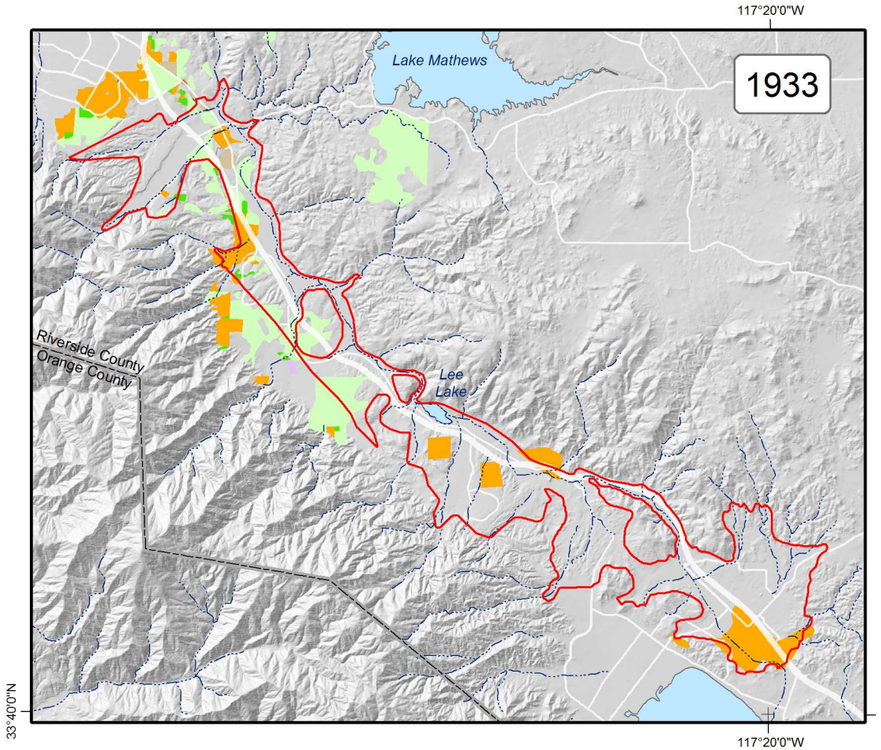
Deep Infiltration of Applied Water in the Upper Temescal Valley Watershed[†]

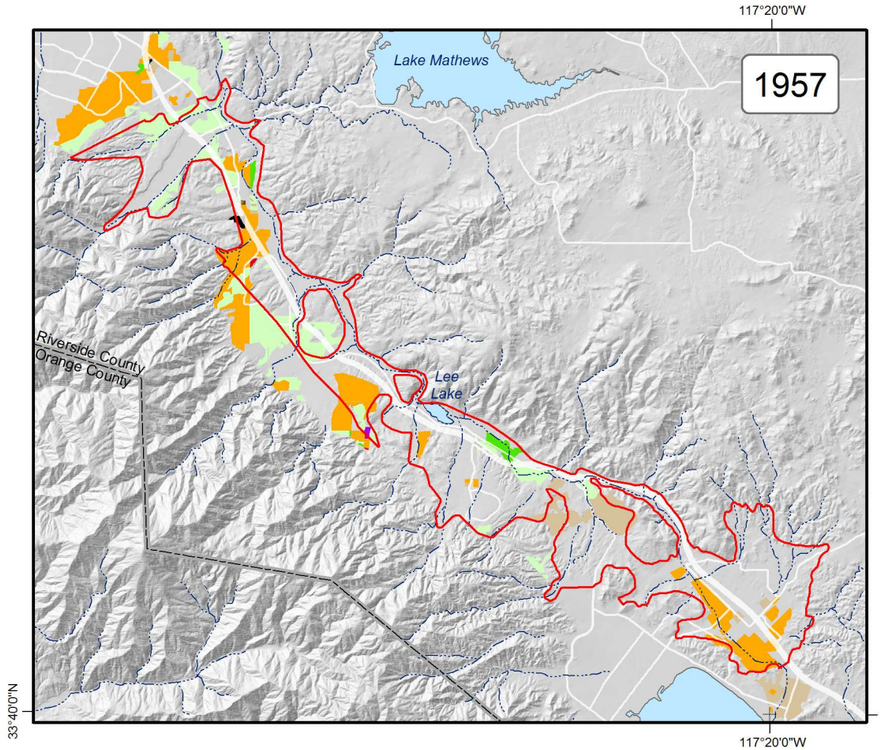
acre-ft per year

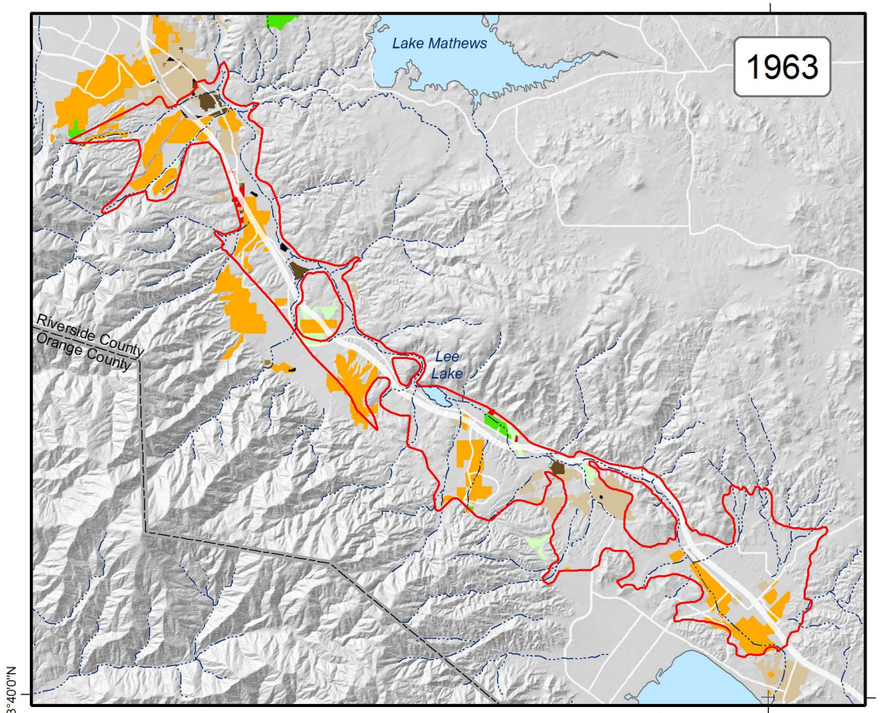
Land Use Type	Percent Impervious[1]	1933	1949	1957	1963	1975	1990	1993	2001	2005	2014	Build-out
Non-Irrigated Field Crops, Pasture, Fruits, and Nuts	2	0	0	0	0	0	0	0	0	0	0	0
Irrigated and Non-Irrigated Citrus	2	3,843	3,311	3,630	5,971	6,057	2,937	2,620	1,288	680	249	381
Irrigated Field Crops, Pasture, Fruits, and Nuts	2	150	150	196	1,504	1,765	199	230	358	582	635	967
Irrigated Vineyards	2	0	0	14	0	0	0	0	0	0	0	0
Dairies and Feedlots	10	0	0	5	25	18	0	0	0	0	0	0
Medium to High Density Urban Residential	75	35	188	342	496	788	187	216	398	555	807	995
Low Density Urban Residential	30	4	4	5	88	97	267	281	291	328	338	1,912
Commercial	90	0	0	0	0	0	13	17	25	41	60	384
Industrial	90	0	0	0	0	0	45	48	50	62	79	258
Special Impervious	95	0	0	0	0	0	0	0	0	0	0	0
Native Vegetation	2	0	0	0	0	0	0	0	0	0	0	0
Totals		**4,032**	**3,654**	**4,192**	**8,084**	**8,725**	**3,649**	**3,412**	**2,411**	**2,248**	**2,167**	**4,896**

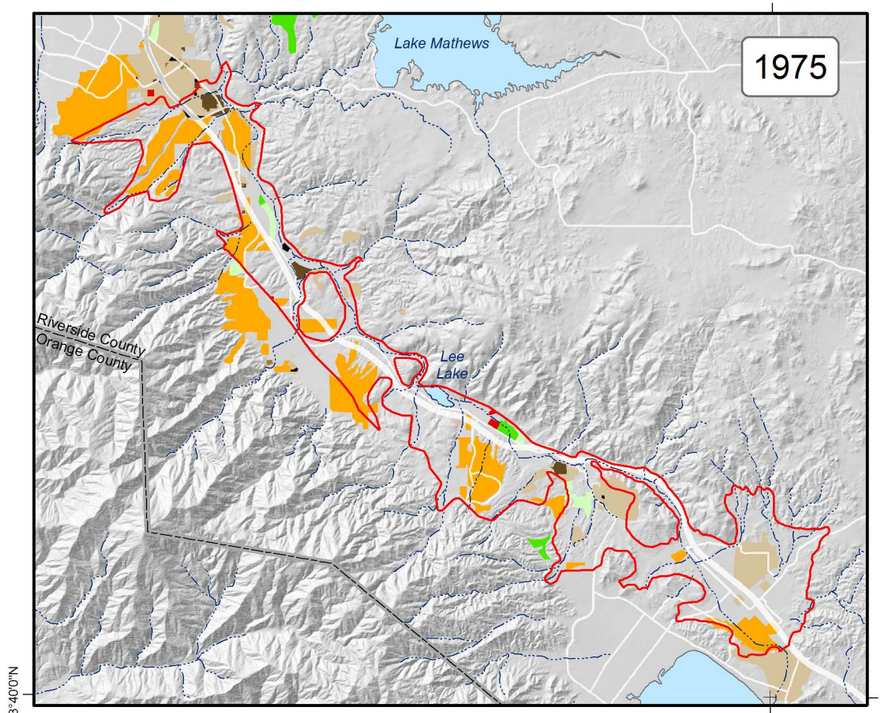
[†]Excludes the deep infiltration of applied water that is tributary to the Coldwater or Temescal GMZs

1 - Source: *2013 Chino Basin Groundwater Model Update and Recalculation of Safe Yield Pursuant to the Peace Agreement* , Table 7-2. October 2015.







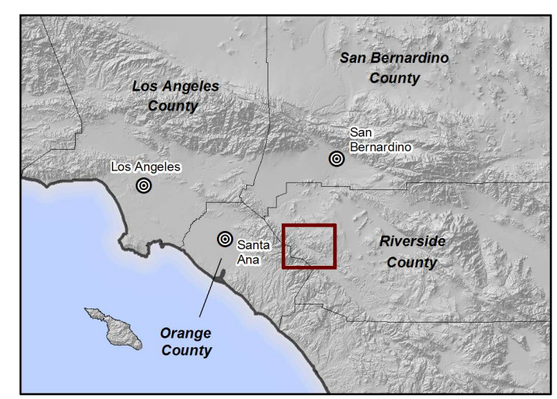


Land Use Type

- Native Vegetation
- Non-Irrigated Field Crops, Pasture, Fruit and Nuts
- Irrigated Field Crops, Pasture, Fruit and Nuts
- Irrigated and Non-Irrigated Citrus
- Dairies and Feedlots
- Undifferentiated Urban
  - Urban Residential
  - Urban Commercial
  - Urban Industrial
- Special Impervious

* Irrigated and non-irrigated vineyards land use not shown; only 1957 DWR land use maps show a total of 10 acres of irrigated vineyards within the Upper Temecal Valley.

Upper Temescal Vallley GMZ



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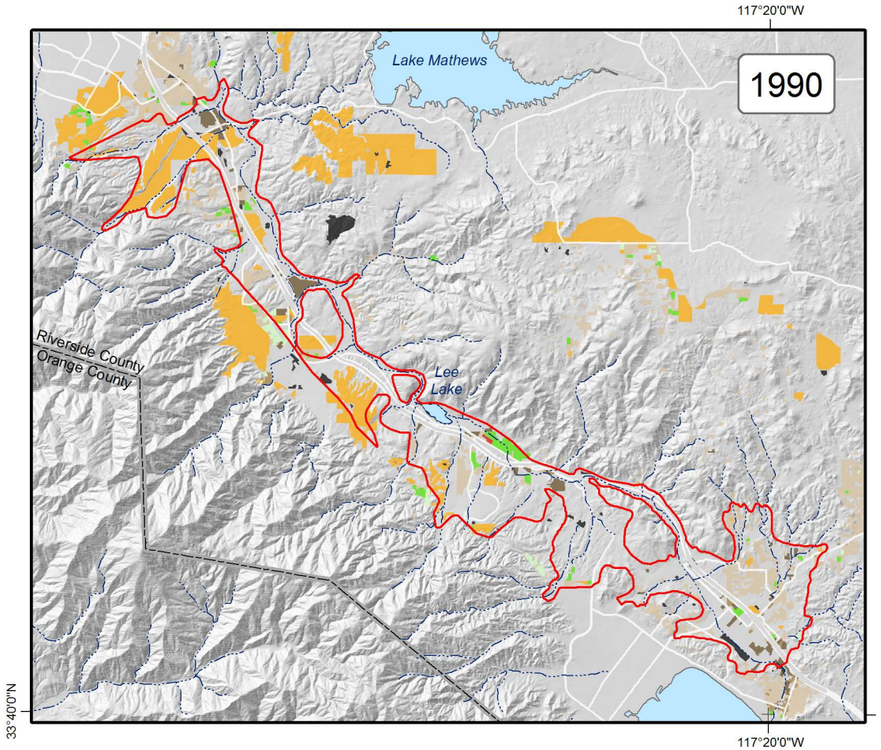
Author: GAR
Date: 8/4/2016
Document Name: Fig_2-1a_LandUse

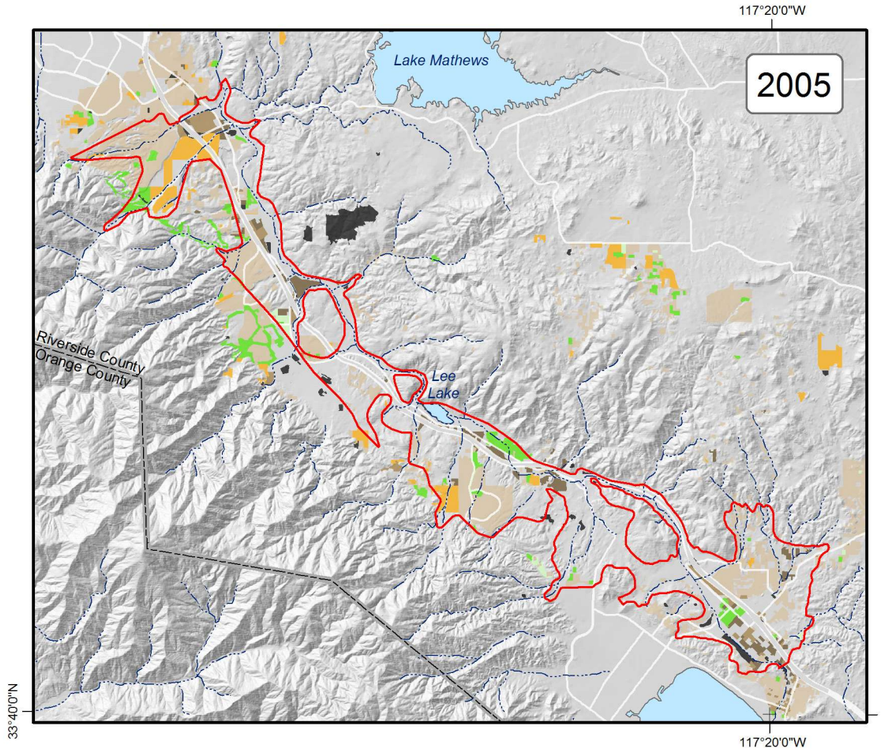
0 2 4 6 8 Miles
0 3 6 9 12 KM

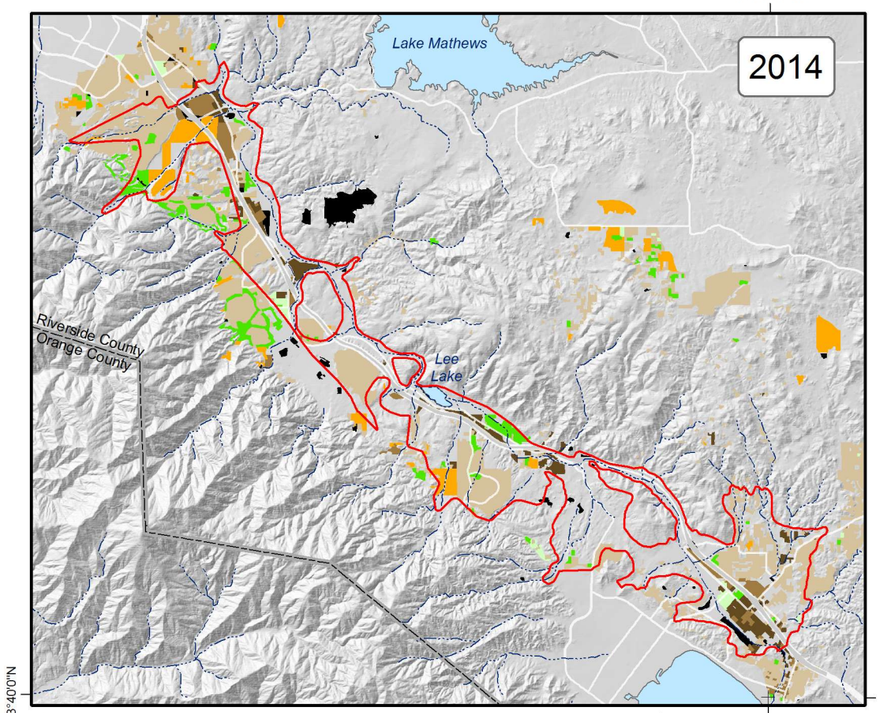
Upper Temescal Valley
Salt and Nutrient Management Plan

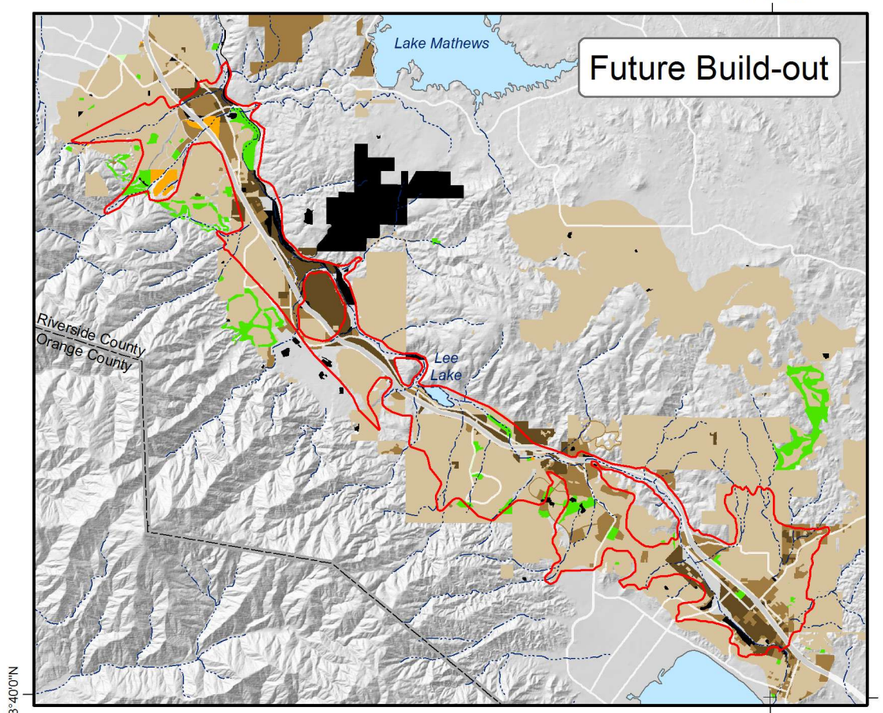
Land Use in the Upper Temescal Valley
1933, 1957, 1963, and 1975

Figure 2-1a







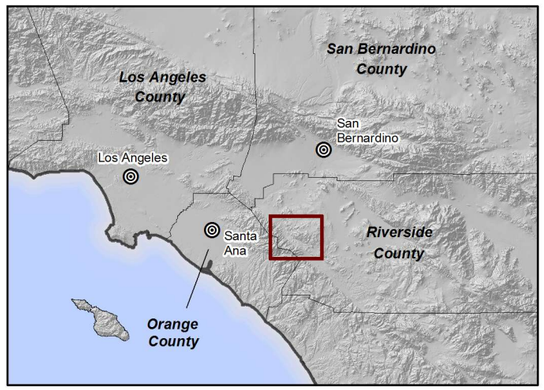


Land Use Type

- Native Vegetation
- Non-Irrigated Field Crops, Pasture, Fruit and Nuts
- Irrigated Field Crops, Pasture, Fruit and Nuts
- Irrigated and Non-Irrigated Citrus
- Dairies and Feedlots
- Undifferentiated Urban
  - Urban Residential
  - Urban Commercial
  - Urban Industrial
- Special Impervious

* Irrigated and non-irrigated vineyards land use not shown; only 1957 DWR land use maps show a total of 10 acres of irrigated vineyards within the Upper Temecal Valley.

Upper Temescal Vallley GMZ



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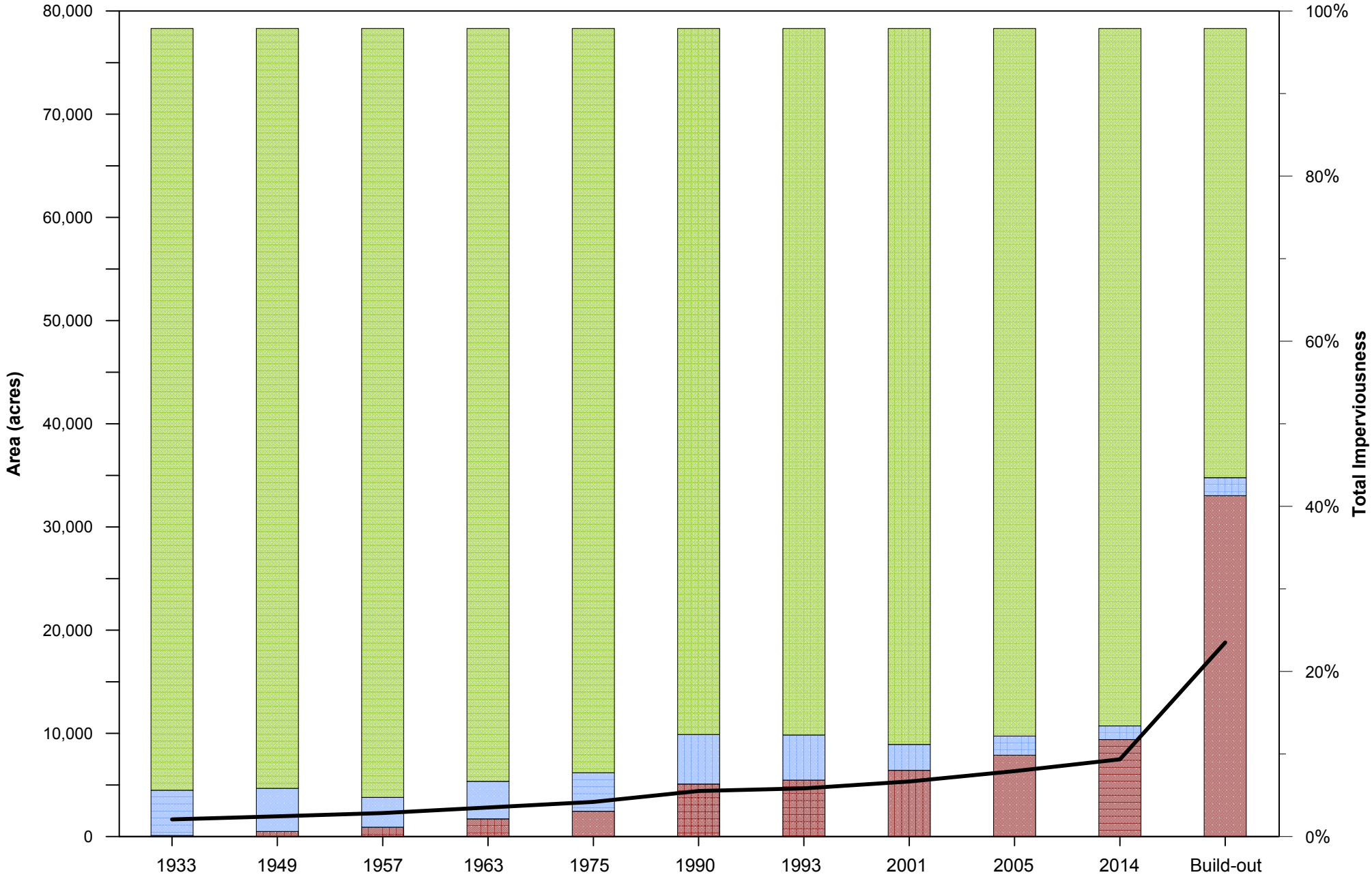
Document Name: Fig_2-1b_LandUse

0 2 4 6 8 Miles
0 3 6 9 12 KM

Upper Temescal Valley
Salt and Nutrient Management Plan

Land Use in the Upper Temescal Valley
1990, 2005, 2014, and Build-out

Figure 2-1b



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Author: CS
Date: 20160601

Urban
Agricultural
Native and Undeveloped
Total Imperviousness

Historical and Projected Distribution of Land Use and Imperviousness of the Upper Temescal Valley Watershed

Figure 2-2

117°20'0"W

All-American Aggregate Pit

Temescal GMZ

USGS 11072000

Lake Mathews

Corona No. 3 WRF

Bedford Wash

Upper Temescal Valley Watershed

Temescal Valley Water District WRF

Riverside County

Orange County

Bedford GMZ

El Sobrante de San Jacinto

Coldwater GMZ

15

Lee Lake Reservoir

Temescal Wash

Lee Lake GMZ

Horsethief WRF

Santa Ana Mountains

Warm Springs GMZ

Elsinore Valley Regional WRF

Railroad Canyon Reservoir

Elsinore GMZ

Eastern Combined RWRF Discharge

Lake Elsinore

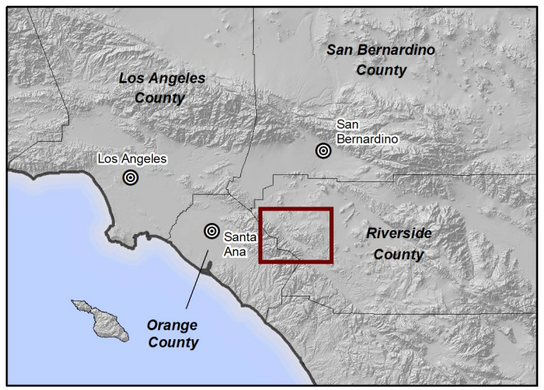
Station 067

33°40'0"N

117°20'0"W

Main Features

- Upper Temescal Valley Groundwater Management Zone (GMZ)
- Other GMZs
- Water Reclamation Facilities (WRF)
- Active WRF Discharge Points to Temescal Wash
- Inactive WRF Discharge Points to Temescal Wash
- Streams and Flood Control Channels
- Lakes and Flood Control Basins
- RCFC&WCD Rainfall Station
- USGS Gaging Station



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Document Name: Fig_2-3_Watershed

0 2 4 Miles

0 2 4 KM

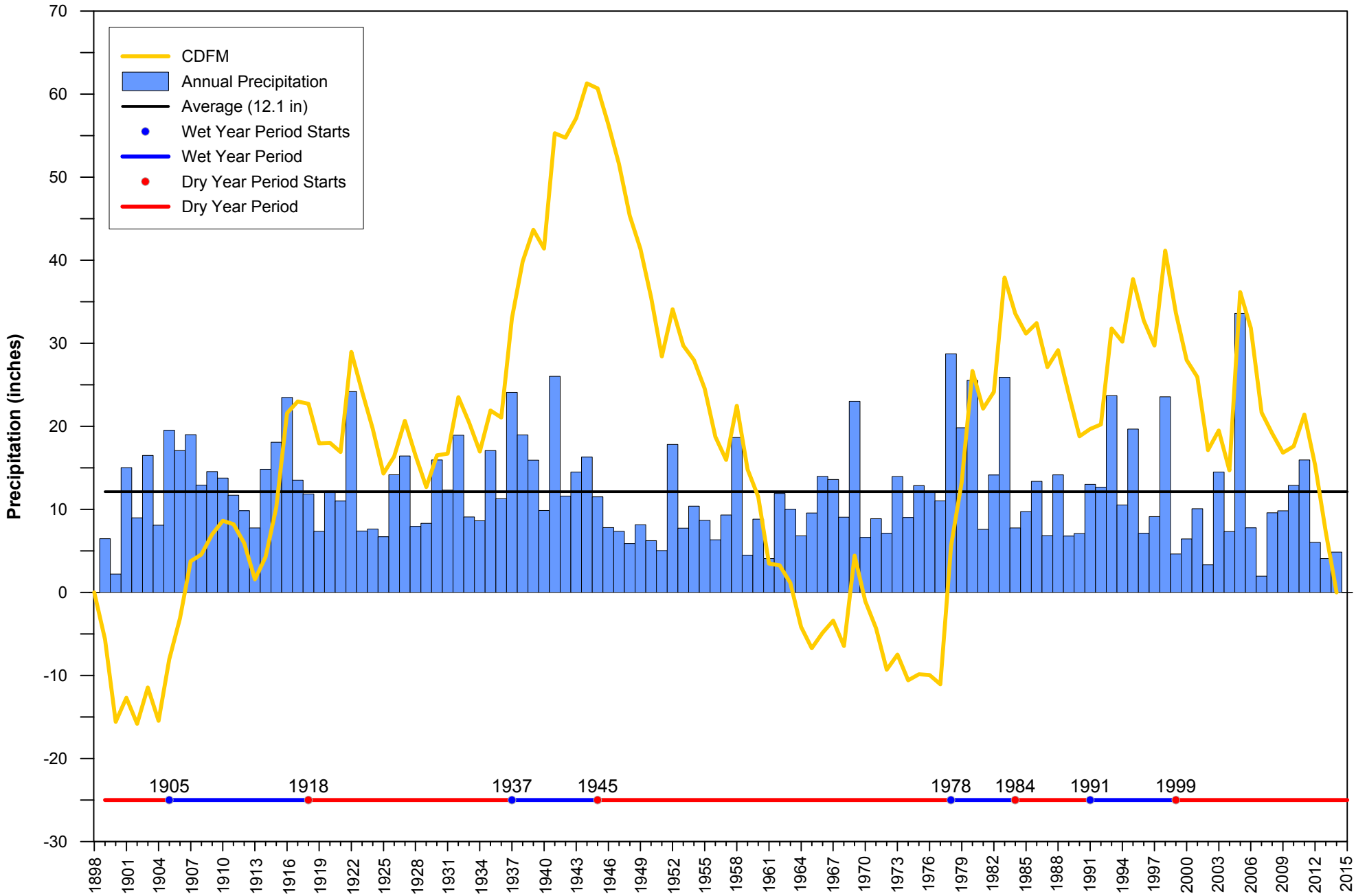
EVMWD

emwd Eastern Municipal Water District

Upper Temescal Valley
Salt and Nutrient Management Plan

Upper Temescal Valley Watershed

Figure 2-3



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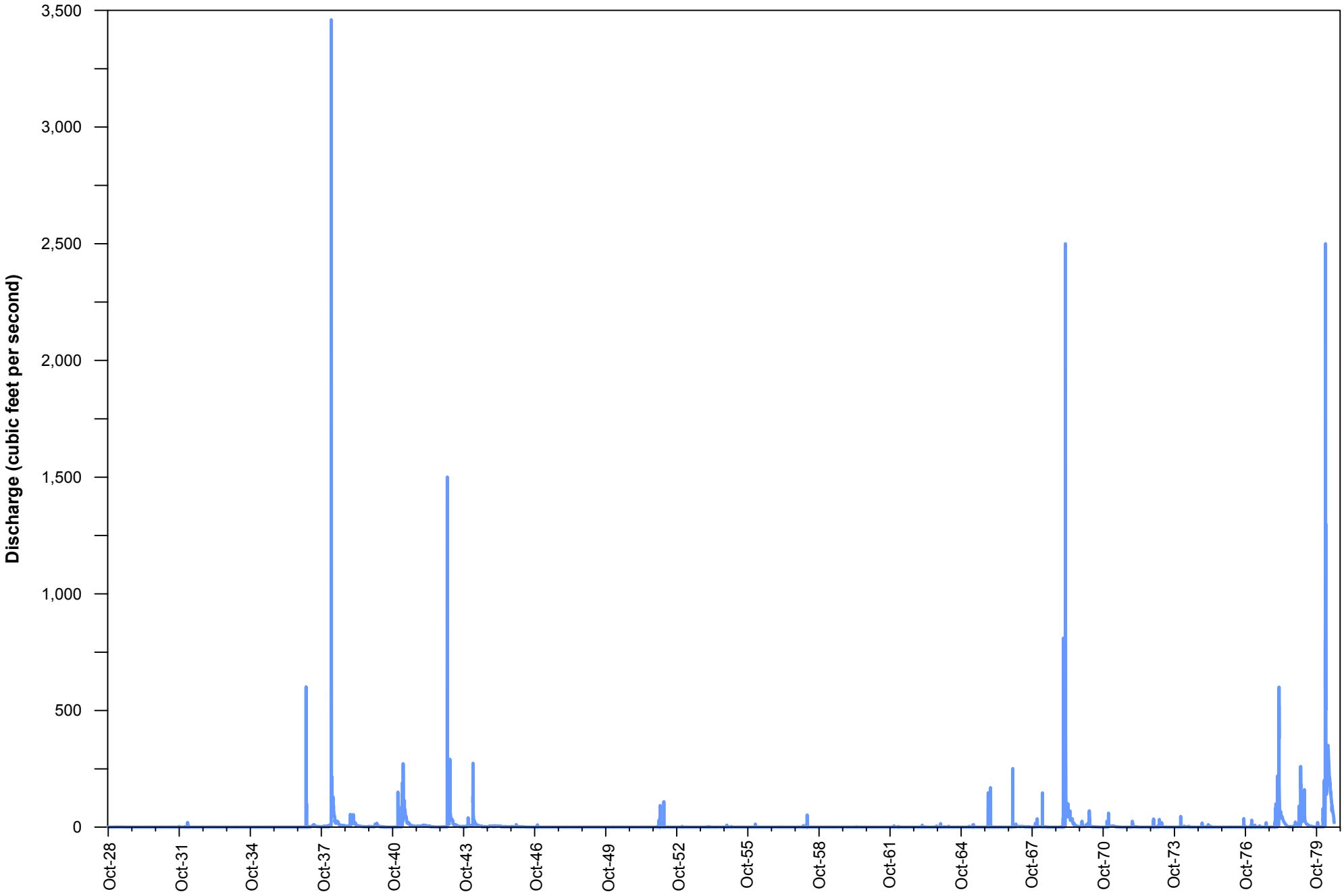
Annual Precipitation and Cumulative Departure from Mean Precipitation - Station Elsinore 067

Figure 2-4



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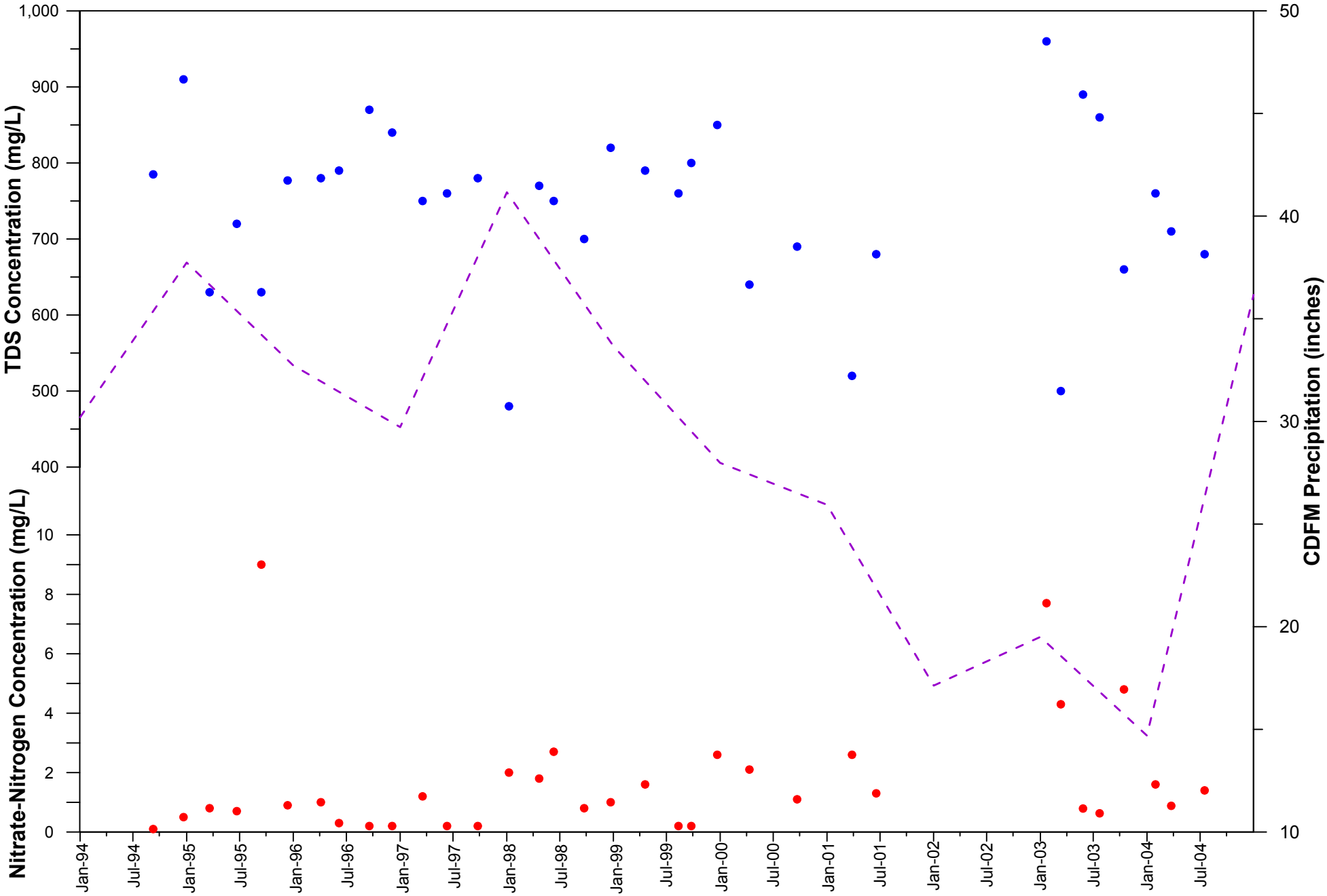
Daily Discharge for Temescal Creek near Corona
USGS Stream-Gage 11072000: Water Year 1929 to 1979

Figure 2-5



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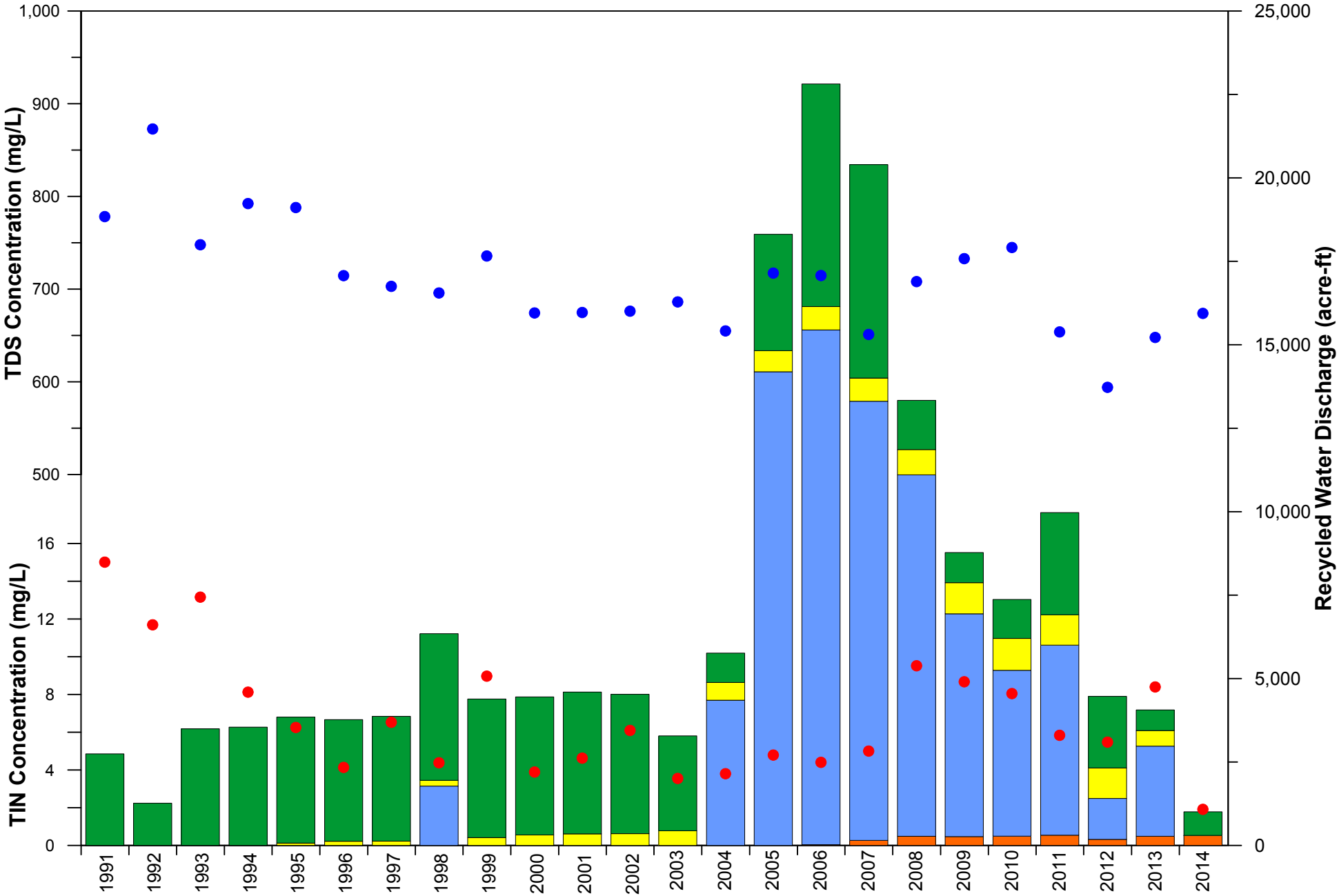
Date: 20160601

* Based on precipitation from Lake Elsinore Station 067 over period from 1898-2014.

TDS and Nitrate-Nitrogen Concentrations of Outflow from All-American Aggregate Pit

Figure 2-6



Total Volume-Weighted TDS
Total Volume-Weighted Nitrate-Nitrogen
EVMWD
Corona 3A
EMWD
LLWD

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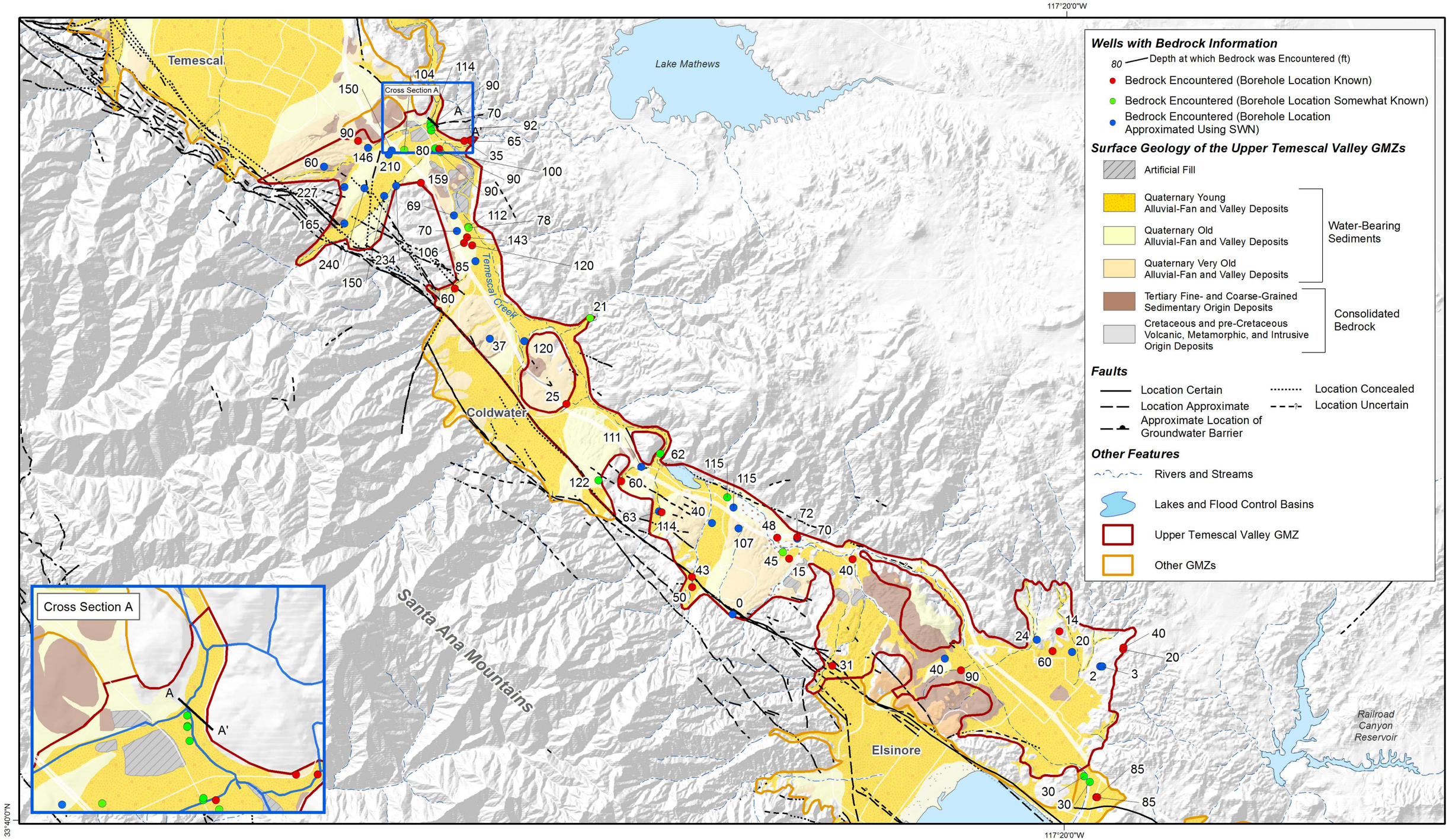
Date: 20151014
File: Fig_2-6

Recycled Water Discharges and Volume-Weighted TDS and Nitrate-Nitrogen Concentrations to Temescal Wash in the Upper Temescal Valley GMZ, 1991-2014

Figure 2-7



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Author: GAR
Date: 20160531
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0 1 2 3 4 Miles
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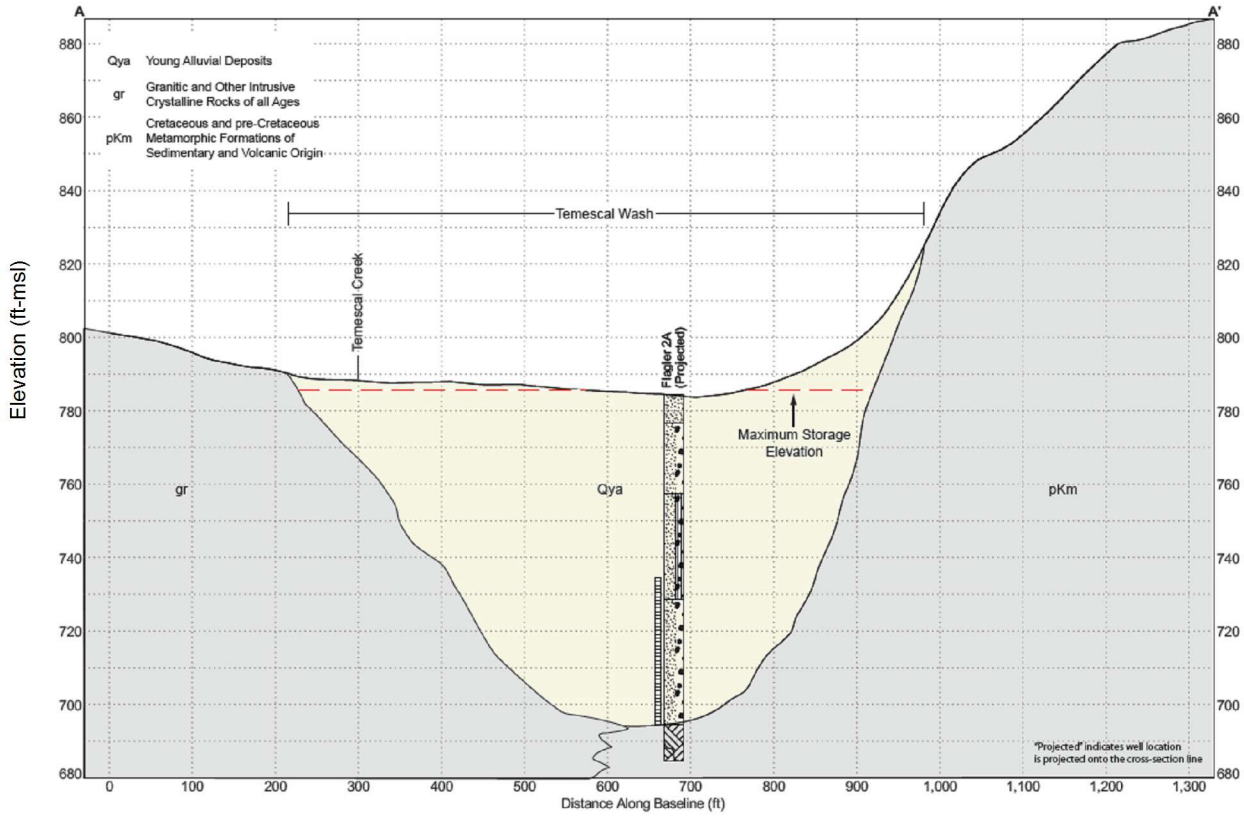
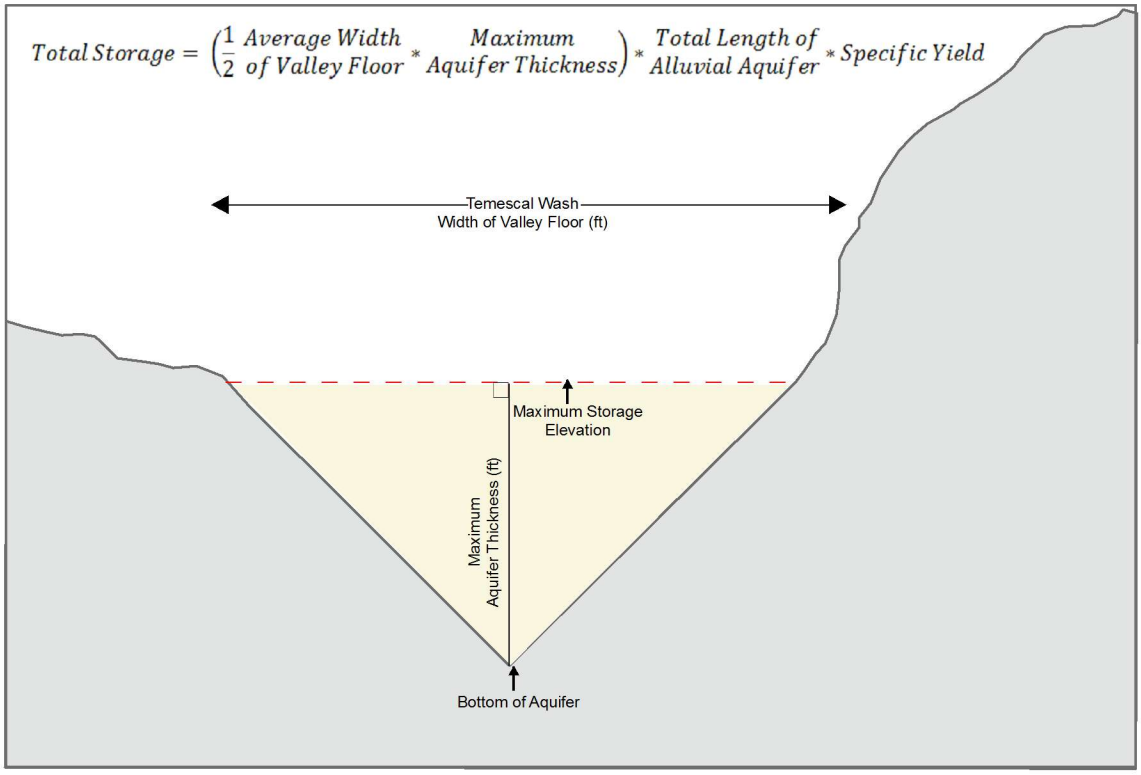
Upper Temescal Valley
Salt and Nutrient Management Plan

Surface Geology and Depth to Bedrock at Wells with Lithology Logs

Figure 2-8





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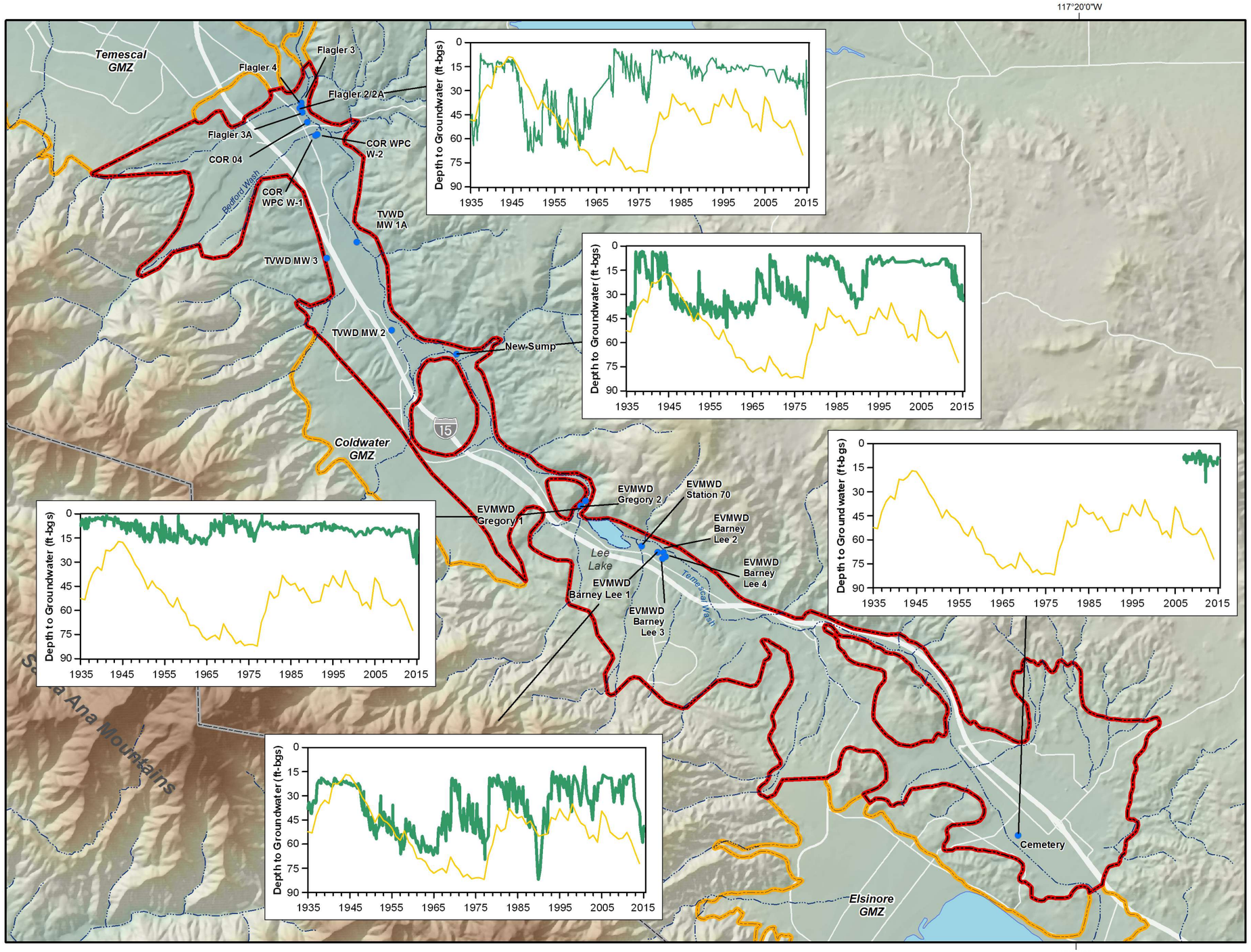
Cross Section of the Alluvial Aquifer in the Upper Temescal Valley GMZ

Figure 2-9



Wells with Groundwater Level Data, 1935-2014

Wells

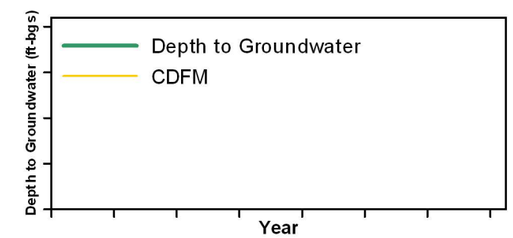
Other Features

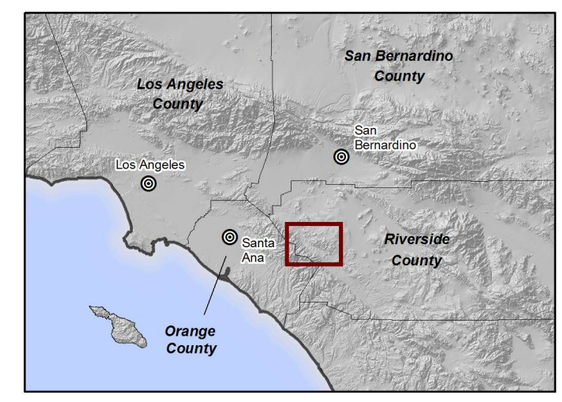
Upper Temescal Valley GMZ

Other GMZs

Streams and Flood Control Channels

Lakes and Flood Control Basins





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Date: 10/31/2016
Document Name: Fig_2-10_GWL_wellsv2

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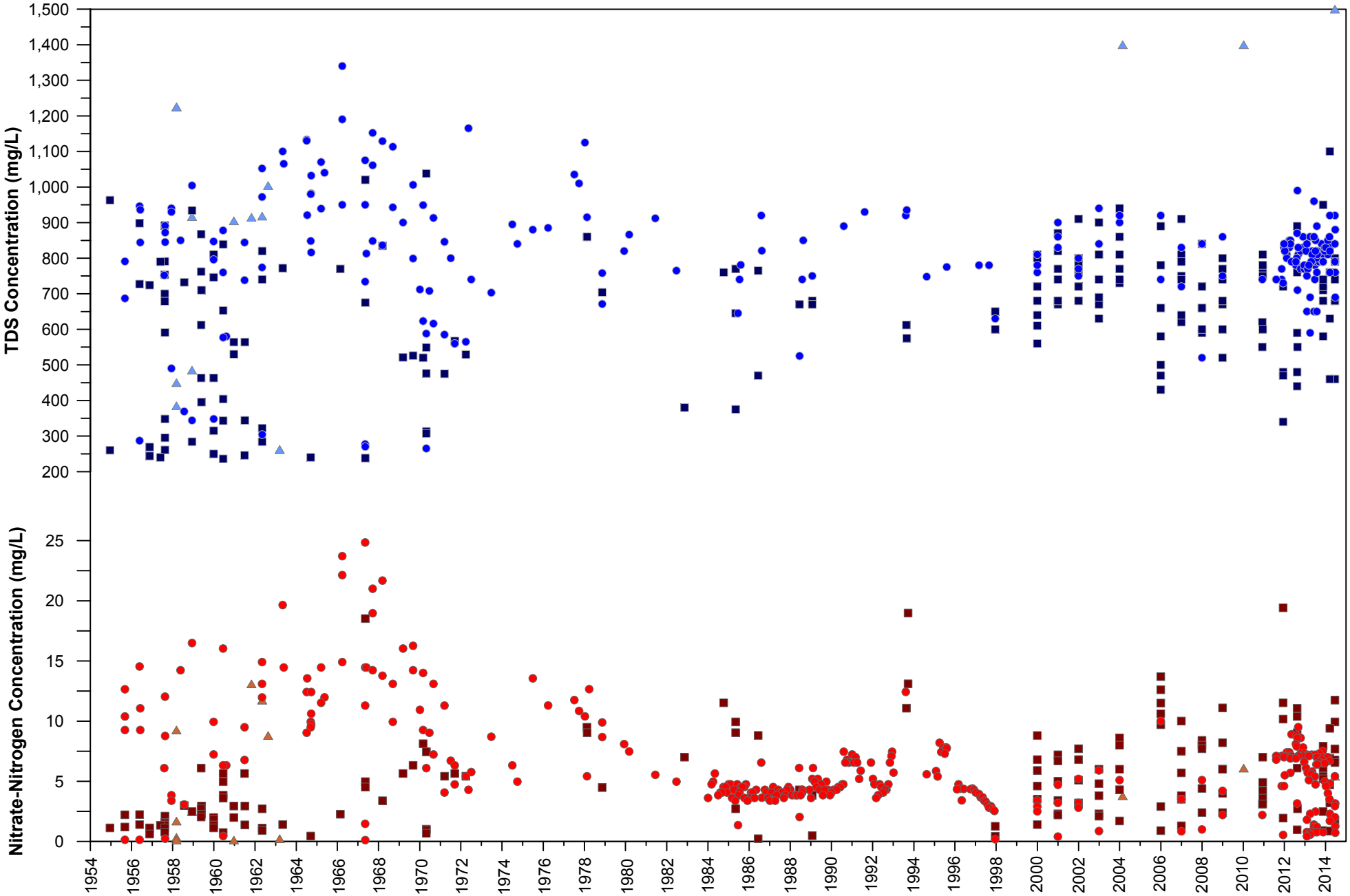
Wells with Groundwater Level Data in the Upper Temescal Valley GMZ, 1935-2014

Figure 2-10



Bedford
Lee Lake
Warm Springs

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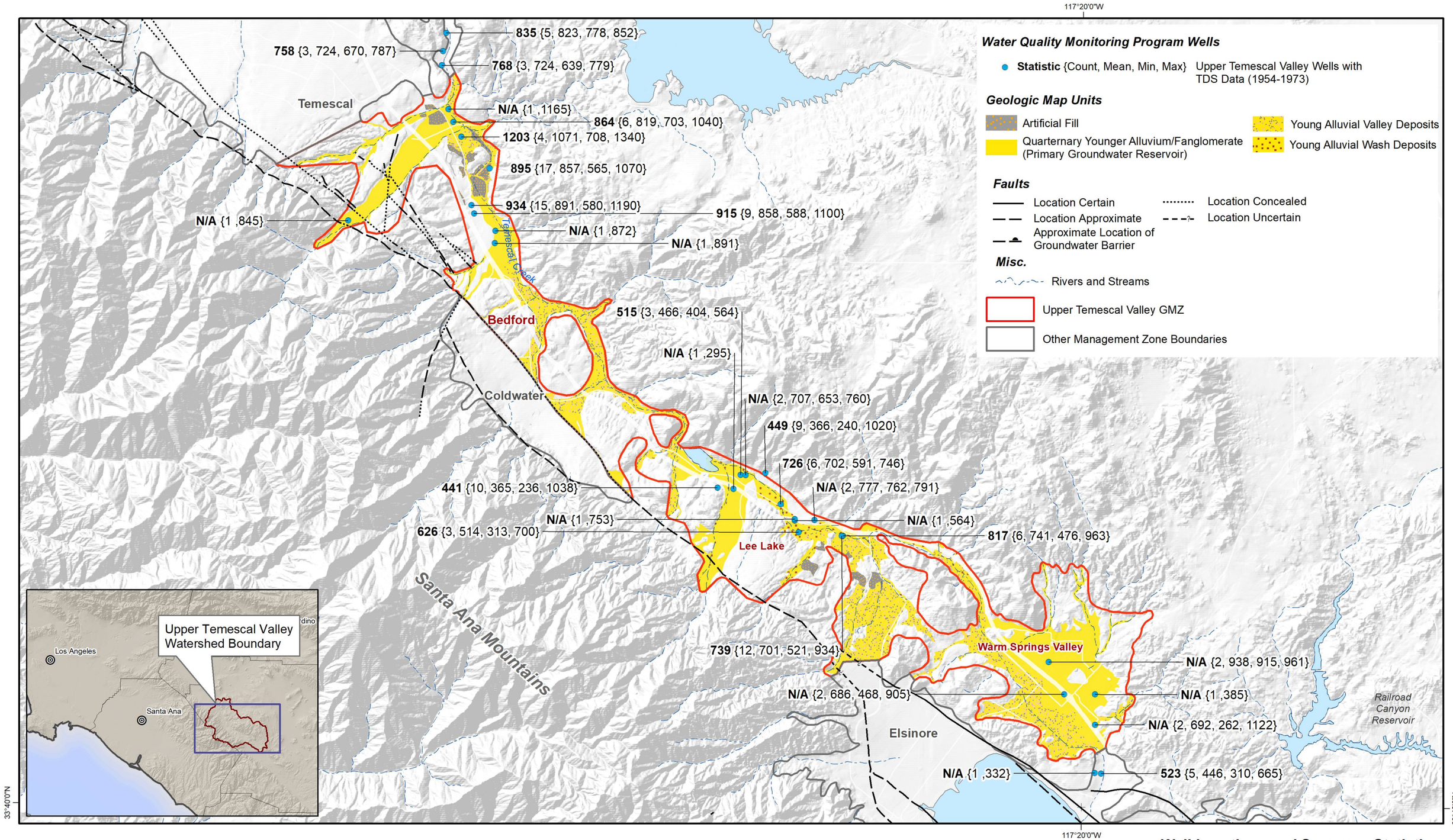
TDS and Nitrate-Nitrogen Concentrations of All Wells in the Upper Temesal Valley GMZ

Figure 2-11



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Date: 20140507
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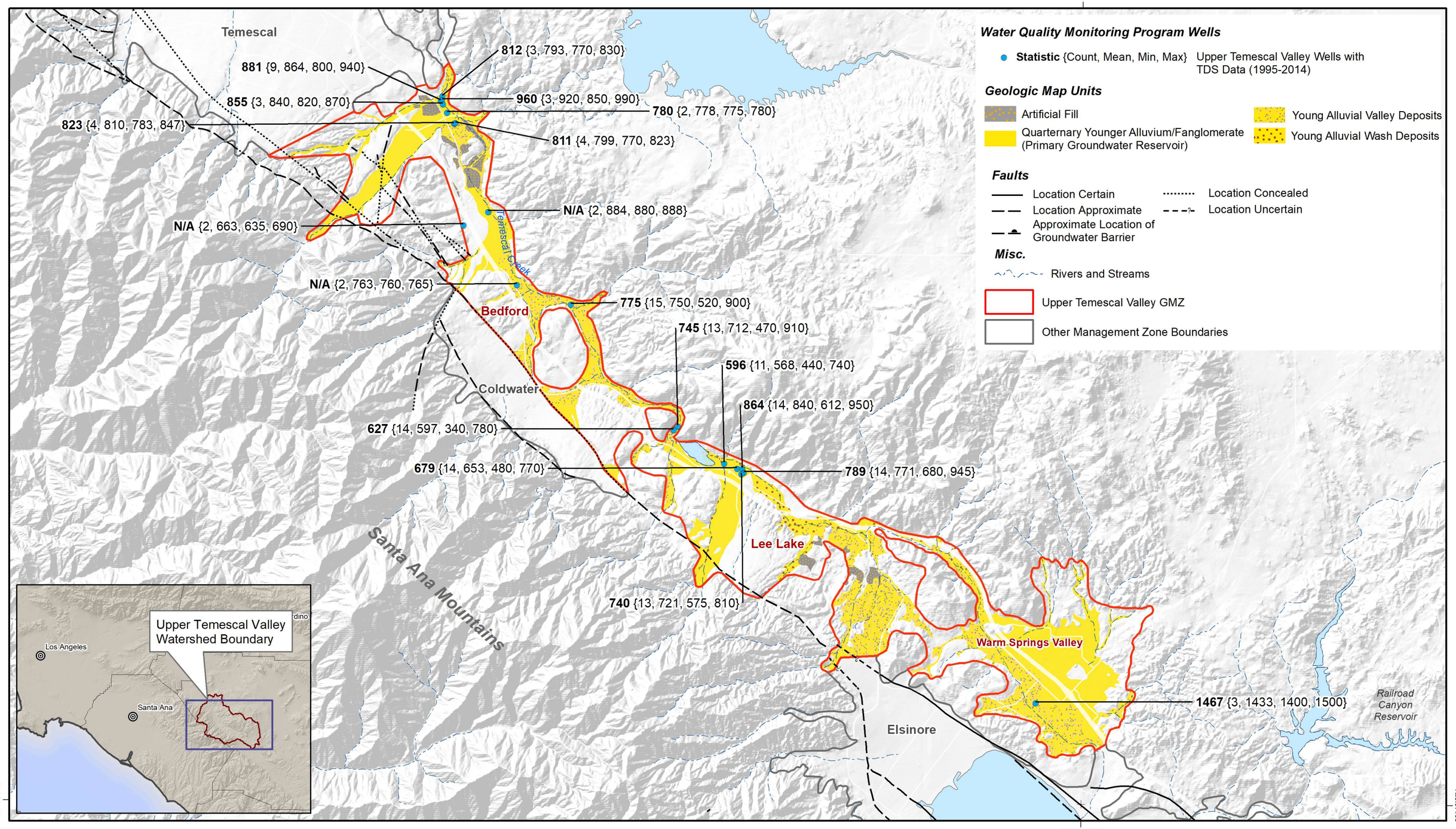
Well Locations and Summary Statistics of TDS Concentrations for Wells with Data over the Objective Setting Period, 1954-1973

Figure 2-12



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Date: 20140507
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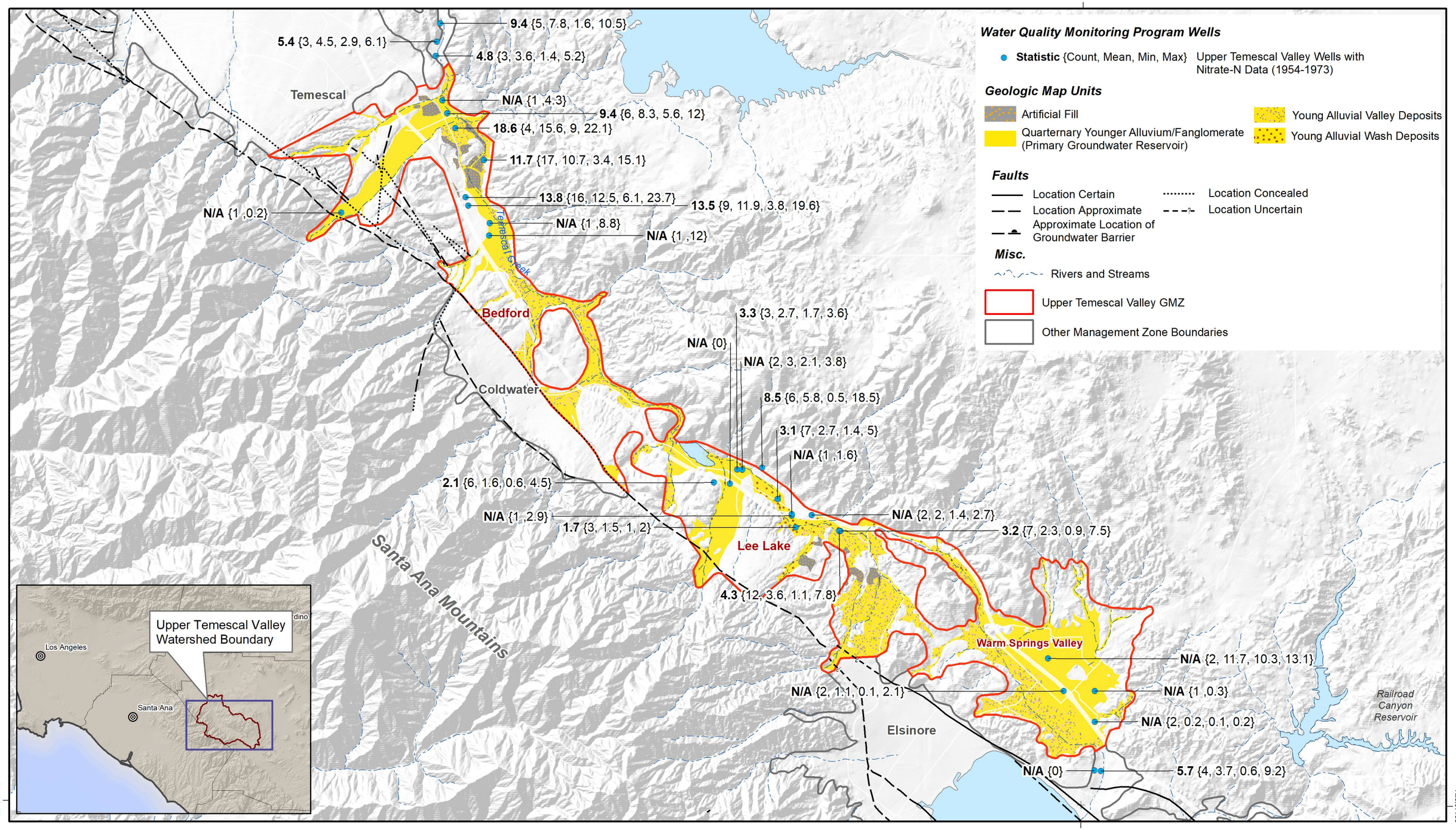
Well Locations and Summary Statistics of TDS Concentrations for Wells with Data over the Current Ambient Period, 1995-2014

Figure 2-13



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Author: CS
Date: 20140507
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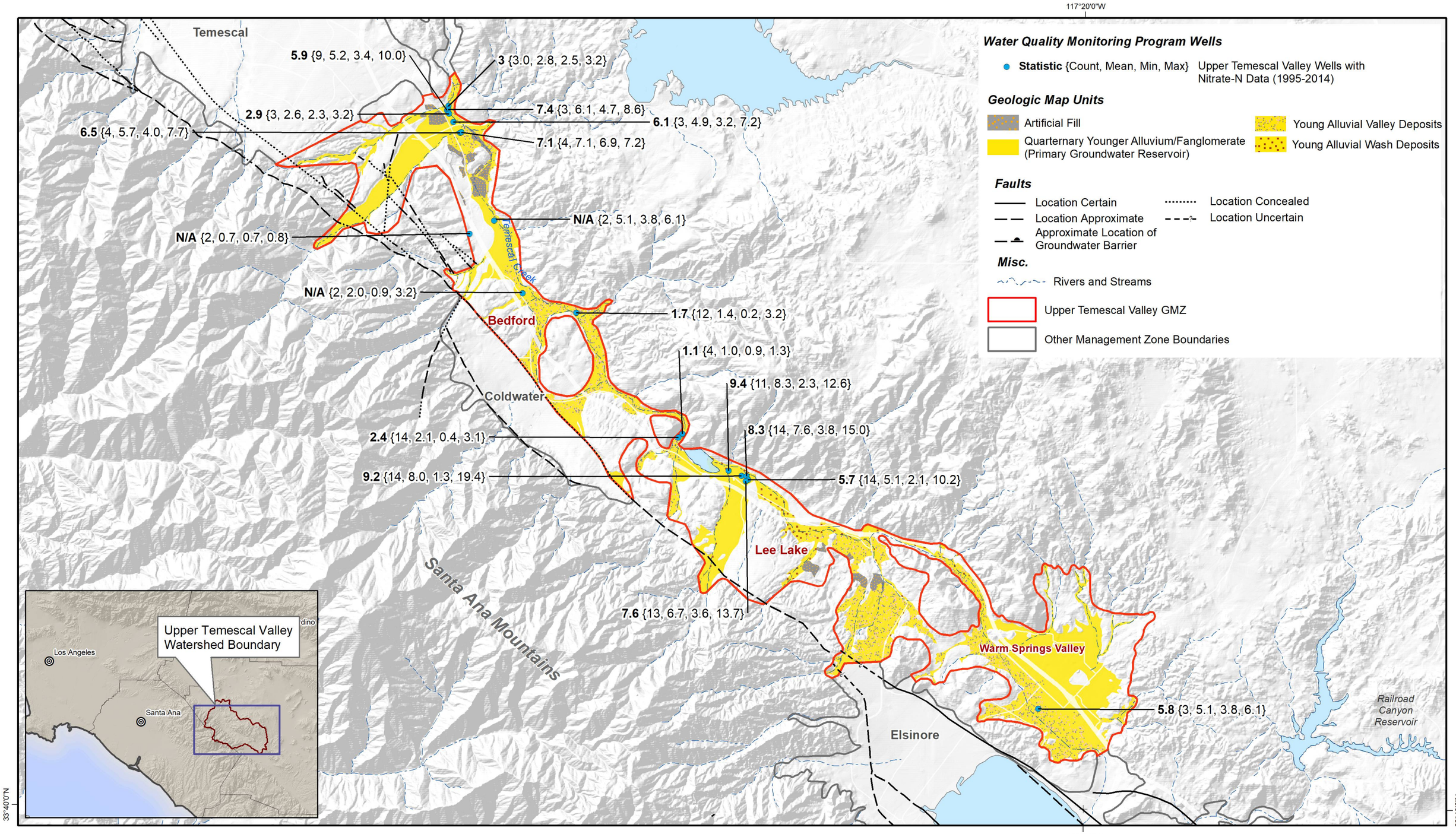
Well Locations and Summary Statistics of Nitrate-N Concentrations for Wells with Data over the Objective Setting Period, 1954-1973

Figure 2-14



Prepared by:

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Wildermuth Environmental, Inc.

Author: CS
Date: 20140507
File: UTV_MWs_fig1_WQ.mxd

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Upper Temescal Valley
Salt and Nutrient Management Plan

Well Locations and Summary Statistics of Nitrate-N Concentrations for Wells with Data over the Current Ambient Period, 1995-2014

Figure 2-15

Section 3 – Historical Ambient Water Quality

This section describes the methodology developed and used to compute historical ambient TDS and nitrate concentrations in the Upper Temescal Valley GMZ. The historical ambient TDS and nitrate will be based on the same 20-year time period used to set the antidegradation objectives in the rest of the Santa Ana Watershed: 1954 to 1973.

3.1 Constantly Stirred Reactor Model Methodology

WEI developed a CSRM to recreate the time-history of the volume-weighted TDS and nitrate concentrations in the Upper Temescal Valley GMZ for the 1954-1973 period. In a CSRM, fluid particles enter a reactor and are instantaneously dispersed throughout the reactor volume. The fluid particles leave the reactor in proportion to their statistical population. This approximation is used to study lakes and reservoirs with continuous inputs and outputs (see, for example, Tchobanoglous & Schroeder, 1987). The extension of this approach to a groundwater basin provides a first-order approximation of the time scale of TDS and nitrate concentration changes.

The CSRM methodology was first used in the Santa Ana Watershed by Water Resources Engineers, Inc. (Water Resources Engineers, Inc., 1969) and formed the basis of the Regional Board's Basin Planning process through the mid-1990s. The CSRM approach is often used by the Regional Board for antidegradation analyses—studies that are meant to provide a first-order approximation of future TDS and nitrate concentrations in GMZs with and without permitted waste discharges.

The approach is as follows:

- Estimate the volume of water in storage and the volume-weighted TDS and nitrate concentrations of the groundwater basin at the start of the simulation period (initial conditions).
- For each time step, the following are performed:
    - Estimate the recharge and discharge volumes, and the change in storage.
    - Estimate the TDS and nitrate concentrations for each recharge component.
    - Assume that the TDS and nitrate concentrations of each discharge are equal to the TDS and nitrate concentrations at the end of the previous time step.
    - Estimate the TDS and nitrate masses in the reactor.
    - Estimate the TDS and nitrate concentrations in the reactor at the end of the time step.

Put simply, the water volume and constituent mass balance for a groundwater basin is:

Recharge – Discharge = Change in Storage

For TDS and nitrate concentrations, an explicit finite-difference approximation is used:

$$VGW_t * CGW_t + \sum_t [R_j * C_j] - \sum_t [D_k * CGW_t] = VGW_{t+1} \times CGW_{t+1}$$

Where:

$\boldsymbol{VGW_t}$	is the volume of groundwater in storage at the beginning of year t
$\boldsymbol{CGW_t}$	is the concentration of groundwater at the beginning of year t
$\boldsymbol{R_j}$	is the volume of the jth recharge term in year t
$\boldsymbol{C_j}$	is the concentration of the jth recharge in year t
$\boldsymbol{D_k}$	is the volume of the kth discharge term in year t
$\boldsymbol{VGW_{t+1}}$	is the volume of groundwater in storage at the beginning of year t +1
$\boldsymbol{CGW_{t+1}}$	is the concentration of groundwater at the beginning of year t +1

The mass balance is solved for CGW_{t+1}, which represents the volume-weighted TDS concentration of the reactor, or GMZ.

The 20-year series of volume-weighted average concentrations for 1953-1974 is used to develop an estimate of the ambient water quality of the GMZ and thus the antidegradation objectives.

In the standard methodology for computing ambient water quality, the TDS and nitrate sample results at individual wells are averaged for each calendar year where more than one water quality observation occurred during that year. Thus, only one value per year, the annual average, is used in the computation of ambient water quality. Then, the annualized average values are subjected to statistical tests for normality and outliers. After any outliers are removed, the average of the annualized averages is computed and is referred to as the mean. Finally, the standard deviation and standard error of the mean are computed. The so-called ambient water-quality statistic for each well is computed as follows:

$$AWQ\ Statistic = mean\ +\ (t * standard\ error\ of\ the\ mean)$$

To mimic this process, the mean and standard error of the mean of the volume-weighted TDS and nitrate concentrations are computed to develop a final ambient water quality estimation, where the mean in this case is the average of the 20 annual volume-weighted concentrations computed by the CSRM for 1954 to 1973.

3.2 Derivation of CSRM Input Terms

The CSRM input terms are:

- Initial conditions – the volume and TDS and nitrate concentrations of groundwater in storage for 1954
- Recharge terms – the annual volume and TDS and nitrate concentrations of streambed recharge[16] and deep infiltration of applied water
- Discharge terms – the annual volume of groundwater production, ET, and rising groundwater

[16] Recall that the sources of surface water that contribute to streambed recharge include storm-water, dry-weather runoff, and recycled water. In the case of the historical period, recycled water discharge is zero.

In a typical CSRM analysis, the initial conditions (storage volume and water quality) are known and the recharge and discharge fluxes are generally well understood. In this investigation, where the historical conditions are being recreated and the groundwater hydrogeology has not been completely characterized, there is uncertainty as to the initial conditions, the storage limitations, and the precise concentrations of the recharge terms. However, because the available groundwater level, production, and quality data provide a reasonable understanding of storage and water quality trends in the Upper Temescal Valley GMZ, these data can be used to dial in the hydrologic fluxes. In other words, input parameters to the CSRM can be calibrated within a range of reasonable expected values to generate a basin-wide, volume-weighted TDS and nitrate concentration time history that best represents the water quality trends observed at wells in the Upper Temescal Valley.

A parameter testing procedure was executed as follows:

- For each CSRM input term, estimate the range of reasonable values based on the available data.
- Using the CSRM, test the range of reasonable values for one to two parameters at a time, keeping all other parameters constant.
- Create a time-history plot comparing the CSRM output concentration for each annual time step to the measured TDS concentrations at all wells in the Upper Temescal Valley GMZ from 1950 to 1975.
- Eliminate parameter values that do not produce a volume-weighted TDS and nitrate concentration time-history that is representative of measured groundwater quality at wells.
- Repeat process until all unknowns are known.

As an example, Figure 3-1 shows the CSRM TDS time-histories produced for a range of initial storage volumes (50, 75, and 100 percent of full) for three plots, each with a different assumption for the total storage capacity, as estimated in Section 2.4.3 (25,000, 50,000 or 75,000 acre-ft). All other initial parameter values are held constant. In this example, the parameter testing procedure indicates that the model projection is insensitive to the initial volume of water in storage. The CSRM produces nearly the exact same water-quality time-history for each assumed storage capacity whether the initial condition is 50 percent, 75 percent, or 100 percent full.

Figure 3-1 also illustrates that a total storage capacity of 25,000 acre-ft is not a reasonable estimate for the Upper Temescal Valley GMZ. The time history of the volume-weighted TDS concentration produced by the CSRM when the storage capacity is 25,000 acre-feet does not reasonably represent the data at wells: at this small storage volume, the model is very sensitive to high-volume storm-water recharge events (see, for example, the CSRM-estimated TDS concentration for the 1969 time-step compared to well measurements in 1969 and shortly thereafter). This example illustrates the importance of accurately representing the entire 20-year time history of the TDS concentration. Given that each of the 20 volume-weighted annual averages will be used to compute the ambient water quality for the period, it is important that individual values are not unreasonably high or low as compared to actual observed water quality in the basin as such a result could skew the final result.

Inset Table 3-A on the following page summarizes the parameters tested, the range of parameter values evaluated, and the final parameter value selected for the uncertain CSRM input terms.

Table 3-A
Range of Parameter Values Tested and the Selected Parameter Value for Each CSRM Input Term for the Historical Period

CSRM Input Parameters	Range of Parameter Values Tested	Sensitivity of Results to Parameter	Selected Parameter Value
Storage Capacity (acre-ft)	25,000 - 75,000 [17]	Sensitive	75,000
Initial Storage Volume (% full)	50 - 100	Insensitive	100
Initial TDS Concentration (mg/L)	250 – 1,250 [18]	Insensitive as to end of period concentration; Sensitive for 20-year average AWQ	750
TDS of Deep Infiltration of Applied Water (mg/L)	600 – 1,800 [19]	Sensitive	1,200
Rising Groundwater (acre-ft)	Set to increase/decrease with climate conditions vs. limit storage near 95% of full	Sensitive	Set to limit groundwater storage near 95% of full
Initial Nitrate-N Concentration (mg/L)	1 – 15 [20]	Insensitive as to end of period concentration; Sensitive for 20-year average AWQ	4
Nitrate-N of Deep Infiltration of Applied Water (mg/L)	10 – 30 [21]	Sensitive	14

The derivation of the remaining input terms is described in the following subsections.

[17] Based on storage capacity estimates made in Section 2.4.3 of this report.

[18] Range of values selected based on range of observed TDS concentration measurements at wells in the early 1950s, as described in Section 2.4.5 of this report.

[19] Based on range of expected values based on source water supplies available, as described in Section 2.2.2 of this report.

[20] Range of values selected based on range of observed TDS concentration measurements at wells, as described in Section 2.4.5 of this report.

[21] Based on range of reasonable values for regional practices, as described in Water Resources Engineers, Inc., 1970a.

3.2.1 Streambed Recharge

The streambed recharge for the 1954 to 1973 period was estimated using WEI's WLAM. The Temescal Wash is included in the current version of the WLAM utilized by the Basin Monitoring Program Task Force (Task Force) and the Regional Board (WEI, 2002; WEI, 2009; and WEI 2014a). The WLAM computes daily discharge at locations throughout the Santa Ana River watershed, the TDS and nitrogen concentrations of that discharge, and the streambed recharge and associated TDS and nitrogen concentrations of that recharge. The Regional Board and the Task Force use the WLAM to evaluate the efficacy of NPDES permits for publically owned treatment works that discharge recycled water to the Santa Ana River and its tributaries and incorporate their findings from the WLAM into Basin Plan amendments.

WEI refined and updated the Temescal Wash reach of the WLAM and subsequently recalibrated the model to estimate storm-water runoff and recharge to the groundwater system underlying the Temescal Wash for the period 1928 through 1980. Inset Table 3-B summarizes the refinements made to the model to characterize historical storm-water recharge in the Upper Temescal Valley GMZ.

Table 3-B
Summary of Improvements to the Temescal Wash Reach of the WLAM

Model Attribute	Temescal Wash Reach in 2009 WLAM Update (WEI, 2010)	Temescal Wash Reach in 2014 for Historical Evaluation
Precipitation Estimates (see Figure 3-2)	6 gages with spatial distribution based on Theissen Polygons	2 gages with spatial distribution based the PRISM[22] data set and local temporal distribution based on the gages
Hydraulic Simulation Areas (see Figure 3-3)	23 HSAs	88 HSAs
Router Configuration (see Figure 3-4)	19 nodes and 18 reaches	70 nodes and 71 reaches
Basis of Channel Geometry	1980s Regional Board QUAL2E model data and field measurements	2008 HEC-RAS files from Riverside County as used in the FEMA Flood Insurance Maps
Calibration Station and Period (See Figure 3-4)	USGS 11072100; 1995 through 2005	USGS 11072000; 1928 through 1980

The precipitation data used in the WLAM version used by the Regional Board and the BMPTF is based on six precipitation stations located in and adjacent to the Temescal Wash Watershed. Daily precipitation for each hydrologic simulation area (HSA) is based on the location of the

[22] http://www.prism.oregonstate.edu/

center of the HSA within a Theissen polygonal network formed by these precipitation stations. In the refined version of the WLAM used herein, WEI estimated the monthly precipitation for each HSA based on the PRISM[23] dataset, which provides an estimate of the precipitation for 800-meter square grid cells distributed over the watershed. These monthly precipitation estimates for each HSA were converted to daily estimates based on two precipitation stations with complete records for the period of 1928 through 1980. Figure 3-2 shows the watershed boundary and compares the Thiessen polygonal network to the PRISM grid. The conversion to the precipitation estimates based on the PRISM dataset has improved the spatial and temporal accuracy of the historical precipitation used in the WLAM for the watershed tributary to the unlined reach of the Temescal Wash.

The spatial resolution of the WLAM was refined to enable more refined stream discharge and streambed recharge estimates and to improve the accuracy of these estimates. The refinements included the division of the watershed into smaller and discrete HSAs and incorporating a more refined channel geometry. The number of HSAs was increased from the 23 used in the prior versions of the WLAM to 85 in the refined version used herein.

The prior versions of the WLAM used channel geometry developed by the Regional Board in the 1980s for water quality investigations with the QUAL2E model. The refinement in the version used herein incorporated the channel geometry developed by Riverside County and used in a HEC-RAS model. WEI acquired this channel geometric data and incorporated it directly into the WLAM. The County's channel geometry is based on survey data and more refined topographic mapping than the Regional Board's QUAL2E model. The County last updated its HEC-RAS model of Temescal Wash in 2008. Incorporation of the County's more refined channel geometry improved the accuracy of the hydraulic routing of storm water through the watershed and storm water recharge over those estimates from prior versions of the WLAM.

For the period 1954 to 1973, total streambed recharge ranged from about 520 to 21,860 acre-ft/yr and averaged about 4,730 acre-ft/yr. The TDS and nitrate concentrations of storm-water runoff in Temescal Wash were assumed to be 100 and 1.0 mg/L, respectively (DDB and WEI, 2006; see also Section 2.3.2 of this report).

3.2.2 Deep Infiltration of Applied Water

The derivation of the deep infiltration of applied water volume was described in Section 2.4.2 of this report. For the period 1954 to 1973, the deep infiltration of applied water ranged from 3,990 to 8,620 acre-ft/yr and averaged 6,950 acre-ft/yr. As described above in the discussion of parameter value calibration, the TDS and nitrate concentrations are estimated to be 1,200 mg/L and 14 mg/L, respectively.

3.2.3 Groundwater Production

Groundwater production for this period is based on reported historical production estimates, as described in Section 2.4.2 and Table 2-5a of this report. Production ranged from 2,716 to

[23] http://www.prism.oregonstate.edu/

5,395 acre-ft/yr and averaged 4,028 acre-ft/yr. The TDS and nitrate concentrations are estimated by the CSRM.

3.2.4 Evapotranspiration

The derivation of ET was described in Section 2.4.2 and Table 2-5b of this report. For the period of 1991 through 2014, ET ranged from 1,017 to 1,790 acre-ft/yr and averaged 1,429 acre-ft/yr. As discussed in Section 2.4.2, there is no assignment of TDS concentration for this discharge term given that ET removes water from the groundwater basin but not its associated TDS mass. Conversely, riparian vegetation assimilate nitrogen, thereby reducing nitrate concentrations. For the purposes of this study, it was assumed that the ET process reduced the nitrate concentration of streambed recharge by 25 percent.

3.3 Results

Figures 3-5 and 3-6 are time history plots showing the following:

- Annual volume of streambed and deep infiltration of applied water recharge
- Annual volume of production, ET, and rising groundwater discharges
- TDS or nitrate concentrations measured at all wells in the Upper Temescal Valley GMZ
- The CDFM precipitation plot based on Elsinore Station D067
- The annual volume-weighted TDS or nitrate concentration of the Upper Temescal Valley GMZ, as estimated by the CSRM
- The computed 20-year mean, standard error of the mean, t-statistic, and the *mean plus t*standard error of the mean*

The annual volume-weighted TDS concentration of the Upper Temescal Valley GMZ ranged from about 699 to 923 mg/L and averaged about 808 mg/L over the 20-year period of 1954 to 1973. Applying the ambient water quality statistic process described in Section 3.1, the historical ambient TDS concentration for the period of 1954 to 1973 is 822 mg/L, as shown below in Table 3-C.

The annual volume-weighted nitrate concentration of the Upper Temescal Valley GMZ ranged from about 4.3 to 9.7 mg/L and averaged about 7.5 mg/L over the 20-year period of 1954 to 1973. Applying the ambient water quality statistic process described in Section 3.1, the historical ambient nitrate concentration for the period of 1954 to 1973 is 7.9 mg/L, as shown below in Table 3-C.

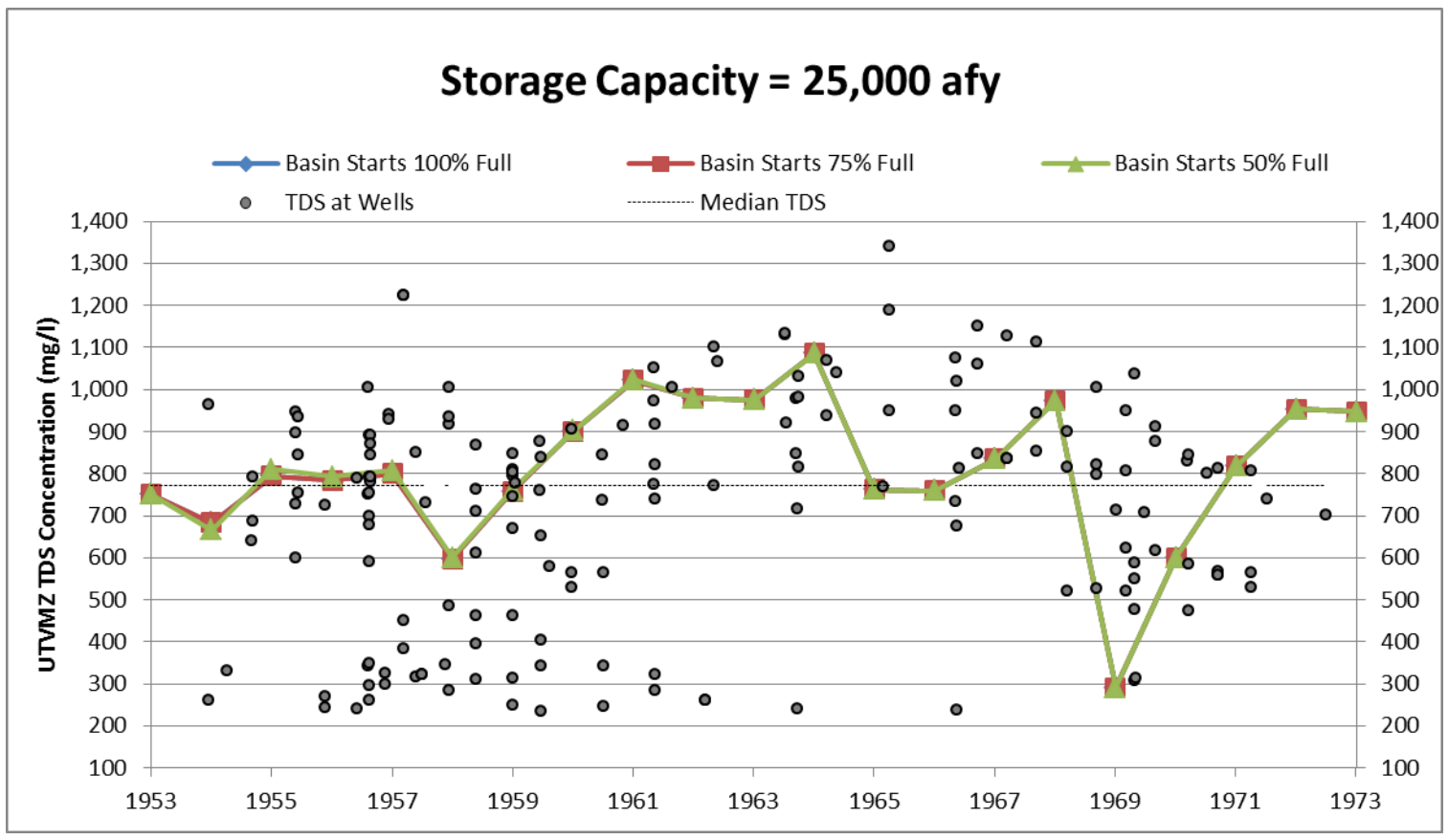
Table 3-C
Calculation of Historical Ambient Water Quality of the Upper Temescal Valley GMZ

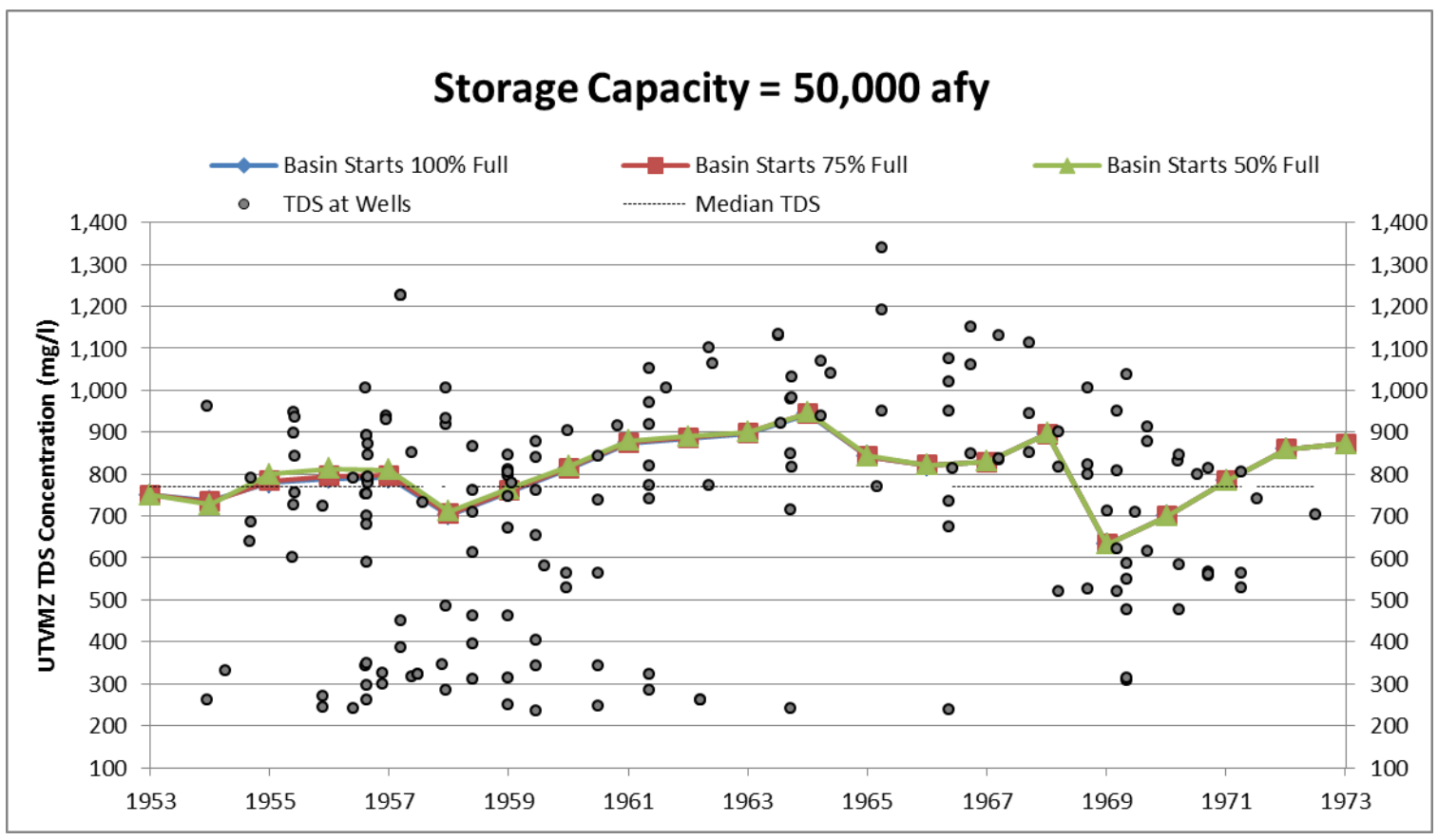
Constituent	20-Year Mean 1954-1973	Standard Error of the Mean	t-statistic	Historical Ambient (mean + t*std error)
TDS	808	15	1.0	822
Nitrate	7.5	0.4	0.99	7.9

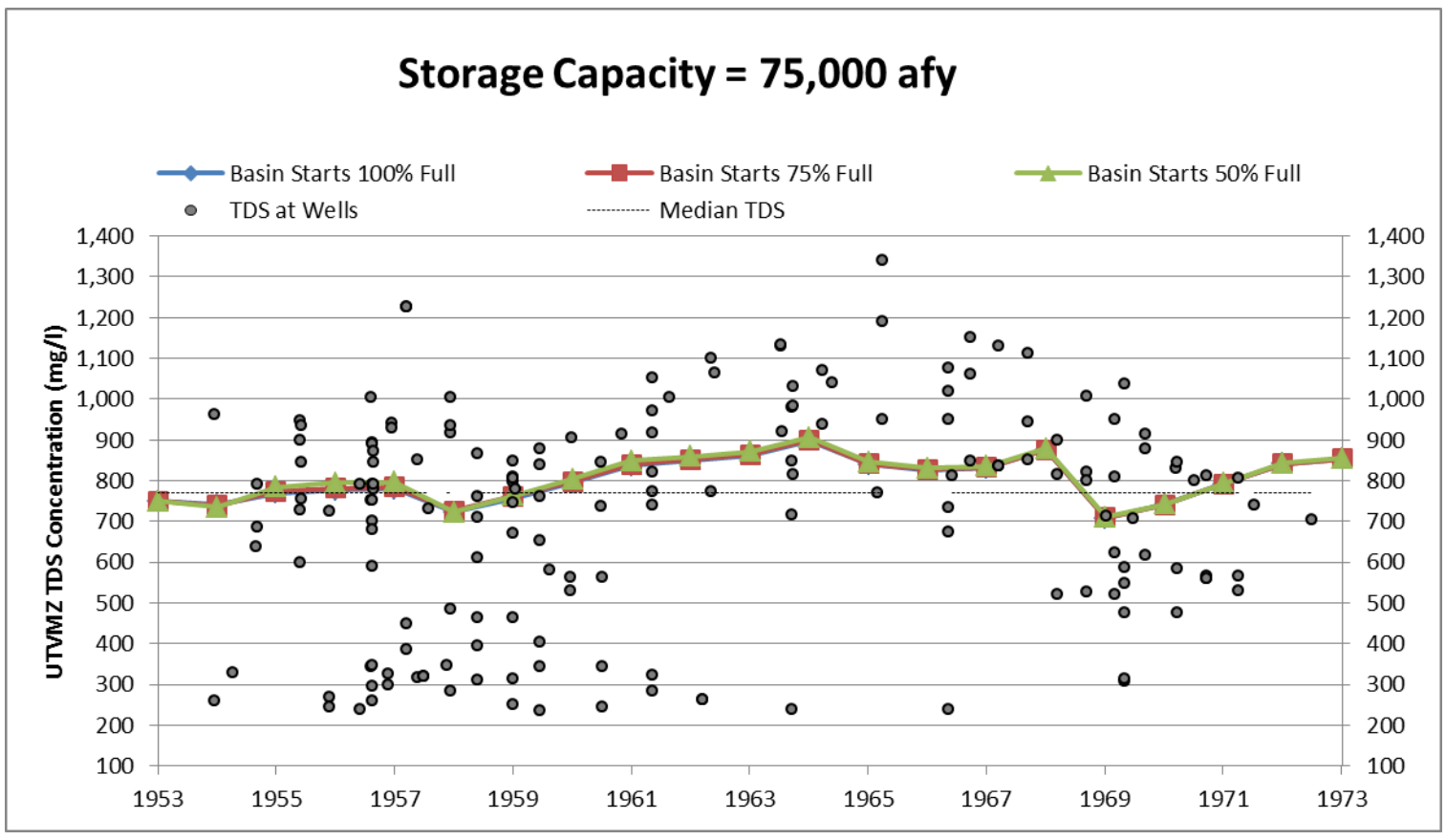
Based on these results, the current TDS discharge limitations in the Elsinore Valley and Eastern NPDES permits are protective of historical ambient water quality (e.g. they are less than 822 mg/L). And, the TDS concentrations of the Elsinore Valley and Eastern discharges that occurred in excess of their TDS permit limitations from 2004 to the present were less than the historical ambient TDS concentration 100 percent of the time (refer to Table 2-4a) meaning they did not cause degradation relative to the historical ambient TDS.

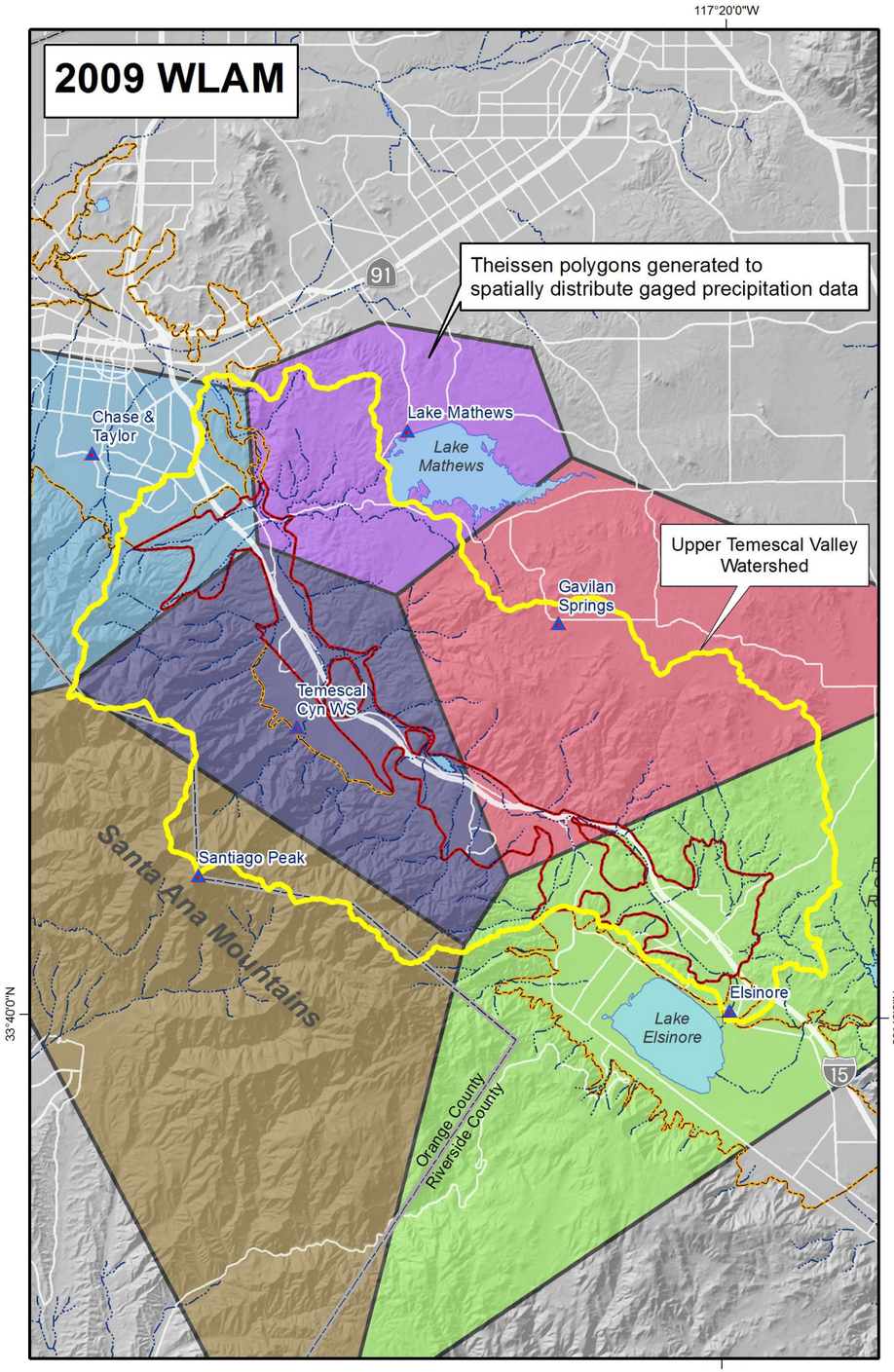
With regards to nitrate, the results suggest that when there is no assimilative capacity for nitrate in the GMZ, the highest permissible discharge limitation would be 10.5 mg/L, when the 25 percent nitrogen loss factor allowed by the Basin Plan is accounted for. Elsinore Valley's discharge limitation is currently 13 mg/L and would need to be reduced to 10.5 mg/L if there is a finding of no assimilative capacity. Eastern's discharge limitation is currently 10 mg/L and there should be no regulatory challenges continuing to permit this discharge limit.

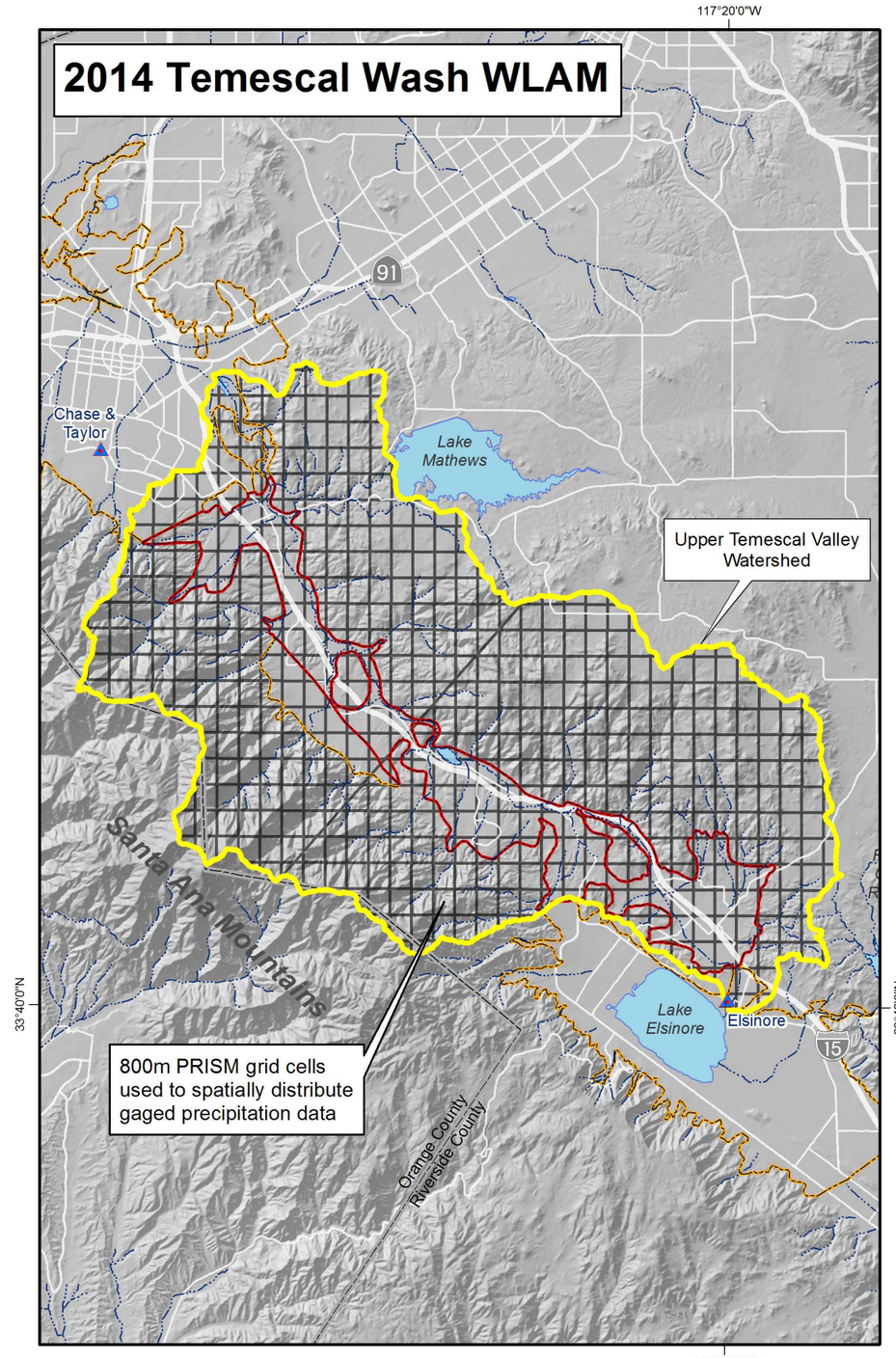
Figure 3-1
CSRM Estimated TDS Time-history Plots for Parameter Testing of Storage Capacity and Initial Volume of Water in Storage in the Upper Temescal Valley GMZ





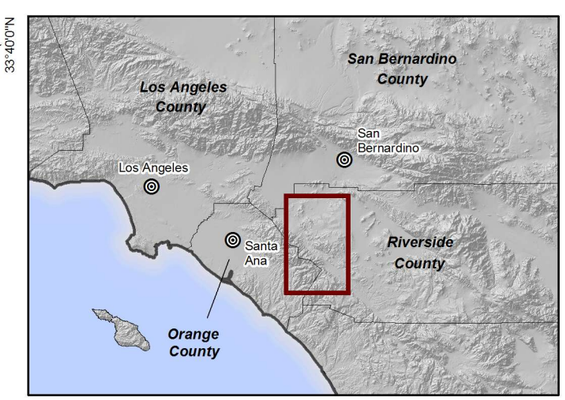






Main Features

- Precipitation Gages Used in Respective Models
- Theissen Polygons
- Upper Temescal Valley Groundwater Management Zone (GMZ)
- Other GMZs
- Streams and Flood Control Channels
- Lakes and Flood Control Basins



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Date: 8/15/2016
Document Name: Fig_3-2_precip

0 2 4 Miles
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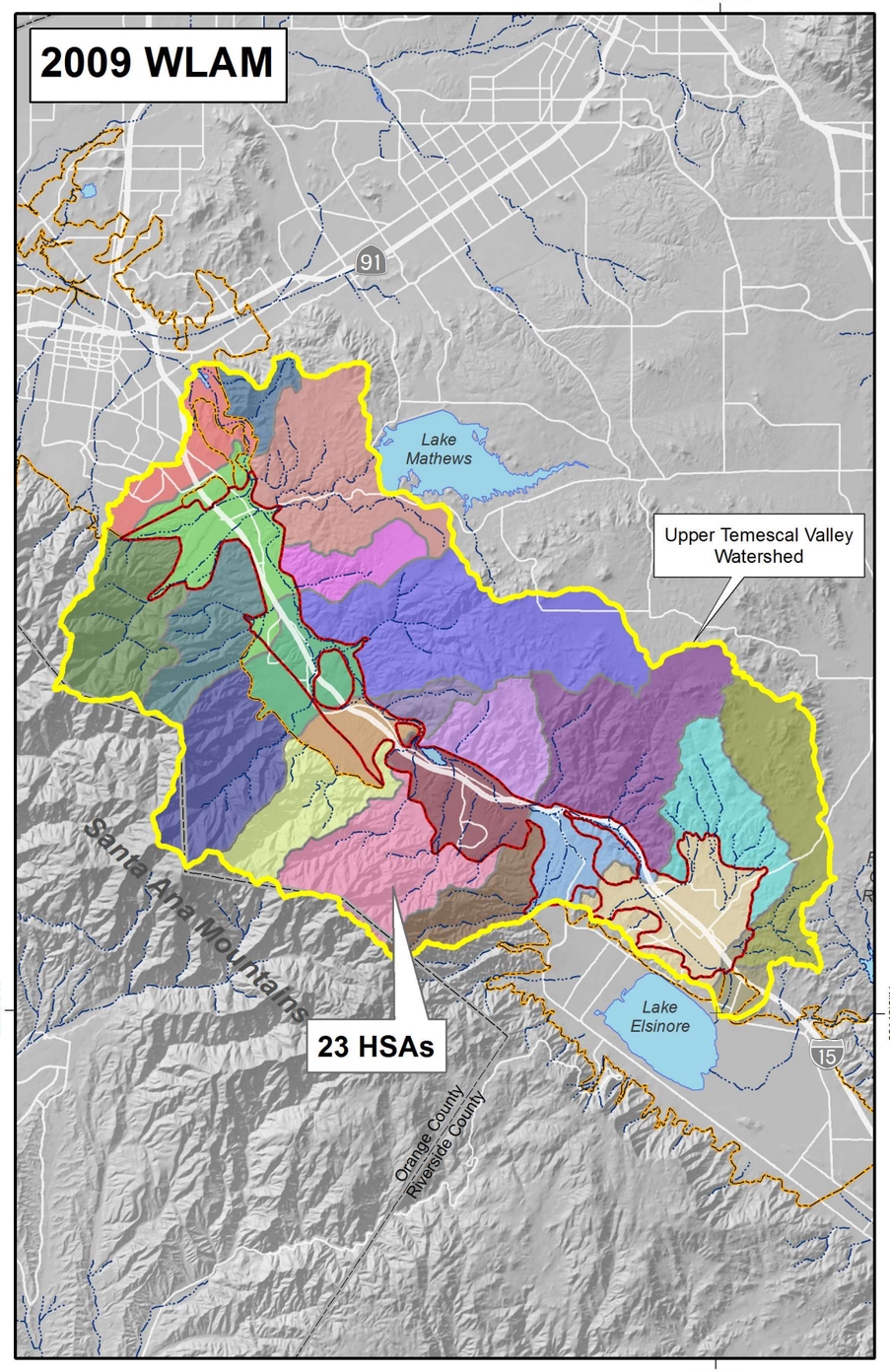
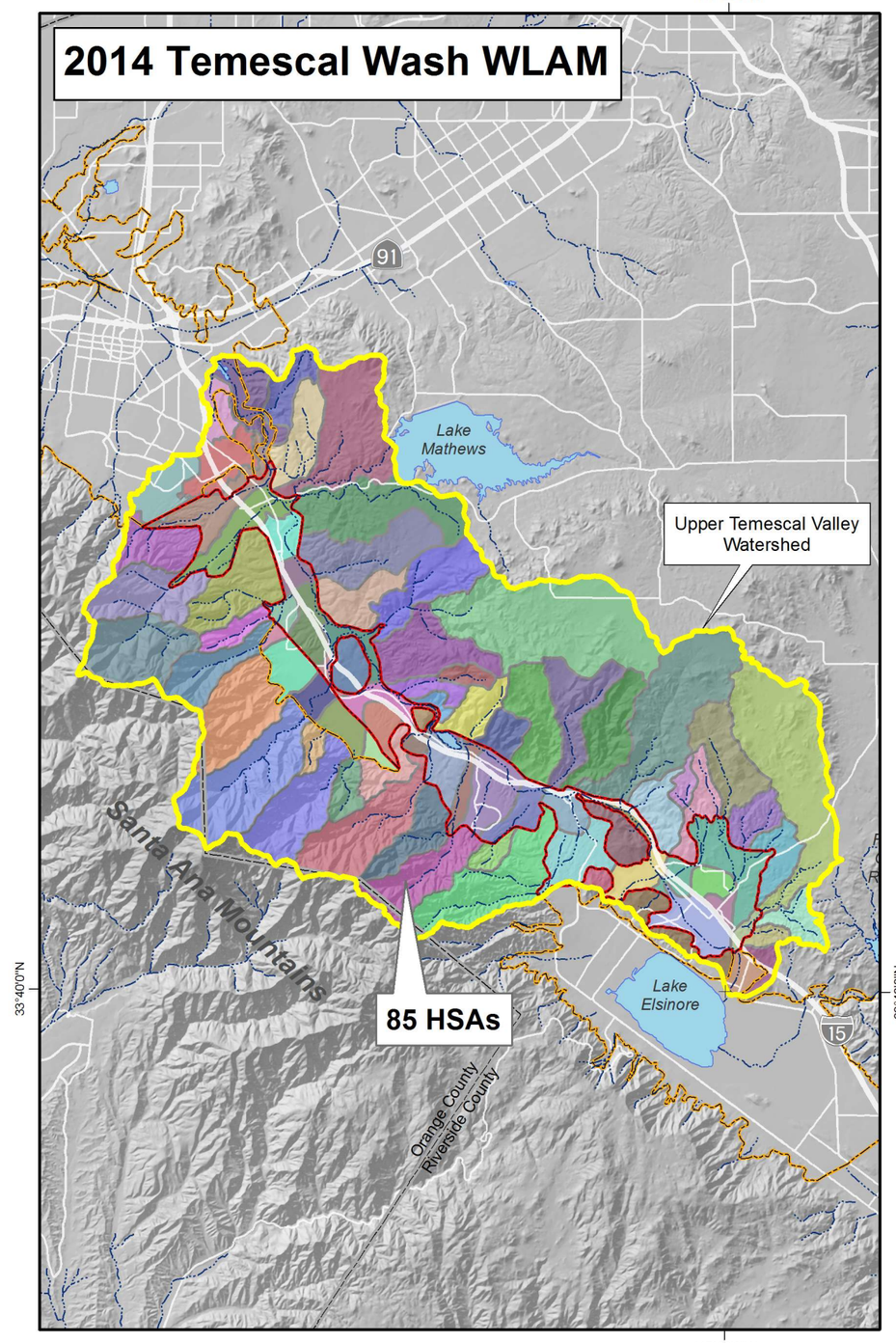
Comparison of Precipitation Data Used to Calibrate the WLAM in the Upper Temescal Valley Watershed for the 2009 and 2014 Updates

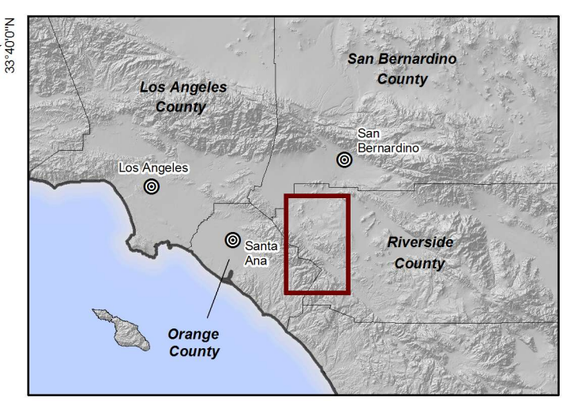
Figure 3-2





Main Features

- Hydrologic Simulation Areas
- Upper Temescal Valley Groundwater Management Zone (GMZ)
- Other GMZs
- Streams and Flood Control Channels
- Lakes and Flood Control Basins



Comparison of Hydrologic Sub Areas Used to Calibrate the WLAM in the Upper Temescal Valley Watershed for the 2009 and 2014 Updates

Figure 3-3

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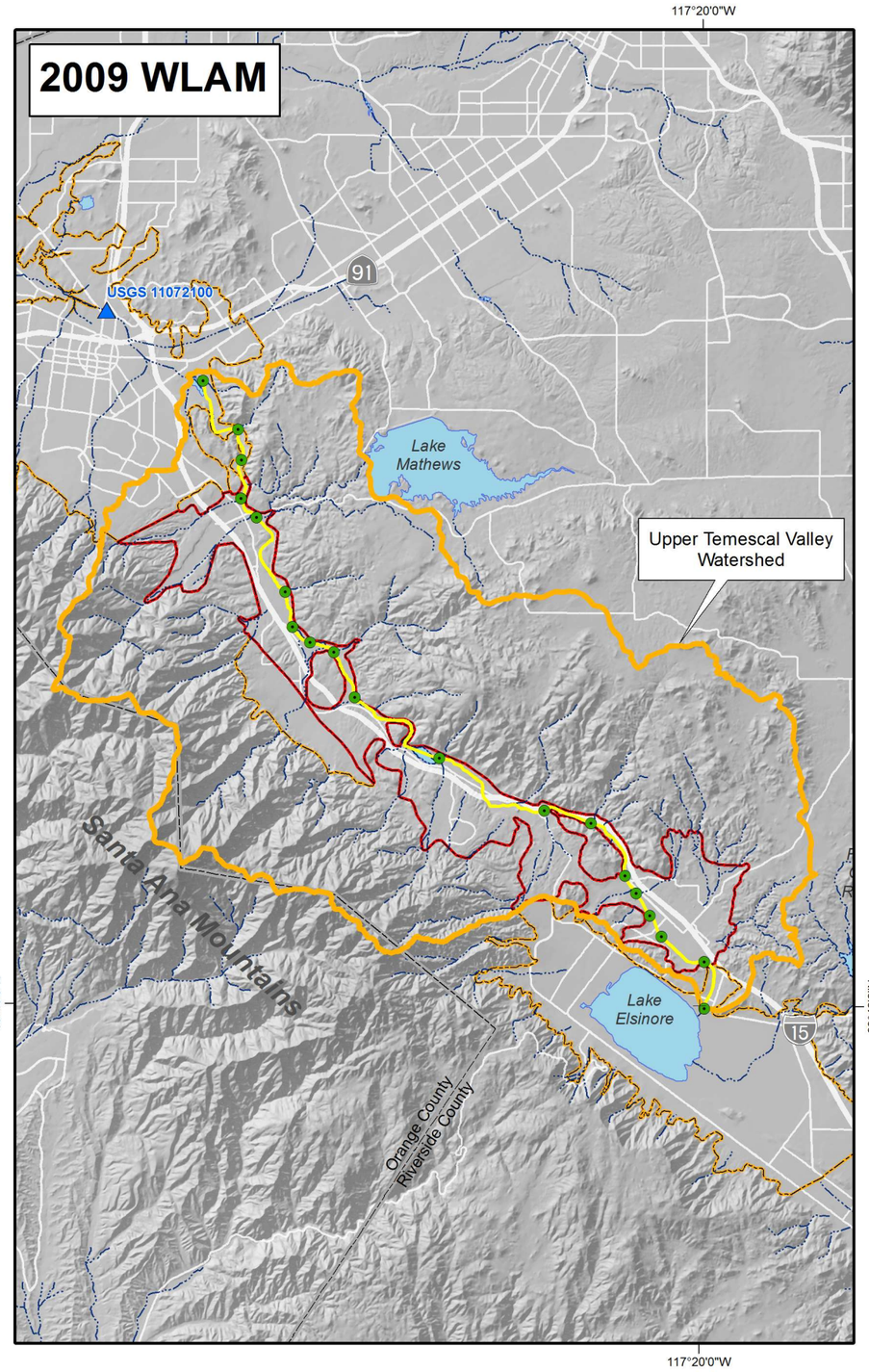
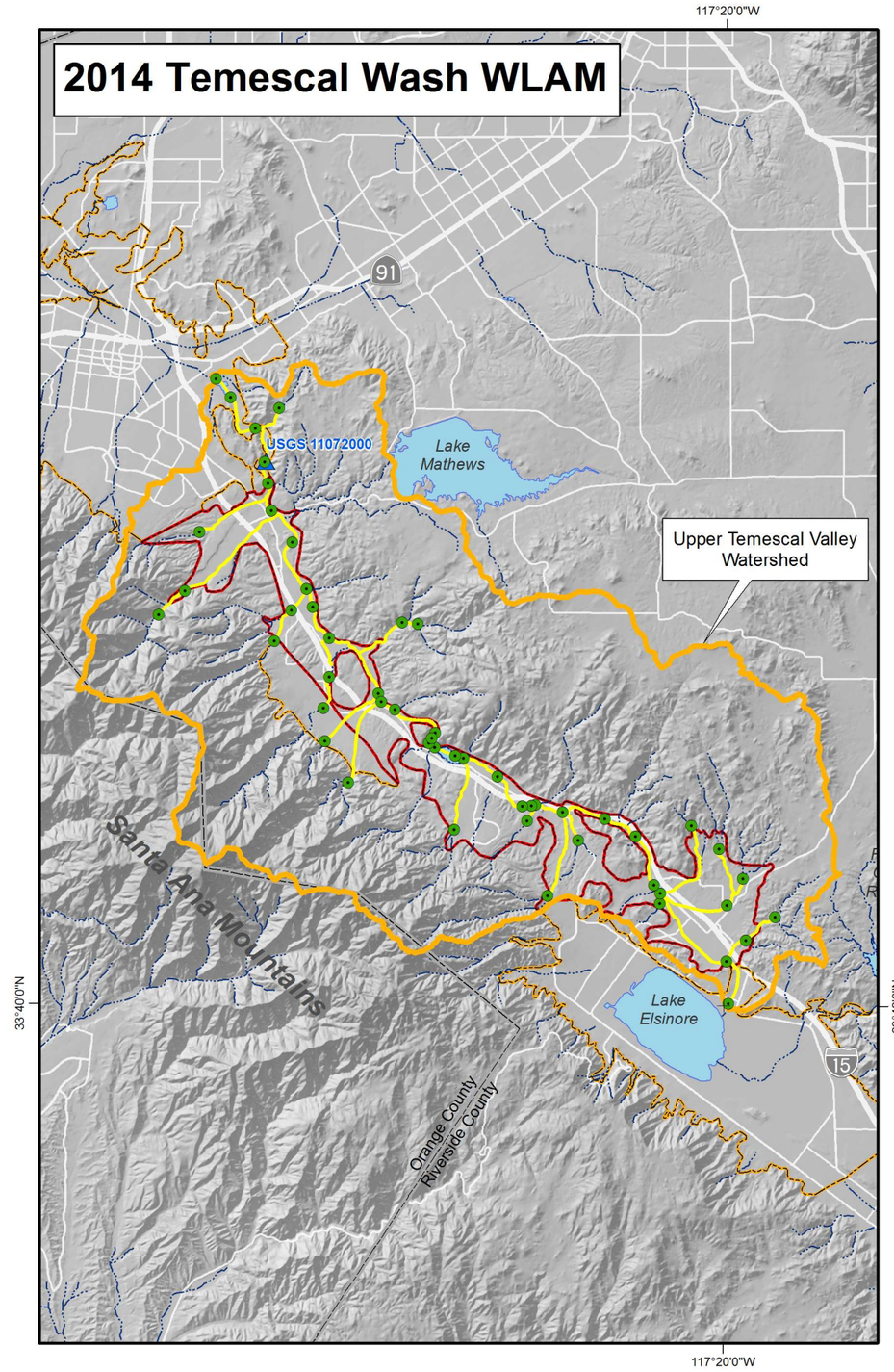
Wildermuth Environmental, Inc.

Author: GAR
Date: 8/15/2016
Document Name: Fig_3-3_HSA

0 2 4 Miles
0 2 4 KM

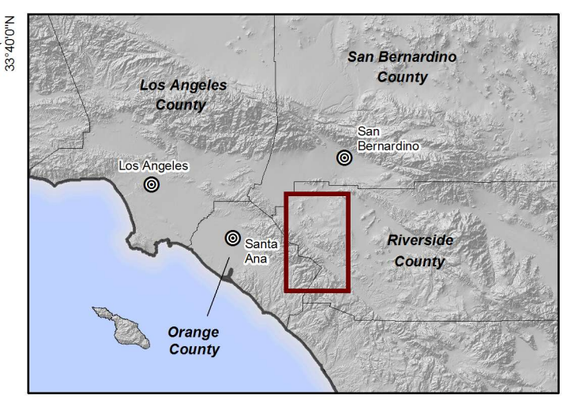
Upper Temescal Valley
Salt and Nutrient Management Plan





Main Features

- Nodes in Router Model
- USGS Gage Used to Calibrate WLAM for Temescal Wash Discharge
- Links in Router Model
- Upper Temescal Valley Groundwater Management Zone (GMZ)
- Other GMZs
- Streams and Flood Control Channels
- Lakes and Flood Control Basins



Comparison of Router Configuration Used to Calibrate the WLAM in the Upper Temescal Valley Watershed for the 2009 and 2014 Updates

Figure 3-4

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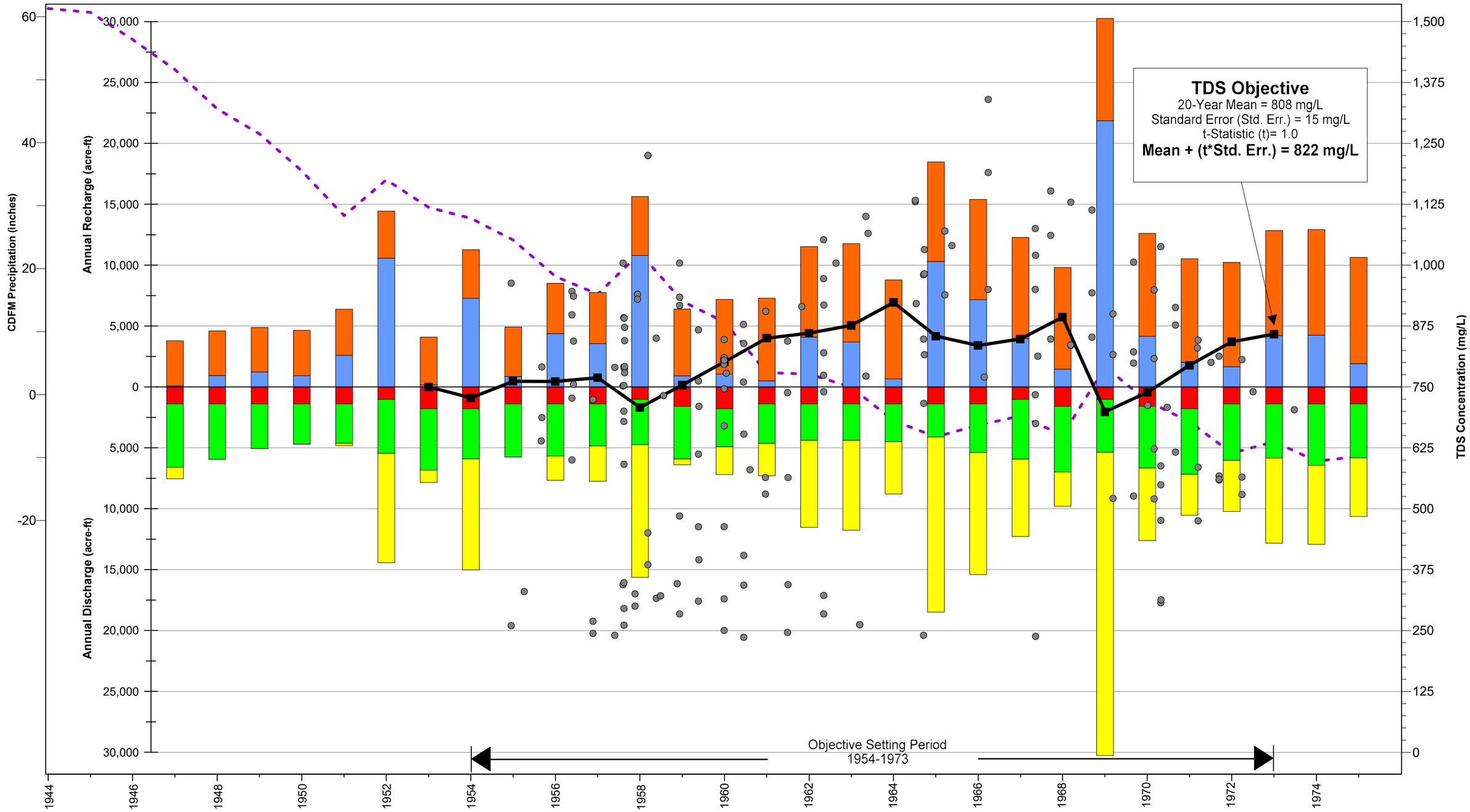
Date: 8/15/2016
Document Name: Fig_3-4_LN

0 2 4 Miles
0 2 4 KM

EVMWD
emwd Eastern Municipal Water District

Upper Temescal Valley
Salt and Nutrient Management Plan



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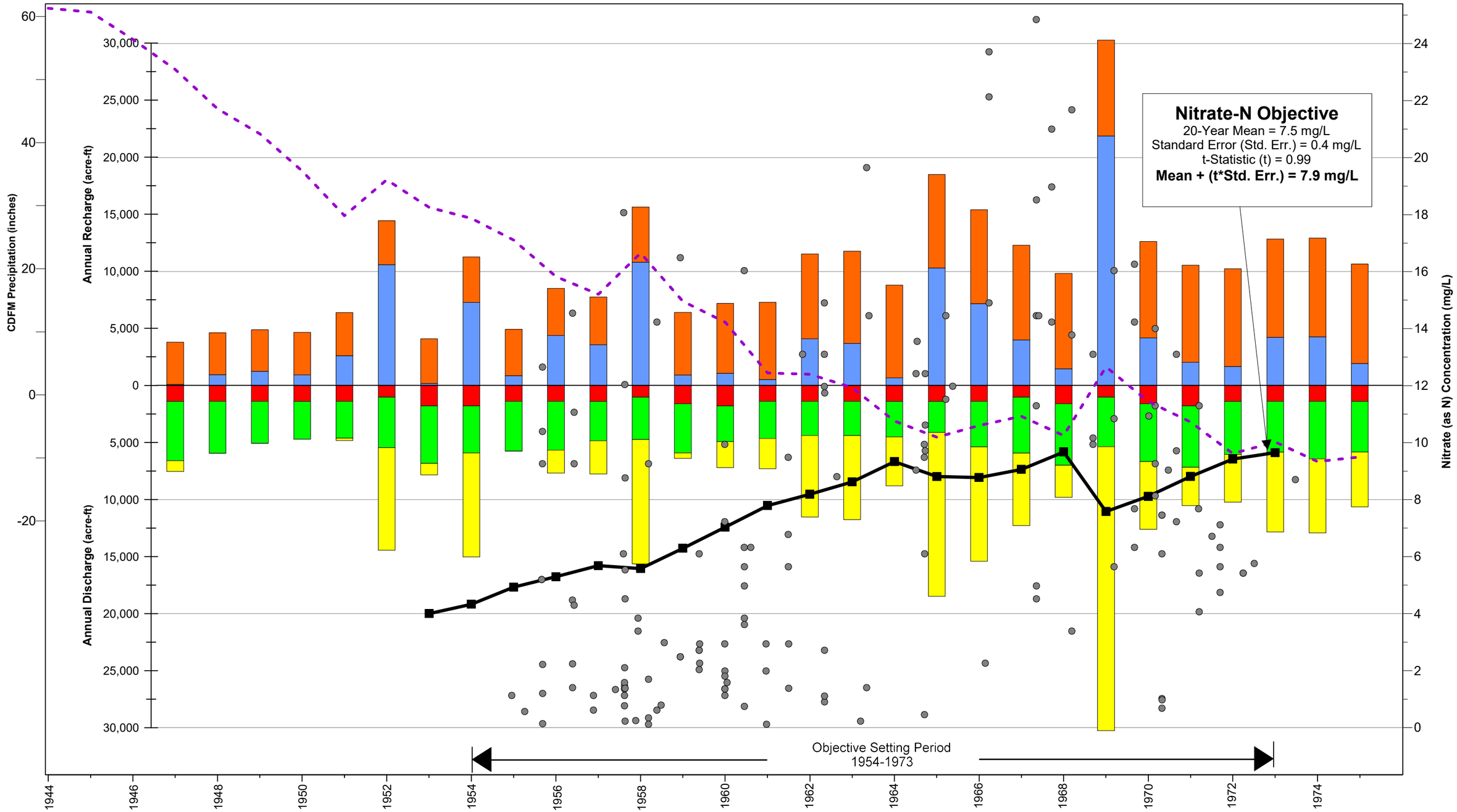
Author: SSA
File: Pump_Infil_UTV.grf

ET
Production
Rising Groundwater
Streambed Recharge
Deep Infiltration of Applied Water
CDFM Precipitation
Measured TDS Concentrations at Wells
Volume-Weighted TDS of UTV GMZ

Historical Period Recharge, Discharge, TDS Concentration, and Ambient Water Quality
Upper Temescal Valley GMZ

Figure 3-5



Prepared by:

WEI
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Author: SSA
File: Pump_Infil_UTV.grf

ET
Production
Rising Groundwater
Streambed Recharge
Deep Infiltration of Applied Water
CDFM Precipitation
Measured Nitrate-N Concentrations at Wells
Volume-Weighted Nitrate-N of UTVMZ

Historical Period Recharge, Discharge, Nitrate-N Concentration, and Ambien Water Quality

Upper Temescal Valley GMZ

Figure 3-6

This section describes the methodology used to compute current ambient TDS and nitrate concentrations in the Upper Temescal Valley GMZ. The current ambient TDS and nitrate will be computed for the 20-year time period of 1995 to 2014.

4.1 Constantly Stirred Reactor Model Methodology

The same CSRM methodology utilized to compute historical ambient water quality, as described in Section 3.1 of this report, was used to compute current ambient water quality for the period of 1995 to 2014. And, as with the historical ambient water quality calculation, the mean and standard error of the mean of the volume-weighted TDS and nitrate concentrations were computed to develop a final ambient water quality estimation, where the mean in this case is the average of the 20 annual volume-weighted concentrations computed by the CSRM for 1995 to 2014.

4.2 Derivation of CSRM Input Terms

The CSRM input terms are:

- Initial conditions – the volume and TDS and nitrate concentrations of groundwater in storage for 1991
- Recharge terms – the annual volume and TDS and nitrate concentrations of streambed recharge[24] and deep infiltration of applied water
- Discharge terms – the annual volume of groundwater production, ET, and rising groundwater

As with the analysis of historical ambient water quality, there was uncertainty as to the initial conditions, the storage limitations, and the precise concentrations of the recharge terms. The same parameter testing procedure described in Section 3.2 of this report was used herein to calibrate the unknown parameter values. The following parameters, selected based on the parameter testing procedure performed for the historical ambient water quality, were not retested and were used for the current ambient water quality analysis:

- Storage Capacity – 75,000 acre-ft
- Initial Storage Volume – 100 percent full
- Rising Groundwater – calculated to limit groundwater storage near 95 percent of full

The table below summarizes the remaining parameters tested, the range of parameter values evaluated, and the final parameter values selected.

[24] Recall that the sources of surface water that contribute to streambed recharge include storm-water, dry-weather runoff, and recycled water.

Table 4-A
Range of Parameter Values Tested and the Selected Parameter Value for Each CSRM Input Term for the Current Period

CSRM Input Parameters	Range of Parameter Values Tested	Sensitivity of Results to Parameter	Selected Parameter Value
Initial TDS Concentration (mg/L)	350 – 1,100 [25]	Insensitive as to end of period concentration; Sensitive for 20-year average AWQ	750
TDS of Deep Infiltration of Applied Water (mg/L)	1,500 – 2,500 [26]	Sensitive	2,000
Initial Nitrate-N Concentration (mg/L)	2 – 18 [27]	Insensitive as to end of period concentration; Sensitive for 20-year average AWQ	4
Nitrate-N of Deep Infiltration of Applied Water (mg/L)	2 – 10 [28]	Sensitive	5

The derivation of the remaining input terms (streambed recharge and the deep infiltration of applied water) is described in the following subsections.

4.2.1 Streambed Recharge

As in the historical time period, streambed recharge was estimated using WEI's WLAM. However, the model developed and used for the historical ambient water quality estimation (described in Section 3.2.1 of this report) required further update and recalibration for the analysis of the current time period. The period of record available for the USGS gaging station used in the calibration of the model ended in 1980 (Station 11072000 - see Figure 3-4). As such, it was only calibrated to represent storm-water runoff and recharge conditions through 1980. In order to calculate storm-water runoff and streambed recharge for the estimate of current ambient water quality, the model calibration had to be updated to use a USGS gaging station with a time-history of data from a more current period and that is reflective of the impacts of recycled water discharges in the Upper Temescal Valley.

[25] Range of values selected based on range of observed TDS concentration measurements at wells, as described in Section 2.4.5 of this report.

[26] Based on range of expected values based on source water supplies available, as described in Section 2.2.3 of this report.

[27] Range of values selected based on range of observed nitrate concentration measurements at wells, as described in Section 2.4.5 of this report.

[28] Based on range of reasonable values for regional practices, as described in section 2.4.2.2 of this report.

The model refinements described in Section 3.2.1 for channel geometry, precipitation estimates, hydraulic simulation areas, and router configuration were all utilized in this update for the current time period. The calibration station, and thus the tributary area, and the calibration period were changed. The calibration station utilized was USGS gaging station 11072100. This gaging station is located in the City of Corona and the area tributary to it is a much larger area than the Upper Temescal Valley Watershed. Specifically, the measured discharges are inclusive of flows generated in the Arlington and Upper Temescal Valley Watersheds. The model was recalibrated for the period of 1991 to 2014 and was selected based on the availability of recycled water discharge data. Additionally, the model was updated to calculate the relative contribution of storm-water runoff and recycled water to streambed recharge in the Upper Temescal Valley GMZ and rising groundwater outflow. The watersheds, gaging station, HSAs, and recycled water discharge points are shown in Figure 4-1.

For the period of 1991 through 2014, the total streambed recharge ranged from 2,523 to 25,307 acre-ft/yr and averaged about 11,436 acre-ft/yr. Of this, the average streambed recharge was comprised of an average of 5,703 acre-ft/yr of storm-water runoff and 5,732 acre-ft/yr of recycled water. The breakdown of annual streambed recharge and recycled water recharges, by source, is summarized in Table 4-1.

The TDS and nitrate concentrations of the streambed recharge of storm-water runoff were assumed to be 100 and 1.0 mg/L, respectively (DDB and WEI, 2006; see also Section 2.3.2 of this report). The TDS and nitrate concentrations of the recycled water discharges were based on the average annual concentrations shown in Table 2-4a (see Section 2.3.3 of this report). Over the period, TDS concentrations of the volume-weighted streambed recharge ranged from 164 to 656 mg/L and averaged 408 mg/L. Nitrate concentrations ranged from 1.0 to 6.0 mg/L and averaged 3.0 mg/L, including the assumption of a 25 percent nitrogen-loss rate.

4.2.2 Deep Infiltration of Applied Water

The derivation of the deep infiltration of applied water volume was described in Section 2.4.2 of this report. For the period of 1991 through 2014, the deep infiltration of applied water ranged from 2,125 to 3,570 acre-ft/yr and averaged 2,514 acre-ft/yr. As described above in the discussion of parameter value calibration, the TDS and nitrate concentrations are estimated to be 2,000 mg/L and 3 mg/L, respectively.

4.2.3 Recharge of Recycled Water Discharges to Percolation Ponds

During the current time period, recycled water from the Elsinore Valley's Horsethief WRF and the TVWD's WRF was discharged to on-site percolation ponds. The recharge is assumed to equal the volume discharged to the ponds, as described in Section 2.3.3 of this report. For the period of 1991 through 2014, total recycled water discharges to ponds ranged from 14 to 575 acre-ft/yr and averaged 175 acre-ft/yr. The TDS and nitrate concentrations are based on measured values at the respective WRFs, as shown in Table 2-4b.

4.2.4 Groundwater Production

Groundwater production for this period was based on reported historical production estimates, as described in Section 2.4.2 and Table 2-5b of this report. For the period of 1991

through 2014, production ranged from 716 to 4,415 acre-ft/yr and averaged 2,633 acre-ft/yr. The TDS and nitrate concentrations are estimated by the CSRM.

4.2.5 Evapotranspiration

The derivation of ET was described in Section 2.4.2 and Table 2-5b of this report. For the period of 1991 through 2014, ET ranged from 1,016 to 1,789 acre-ft/yr and averaged 1,391 acre-ft/yr. As discussed in Section 2.4.2, there is no assignment of TDS concentration for this discharge term given that ET removes water from the groundwater basin but not its associated TDS mass. Conversely, riparian vegetation assimilates nitrogen, thereby reducing nitrate concentrations. For the purposes of this study, it was assumed that the process of ET reduced the nitrate concentration of streambed recharges by 25 percent.

4.3 Results

Figures 4-2 and 4-3 are time history plots showing the following for the time period of 1991 to 2014, used to compute the current ambient TDS and nitrate concentrations:

- Annual volume of streambed and deep infiltration of applied water recharge
- Annual volume of production, ET, and rising groundwater
- TDS and nitrate concentrations measured at all wells in the Upper Temescal Valley GMZ (Figures 4-2 and 4-3, respectively)
- The CDFM precipitation time series based on Elsinore Station D067
- The annual volume-weighted TDS and nitrate concentrations (Figures 4-2 and 4-3, respectively) of the Upper Temescal Valley GMZ as estimated by the CSRM
- The computed 20-year mean, standard error of the mean, t-statistic, and the *mean plus t*standard error of the mean* for the 20-year period of 1995 to 2014

The annual volume-weighted TDS concentration of the Upper Temescal Valley GMZ ranged from about 635 to 845 mg/L and averaged about 738 mg/L over the 20-year time period of 1995 to 2014. Applying the ambient water quality statistic process described in Section 3.1, the current ambient TDS concentration for the period of 1995 to 2014 is 751 mg/L, as shown in Table 4-B below.

The annual volume-weighted nitrate concentration of the Upper Temescal Valley GMZ ranged from about 4.5 to 5.9 mg/L and averaged about 4.5 mg/L over the 20-year time period of 1995 to 2014. Applying the ambient water quality statistic process described in Section 3.1, the current ambient nitrate concentration for the period of 1995 to 2014 is 4.7 mg/L, as shown in Table 4-B below.

Table 4-B
Calculation of Current Ambient Water Quality of the Upper Temescal Valley GMZ

Constituent	20-Year Mean 1954-1973	Standard Error of the Mean	t-statistic	Current Ambient (mean + t*std error)
TDS	738	13	1.0	751
Nitrate	4.5	0.2	1.0	4.7

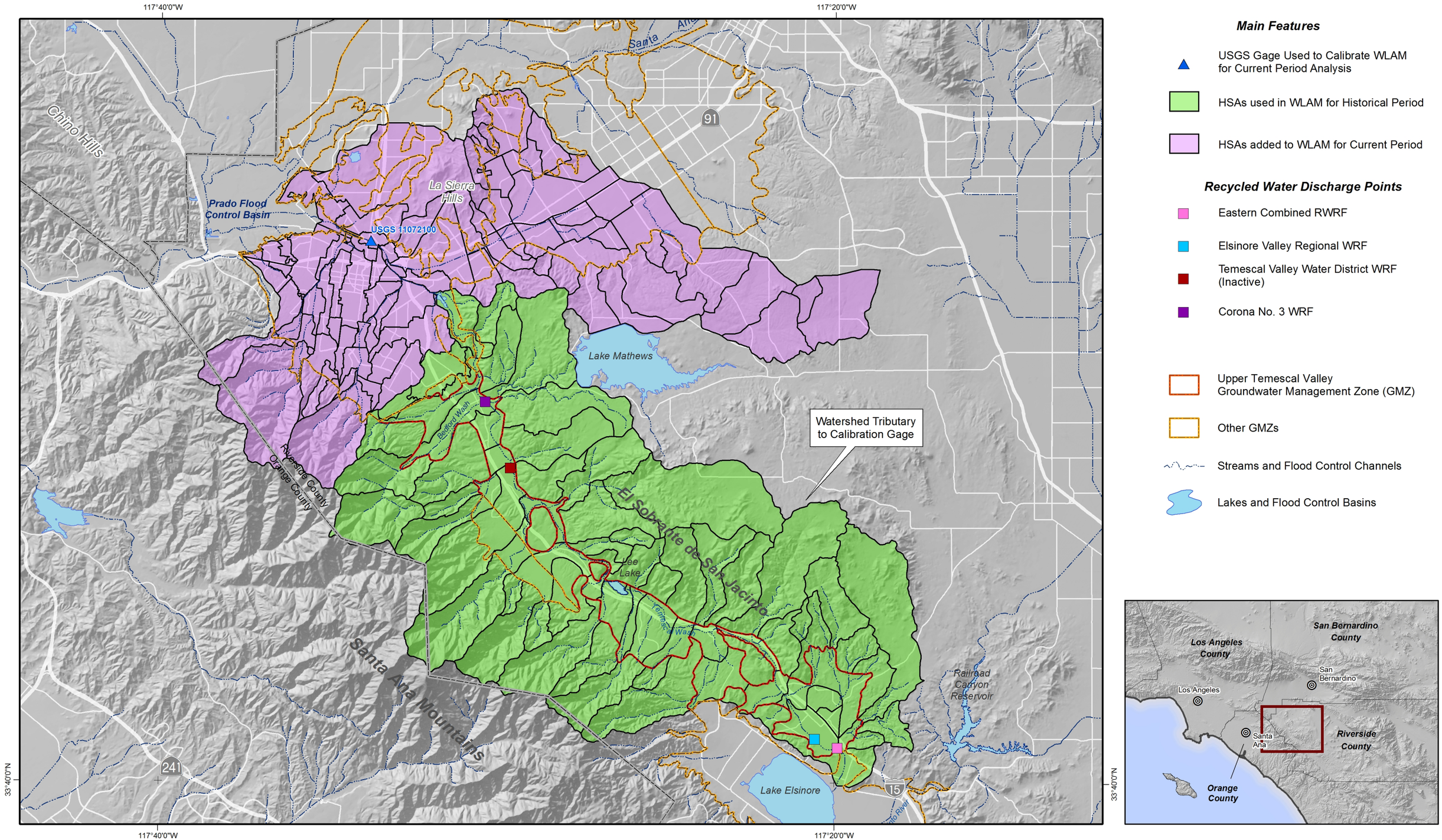
Based on these results, the current TDS discharge limitations in the Elsinore Valley and Eastern NPDES permits are protective of current ambient water quality (e.g. they are less than 751 mg/L). And, the TDS concentrations of the Elsinore Valley and Eastern discharges that occurred in excess of their TDS permit limitations were less than the current ambient TDS concentration 90 percent and 82 percent, respectively, for the 2004-2014 period (refer to Table 4-1). When the recycled water discharges are volume-weighted with the streambed recharge of storm-water runoff—which is a factor used by the Regional Board to evaluate compliance with the antidegradation objectives in the Wasteload Allocation process—the volume-weighted TDS concentration was less than the current ambient concentration 100 percent of the time over the eleven-year period of 2004-2014 (again, refer to Table 4-1). Thus, there were no impairments of historical or current ambient groundwater quality as a result of the permit violations.

With regards to nitrate, the current discharge limitations are greater than current ambient. The implication of this is that the discharges will need to perform an antidegradation analyses[29] to support their NPDES discharge permit renewals to demonstrate that the discharges in excess of current ambient are to the maximum benefit of the State of California. The antidegradation analysis is included in Section 6 of this report.

[29] Antidegradation analyses are performed in support of Waste Discharge Requirements when a GMZ has assimilative capacity for TDS and/or nitrate, and the proposed discharge has a concentration greater than the objective or the current ambient water quality and will have the potential to degrade water quality relative to the current ambient water quality concentration.

Table 4-1
Breakdown of Storm-Water Runoff and Recycled Water Contributions to Streambed Recharge
**Includes 25 Percent N-Loss*

FY	Storm-water Runoff			EMWD Recycled Water			EVMWD Recycled Water (Regional WRF)			TCWD Recycled Water			City of Corona Recycled Water			Subtotal of Recycled Water			Total Streambed Recharge		
	Q (acre-ft/yr)	TDS (acre-ft/yr)	N (acre-ft/yr)	Q (acre-ft/yr)	TDS (acre-ft/yr)	N (acre-ft/yr)	Q (acre-ft/yr)	TDS (acre-ft/yr)	N (acre-ft/yr)	Q (acre-ft/yr)	TDS (acre-ft/yr)	N (acre-ft/yr)	Q (acre-ft/yr)	TDS (acre-ft/yr)	N (acre-ft/yr)	Q (acre-ft/yr)	TDS (acre-ft/yr)	N (acre-ft/yr)	Q (acre-ft/yr)	TDS (acre-ft/yr)	N (acre-ft/yr)
1991	6,848	100	0.75	0			2,110	778	17.42	0			0			2,110	778	17.42	8,957	260	4.68
1992	7,306	100	0.75	0			1,265	873	8.79	0			0			1,265	873	8.79	8,571	214	1.94
1993	11,541	100	0.75	0			1,607	748	9.97	0			0			1,607	748	9.97	13,148	179	1.88
1994	3,356	100	0.75	0			3,543	792	6.10	0			0			3,543	792	6.10	6,899	456	3.50
1995	20,760	100	0.75	0			2,081	791	4.91	35	595	2.1	0			2,116	788	4.86	22,876	164	1.13
1996	4,135	100	0.75	0			3,518	719	3.24	120	595	1.6	0			3,638	714	3.18	7,773	388	1.89
1997	5,373	100	0.75	0			3,119	707	4.99	110	595	2.3	0			3,229	703	4.89	8,602	326	2.31
1998	13,845	100	0.75	1,665	645	3.1	1,102	720	3.37	77	595	2.8	0			2,844	673	3.20	16,689	198	1.17
1999	633	100	0.75	0			4,152	744	6.93	234	595	3.1	0			4,386	736	6.73	5,019	656	5.97
2000	3,200	100	0.75	0			3,884	687	2.90	297	511	3.1	0			4,181	674	2.92	7,380	425	1.98
2001	3,269	100	0.75	0			4,139	687	3.52	340	531	2.9	0			4,478	675	3.47	7,747	432	2.32
2002	293	100	0.75	0			4,176	688	4.76	354	536	2.3	0			4,529	676	4.57	4,823	641	4.34
2003	8,442	100	0.75	0			1,846	714	2.78	357	505	2.7	0			2,202	680	2.77	10,644	220	1.17
2004	4,508	100	0.75	3,666	658	4.4	881	707	0.90	496	544	4.0	0			5,043	655	3.75	9,551	393	2.33
2005	15,889	100	0.75	6,354	723	4.5	2,664	706	1.06	400	640	4.1	0			9,418	715	3.52	25,307	329	1.78
2006	2,661	100	0.75	14,235	729	5.5	6,464	702	1.04	684	515	6.1	21	834	2.46	21,404	714	4.15	24,065	646	3.77
2007	130	100	0.75	13,153	641	6.4	6,396	682	2.30	693	484	3.9	150	950	3.75	20,392	651	5.02	20,522	648	5.00
2008	4,220	100	0.75	8,409	712	8.1	1,302	767	1.40	717	534	5.5	246	701	5.71	10,674	707	7.04	14,893	535	5.26
2009	5,097	100	0.75	6,533	749	7.6	698	783	1.98	787	565	4.5	159	749	3.68	8,177	734	6.73	13,274	491	4.44
2010	5,794	100	0.75	2,344	787	7.3	967	738	2.25	887	548	5.4	238	687	3.23	4,436	723	5.63	10,230	370	2.87
2011	6,529	100	0.75	4,968	683	6.1	2,447	644	1.50	763	503	4.0	189	662	2.96	8,368	655	4.50	14,897	411	2.85
2012	1,058	100	0.75	1,228	665	9.1	2,148	582	1.51	910	514	4.3	181	664	3.64	4,467	594	4.27	5,525	499	3.59
2013	480	100	0.75	2,701	668	7.5	618	631	1.44	466	553	6.6	274	648	4.81	4,059	648	6.30	4,539	590	5.71
2014	1,516	100	0.75	0			706	682	0.90	0			301	655	2.69	1,007	674	1.43	2,523	329	1.02
Min	130	100	0.75	0	641	3.1	618	582	0.9	0	484.0	2	0	648	2.5	1,007	594	1.4	2,523	164	1.0
Max	20,760	100	0.75	14,235	787	9.1	6,464	873	17.4	910	639.5	7	301	950	5.7	21,404	873	17.4	25,307	656	6.0
Average	5,703	100	0.75	2,719	696	6.3	2,576	720	4.0	364	550.4	4	73	728	3.7	5,732	708	5.5	11,436	408	3.0



Prepared by:

WEI
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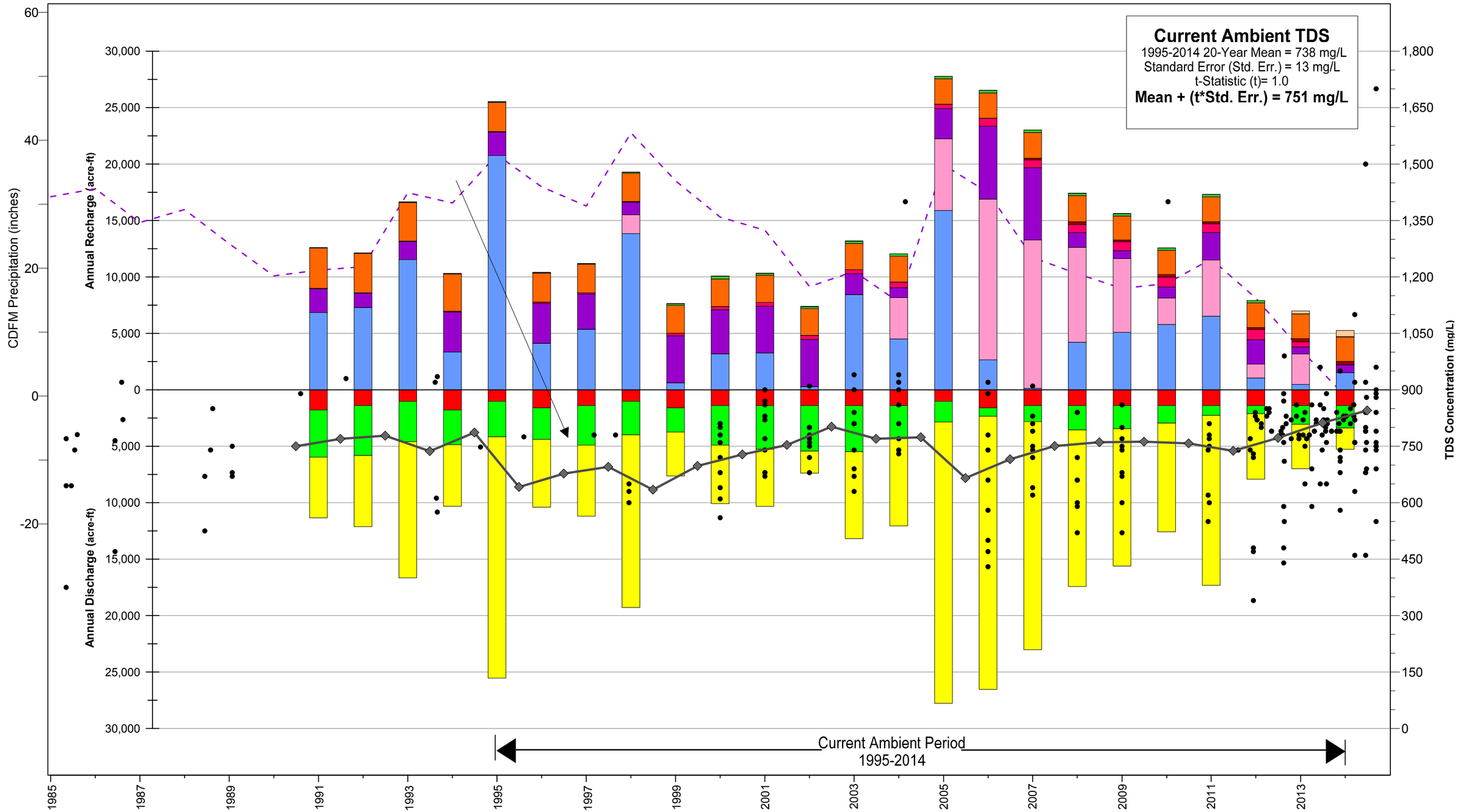
Author: CS
Date: 8/15/2016
Document Name: Fig_4-1_ModelExtent

0 2 4 Miles
0 2 4 KM

Upper Temescal Valley
Salt and Nutrient Management Plan

Boundary for the Calibration of the WLAM in the Upper Temescal Valley Watershed for the Current Ambient Water Quality Period

Figure 4-1



ET
Production
Rising Groundwater
Streambed Recharge (Storm-water)
Strembed Recharge (Eastern RW)
Strembed Recharge (Elsinore RW)
Strembed Recharge (TVWD RW)
Strembed Recharge (Corona RW)
Deep Infiltration of Applied Water
RW Recharge at Horsethief Ponds
RW Recharge at TVWD Ponds
CDFM Precipitation
Measured TDS Concentrations at Wells
Volume-Weighted TDS of UTV GMZ

Prepared by:
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Date: 20140407
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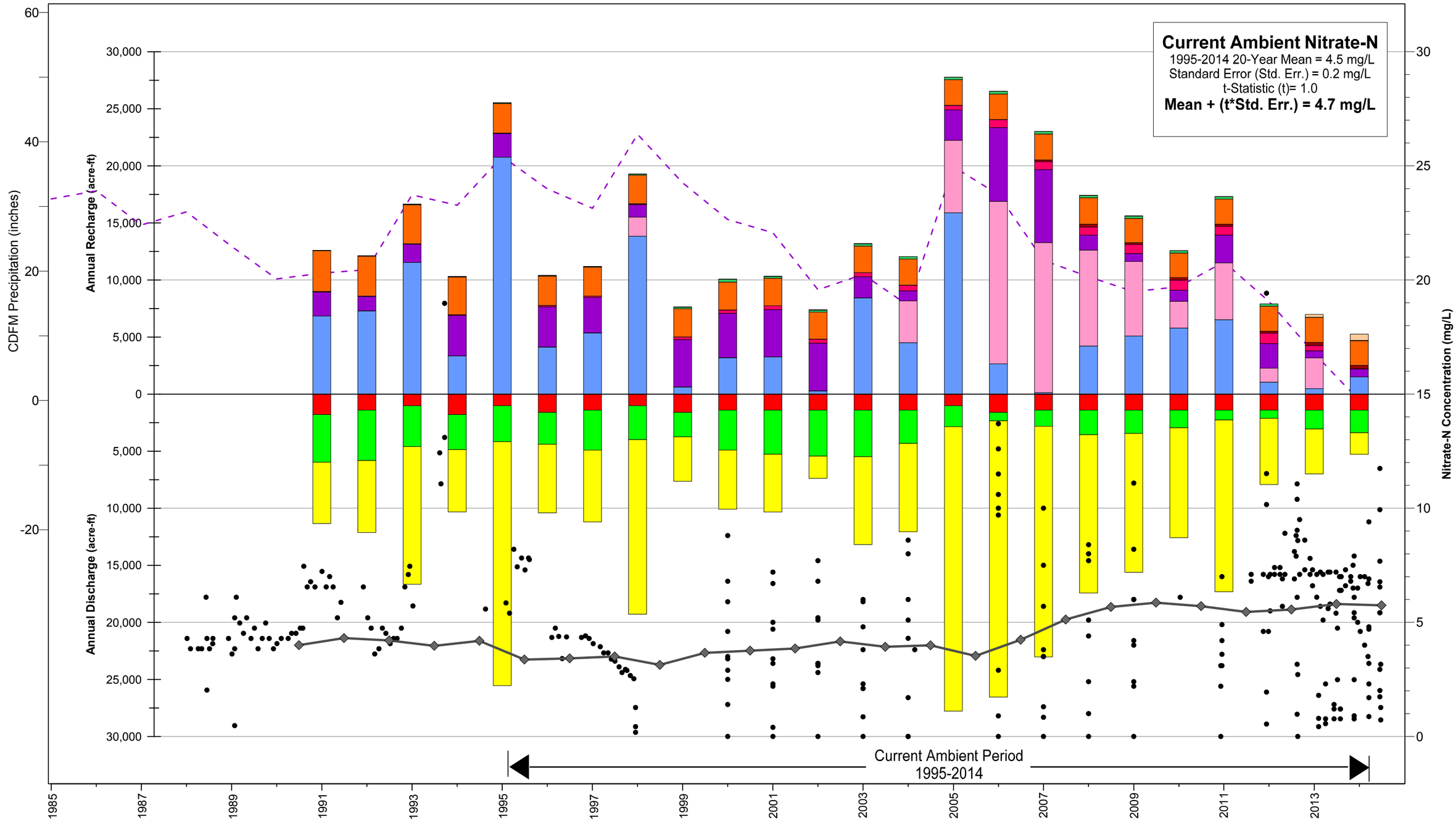
Current Period Recharge, Discharge, TDS Concentration, and Ambient Water Quality
Upper Temescal Valley GMZ

Figure 4-2



ET
Production
Rising Groundwater
Streambed Recharge (Storm-water)
Streambed Recharge (Eastern RW)
Streambed Recharge (Elsinore RW)
Streambed Recharge (TVWD RW)
Streambed Recharge (Corona RW)
Deep Infiltration of Applied Water
RW Recharge at Horsethief Ponds
RW Recharge at TVWD Ponds
CDFM Precipitation
Measured N Concentrations at Wells
Volume-Weighted N of UTV GMZ

Prepared by:
WEI
Author: GAR
Date: 20140407
File: Pump_Infil_UTV.grf

Current Period Recharge, Discharge, Nitrate-N Concentration, and Ambien Water Quality

Upper Temescal Valley GMZ

Figure 4-3

Section 5 – Projection of Future Ambient Water Quality

This section describes the methodology developed and used to make projections of future ambient TDS and nitrate concentrations in the Upper Temescal Valley GMZ.

5.1 Methodology

The CSRM methodology used to calculate historical and current ambient water quality was used to develop projections of future ambient TDS and nitrate concentrations. For developing projections of ambient water quality, a 65-year planning hydrology was used to characterize the range of projected ambient water quality under variable climate conditions. The 65-year hydrology was developed based on the Upper Temescal Valley precipitation record for 1950 to 2014 (see Section 2.3.1 and Figure 2.4) and current and future cultural conditions.

Planning scenarios were developed to bracket the reasonable range of current and projected cultural conditions with this long-term hydrology. The results for each planning scenario are presented herein as the time history of annual volume-weighted TDS and nitrate concentrations, as computed by the CSRM, and the running 20-year ambient water quality result. Minimum, maximum, and average ambient water quality results for the 65-year planning hydrology are reported for each scenario. The 20-year ambient water quality result for each annual time-step in the planning hydrology is calculated using the same equation used for the historical and current ambient water quality calculations: the mean is based on the preceding 20-year period (see section 3.2 of this report). To create a complete running 20-year ambient water quality time history for the 65-year planning hydrology, the results for the last 19 years of the planning hydrology are used to compute the 20-year mean for the first year of the planning period and so on. Note that the results for any given point in the planning hydrology are not meant to represent a specific year in the future, but rather, when taken as a whole, the time-history represents the range of expected water quality fluctuations that can be expected during wet and dry periods under the assumed planning conditions for each scenario.

5.2 Planning Scenarios

Three planning conditions were varied to create a total of eight projection scenarios: land use, recycled water discharge, and groundwater production.

5.2.1 Land Use

Two land use scenarios were used to develop the projections: the conditions representing 2014 (current) and build-out. The land use maps for these two periods are shown in Figure 2-1b.

5.2.2 Recycled Water Discharge

The volume of future recycled water discharges in the Upper Temescal Valley is dependent on development, planned recycled water reuse for direct and indirect uses, and in some cases, on climate conditions. For some dischargers, it was appropriate to develop a low-discharge and a

high-discharge scenario. The assumptions developed for each discharge in the Upper Temescal Valley are described below and the associated discharge volumes and TDS and nitrate concentrations of each discharge are summarized in Inset Table 5-A. The assumptions are consistent with the current permitted discharge limitations and the recent waste load allocation study (Scenario 8) performed for the Regional Board (WEI, 2015b).

Table 5-A
Recycled Water Discharge Planning Assumptions

Discharge Source and TDS and Nitrate Concentrations (mg/L)	Current (2014) Conditions		Build Out (2100) Conditions	
	Low Recycled Water Discharge	*High Recycled Water Discharge*	*Low Recycled Water Discharge*	*High Recycled Water Discharge*
Eastern to Temescal Wash TDS: 650 Nitrate: 10	1 month per year at 54 mgd (5,000 acre-ft/yr)	**Wet Years:** 6 months per year at 54 mgd (5,000 acre-ft/yr) **Dry years:** 1 month per year at 54 mgd (29,210 acre-ft/yr)	1 month per year at 54 mgd (5,000 acre-ft/yr)	**Wet Years:** 6 months per year at 54 mgd (5,000 acre-ft/yr) **Dry years:** 1 month per year at 54 mgd (29,210 acre-ft/yr)
Elsinore Valley - Regional WRF to Temescal Wash TDS: 700 Nitrate: 13	0.5 mgd 563 acre-ft/yr	0.5 mgd 563 acre-ft/yr	0.5 mgd 563 acre-ft/yr	0.5 mgd 563 acre-ft/yr
Elsinore Valley - Horsethief to Ponds TDS: 675 Nitrate: 10	0.15 mgd 140 acre-ft/yr	0.15 mgd 140 acre-ft/yr	0.7 mgd 740 acre-ft/yr	0.7 mgd 740 acre-ft/yr
Elsinore Valley - Alberhill to Temescal Wash TDS: 700 Nitrate: 13	0 mgd 0 acre-ft/yr	0 mgd 0 acre-ft/yr	0 mgd 0 acre-ft/yr	3 mgd 3,400 acre-ft/yr
TVWD to Ponds or Temescal Wash TDS: 650 Nitrate: 13	0 mgd 0 acre-ft/yr	0.5 mgd 563 acre-ft/yr	0 mgd 0 acre-ft/yr	0.5 mgd 563 acre-ft/yr
City of Corona 3A to Temescal Wash TDS: 700 Nitrate: 10	0 mgd 0 acre-ft/yr	0.5 mgd 563 acre-ft/yr	0 mgd 0 acre-ft/yr	0.5 mgd 563 acre-ft/yr

5.2.2.1 Eastern Discharge to Temescal Wash

The discharge to Temescal Wash is dependent on recycled water reuse and climate conditions. During peak outdoor water demand months (the warmer summer months), when recycled water demand exceeds recycled water production, recycled water deliveries are supplemented from recycled water storage facilities. During the cooler, wetter times of year when recycled water demands decrease, surplus recycled water is stored in recycled water storage ponds, either on-site at the RWRFs or off-site throughout Eastern's service area. When the volume of recycled water generated is in excess of Eastern's recycled water demand and storage capacity, recycled water is conveyed via pipeline to the Upper Temescal Valley and discharged to the Temescal Wash. In very wet years, recycled water is discharged to the Wash just ahead of anticipated storms to ensure the on-site storage ponds do not overflow. Even as Eastern expands its recycled water reuse program, it expects to continue discharging to the Temescal Wash on a periodic basis to regulate storage. For the planning projections, the hydrology was divided into wet years and dry years. In this case, a "wet" year means precipitation is greater than the long term-average, and a "dry" year means precipitation is less than the long-term average. In wet years, Eastern could discharge for as long as six months at a time at its full permitted discharge capacity of 54 mgd. In dry years, Eastern will only discharge for one month at its full discharge capacity. The planning projections assume that the discharges will occur at the existing NPDES permit limitations for TDS and nitrate of 650 and 10 mg/L, respectively.

5.2.2.2 Elsinore Valley Discharges to Temescal Wash and Percolation Ponds

Elsinore Valley – Regional WRF Discharge to Temescal Wash. Elsinore Valley will continue its minimum required discharge to Temescal Wash to support riparian habitat located directly downstream of the Regional WRF discharge point. This discharge is not anticipated to increase or decrease above current levels. The planning projections assume that the discharges will occur at the existing NPDES TDS and nitrate limitations of 700 and 13 mg/L, respectively.

Elsinore Valley – Horsethief WRF Discharge to Ponds. The current recycled water produced at this plant will increase as the tributary service area continues to develop. Of the total recycled water produced, that which is not utilized for non-potable reuse will be discharged to the on-site percolation ponds. The planning projections assume that the discharges will have TDS and nitrate concentrations of 675 and 10 mg/L, respectively.

Elsinore Valley – Alberhill WRF. To accommodate future planned growth in the Upper Temescal Valley, Elsinore Valley will need to expand its wastewater treatment capacity. For this analysis, a new Alberhill WRF was assumed to be in operation under build-out conditions. The discharge to Temescal Wash was bracketed from a low of 0 mgd to a high of 3 mgd. In the low-discharge scenario, it is assumed that 100 percent of the recycled water is reused. It is assumed that the discharges will occur at the same TDS and nitrate discharge concentrations as the Regional WRF of 700 and 13 mg/L, respectively.

5.2.2.3 TVWD Discharge to Percolation Ponds

The TVWD area is not expected to experience much growth, so recycled water discharges were assumed not to increase over current levels of about 1 mgd. The discharge to the on-site percolation ponds was bracketed from a low of 0 mgd to a high of 0.5 mgd. In the low-discharge scenario, it is assumed that 100 percent of TVWD's recycled water is reused. The planning projections assume that the discharges will occur at the existing NPDES TDS and nitrate limitations of 650 and 13 mg/L, respectively.

5.2.2.4 Corona Plant 3 Discharge to Temescal Wash

The Corona service area tributary to Plant 3 is not expected to experience much growth, so recycled water discharges were assumed to not increase over their current level of about 1 mgd. The discharge to Temescal Wash was bracketed from a low of 0 mgd to a high of 0.5 mgd. In the low-discharge scenario, it is assumed that 100 percent of Corona's Plant 3 recycled water is reused – as is currently the City's practice. The planning projections assume that the discharges will occur at the existing NPDES TDS and nitrate limitations of 700 and 10 mg/L, respectively.

5.2.3 Groundwater Production

As described in Section 2, current groundwater production in the Upper Temescal Valley is low compared to historical use. However, several of the agencies are considering increasing production in the future, including Elsinore Valley, the City of Corona, and the TVWD. Thus, to bookend the impacts of production on the projections, two scenarios were developed: a low-production scenario of 1,300 acre-ft/year and a high-production scenario of 4,400 acre-ft/yr.

5.2.4 Summary of Planning Scenarios

The various, reasonable permutations of land use, recycled water discharge, and groundwater production were used to create eight planning scenarios that bracket the reasonable range of projected conditions. The scenario representations are summarized below in Table 5-B.

Table 5-B
Summary of Planning Scenarios for Future Projections of Ambient Water Quality

	Current (2014) Land Use Conditions		Build Out (2100) Land Use Conditions	
	Low Recycled Water Discharge	High Recycled Water Discharge	Low Recycled Water Discharge	High Recycled Water Discharge
Low Groundwater Production	Scenario 1a	Scenario 2a	Scenario 3a	Scenario 4a
High Groundwater Production	Scenario 1b	Scenario 2b	Scenario 3b	Scenario 4b

5.3 Derivation of CSRM Input Terms

The CSRM input terms are described below. Appendix Tables C-1 through C-8 document the annual recharge and discharge time histories described below.

5.3.1 Initial Conditions

The initial storage of the Upper Temescal Valley GMZ was assumed to be full, consistent with the historical and current ambient analyses. The initial TDS and nitrate concentrations were assumed to equal the ending TDS and nitrate concentrations from the current ambient water quality analysis: 845 mg/L and 5.7 mg/L (i.e. the annual volume-weighted values calculated by the CSRM for 2014), respectively. The same initial conditions were assumed for all eight planning scenarios.

5.3.2 Recharge Terms

The recharge terms include streambed recharge, the deep infiltration of applied water, and recycled water recharge from discharges to percolation ponds. The annual recharges and the associated TDS and nitrate concentrations for each planning scenario are summarized in Appendix C as Tables C-1 through C-8.

Streambed Recharge. The version of the WLAM calibrated and used to compute streambed recharge for the current ambient water quality analysis (described in Section 4.2.1) was used to develop the streambed recharge estimates for each of the eight planning scenarios (Appendix Tables C-1 through C-8 contain the annual time series of streambed recharge estimates generated by the WLAM).

The TDS and nitrate concentrations of the streambed recharge of storm-water runoff were assumed to be 100 and 1.0 mg/L, respectively (DDB and WEI, 2006; see also Section 2.3.2 of this report). The TDS and nitrate concentrations of recycled water discharges were based on the assumptions shown in Inset Table 5-A in Section 5.2.

Deep Infiltration of Applied Water. For the scenarios based on 2014 land use, the deep infiltration of applied water was assumed to be 2,167 acre-ft/year. For the scenarios based on build-out land use, the deep infiltration of applied water was assumed to be 4,896 acre-ft/year. These values are based on the derivations of applied water in Section 2.4.2 of this report and are assumed to be constant for the entire planning projection.

The TDS and nitrate concentrations were assumed to be the same values derived for the current ambient calculation of 2,000 and 4 mg/L, respectively, as documented in Section 4.2.

Recycled Water Discharges to Ponds. The recycled water discharges to ponds are based on the planning assumptions shown in Inset Table 5-A in Section 5.2.2.

5.3.3 Discharge Terms

The discharge terms include groundwater production, ET, and rising groundwater. For production and rising groundwater, the TDS and nitrate concentrations were estimated by the CSRM. The annual discharges associated with each planning scenario are summarized in Appendix C as Tables C-1 through C-8.

Groundwater Production. The low-production (1,300 acre-ft/year) and high-production (4,400 acre-ft/yr) volumes are based on the scenarios discussed above in Section 5.2 and are assumed to be constant for the entire planning projection.

Evapotranspiration by Riparian Vegetation. ET is assumed to be 1,400 acre-ft per year for all planning scenarios and is assumed to be constant for the entire planning period. The ET is based on the average ET of the historical and current ambient time periods, as derived in Section 2.4.2 (see Tables 2-5a and 2-5b). There is no export of TDS through ET, as previously discussed in Section 2.4.2. And, the process of ET will reduce the nitrate concentration of the streambed recharge by 25 percent, consistent with the methods used in the historical and current ambient analyses described in Sections 3 and 4 of this report.

Rising Groundwater. Rising groundwater is computed to limit groundwater storage to near 95 percent of full, consistent with the methods used in the historical and current ambient analyses described in Sections 3 and 4 of this report.

5.4 Results

The TDS concentration projections are shown in Figures 5-1 and 5-2, and the nitrate concentration projections are shown in Figures 5-3 and 5-4. For each scenario, the annual volume-weighted TDS or nitrate concentrations computed by the CSRM are shown as time-history plots with colored circle symbols to represent annual values. The associated running 20-year ambient water quality computation for each scenario is depicted as a solid time-history line, using the same color as the circle symbols. Also shown are the historical (red dashed line) and current (blue dashed line) ambient water quality values documented in Sections 3 and 4 of this report. Finally, the plots include a reference to describe the climate conditions, as wet or dry periods, for the planning hydrology.

The minimum, maximum and average concentration values for the ambient water quality projections are summarized in Inset Table 5-C below.

Table 5-C
Summary Statistics of Ambient Water Quality Projections for the 65-year Planning Hydrology

Scenario	Projected Ambient TDS Concentrations (mg/L)			Projected Ambient Nitrate Concentrations (mg/L)		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Scenario 1a	731	875	800	4.3	5.5	4.8
Scenario 1b	698	840	760	4.3	5.5	4.8
Scenario 2a	696	821	751	5.9	6.5	6.2
Scenario 2b	686	807	737	6.0	6.5	6.2
Scenario 3a	885	999	948	4.0	5.0	4.5
Scenario 3b	848	959	906	4.0	5.0	4.4
Scenario 4a	805	910	587	5.8	6.3	6.1
Scenario 4b	794	900	844	5.8	6.3	6.1

5.4.1 Total Dissolved Solids Concentration Projections

Figure 5-1 shows the TDS concentration projections for Scenarios 1a, 1b, 2a, and 2b for the 65-year planning hydrology, all of which are based on current land use conditions. The following conclusions can be made based on these projections:

- The TDS concentration in the Upper Temescal Valley GMZ is projected to increase in dry periods and decrease in wet periods, consistent with the observed trends in the historical and current time periods.
- Increased wastewater discharges (2a and 2b) have the effect of lowering ambient TDS concentrations (improving water quality) in the Upper Temescal Valley GMZ relative to the low-discharge scenarios (1a and 1b). This effect is driven by the high-volume (nearly 30,000 acre-ft/yr) wet-year discharges by Eastern—the TDS of which is lower in concentration than the current ambient TDS concentration in the Upper Temescal Valley GMZ and the other sources of recharge.

- Increased groundwater production (1b and 2b) has the effect of lowering ambient TDS concentrations relative to a low-production scenario (1a and 2a). Higher volumes of production create more space in the GMZ for lower TDS concentration surface-water to recharge. The water quality improvement resulting from high-production levels is more pronounced in the low-discharge scenario (1b vs. 2b).

- For the low-discharge scenarios (1a and 1b), the projected ambient TDS concentration is generally less than the historical ambient TDS concentration of 822 mg/L. The ambient TDS concentration increases above the historical ambient about 38 percent and 15 percent of the time for Scenarios 1a and 1b, respectively. In other words, during these periods, there will be no assimilative capacity in the Upper Temescal Valley GMZ. However, assimilative capacity would be restored after a wet period, as shown in the projections. When assimilative capacity exists, the Regional Board may require the dischargers to perform an antidegradation analysis in support of their NPDES discharge permit renewals if the current ambient TDS concentration is less than the recycled water discharge limitations.

- For the high-discharge scenarios (2a and 2b), the projected ambient TDS concentration is less than the historical ambient TDS concentration of 822 mg/L 100 percent of the time. The implication is that under high-discharge scenarios, there will be no regulatory compliance challenges for recycled water so long as the discharge limitations are less than the historical ambient and if Elsinore Valley and Eastern meet their respective discharge limitations.

- The projected ambient TDS concentration is less than Elsinore Valley's current discharge limitation of 700 mg/L about 5, 6, and 26 percent of the time for scenarios 1b, 2a, and 2b, respectively. The implication is that Elsinore Valley may be required to perform antidegradation analyses on a periodic basis to support their NPDES discharge permit renewals when current ambient is less than the permitted discharge limitation. For scenario 1a, the projected ambient TDS concentration is never less than the discharge limitation of 700 mg/L, and thus there would be no regulatory compliance challenges for Elsinore Valley in this scenario—if they meet the discharge limitation—because the discharge limitation is always less than historical and current ambient.

- The projected ambient TDS concentration is never less than Eastern's current discharge limitation of 650 mg/L. The implication is that Eastern would have no regulatory compliance challenges in all four scenarios—if they meet the discharge limitation—because the discharge limitation is always less than historical and current ambient.

Figure 5-2 shows the TDS concentration projections for Scenarios 3a, 3b, 4a, and 4b for the 65-year planning hydrology, all of which are based on build-out land use conditions. The following additional conclusions can be made based on these projections:

- As with the current land use projections, increased wastewater discharges (4a and 4b) have the effect of lowering the ambient TDS concentration (improving water quality) in the Upper Temescal Valley GMZ relative to the low-discharge scenarios (3a and 3b). And, increased production (3b and 4b) has the effect of lowering ambient TDS concentrations relative to a low-production scenario.

- The TDS concentrations in the Upper Temescal Valley for the build-out land use scenarios are expected to be higher than the TDS concentration projected for the scenarios based on current land use. This increase is driven by the large increase in the deep infiltration of applied water that has high-TDS concentrations. At build-out, this poor-quality water contributes twice as much recharge to the GMZ as compared to current conditions. Changes in future irrigation practices could impact this result. If irrigation efficiency increases in the future, then the TDS concentration of the deep infiltration of applied water will increase, further degrading the groundwater quality. However, if outdoor water consumption declines, the impact of this applied water will be lessened.

- For the low-discharge scenarios (3a and 3b), the projected ambient TDS concentration is greater than the historical ambient TDS concentration of 822 mg/L 100 percent of the time. In other words, there will no longer be assimilative capacity in the GMZ. The implication is that in these scenarios is that there will be no regulatory compliance challenges for recycled water discharges so long as the discharge limitations are less than the historical ambient and if Elsinore Valley and Eastern meet their respective discharge limitations.

- For the high-discharge scenarios, the ambient TDS concentration is projected to be greater than the historical ambient TDS concentration of 822 mg/L about 86 and 57 percent of the time for Scenarios 4a and 4b, respectively. Thus, there will be periods when assimilative capacity exists. The implication is that the Regional Board may require the dischargers to perform an antidegradation analysis in support of their NPDES discharge permit renewals if the current ambient TDS concentration is less than the recycled water discharge limitations.

- The projected ambient TDS concentration is never less than Elsinore Valley's nor Eastern's current discharge limitations in all four scenarios based on build out land use conditions. The implication is that there will be no regulatory compliance challenges—if they meet their respective discharge limitations—because the discharge limitations are always less than historical and current ambient and would thus comply with the Basin Plan.

5.4.2 Nitrate Concentration Projections

Figure 5-3 shows the nitrate concentration projections for Scenarios 1a, 1b, 2a, and 2b for the 65-year planning hydrology, all of which are based on current land use conditions. The following conclusions can be made based on these projections:

- Similar to TDS, the nitrate concentration is projected to increase in dry periods and decrease in wet periods.

- In contrast to TDS, increased wastewater discharges (2a and 2b) have the effect of increasing nitrate concentrations in the Upper Temescal Valley GMZ relative to the low-discharge scenarios (1a and 1b). This effect is driven by the high-volume (nearly 30,000 acre-ft/yr) wet-year discharges by Eastern—the nitrate concentration of which is higher than the other major sources of recharge (stormwater runoff and applied water), but still below the historical ambient concentration.

- Also in contrast to TDS, groundwater production appears to have no impact on projected nitrate concentrations in the Upper Temescal Valley GMZ. The streambed recharge of recycled water discharges is driving the nitrate concentration trends in the GMZ.

- For all current land use scenarios, the projected ambient nitrate concentration is less than the historical ambient nitrate concentration of 7.9 mg/L 100 percent of the time. Thus it is projected that there will continue to be assimilative capacity for nitrate in the GMZ. The implication is that the existing nitrate discharge limitations of 13 and 10 mg/L can continue to be permitted, but to do so the dischargers will be required to perform antidegradation analyses and request access to assimilative capacity in for each NPDES permit renewal cycle.

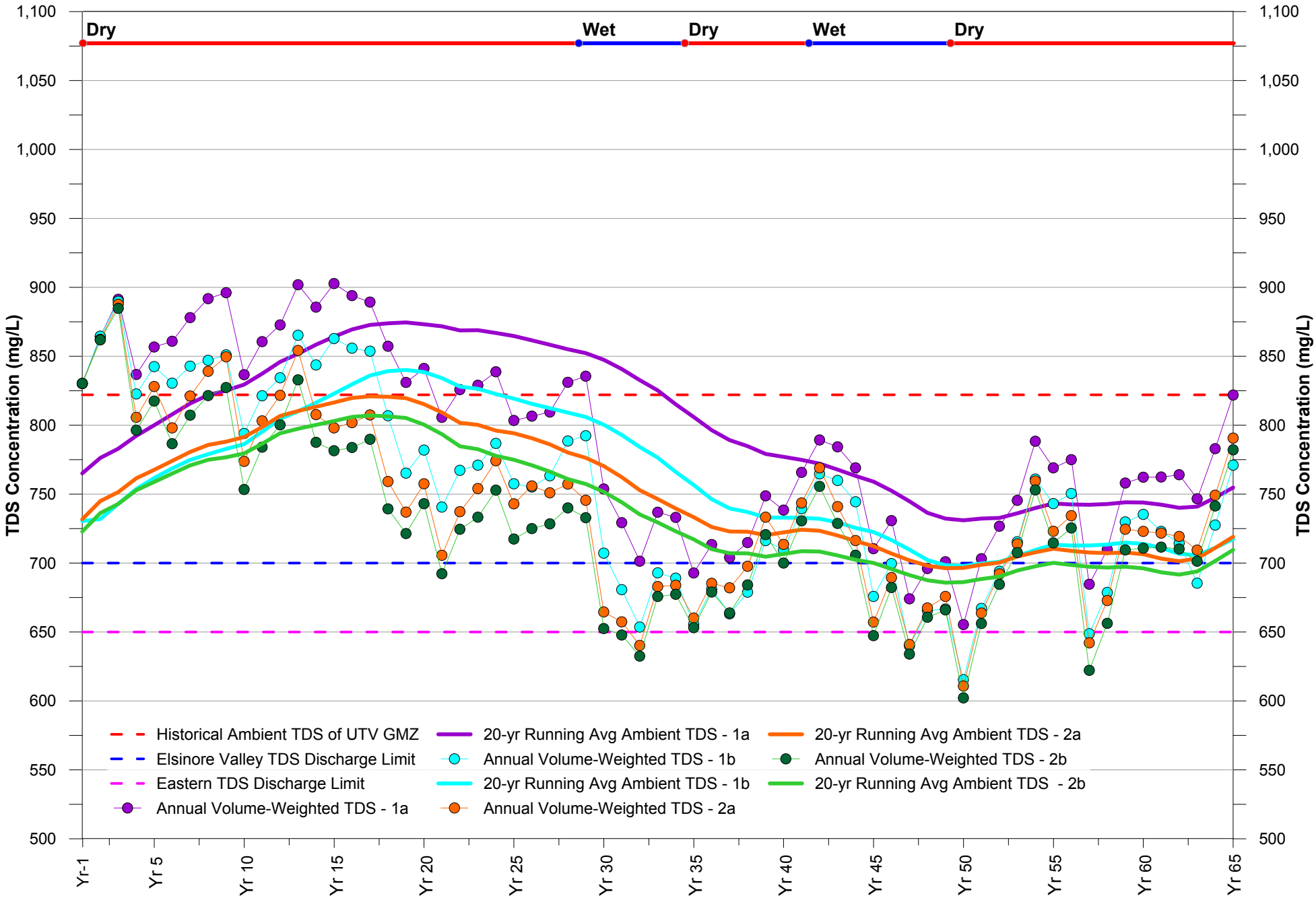
Figure 5-4 shows the nitrate concentration projections for Scenarios 3a, 3b, 4a, and 4b for the 65-year planning hydrology, all of which are based on build-out land use conditions. The following additional conclusions can be made based on these projections:

- As with current land use, increased wastewater discharges (4a and 4b) have the effect of increasing nitrate concentrations in the Upper Temescal Valley GMZ relative to the low-discharge scenarios (3a and 3b). And, groundwater production appears to have no impact on projected nitrate concentrations. In the high-discharge scenarios, the streambed recharge of recycled water discharges is driving the nitrate concentration trends in the GMZ.

- For all build-out scenarios, the projected ambient nitrate concentration is less than the historical ambient nitrate concentration of 7.9 mg/L 100 percent of the time. Thus it is projected that there will continue to be assimilative capacity for nitrate in the GMZ. The implication is that the existing nitrate discharge limitations of 13 and 10 mg/L can continue to be permitted, but to do so the dischargers will be required to perform antidegradation analyses and request access to assimilative capacity for each NPDES permit renewal cycle.

5.4.3 Most Probable TDS and Nitrate Concentration Projections for the Upper Temescal Valley GMZ

Although eight planning scenarios were developed to bracket a range of outcomes based on land use, recycled water discharge permits, and groundwater production, it is reasonable to assume that in the near-term, planning scenarios 1a and 1b represent the most probable planning conditions and, therefore, TDS and nitrate concentration projections. These planning scenarios represent current land use conditions, low wastewater discharges similar to what has occurred in the last several years, and variations on groundwater production from low to high. Elsinore Valley, the TVWD, and the City of Corona are all investigating the feasibility of increasing production in the Upper Temescal Valley GMZ, so scenario 1b is probable in the next five years. Thus, in the near-term, it should be expected that ambient TDS and nitrate concentrations will remain below the historical ambient concentrations 100 percent of the time.



Prepared by:

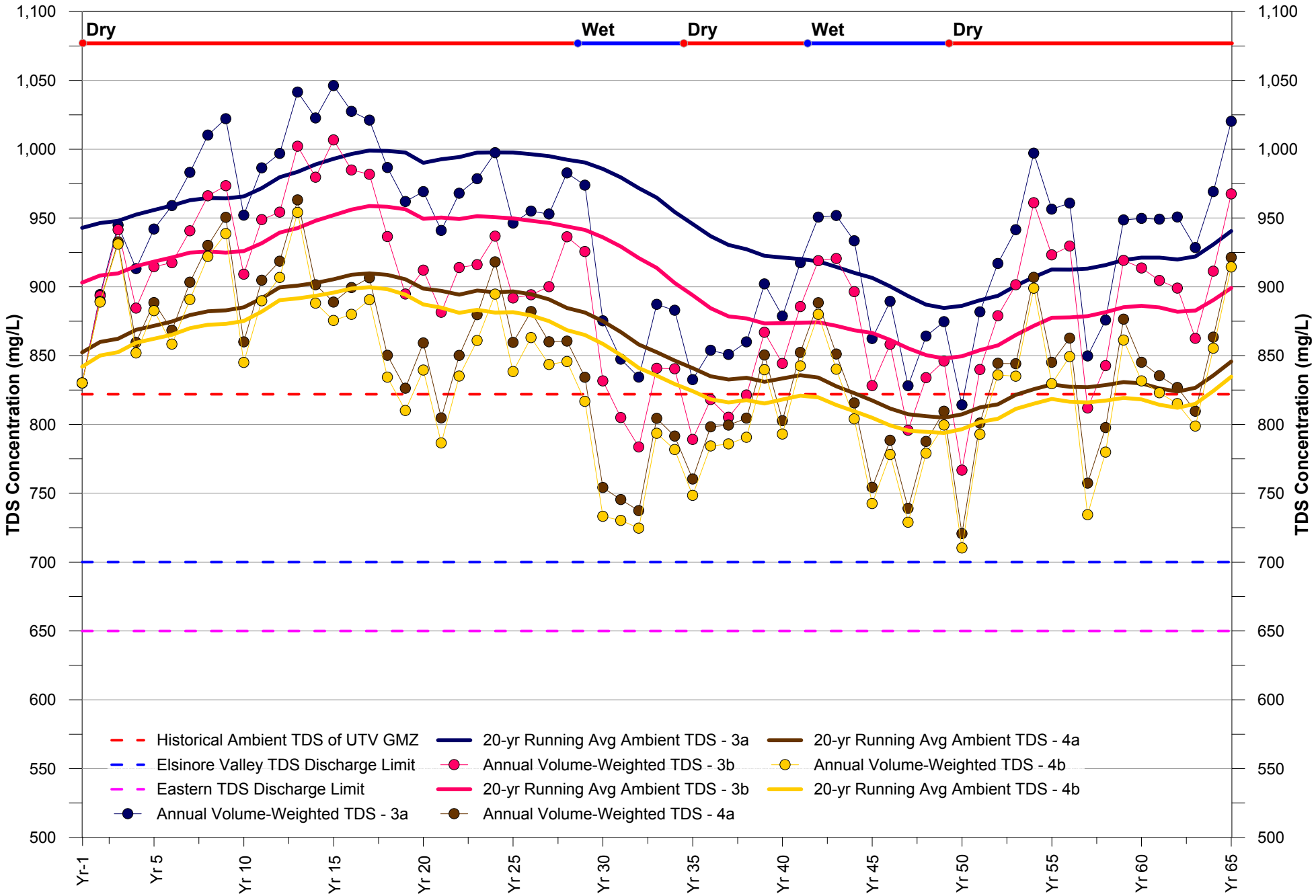
WEI
Wildermuth Environmental, Inc.

Author: CS
Date: 20160812
File: Figure 5-3

Projected Annual Volume-Weighted and 20-year Running Average Ambient TDS Concentration

Scenarios 1a, 1b, 2a and 2b

Figure 5-1



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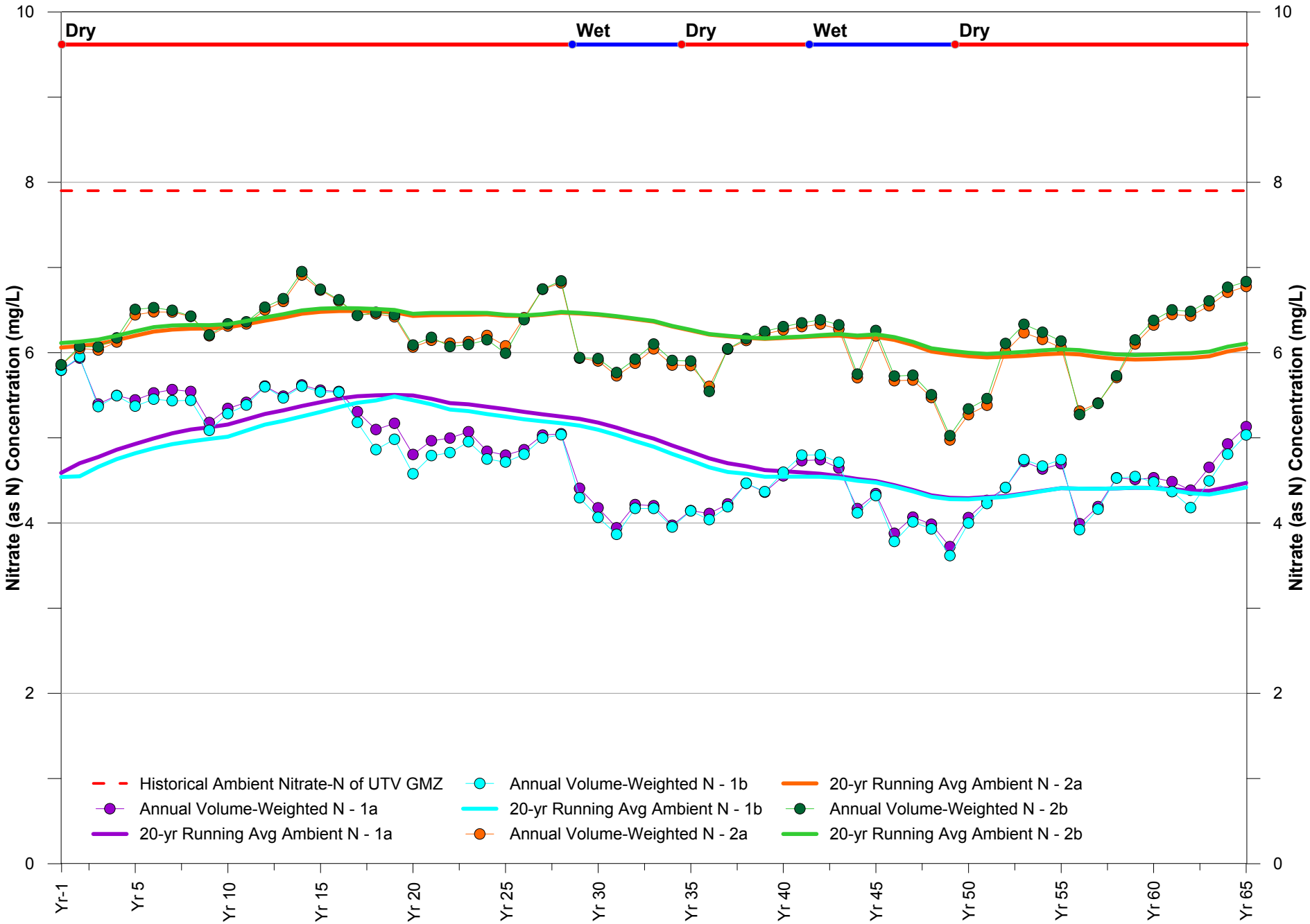
WEI
Wildermuth Environmental, Inc.

Author: CS
Date: 20160812
File: Figure 5-3

Projected Annual Volume-Weighted and 20-year Running Average Ambient TDS Concentration

Scenarios 3a, 3b, 4a and 4b

Figure 5-2



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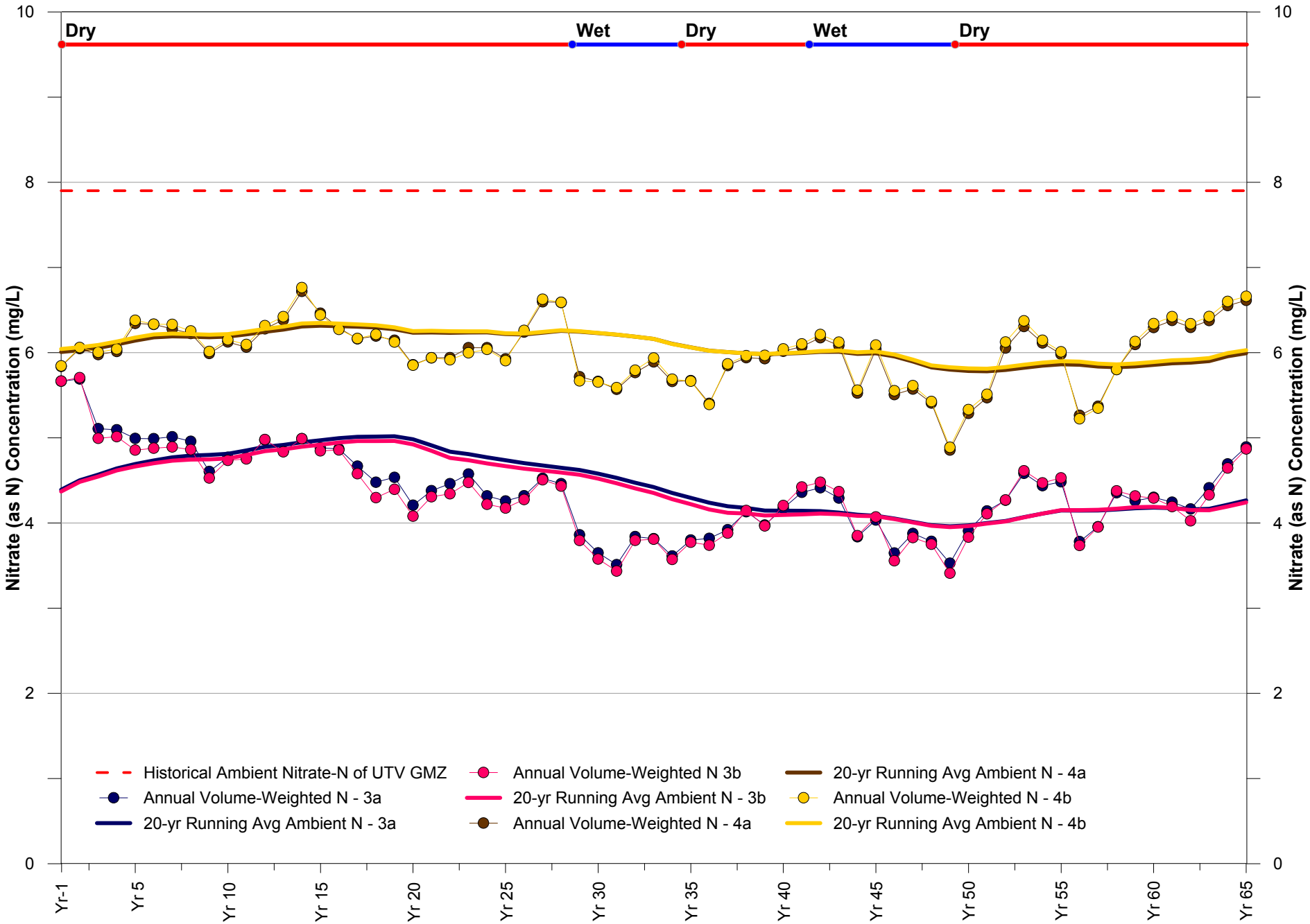
Author: CS
Date: 20160812
File: Figure 5-3

Projected Annual Volume-Weighted and 20-year Running Average Ambient Nitrate-N Concentration

Scenarios 1a, 1b, 2a and 2b

Figure 5-3



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Date: 20160812
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Projected Annual Volume-Weighted and 20-year Running Average Ambient Nitrate-N Concentration

Scenarios 3a, 3b, 4a and 4b

Figure 5-4

Section 6 – Salt and Nutrient Management Plan

This section summarizes the conclusions of the analyses performed for this SNMP, provides recommendations for establishing Basin Plan TDS and nitrate antidegradation objectives, describes an antidegradation analysis to support the permitting process for the discharge and reuse of recycled water in the Upper Temescal Valley GMZ by Elsinore Valley and Eastern, and documents the SNMP actions that will be implemented by Elsinore Valley and Eastern.

6.1 Summary and Conclusions of Water Quality Analysis of the Upper Temescal Valley

The Regional board required Elsinore Valley and Eastern to develop this SNMP as an offset for violations of their TDS concentration limitations for discharges to the Temescal Wash that occurred from 2004 through the present. The objective of the data compilation and analyses documented herein was to characterize the hydrology and hydrogeology, the development of land use and water supplies from the 1930s to the present, and the impact that the development of the watershed has had on the hydrology and water quality of the Upper Temescal Valley GMZ. More specifically, the objective was to develop a scientifically based, defensible alternative methodology to estimate historical and current ambient TDS and nitrate concentrations to establish Basin Plan objectives and determine if the recycled water TDS and nitrate concentration limitations established in the waste discharge permits issued to Elsinore Valley or Eastern need to be modified, based on the objective and current ambient concentrations.

The work performed to develop this SNMP represents the most comprehensive effort to collect, summarize, and analyze historical and current data and information on the water resources of the Upper Temescal Valley. The following summarizes the major conclusions of the work performed and documented in Sections 2 through 5 of this report:

- The groundwater storage capacity of the Upper Temescal Valley GMZ is small, likely on the order of 75,000 acre-ft.
- Based on average annual recharge to the basin for historical and current times, the turnover of the groundwater basin is on the order of five to seven years. Thus, over a 20-year period, turnover might occur four to five times. For this reason, it is reasonable to expect the ambient water quality to be similar to the volume-weighted concentration of the recharge sources.
- Water quality data available from the 1950s to the present demonstrate that the water quality in the Upper Temescal GMZ is highly variable across space and time, and at individual wells. And, that water quality is significantly influenced by climate conditions: water quality improves over wet periods and degrades over dry periods. The TDS concentration has been shown herein to vary at individual wells by 400 to 800 mg/L over a 20-year period. The water quality data supports the conclusions on basin storage capacity and turnover rates.
- Locally imported waters have been utilized in the Upper Temescal Valley Watershed since the late 1890s. Some sources relied upon in the early 1900s were very high in TDS concentration (greater than 1,000 mg/L), including water from Lake Elsinore and groundwater from the San Jacinto Valley. As the land was being developed through the 1970s, new sources of imported water were regularly introduced to meet growing

water demands and to replace the abandoned poor-quality sources. The primary use of water through the 1970s was for irrigation of agricultural crops.

- ET is a significant source of outflow from the GMZ, and because the associated mass of TDS is not exported, ET results in the concentration of TDS in the GMZ.
- Historical ambient TDS and nitrate concentrations are estimated to be 822 and 7.9 mg/L respectively. The high ambient TDS and nitrate concentrations are explained by high-volume of high-TDS and high-nitrate concentration of the deep infiltration of applied water.
- Urban development accelerated after 1975. Although a significant portion of the Watershed remains undeveloped in 2014, urban land uses dominate the developed parts of the watershed, and the remaining irrigation uses are urban in character: homes, golf course, and parks. These uses are primarily served with high-quality, low-TDS sources of water, such as imported SWP water. There are some non-potable demands that are served exclusively with recycled water and high-TDS groundwater.
- Average annual recharge has increased over time with urban development. The development has increased the imperviousness of the watershed, resulting in greater storm-water runoff and, thus, greater streambed recharge volumes. And, recycled water discharges to the Temescal Wash were introduced in the 1980s, the TDS concentrations of which were lower than the historical ambient TDS concentration, which subsequently reduced the volume-weighted TDS concentration in the GMZ.
- Current ambient TDS and nitrate concentrations are estimated to be 751 and 4.7 mg/L, respectively. With the increase in low TDS concentration storm and recycled water, it is not surprising that the current ambient TDS concentration is less than historical ambient TDS concentration.
- Urbanization has resulted in less variability in the concentration of the recharge sources to the GMZ, reducing the variability of water quality measured at wells. That said, water quality still varies with climate conditions, just at a lesser magnitude today than occurred in the past. This observed change could be attributable to the reduction in the number of wells with TDS concentration measurements or a change in the recharge sources and their respective TDS concentrations.
- Future land use changes will generate a significant amount of new poor quality recharge to the GMZ through the deep infiltration of applied water that is high in TDS. The continued urbanization will also generate a significant amount of new low-TDS storm-water flows in wet years.
- Water quality is projected to degrade over time due to changes in land use, but the projections show water quality will continue to vary with climate conditions. Groundwater production and recycled water discharges will influence ambient TDS in the Upper Temescal Valley GMZ, but will not be the primary factors driving degradation.
- Groundwater production has significantly decreased over time. Future projections of ambient water quality demonstrated that increased groundwater production improves TDS concentrations by turning over the basin faster and creating more space for high-quality storm-water runoff and recycled water to recharge. Elsinore Valley and other agencies in the Upper Temescal Valley are looking to increase production from the GMZ to improve local water supply reliability.

- Recycled water discharges will impact TDS and nitrate in different ways. A permanent reduction in recycled water discharges will result in increasing TDS relative to current ambient water quality since the quality of the discharges are all less than current ambient. That said, because the recycled water TDS concentration is less than the historical ambient, it will not degrade the basin relative to historical ambient water quality. Conversely, nitrate concentrations will decrease relative to current ambient if recycled water discharges are reduced because the recycled water is higher in nitrate than the other recharges sources to the GMZ. Because of the dilution afforded by stormwater runoff, the nitrate concentration is not projected to increase above the historical ambient concentration in the future.
- Although eight planning scenarios were developed to bracket a range of outcomes based on land use, recycled water discharge permits, and groundwater production, it is reasonable to assume that in the near-term, planning scenarios 1a and 1b represent the most probable TDS and nitrate concentration projections. These planning scenarios represent current land use conditions, low wastewater discharges similar to what has occurred in the last several years, and variations on groundwater production from low to high. Elsinore Valley, the TVWD, and the City of Corona are all investigating the feasibility of increasing production in the Upper Temescal Valley GMZ, and so scenario 1b is probable in the next five years.

- In the near-term (under scenario 1b) it should be expected that ambient TDS concentrations will remain below the historical ambient concentrations 100 percent of the time and will occasionally be lower than the Elsinore Valley's TDS discharge limitation of 700 mg/L (about 5 percent of the time). The implication is that is that Elsinore Valley would have minimal TDS regulatory compliance challenges—if they meet the discharge limitation—but they may be required to perform antidegradation analyses on a periodic basis to support their NPDES discharge permit renewals when current ambient is less than the permitted discharge limitation. The ambient TDS concentration is not projected to be below Eastern's current discharge limitation of 650 mg/L, and thus Eastern would have no TDS regulatory compliance challenges—if they meet the discharge limitation—because the discharge limitation is always less than historical and current ambient.

- In the near-term (under scenario 1b) it should be expected that ambient nitrate concentrations will also remain below the historical ambient concentrations 100 percent of the time and there will continue to be assimilative capacity for nitrate in the GMZ. The implication is that the existing nitrate discharge limitations of 13 and 10 mg/L can continue to be permitted, but to do so the dischargers will be required to perform antidegradation analyses and request access to assimilative capacity for each NPDES permit renewal cycle.

- The TDS concentrations of the Elsinore Valley and Eastern discharges that occurred in excess of their permit limitations were less than the historical ambient TDS concentration 100 percent of the time and less than the current ambient TDS concentration 82 and 90 percent of the time for the period of 2004-2014, respectively. Over the same period, when volume-weighted with the streambed recharge of storm-water runoff, the volume-weighted TDS concentration was less than the current ambient TDS concentration 100 percent of the time. Thus, these exceedances did not

result in an impairment of groundwater quality relative to historical or current ambient TDS concentrations

- There is limited data available today to adequately characterize groundwater quality and storage. A new groundwater and surface water monitoring program is needed to validate the methods and findings described in this report and to support future efforts to recompute current and project future ambient water quality.

6.2 Recommended Basin Plan Objectives for the Upper Temescal Valley GMZ

Elsinore Valley and Eastern recommend that the Regional Board adopt TDS and nitrate antidegradation objectives for the Upper Temescal Valley in a manner consistent with the 2004 Basin Plan amendment. The 2004 antidegradation objectives were based on historical ambient water quality for the period of 1954 to 1973. In the case of TDS, the historical values were rounded to the nearest ten to set the objective. For nitrate, the historical value was rounded to the nearest tenth.

Applying this methodology, the proposed antidegradation objectives are as follows:

Table 6-A
Proposed Antidegradation Objectives for TDS and Nitrate

Constituent	Calculated Historical Ambient Concentration	Antidegradation Objective
TDS (mg/L)	822	820
Nitrate (mg/L)	7.9	7.9

6.3 Antidegradation Analysis to Support Current TDS and Nitrate Discharge Limitations

Antidegradation analyses are performed in support of Waste Discharge Requirements and NPDES permit renewals when a GMZ has assimilative capacity for TDS and/or nitrate, and the proposed discharge has a concentration greater than the objective or the current ambient water quality and will have the potential to degrade water quality relative to the current ambient water quality concentration. If constituent concentrations are projected to increase relative to current ambient concentrations, the discharger must request an allocation of assimilative capacity for the discharge. Assimilative capacity is defined as the amount, in mg/L, of degradation that can occur before a GMZ exceeds its Basin Plan objective. The assimilative capacity available in the Upper Temescal Valley GMZ is shown in Table 6-B. Note that just as with the objectives, the current ambient calculations are rounded.

Table 6-B
Assimilative Capacity for TDS and Nitrate

Constituent	Antidegradation Objective	Current Ambient	Assimilative Capacity
TDS (mg/L)	820	750	70
Nitrate (mg/L)	7.9	4.7	3.2

As described in Section 5.4.3, Scenarios 1a and 1b represent the most likely near-term planning conditions and water quality projections. These planning scenarios represent current land use conditions, low wastewater discharges similar to what has occurred in the last several years, and variations on groundwater production from low to high. Increases in groundwater production are planned for the Upper Temescal Valley in the next five years. For this reason, Scenario 1b will be used for the purpose of the antidegradation analysis.

6.3.1 Total Dissolved Solids

In the case of TDS, there is 70 mg/L of assimilative capacity in the Upper Temescal Valley GMZ. Thus, any discharges with TDS concentrations in excess of the current ambient TDS concentration require a full antidegradation analysis to document the amount of assimilative capacity that will be used by the waste discharge. Currently, the Elsinore Valley TDS discharge limitation is 700 mg/L, and the Eastern limitation is 650 mg/L. As such, no allocation of assimilative capacity is required for Elsinore Valley or Eastern.

6.3.1.1 Salt Offset Strategy for Violation of TDS Permit Limitations

Although there are no regulatory compliance concerns as they relate to permitting Elsinore Valley's and Eastern's recycled water discharges at the existing TDS permit limitations established in the existing waste discharge permits, their discharges will continue to occasionally exceed the discharge limitations, thus requiring a salt mitigation strategy to be adopted. During the current drought, both agencies have seen the TDS concentrations of their recycled water effluent increase in response to the increase in the TDS concentration of their source water supplies. The increase in the source water supply was driven by the increased use of CRA water relative to SWP water.

This is not a problem unique to Elsinore Valley and Eastern. Several agencies across the Santa Ana River Watershed, and elsewhere in Southern California, have seen similar increases in source water TDS concentrations and commensurate violations of permit TDS concentration limits. At the request of the Task Force, and through efforts lead by Eastern, the Regional Board is evaluating options to update its TDS management plan for regulating recycled water discharges during times of drought. Recognizing that the source water supplies available to the agencies in times of drought are often beyond the control of the agencies, the Regional Board is seeking to evaluate a variety of alternative management and permitting strategies that take these climate-driven occurrences into account. The ultimate goal is to avoid issuing mandatory minimum penalties while still regulating the recycled water discharges to protect the beneficial uses of surface and groundwater quality. Development of this policy will involve extensive technical studies to demonstrate the impacts of the various management strategies considered. This work will be led by the Task Force beginning in 2017. In lieu of developing a specific salt

mitigation strategy in this SNMP to address permit violations, Elsinore Valley and Eastern propose to participate in the Task Force efforts and will adopt and implement a TDS management strategy that is consistent with any new Regional Board management plan. Participation in the Task Force study will be a management action under this SNMP (see Section 6.4).

6.3.1.2 Request to Increase the TDS Permit Limitation for Eastern Discharges to the Temescal Wash

Although there have been no new violations of its TDS permit limitation for discharges to the Temescal Wash, which have been zero acre-ft/yr since March of 2013, had wet-conditions required Eastern to discharge, the TDS concentration of the discharge would have violated the 650 mg/L permit limitation. Recognizing that discharges to the Temescal Wash had consistently violated the limitation since 2004 due to source water quality and that the violations will continue if discharges occur in wet-periods, Eastern is requesting to increase its TDS permit limitation to 700 mg/L. A limitation of 700 mg/L is less than both the historical and current ambient TDS of the Upper Temescal Valley GMZ.

To demonstrate the impact of the proposed permit limit increase on the TDS concentration of the Upper Temescal Valley GMZ, a new TDS concentration projection based on the planning assumptions for scenario 1b was developed. Figure 6-1 shows the TDS concentration projections for Scenario 1b under the two TDS permit limits, holding all other assumptions constant. The summary statistics of the ambient TDS concentration projection are shown below in Table 6-C. Table 6-C also shows the ten-year running average streambed recharge concentration in each of the two scenarios as estimated by the WLAM.

Table 6-C
Projected Ambient TDS and 10-Year Running Average TDS Streambed Recharge Concentrations in the Upper Temescal Valley GMZ Under Various Eastern TDS Permit Limits

Scenario	Projected Ambient TDS Concentrations (mg/L)			WLAM Projected 10-Year Running Average Streambed Recharge TDS Concentrations (mg/L)		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Scenario 1b with Eastern TDS Permit Limit of 650 mg/L	698	840	760	322	480	398
Scenario 1b with Eastern TDS Permit Limit of 700 mg/L	715	856	778	340	511	421

Per the methods used by the Regional Board in the wasteload allocation analysis (see WEI, 2015b for example), the maximum of the ten-year average streambed recharge over a long-term hydrologic period is used to define the worst-case streambed recharge concentration and to determine if a recycled water discharge will degrade water quality relative to historical and current ambient concentrations or the objectives of the underlying GMZ.

A recycled water discharge concentration of 700 mg/L increases the minimum, maximum, and average ambient TDS concentration of the Upper Temescal Valley GMZ by about 18 mg/L over the 65-year planning hydrology, an average increase of less than three percent. And, although the ten-year running average streambed recharge concentration also increases by about 23 mg/L on average, it remains well below the current ambient TDS concentration: in the driest ten-year period (e.g. the maximum), the volume-weighted streambed recharge is projected to be about 511 mg/L. This result indicates that the other sources of high-TDS recharge, namely the deep infiltration of applied water (estimated to be about 2,000 mg/L), are the main drivers of ambient TDS concentration increases in the Upper Temescal Valley GMZ. Increasing the Eastern TDS permit limit will result in less dilution of the high-TDS recharge sources to the Upper Temescal GMZ. In the absence of the deep infiltration of applied water, recycled water discharges by Eastern at a TDS concentration of 700 mg/L would cause a lowering of the ambient TDS concentration relative to the historical and current ambient TDS concentrations.

That said, an increase of the TDS permit limitation would increase the projected ambient TDS concentration relative to the existing status-quo conditions, and thus, an allocation of existing assimilative will be required by the Regional Board. Additionally, an application to increase the TDS permit limit will also require a demonstration that the increased TDS concentration of the discharge will not result in the violation of surface water or groundwater quality objectives at or Below Prado Dam. Such a demonstration is beyond the scope of this study. The application to revise the TDS permit limit, and the associated technical analyses, will be pursued by Eastern as a management action under this SNMP (see Section 6.4).

6.3.2 Nitrate

In the case of nitrate, there is 3.2 mg/L of assimilative capacity in the Upper Temescal Valley GMZ. Thus, any discharges with nitrate concentrations in excess of the current ambient nitrate concentration require a full antidegradation analysis to document the amount of assimilative capacity that will be used by the waste discharge. Currently, Elsinore Valley and Eastern have nitrate discharge limitations of 13 and 10 mg/L, respectively. The Basin Plan includes a default assumption of a 25-percent nitrogen loss in the recharge of recycled water discharged to surface waters. Thus, for regulatory purposes the permitted discharge of 13 and 10 mg/L nitrogen are equivalent to recharge TDS concentrations of 9.8 and 7.5 mg/L (e.g. *10 mg/L * 0.75 = 7.5*). Further, to be consistent with the methods used by the Regional Board in the wasteload allocation analysis (see WEI, 2015b for example), the maximum of the ten-year average streambed recharge over a long-term hydrologic period is used to define the worst case streambed recharge. In planning Scenario 1b, the annual volume-weighted streambed recharge ranges from 1.1 to 7.7 mg/L and averages 4.5 mg/L. The ten-year rolling average ranges from 3.6 to 5.6 mg/L and averages 4.5 mg/L. While the maximum of the 10-year rolling average nitrate concentration is less than the antidegradation objective of 7.9 mg/L, it is greater than current ambient concentration of 4.7 mg/L, thus requiring an allocation of assimilative capacity for both agencies because the nitrate concentration in the Upper Temescal Valley GMZ is projected to increase in Scenario 1b.

Scenario 1b shows that ambient nitrate concentrations will range from 4.3 to 5.5 mg/L and will average 4.8 mg/L over wet and dry conditions. Using the average value, and assuming the degradation is driven solely by the combined recycled water discharges (which are the highest nitrate source), a degradation of about 0.1 mg/L *(4.8 - 4.7 = 0.1)* will occur, the equivalent of three percent of the available assimilative capacity.

An allocation of assimilative capacity requires a demonstration that beneficial uses are protected and that the allocation is to the maximum benefit of the people of the State of California. The projected range of nitrate concentrations in the GMZ is less than the Maximum Contaminant Level of 10 mg/L for nitrate, and thus the degradation will not impair beneficial uses for potable and non-potable wells. The maximum benefit demonstration for each discharge follows.

- *Elsinore Valley – Regional WRF discharge to the Temescal Wash*. This discharge is being done (and is required) to support the riparian vegetation located downstream of its discharge point. The protection of this environmental resource is of maximum benefit.

- *Elsinore Valley – Horsethief WRF*. The absolute minimum amount of recycled water is discharged to the on-site percolation ponds when recycled water production exceeds recycled water demands. The allocation of assimilative capacity supports the reuse of recycled water in the Elsinore Valley's Horsethief service area, which reduces the amount of imported water that has to be imported from Northern California through the SWP and thus reduces demands on the environmentally sensitive Sacramento-San Joaquin Delta and helps meet the State Board's recycled water reuse goals, both of which provide maximum benefit to the State.

- *Eastern Discharge to the Temescal Wash*. The absolute minimum amount of recycled water is discharged to the Temescal Wash when recycled water production exceeds recycled water demands and wet period conditions require that storage ponds in the San Jacinto Valley be drained. The allocation of assimilative capacity supports the reuse of recycled water in the Eastern's service area, which reduces the amount of imported water from Northern California through the SWP and thus reduces demands on the environmentally sensitive Sacramento-San Joaquin Delta and helps meet the State Board's recycled water reuse goals, both of which provide maximum benefit to the State.

Elsinore Valley and Eastern will implement this SNMP as a condition of being granted an allocation of assimilative capacity for nitrate.

6.4 Salt and Nutrient Management Plan Actions

Based on the characterization of the Upper Temescal Valley GMZ, the recommended Basin Plan objectives, the current and projected TDS and nitrate concentrations, and the anti-degradation analyses performed herein, the following are the recommended management actions to be implemented by Elsinore Valley and/or Eastern pursuant to this SNMP:

- Implementation of a new SNMP Monitoring and Reporting Program, including the addition of new groundwater and surface water monitoring locations, in the Upper Temescal Valley GMZ to validate the methods and findings described in this report and

to support future efforts to recompute current and project future ambient water quality.

- Triennial reporting of the water supply and discharge water quality management activities of each agency, including water supply and discharge water quality trends over the reporting period.
- Recomputation of current ambient water quality and ambient water quality projections for the Upper Temescal Valley per the methodologies developed herein by June 30, 2020 and thereafter based on a method and schedule approved by the Regional Board.
- Participation in Task Force efforts to periodically update the Wasteload Allocation for the Santa Ana River Watershed.
- Participation in Task Force efforts to assist the Regional Board in the development of updated TDS management strategies for recycled water discharges during times of drought.
- Submittal of an application for a new TDS waste discharge limitation for Eastern's discharge of recycled water to the Temescal Wash, and develop a plan and schedule for an alternative approach if a new limitation is not approved by the Regional Board.
- Annual reporting of progress and activities related to this SNMP to the Regional Board.
- Periodic update of the SNMP Actions.

Each of these efforts and the proposed schedule for implementation is described in greater detail below.

6.4.1 SNMP Monitoring and Reporting Program

The goal of the SNMP monitoring program is to provide the data required to calculate ambient TDS and nitrate concentrations with the same methodology used herein to estimate historical and current ambient water quality, to make projections of future ambient water quality, and to provide the data required to evaluate wasteload allocations. The types of data required for these analyses include groundwater level, production, and water quality; surface water discharge and quality; recycled water discharge and quality; water supply plans; land use; and watershed drainage maps.

6.4.1.1 SNMP Field Monitoring Program

Figure 6-2 is a map of the monitoring sites included in the proposed SNMP field monitoring program. The figure includes:

- The location of 12 existing wells that will be monitored for water levels and water quality.
- The conceptual location of up to four new wells to be constructed and added to the monitoring program. One site is a new production well being constructed by Elsinore Valley; the remaining three sites are conceptual locations for new monitoring wells.
- The approximate location of five in-stream surface water monitoring sites.

- The location of two proposed instantaneous discharge measurement stations: one at the outlet of Lee Lake dam and one at the outlet of the All-American Aggregate Pit.

Groundwater level and water quality. Where practicable[30], integrated data loggers will be installed to continuously measure groundwater levels and electrical conductivity (EC). As illustrated by the available historical water quality data at wells, TDS concentrations are highly variable and fluctuate in response to wet and dry periods, and the installation of continuously recording EC probes will help to fully characterize how water quality fluctuates seasonally and over wet and dry periods. To capture the range of constituent concentrations at wells, water quality grab samples should initially be performed on a quarterly frequency. The minimum water quality constituents to be measured are listed in Table 6-1 and include TDS, nitrate, and the major anions and cations. If after the initial monitoring period the laboratory measurements can be correlated to the continuous EC readings, the grab sampling rate would be reduced. Where it is not practical to install transducers, groundwater level measurements should be collected on a monthly basis and water quality on a quarterly basis. Again, after the initial monitoring period the groundwater level will be evaluated to adjust the monitoring accordingly. The existing wells (12 wells) to be monitored are shown in Figure 6-2 and are listed in Table 6-2, along with the required measurement types.

To fill spatial data gaps in the Warm Springs GMZ and the southeastern portion of the Lee Lake GMZ, additional wells (either new construction or existing private wells) will need to be monitored per the same protocols as the existing wells once they are identified or constructed. Elsinore Valley is constructing a new production well near the site of the former Barney Lee wells that were destroyed as part of a new residential development. The conceptual location of this production well is shown in Figure 6-2. Conceptual locations for additional wells are shown in Figure 6-2 to illustrate the minimum spatial distribution required to fill existing data gaps.

Elsinore Valley has conducted extensive outreach efforts throughout the Valley to identify existing wells that can be included in the monitoring program. One well, owned by Southern California Edison has already been identified (shown in Figure 6-2 and Table 6-2) and included in the program. There are seven additional private wells located in the Warm Springs Valley and Lee Lake areas that Elsinore Valley has requested access for sampling. Thus far no agreements have been reached.

Additionally, Elsinore Valley is in the process of performing a detailed hydrogeologic investigation of the Warm Springs area in support of its efforts to increase groundwater production. The results of the study will be used to site new groundwater monitoring wells if access to the seven private wells is denied. The hydrogeologic study is planned for completion by the end of 2017.

Surface-water discharge and water quality. As previously noted in this report, there are no existing surface water monitoring programs in the Upper Temescal Valley. Given that very little is understood about surface-water discharge, quality, and its interactions with groundwater, an initial one-year synoptic survey of the watershed will be performed. In the initial year, the

[30] It may not be possible to install transducers in all existing, active production wells, depending on how the wells were constructed and equipped.

program will include a greater frequency of monitoring than will be required in the long-term to characterize discharge and water quality.

The five initially proposed in-stream surface water monitoring stations are shown in Figure 6-1 and listed in Table 6-3. The preliminary locations were based on a review of geology maps, drainage maps, roads, aerial photography, and land use maps. A field reconnaissance investigation will be performed to determine the precise locations to collect samples within the creek based on access and safety considerations.

During the first year of monitoring, the sites will be visited on an approximately biweekly basis to capture the full range of wet and dry conditions.[31] During each visit, a grab water quality sample will be collected, and a stream discharge measurement made. The minimum water quality parameters to be measured are listed in Table 6-1 and include TDS, nitrate, and the major anions and cations. In some cases, low-flow or no-flow conditions will preclude the ability to collect samples or discharge measurements. Photographs will be collected during every visit, and flow conditions will be documented by field personnel (even if samples and measurements cannot be collected).

Instantaneous discharge measurements will be required to calibrate the surface water model used in the ambient TDS and nitrate determinations and for the wasteload allocation. A surface water monitoring station has already been constructed at the outlet of Lee Lake dam. The Elsinore Valley is currently coordinating with the landowners and the RCFC&WCD to secure permission to install a second monitoring station at the outlet of the All-American Aggregate Pit, if feasible. The monitoring stations will consist of a stage recorder in the reservoirs and flow meters installed in the outlet works (or devices that record the gate opening) and will be connected to a digital recorder. The discharge from Lake Elsinore, if it occurs, can be calculated from the continuous stage recorder that is maintained at the Lake. The data will be analyzed to produce discharge estimates at 15-minute intervals and aggregated to daily discharge measurements for surface water model calibration. Additionally, if outflow is occurring, water-quality grab samples will be collected at these two stations at the same frequency as the in-stream surface water sites (biweekly for the first year).

After one year of high-frequency monitoring, the discharge and water quality results will be evaluated to establish a revised program of stations and monitoring frequencies to characterize surface water quality and surface and groundwater interactions in the Upper Temescal Valley.

6.4.1.2 Compilation of Other Data Sets

The following data sets will be collected, compiled and maintained as part of the SNMP database:

[31] The schedule is stated as "approximate" as it may not be possible to access the sites during extreme wet conditions. If it's not safe to collect samples and measure discharge, the monitoring event will not occur.

Water supply plans. This data includes the sources of water supplied, the monthly volume supplied from each source, the water quality of each source,[32] the approximate amounts of each source used indoors and outdoors, the locations of use (e.g. pressure zones), and projected future water supply plans. Water use data will be collected from Elsinore Valley, the TVWD, and the City of Corona on an annual basis. Future water supply projections will be collected, as needed, for preparing projections of ambient water quality (see Section 6.4.1.4).

Private Groundwater Production. To the extent practicable, the location of private groundwater wells will be documented, and the associated volumes of groundwater produced will be estimated if reported values are not available. The status of private groundwater use will be updated as the information becomes available.

Land use. This data includes the current and future land use surveys that were used in the development of the 2014 ambient TDS and nitrate concentrations, any subsequent periodic Southern California Association of Governments (SCAG) land use surveys, and general plan land use maps from all agencies in the Upper Temescal Valley. This information can be collected and compiled during the update of ambient water quality (see Section 6.4.3).

Drainage system. This data includes information on any drainage system changes that occurred during the time period for which ambient TDS and nitrate concentrations are being estimated and any future planned changes. This information can be collected and compiled during the update of ambient water quality (see Section 6.4.3).

6.4.1.3 Data Management

All data collected and compiled for the Upper Temescal Valley SNMP monitoring program will be processed into electronic formats, checked for quality assurance and quality control (QA/QC), and stored in a centralized project database

6.4.1.4 Reporting

The reporting period for the Upper Temescal Valley SNMP will be the water year (October 1 to September 30). An annual report will be prepared and submitted to the Regional Board by January 31 of each year following the end of the reporting period. The report will include, at a minimum: a summary of the monitoring and data collection efforts performed, tables and charts of the monitoring results, and any recommended changes to the monitoring program. This report will be incorporated as part of the larger Annual SNMP Progress Report described in Section 6.4.7. Additionally, prior to the completion of the first annual report, quarterly progress reports will be submitted to the Regional Board.

6.4.1.5 Implementation Schedule

The Upper Temescal Valley SNMP Monitoring Program will be implemented according to the following schedule:

- Finalize agreements with cooperating agencies for implementation of the SNMP monitoring program by October 31, 2017.

[32] The potable municipal water supply sources and recycled water sources are being tested for water quality in compliance with the requirements of the California Department of Drinking Water and the Regional Board. Annual measurements are acceptable.

- Determine a list of wells suitable for the installation of integrated water level transducer/and EC sensor data loggers within 45 days of the Regional Board's approval of the SNMP.
- Install integrated water level transducer/and EC sensor data loggers and initiate groundwater level and water quality grab sample monitoring within 90 of the Regional Board's approval of the SNMP.
- Perform surface water monitoring site reconnaissance within 30 days of the Regional Board's approval of the SNMP.
- Initiate biweekly surface water monitoring within 60 days of the Regional Board's approval of the SNMP.
- Quarterly progress reports on the status of the monitoring program implementation and results will be submitted to the Regional Board through the completion of the first annual report. The report will be submitted by the last day of the month following the end of the quarter (e.g. January 31, April 30, July 31, and October 31).
- Deliver first annual report of the SNMP Monitoring Program by January 31, 2019.
- Prepare report documenting the proposed location of new groundwater monitoring locations (existing private wells or newly constructed monitoring or production wells) to the Regional Board within 60 days of the incorporation of the Upper Temescal Valley SNMP into the Basin Plan. The report will include a schedule for construction of any new wells proposed for construction.

6.4.2 Triennial Report of Water Supply and Discharge Water Quality Management

Every three years, Elsinore Valley and Eastern will prepare a report of their respective efforts to manage the TDS concentration of their water supply sources and recycled water discharges. Each agency will prepare its own separate report of activities. The report will include: a characterization of the service area, source water supplies, and recycled water discharge and reuse; descriptions of the current and potential future activities to manage/improve the TDS concentration of supply sources and/or wastewater; and a characterization of the TDS concentrations of source waters and recycled waters to demonstrate how water quality is trending over time.

Eastern is already developing this report for compliance with its Maximum Benefit Commitments in the San Jacinto Upper Pressure GMZ. Eastern's next report is due in August 2018 for the reporting period of 2015-2018, and every three years thereafter. Elsinore Valley will prepare its first report in accordance with the schedule being implemented by Eastern (e.g. August 2018 and every three years thereafter).

6.4.3 Recomputation of Current Ambient Water Quality and Projections of Future Ambient Water Quality

Current ambient TDS and nitrate concentrations will be recomputed by June 30, 2020. The same (or functionally equivalent) surface water and groundwater modeling tools will be updated and recalibrated to include the new datasets collected through the SNMP monitoring program. This effort will also include preparing updated projections of future ambient water

quality based on the recycled water reuse and development plans of the agencies in the Upper Temescal Valley to determine if new SNMP management actions are needed. The recomputation effort will be performed so that the results are available at the same time as of the next ambient water quality update prepared by the Basin Monitoring Task Force. Upon completion of the technical work in 2020, Elsinore Valley and Eastern will work with the Regional Board to establish a plan and schedule for ongoing updates to the ambient water quality calculations.

6.4.4 Participation in the Update of the Wasteload Allocation for the Santa Ana River Watershed

The Regional Board periodically requires the Basin Monitoring Task Force to update the wasteload allocation for the Santa Ana River Watershed. This is a comprehensive surface water modeling analysis to evaluate the current and future impacts of recycled water discharges on the quality of the Santa Ana River and its tributaries and the underlying GMZs. Elsinore Valley and Eastern will participate financially, or with in-kind contributions of the robust data and models developed for this SNMP,[33] in the watershed-wide effort when it is required by the Regional Board.

6.4.5 Participation in the Update of the Regional Board's TDS Management Plan for Recycled Water Discharges during Times of Drought

As previously described in Section 6.3.1.1, the Regional Board is evaluating options to update its TDS management plan for regulating recycled water discharges during times of drought. Development of such a policy will require extensive technical studies to be performed by the Task Force to demonstrate the impacts of the various management strategies considered. Elsinore Valley and Eastern will participate financially, or with in-kind contributions, in the Task Force study and will incorporate the adopted salt offset strategies, as appropriate, into a future update of this SNMP. The technical work in support of the policy effort is scheduled to be completed by December 2017. The Task Force will begin its effort to develop compliance strategies upon completion of the technical work.

6.4.6 Application to Revise the TDS Permit Limitation for Eastern's Discharge of Recycled Water to Temescal Wash

As described in Section 6.3.1.2, Eastern will apply to increase its TDS permit limitation for its recycled water discharges to the Temescal Wash from 650 to 700 mg/L. This SNMP provides the technical analysis and characterization of the impacts of an increased permit limit on the Upper Temescal Valley GMZ. However, as noted, the application will also require a demonstration of the impacts to the TDS concentration of the Santa Ana River at Prado Dam. Such a demonstration requires the use of the watershed-wide WLAM. The WLAM will be updated, calibrated and used to simulate new planning projects beginning in February 2017. The effort will be led by the Task Force. Eastern will financially participate in that effort and

[33] The WLAM application developed in this SNMP is much more detailed than in the WLAM used by the Task Force and can be inserted into the current model, thereby enhancing it.

will include planning scenarios under the proposed TDS permit limitation to make the required impact characterization. The application to increase the permit limit will be completed within one year of the Regional Board's approval of the WLAM update.

In the event that the application to increase the TDS permit limit is not approved by the Regional Board, Eastern will submit a plan and schedule to develop a salt offset option for discharges to the Temescal Wash within 6 months of the rejection of the application.

6.4.7 Annual Reporting of SNMP Progress and Activities

Elsinore Valley and Eastern will prepare a joint report on their progress and activities related to the SNMP, including progress towards meeting compliance schedules for the management actions described herein. The report will be submitted to the Regional Board by January 31st each year and will include the annual report of the SNMP Monitoring Program. The first annual report will be submitted to the Regional Board by January 31, 2019.

6.4.8 Periodic Update of the Salt and Nutrient Management Plan Actions

The SNMP Actions will be updated upon completion of the next recomputation of current ambient water quality and projections of future ambient water quality. The updated actions will be reported together with the ambient water quality analysis, and will include an approved plan and schedule for ongoing updates to the ambient water quality calculations and the SNMP management actions.

Table 6-1
Water Quality Constituents to Analyze for the Upper Temescal Valley SNMP Monitoring Program

Laboratory Parameters
Alkalinity (including: Bicarbonate, Carbonate, Hydroxide)
Ammonia-nitrogen
Calcium
Chloride
Magnesium
Nitrate (as nitrogen)
Nitrite (as nitrogen)
pH
Potassium
Sodium
Specific Conductance @ 25 degrees C
Sulfate
Total Dissolved Solids
Field Parameters
pH
Specific Conductance @ 25 degrees C
Temp

Table 6-2
Groundwater Monitoring Sites for the Upper Temescal Valley SNMP Field Program

Well Information					Proposed Monitoring Type and Frequecny		
Owner's Well Name	Owner's Well Use	Owner	Latitude	Longitude	Monthly Manual Water Level[1]	Quaerterly Download of Integrated Data Logger for Continous Water Level and EC[2]	Quarterly Water Quality[3]
Flagler 2A	Potable Municipal	Elsinore Valley	33.828	-117.511	X	TBD	X
Flagler 3A	Non-Potable Municipal	Elsinore Valley	33.827	-117.511	X	TBD	X
New Sump	Non-Potable Municipal	Elsinore Valley	33.781	-117.475	X	TBD	X
Gregory 1	Non-Potable Municipal	Elsinore Valley	33.753	-117.446	X	TBD	X
Gregory 2	Non-Potable Municipal	Elsinore Valley	33.752	-117.447	X	TBD	X
SCE Well	Monitoring	Southern California Edison	33.736	-117.416	X	TBD	X
Cemetary Well	Non-Potable Municipal	Elsinore Valley	33.690	-117.347	X	TBD	X
WPC W1	Monitoring	Corona	33.823	-117.508	X	TBD	X
WPC W2	Monitoring	Corona	33.823	-117.507	X	TBD	X
MW-1	Monitoring	Temescal Valley WD	33.802	-117.498	X	TBD	X
MW-2	Monitoring	Temescal Valley WD	33.786	-117.490	X	TBD	X
MW-3	Monitoring	Temescal Valley WD	33.799	-117.505	X	TBD	X

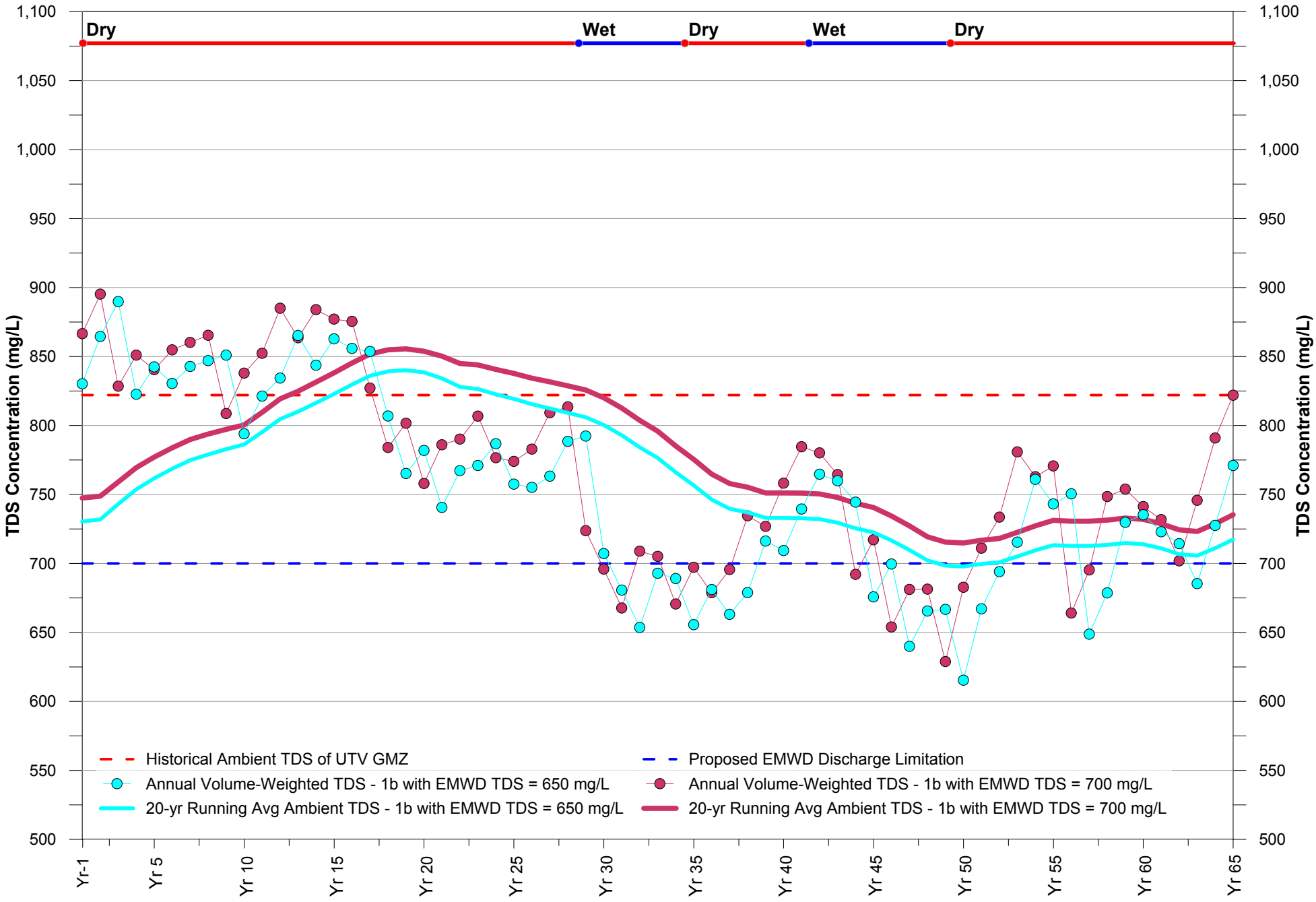
[1] The frequency will be reduced to quarterly if an integrated data logger for continuous water level and EC readings is installed.
[2] A field reconnaissance effort to evaluate the feasibility of installing integrated data loggers will be performed by January 31, 2017.
[3] The list of water quality parameters to be measured is provided in Table 6-1.

Table 6-3
Surface-Water Monitoring Sites for the Upper Temescal Valley SNMP Field Program

Monitoring Station Information				Manual Biweekly Discharge Measurement	Continuous Discharge Measurement	Biweekly Water Quality[1]
Station Name	Owner, If applicable	Latitude	Longitude			
Station 1	na	33.707	-117.362	X		X
Station 2	na	33.729	-117.396	X		X
Lee Lake Outlet	Elsinore Valley MWD	33.750	-117.445		X	X
Station 3	na	33.760	-117.459	X		X
Station 4	na	33.782	-117.478	X		X
Station 5	na	33.824	-117.506	X		X
All American Aggregate Pit Outlet[2]	Private Owner	33.868	-117.530		X	X

[1] The list of water quality parameters to be measured is provided in Table 6-1.

[2] Property access has not yet been granted; Elsinore Valley is working with the owner and RCFC&WCD to obtain access and install equipment, if feasible.



Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: CS
Date: 20160812
File: Figure 5-3

Projected Annual Volume-Weighted and 20-year Running Average Ambient TDS Concentration

Scenario 1b - Comparison of EMWD Discharge Concentrations

Figure 6-1

117°20'0"W

All American Aggregate Pit

Temescal GMZ

Lake Mathews

Flagler 2A

Flagler 3A

COR WPC W-2

COR WPC W-1

Bedford Wash

TVWD MW 1A

TVWD MW 3 - Bedford Motorway

TVWD MW 2 - Driving Range

EVMWD New Sump

Riverside County

Orange County

El Sobrante de San Jacinto

Upper Temescal Valley Watershed

15

Coldwater GMZ

EVMWD Gregory 1

EVMWD Gregory 2

Lee Lake

SCE Well

Temescal Wash

Santa Ana Mountains

Railroad Canyon Reservoir

Cemetary

Elsinore GMZ

Lake Elsinore

33°40'0"N

117°20'0"W

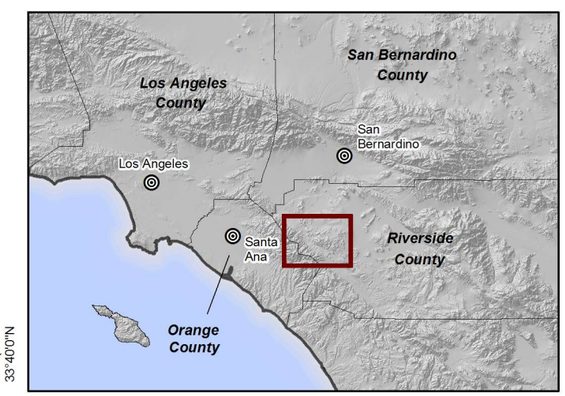
33°40'0"N

Monitoring Locations

- Groundwater Monitoring Location
- In-Stream Surface Water Monitoring Site
- Continuous Flow Gage
- Proposed Location of New Production Well
- Approximate Location of New Monitoring Well

Other Features

- Upper Temescal Valley GMZ
- Other GMZs
- Streams and Flood Control Channels
- Lakes and Flood Control Basins



Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: CS
Date: 8/16/2016
File: Fig_6-2_MonitoringProgram

0 2 4 Miles

0 2 4 KM

Upper Temescal Valley
Salt and Nutrient Management Plan

Groundwater and Surface Water Monitoring Sites for the SNMP Monitoring Program

Figure 6-2

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Appendix A

Rationale for Creating the Upper Temescal Valley Groundwater Management Zone

September 8, 2014

Elsinore Valley Municipal Water District
Attention: Ganesh Krishnamurthy
31315 Chaney Street
PO Box 3000
Lake Elsinore, CA 92531-3000

Eastern Municipal Water District
Attention: Jayne Joy
2270 Trumble Road
P.O. Box 8300
Perris, CA 92572-8300

Subject: ***Rationale for Creating the Upper Temescal Valley Groundwater Management Zone***

Dear Mr. Krishnamurthy and Ms. Joy:

The purpose of this letter is to provide rationale for proposing that the Bedford, Lee Lake, and Warm Springs Valley Groundwater Management Zones (GMZs) be combined into one single management unit: the Upper Temescal Valley GMZ.

Background

In our scope-of-work proposal for the *Development of an Upper Temescal Valley Salt and Nutrient Management Plan*, dated May 13, 2014, we (Wildermuth Environmental Inc. [WEI]) proposed a methodology for computing historical ambient water quality and proposing antidegradation objectives for the Bedford, Lee Lake, and Warm Springs Valley GMZs. Specifically, the proposal described performing the analysis for the Upper Temescal Valley GMZ, a single GMZ that combines the Bedford, Lee Lake, and Warm Springs GMZs into one.

As discussed in a previous correspondence from WEI to the Eastern Municipal Water District (Eastern) and the Elsinore Valley Municipal Water District (Elsinore Valley), dated August 26, 2014,[1] the Santa Ana Regional Water Quality Control Board (Regional Board) posed several questions about the work performed to date that would require a change in the planned scope of work for the Upper Temescal Valley Salt and Nutrient Management Plan (SNMP). One of these questions was:

[1] *Request to Amend the Scope of Work and Budget for Work Order No. 75879/Purchase Order No. 4927*, letter from Wildermuth Environmental Inc. to Elsinore Valley and Eastern dated August 28, 2014.

> Can WEI run the analysis on the individual GMZs (instead of one model for the whole Upper Temescal Valley GMZ) to see if there should be different objectives for the Warm Springs, Lee Lake, and Bedford GMZs? The management zones were delineated separately in 2000, and the Regional Board wants to be certain that there is a good reason why the Basin Plan should be amended to combine them together as one.

The Regional Board directed Eastern, Elsinore Valley, and WEI to proceed but reserved the right to request further analysis for the un-combined GMZs. Eastern and Elsinore Valley do not want to proceed with the remainder of the Upper Temescal Valley SNMP analysis until a final decision is made by the Regional Board as to whether the GMZs should be combined or not. It is WEI's professional opinion that it is appropriate to continue with the analysis for the combined Upper Temescal Valley GMZ. The following rationale supports this opinion.

2004 Delineation of the Upper Temescal Valley Groundwater Management Zones

The GMZs adopted in the 2004 Basin Plan amendment (Resolution R8-2004-0001) replaced the groundwater subbasins used in prior versions of the Basin Plan. The subbasins used in the prior Basin Plan were delineated based on zones of comparable water quality. In the mid-1990s, it was demonstrated that it was not possible for the Regional Board to regulate waste discharges to protect water quality in the subbasins because they were not defined based on the hydrology of the groundwater basins. In some cases, managing waste discharges to the subbasin objectives actually led to degradation of down-gradient subbasins. Through the work of the TIN/TDS Task Force, the Regional Board came to understand that it needed to base its water quality management strategy on hydrologically defined management units. Thus, the management units were re-defined based on hydrology and are now referred to as GMZs; R8-2004-0001 replaced the subbasins of the prior Basin Plan with the hydrologically defined GMZs (see TIN/TDS Study – Phase 2A Final Report[2] [Phase 2A report]).

In Section 3 of the Phase 2A report, GMZs are defined as "hydrologically-distinct groundwater units from a groundwater flow and water quality perspective. Groundwater flow was the principal phenomena studied and utilized to construct management zones; water quality data were used to augment our understanding of the flow regime." To delineate the GMZs, boundaries were "placed along impermeable barriers to groundwater flow, at bedrock constrictions, and between distinct flow systems. Groundwater flow between management zones is generally restricted."

Section 3.3.4 of the Phase 2A report describes the delineation of the GMZs in the Elsinore – Temescal Valleys. The following is an excerpt from the report describing the hydrogeologic features used to delineate the GMZs in this region[3]:

> "Figure 3-13 is an equal elevation contour map of the effective base of the freshwater aquifers in this region. Note the numerous bounding faults and the steep slope of the base of the freshwater beneath Lake Elsinore (Elsinore Basin). The Elsinore Basin is shallow on its perimeter,

[2] WEI, 2000. *Development of Groundwater Management Zones – Estimation of Historical and Current TDS and Nitrogen Concentrations in Groundwater.* TIN/TDS Study – Phase 2A Final Technical Memorandum. Prepared for the TIN/TDS Task Force, July 2000.
[3] The figures referenced in the excerpt are included as attachments to this memo.

> but is extremely deep at its center (greater than 2,000 feet below ground surface) due to intense faulting and contemporaneous sedimentation (Geoscience, 1994). The Coldwater Basin, located northwest of the Elsinore Basin between the North Glen Ivy and South Glen Ivy faults, is similar in structural origin and reaches a maximum depth of about 700 feet. The Temescal and Arlington basins to the north are comparatively broad and shallow, but exhibit a channel-like bedrock feature parallel to the long axis of each basin (Eckis, 1934; DWR, 1970).
>
> The base of the aquifer underlying the central portion of the Temescal Valley is unmapped, and the literature review performed in this study did not locate such a map. The significant aquifers within this region are restricted to a narrow band of saturated alluvium along Temescal Wash. Analysis of driller's logs of wells located along this reach of Temescal Wash indicates consolidated, non-water-bearing bedrock at a depth of about 100 feet below ground surface…
>
> In general, groundwater flow mimics surface drainage patterns. Figures 3-14 and 3-15 are groundwater elevation contour maps for Fall 1973 and Fall 1997 that show this general groundwater flow pattern. The Elsinore Basin is practically surrounded by impermeable bedrock hills, and surface water drains internally to Lake Elsinore. Similarly, groundwater flows internally – from the flanks of the surrounding hills (areas of recharge) towards the main groundwater reservoirs underlying Lake Elsinore. Groundwater does not exit the Elsinore Basin except via groundwater production and evapotranspiration where and when groundwater is near the ground surface. In the Temescal Valley and the Arlington Basin, groundwater flows from the flanks of the surrounding hills (areas of recharge) toward surface drainage tributaries (e.g. Temescal Wash and the Arlington Drain) and, thence, toward Prado Basin (area of discharge)."

The Elsinore and Coldwater GMZs were delineated based on the distinct geologic structures that created the deep aquifers and internal flow systems. The delineation of the Warm Springs, Lee Lake, and Bedford GMZs in the Phase 2A report and the current Basin Plan were based on the limited data and published reports available to the Nitrogen/TDS Task Force and limited funding to conduct research in this area. No bedrock contours could be developed, and the data were so limited that it was not possible to develop TDS and nitrogen objectives for these GMZs. The features used to separate the Upper Temescal Valley into three GMZs are narrow gaps where the bedrock is shallow and the alluvium is thin.. A similar bedrock constriction along Temescal Wash separates the Bedford GMZ from the Temescal GMZ, however, the Temescal Wash downstream of the All American Aggregate Pit is concrete lined and does not recharge the Temescal GMZ.

Rationale for Creating the Upper Temescal Valley GMZ

As described in the Phase 2A report, "the significant aquifers within this region are restricted to a narrow band of saturated alluvium along Temescal Wash. Analysis of driller's logs of wells located along this reach of Temescal Wash indicates consolidated, non-water-bearing bedrock at a depth of 100 feet below ground surface." The follow-up work performed for the Upper Temescal Valley SNMP confirms this description. Figure 1 shows the locations of wells where bedrock was encountered during well construction, with the depth to bedrock annotated at each well. Figure 1 also shows the location of water bearing alluvium in the Upper Temescal Valley. The alluvial sediments along Temescal Wash generally range between 40 to 120 feet deep and are horizontally confined by the impermeable rocks of the mountain ranges on both sides of the wash. The wash thalweg (deepest point of the channel) provides a vertical control on the effective width and depth of the groundwater system. Figure 2 is a

representative cross section of the Upper Temescal Valley alluvial aquifer along the Temescal Wash at the Flagler 2A well in Bedford (see cross section location on Figure 1). Also shown in Figure 2 is a simplification of the cross section that allows for the estimation of groundwater storage capacity. The simplification depicts the aquifer as a prism where storage capacity can be calculated as:

$$Storage = \left(\frac{1}{2}\begin{matrix} Average\ Width \\ of\ Valley\ Floor \end{matrix} * \begin{matrix} Maximum \\ Aquifer\ Thickness \end{matrix}\right) * \begin{matrix} Total\ Length\ of \\ Alluvial\ Aquifer \end{matrix} * Specific\ Yield$$

The valley floor ranges in width from 50 to 12,000 feet, averaging about 1,400 feet. On average, the aquifer thickness at the thalweg is no more than 100 feet. The total length of the alluvial aquifer is about 30 miles. Specific yield is estimated to range between 0.10 and 0.20. These values yield a total storage capacity estimate ranging from about 25,000 to 75,000 acre-ft. As such, it can be said that the Upper Temescal Valley has limited groundwater resources.

The primary sources of recharge in the Upper Temescal Valley are streambed infiltration from stormwater and treated wastewater discharges (from Elsinore Valley and Eastern treatment plants) and the deep infiltration of return flows from outdoor water use (agricultural and urban). As groundwater flows northwest, it is forced to the surface by high groundwater levels and/or bedrock constrictions (shallow bedrock, bedrock bank constrictions, or both). Thus, rising groundwater in the Warm Springs Valley contributes to streambed infiltration in Lee Lake, and rising groundwater in Lee Lake contributes to streambed infiltration in Bedford. More generally stated, groundwater and surface water continuously interact from the headwaters of Temescal Wash at the Lake Elsinore discharge point down to the All American Aggregate pit in Corona. In essence, the Upper Temescal Valley GMZs are a series of small cascading reservoirs with each reservoir completely passing its water to the next downstream reservoir. Based on our analysis of historical inflows and outflows, the turnover rate of the Upper Temescal Valley GMZ is about 11 years (computed as the average volume of water in storage divided by the average outflow).

Historical water quality data at wells support this conceptualization of the Upper Temescal Valley as a series of cascading reservoirs. The TDS concentrations are highly variable both spatially and at individual wells. This variability is reflective of wet and dry climate cycles, the small effective storage, and the surface and groundwater interchange along the Temescal Wash. Figure 3 shows the location of wells with TDS data during the antidegradation objective setting period (1954 to 1973). Each well is labeled with TDS measurement statistics over the 20-year period. The bold value represents the ambient water quality statistic,[4] and the values in parentheses (in order) are the number of annualized average values over the 20-year period, the mean of the annualized averages, the minimum annualized average, and the maximum annualized average. As Figure 3 shows, annualized average TDS concentrations at individual wells vary by as much as 700 mg/L. Figure 4 is a time-history plot of all TDS concentrations measured at wells from 1954 to 1973. Figure 4 demonstrates that all three GMZs generally have the same range of TDS concentrations and that no one GMZ has predominantly better or worse water quality than the other: they all have wells with high and low TDS concentrations. The fact that all three GMZs do not universally reflect the same water quality at any given time is reflective of the time it takes

[4] See WEI, 2014. *Recomputation of Ambient Water Quality in the Santa Ana River Watershed for the Period 1993 to 2012.* Technical Memorandum. Prepared for the Santa Ana Watershed Project Authority Basin Monitoring Program Task Force. August 2014. Note that a simplified method to compute the ambient water quality statistics was used for this data analysis -- the data used to compute the statistics shown on Figure 3 were not subject to the Shapiro-Wilk test for normality and outliers.

for the groundwater in the upgradient basins to pass to the downgradient basins. The range of TDS concentration sample results observed from 1954 to 1973 follows:

- **Bedford** – 9 wells, sample result values range from a low of 265 mg/L to a high of 1,340 mg/L.
- **Lee Lake** – 12 wells, sample result values range from a low of 236 mg/L to a high of 1,038 mg/L.
- **Warm Springs** – 4 wells, sample result values range from a low of 262 mg/L to a high of 1,225 mg/L.

Recommendation

It is the Regional Board's goal to define management zones on hydrologically based criteria. The hydrologic and water quality data demonstrate that the Bedford, Lee Lake, and Warm Springs Valley GMZs are a series of cascading groundwater units in which the groundwater from each unit passes its water to the next downstream unit. And, these units are all subject to the same recharge sources: streambed infiltration of stormwater from the Temescal Wash and its tributaries, streambed infiltration of treated wastewater discharges, and the deep infiltration of return flows from outdoor water use (agricultural and urban). Accordingly, the Upper Temescal Valley should be managed as one hydrologically continuous unit: the Upper Temescal Valley GMZ.

If you have any questions or concerns about the information contained herein, please contact us at (949) 420-3030.

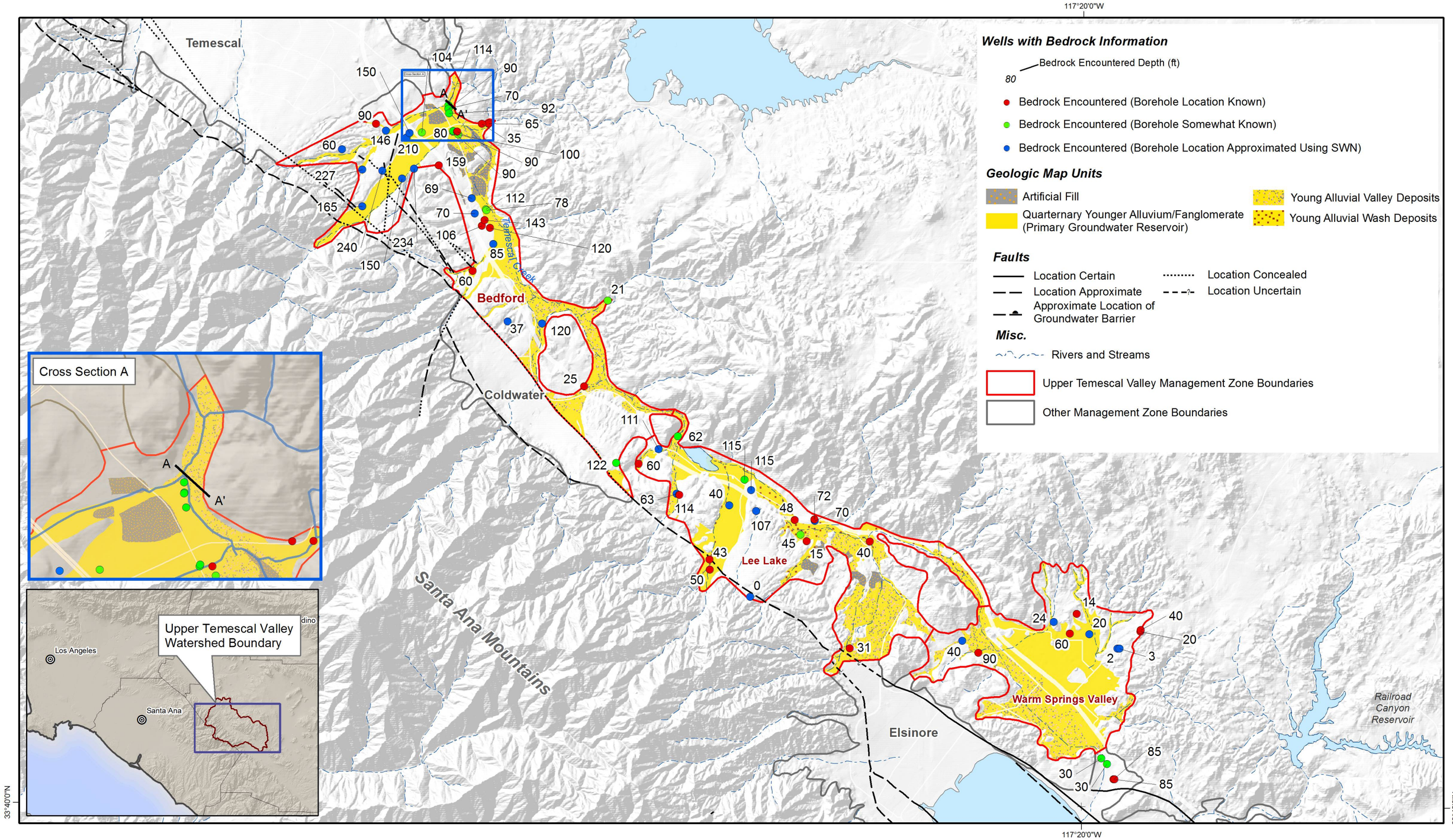
Very truly yours,

Wildermuth Environmental, Inc.

Mark Wildermuth, PE
President, Principal Engineer III

Samantha Adams
Principal Scientist I

Encl.: Figures 1 through 4



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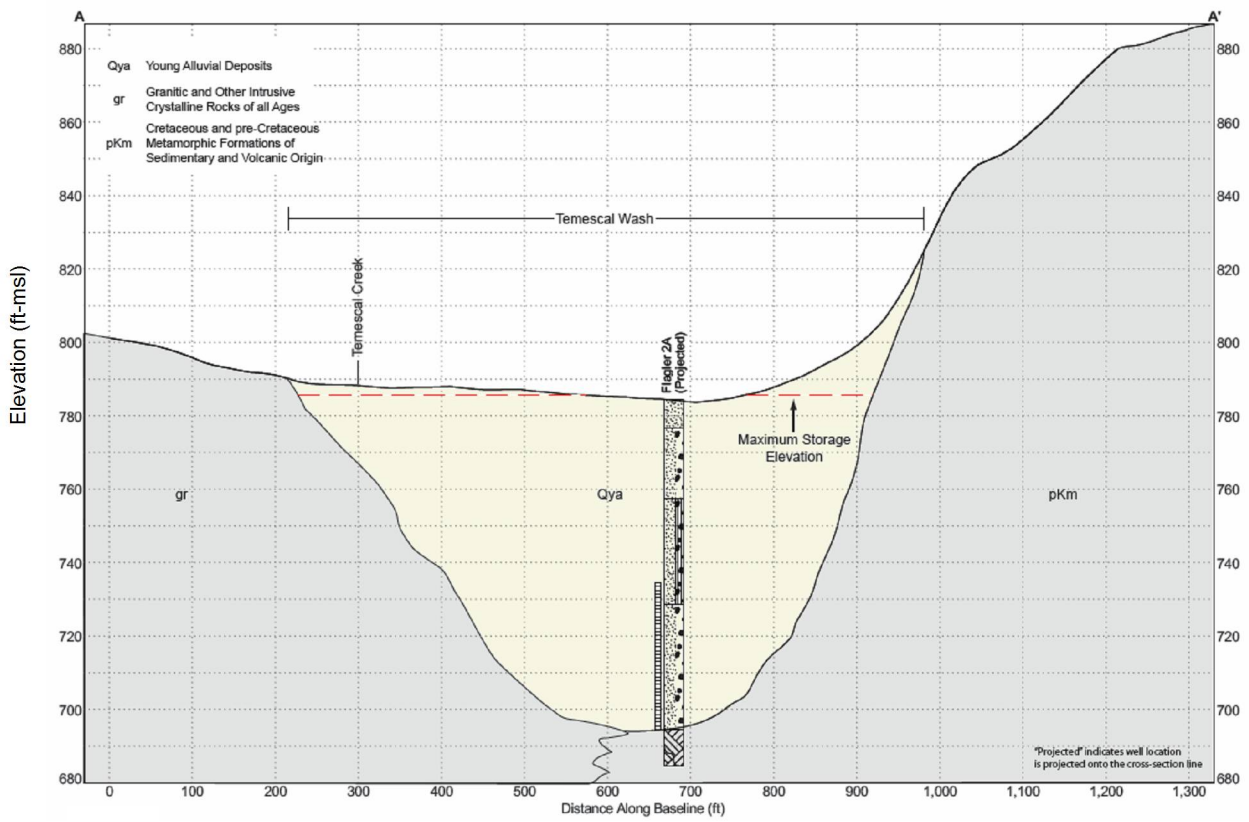
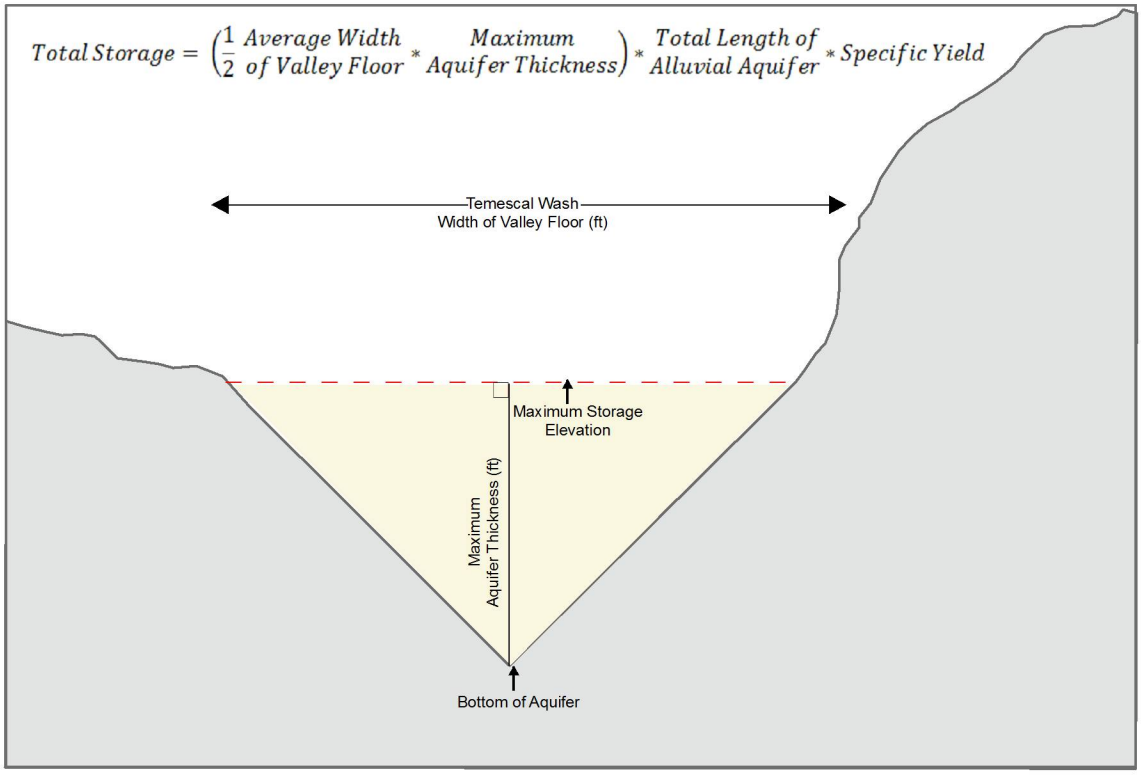
0 1 2 3 4 Miles
0 2 4 6 Kilometers

Upper Temescal Valley Monitoring Program

Depth to Bedrock at Wells with Lithology Logs

Figure 1





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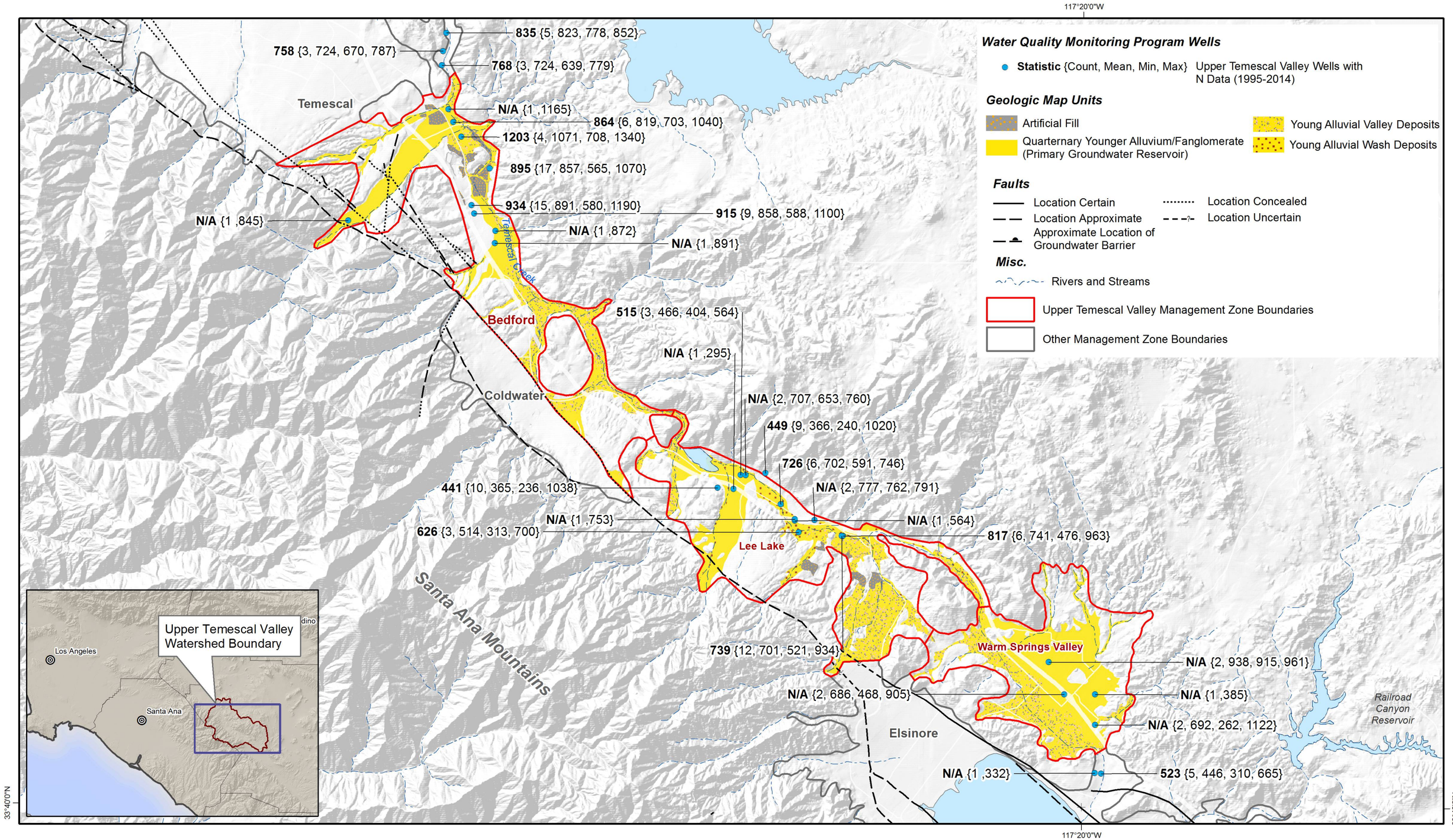
Cross Section of the Alluvial Aquifer in the Upper Temescal Valley

Figure 2



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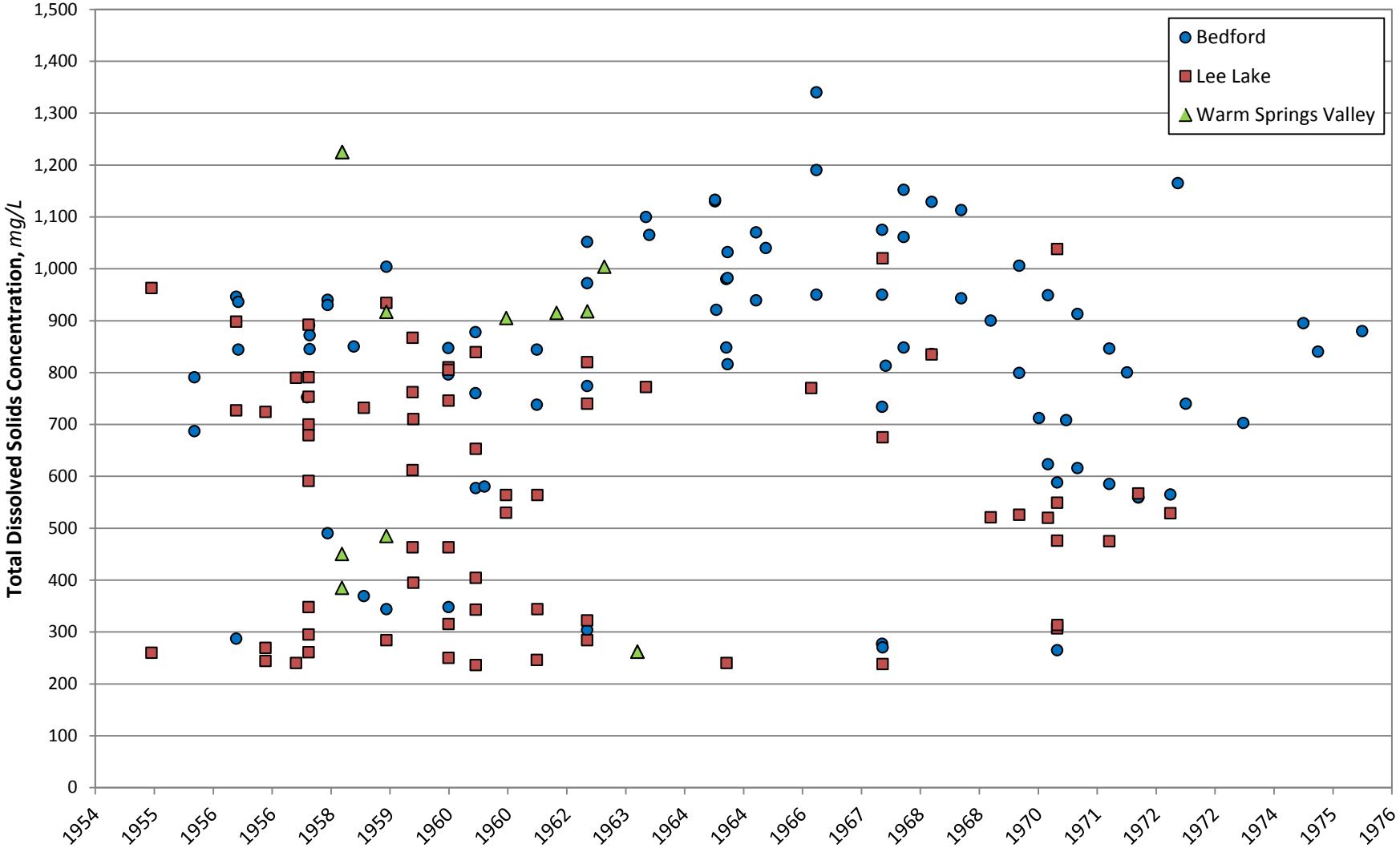
0 1 2 3 4 Miles
0 2 4 6 Kilometers

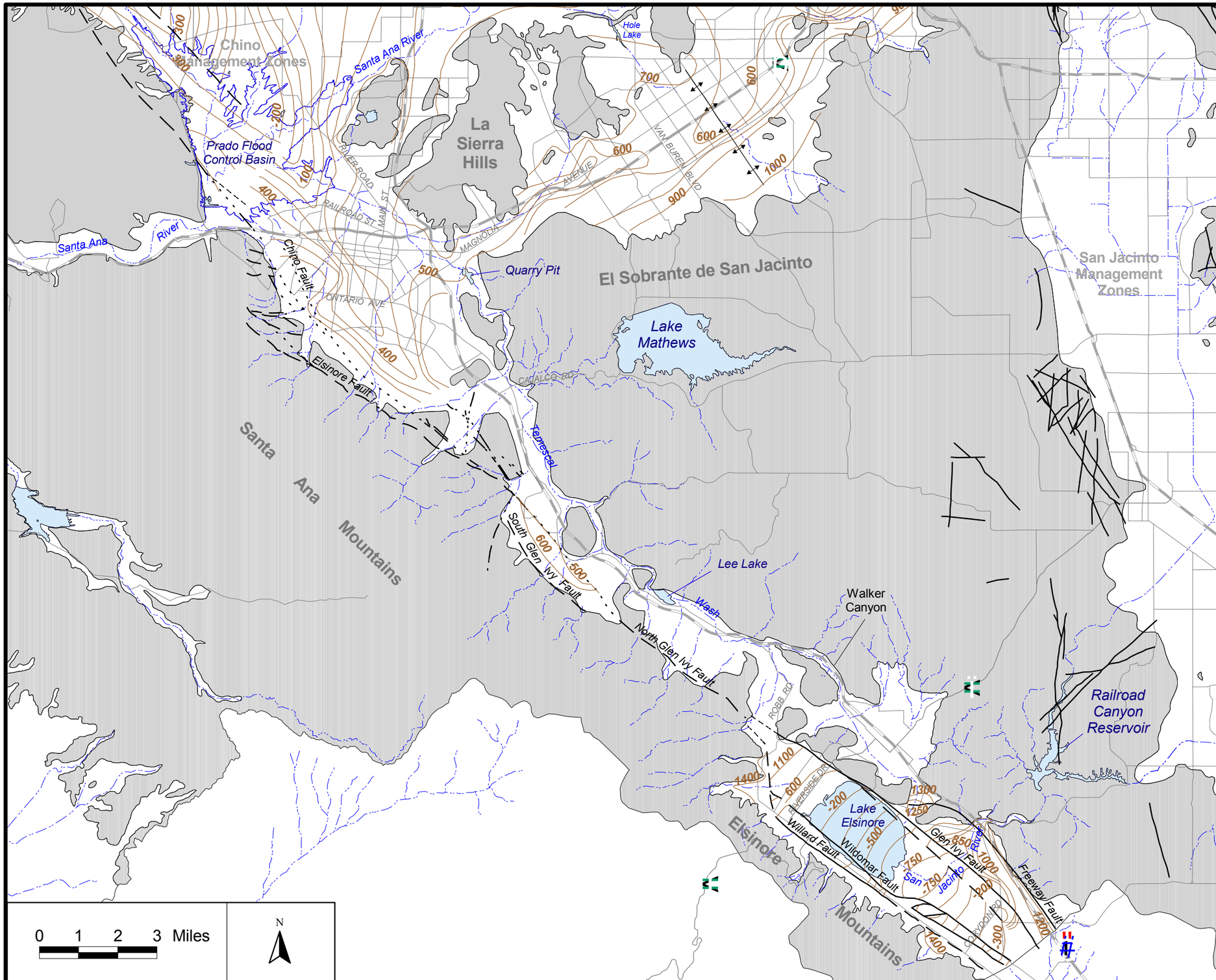
Upper Temescal Valley Monitoring Program

Location of Wells with TDS Data over Objective Setting Period (1954-1973)

Figure 3

Figure 4
Total Dissolved Solids Concentration Measured at Wells in the Upper Temescal Valley
1954 - 1975





TIN/TDS Phase 2A -- Task 3

Develop Updated Boundary Maps for Management Zones

Legend

1200 — Equal Elevation Contour of the Effective Base of Freshwater Aquifers (feet above mean sea level)

Other Map Features

- Unconsolidated Sediments
- Semi-consolidated Sediments
- Consolidated Bedrock
- Faults (solid where known, dashed where approximate, dotted where concealed, queried where uncertain)
- Groundwater Divide
- Major Roads & Highways
- Waterways, Reservoirs & Spreading Grounds

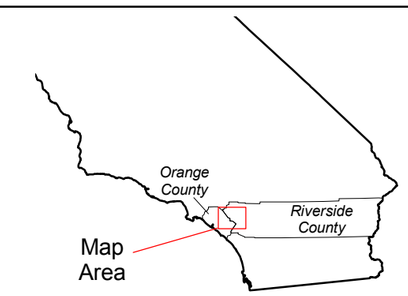


Figure 3-13

Elevation Contours of the Effective Base of Freshwater Aquifers

Elsinore -- Temescal Valleys

WE WILDERMUTH ENVIRONMENTAL, INC.

Prepared by: AEM | *Date: July, 2000*

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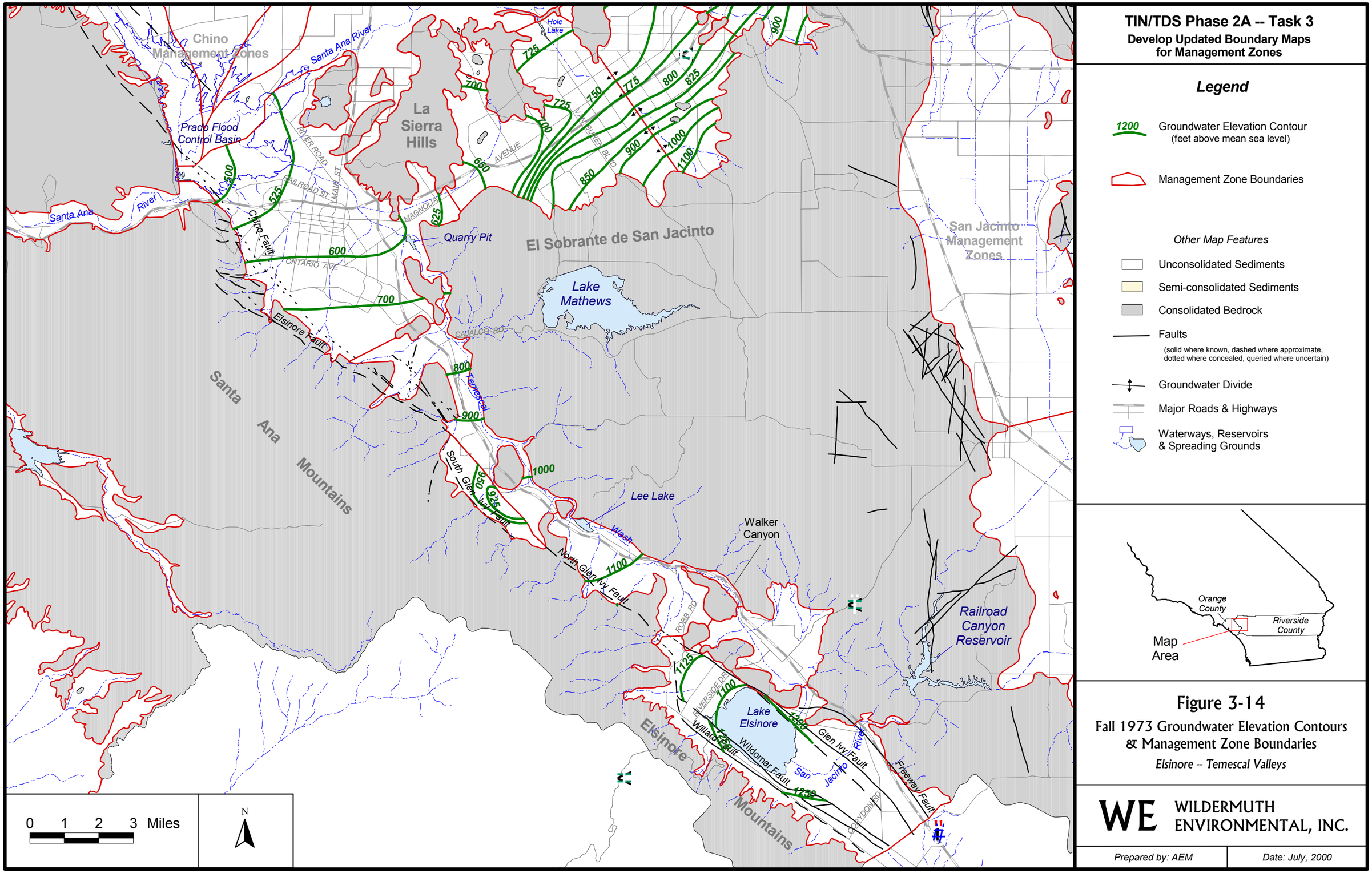

Figure 3-14

Fall 1973 Groundwater Elevation Contours & Management Zone Boundaries

Elsinore -- Temescal Valleys

WE WILDERMUTH ENVIRONMENTAL, INC.

Prepared by: AEM | *Date: July, 2000*

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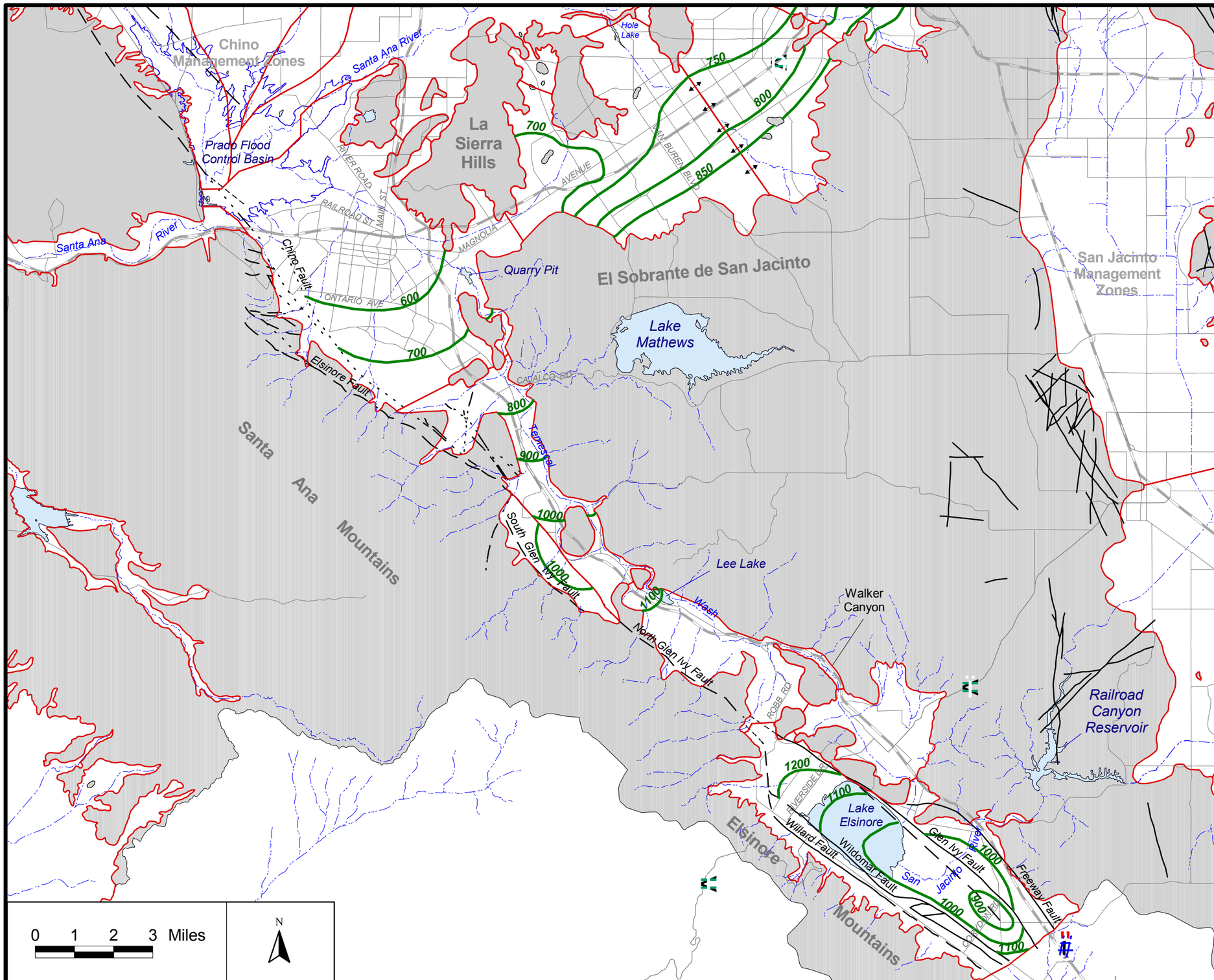

TIN/TDS Phase 2A -- Task 3

Develop Updated Boundary Maps for Management Zones

Legend

1200 Groundwater Elevation Contour (feet above mean sea level)

Management Zone Boundaries

Other Map Features

- Unconsolidated Sediments
- Semi-consolidated Sediments
- Consolidated Bedrock
- Faults (solid where known, dashed where approximate, dotted where concealed, queried where uncertain)
- Groundwater Divide
- Major Roads & Highways
- Waterways, Reservoirs & Spreading Grounds

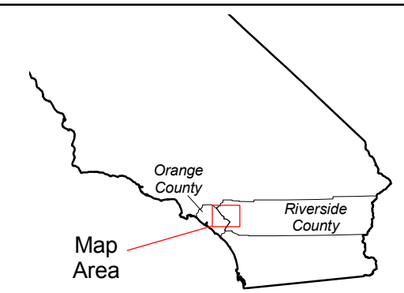

Figure 3-15

Fall 1997 Groundwater Elevation Contours & Management Zone Boundaries

Elsinore -- Temescal Valleys

WE WILDERMUTH ENVIRONMENTAL, INC.

Prepared by: AEM | *Date: July, 2000*

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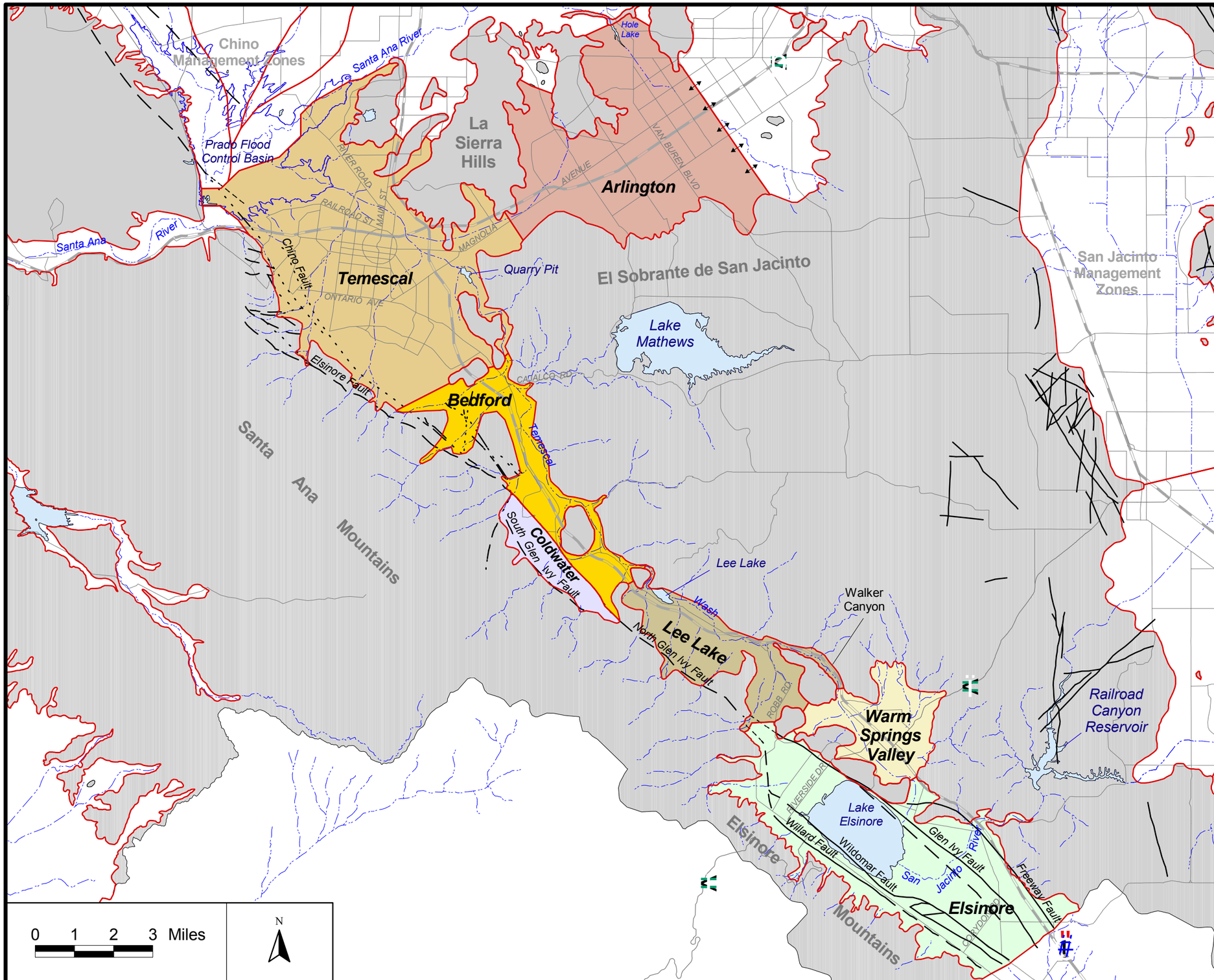

TIN/TDS Phase 2A -- Task 3

Develop Updated Boundary Maps for Management Zones

Legend

Management Zone Boundaries

Other Map Features

- Unconsolidated Sediments
- Semi-consolidated Sediments
- Consolidated Bedrock
- Faults (solid where known, dashed where approximate, dotted where concealed, queried where uncertain)
- Groundwater Divide
- Major Roads & Highways
- Waterways, Reservoirs & Spreading Grounds

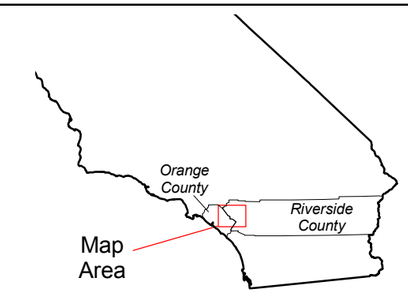

Figure 3-16

Preliminary
Management Zone Boundaries

Elsinore -- Temescal Valleys

WE WILDERMUTH ENVIRONMENTAL, INC.

Prepared by: AEM | *Date: July, 2000*

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Appendix B

Database of Wells, Water Quality, Water Level, and Production *(on CD)*

Appendix C

Time History of Annual Recharge and Discharge in the Upper Temescal Valley Groundwater Management Zone for the Projection of Future TDS and Nitrate Concentrations

Appendix C-1
Recharge and Discharge to the Upper Temescal Valley Groundwater Management Zone
Scenario 1a

Hydrologic Year	Recharge															Discharge			
	Streambed Recharge of Stormwater Runoff			Streambed Recharge of Recycled Water			Deep Infiltration of Applied Water			Recycled Water Discharge to Ponds			Total			Groundwater Production	ET	Rising Groundwater Outflow	Total
	Q	TDS	N	Q	TDS	N	Q	TDS	N	Q	TDS	N	Q	TDS	N				
1950	1,824	100	0.75	5,425	654	7.7	2,167	2,000	4.0	140	675	10	9,556	854	5.6	1,300	1,400	5,606	8,306
1951	877	100	0.75	5,007	655	7.7	2,167	2,000	4.0	140	675	10	8,191	952	6.0	1,300	1,400	5,491	8,191
1952	9,012	100	0.75	1,658	664	8.1	2,167	2,000	4.0	140	675	10	12,977	496	2.3	1,300	1,400	10,277	12,977
1953	1,927	100	0.75	4,582	656	7.8	2,167	2,000	4.0	140	675	10	8,816	865	5.3	1,300	1,400	6,116	8,816
1954	3,545	100	0.75	3,404	658	7.9	2,167	2,000	4.0	140	675	10	9,256	759	4.3	1,300	1,400	6,556	9,256
1955	2,015	100	0.75	4,346	656	7.8	2,167	2,000	4.0	140	675	10	8,668	863	5.2	1,300	1,400	5,968	8,668
1956	2,314	100	0.75	3,855	657	7.8	2,167	2,000	4.0	140	675	10	8,476	849	4.9	1,300	1,400	5,776	8,476
1957	3,103	100	0.75	3,652	657	7.8	2,167	2,000	4.0	140	675	10	9,062	788	4.5	1,300	1,400	6,362	9,062
1958	8,497	100	0.75	4,503	655	7.7	2,167	2,000	4.0	140	675	10	15,307	537	3.3	1,300	1,400	12,607	15,307
1959	1,444	100	0.75	4,981	656	7.7	2,167	2,000	4.0	140	675	10	8,732	898	5.7	1,300	1,400	6,032	8,732
1960	2,431	100	0.75	4,556	656	7.8	2,167	2,000	4.0	140	675	10	9,294	824	5.1	1,300	1,400	6,594	9,294
1961	641	100	0.75	4,912	656	7.8	2,167	2,000	4.0	140	675	10	7,860	981	6.2	1,300	1,400	5,160	7,860
1962	4,639	100	0.75	4,259	656	7.8	2,167	2,000	4.0	140	675	10	11,205	686	4.2	1,300	1,400	8,505	11,205
1963	1,549	100	0.75	5,171	655	7.7	2,167	2,000	4.0	140	675	10	9,027	883	5.7	1,300	1,400	6,327	9,027
1964	3,894	100	0.75	4,482	656	7.8	2,167	2,000	4.0	140	675	10	10,683	726	4.5	1,300	1,400	7,983	10,683
1965	3,490	100	0.75	4,950	655	7.7	2,167	2,000	4.0	140	675	10	10,747	746	4.7	1,300	1,400	8,047	10,747
1966	6,341	100	0.75	3,850	656	7.7	2,167	2,000	4.0	140	675	10	12,498	607	3.6	1,300	1,400	9,798	12,498
1967	6,342	100	0.75	3,562	655	7.7	2,167	2,000	4.0	140	675	10	12,211	606	3.5	1,300	1,400	9,511	12,211
1968	2,922	100	0.75	4,661	656	7.8	2,167	2,000	4.0	140	675	10	9,890	786	4.9	1,300	1,400	7,190	9,890
1969	8,029	100	0.75	1,362	665	8.2	2,167	2,000	4.0	140	675	10	11,698	525	2.3	1,300	1,400	8,998	11,698
1970	2,169	100	0.75	4,926	656	7.8	2,167	2,000	4.0	140	675	10	9,402	838	5.3	1,300	1,400	6,702	9,402
1971	3,714	100	0.75	4,446	656	7.7	2,167	2,000	4.0	140	675	10	10,467	737	4.5	1,300	1,400	7,767	10,467
1972	3,014	100	0.75	4,515	656	7.8	2,167	2,000	4.0	140	675	10	9,836	782	4.8	1,300	1,400	7,136	9,836
1973	7,432	100	0.75	3,809	656	7.8	2,167	2,000	4.0	140	675	10	13,548	566	3.3	1,300	1,400	10,848	13,548
1974	4,352	100	0.75	2,903	659	7.9	2,167	2,000	4.0	140	675	10	9,562	709	3.8	1,300	1,400	6,862	9,562
1975	3,871	100	0.75	4,940	655	7.7	2,167	2,000	4.0	140	675	10	11,118	724	4.6	1,300	1,400	8,418	11,118
1976	1,937	100	0.75	5,073	655	7.7	2,167	2,000	4.0	140	675	10	9,317	853	5.4	1,300	1,400	6,617	9,317
1977	3,636	100	0.75	4,020	657	7.8	2,167	2,000	4.0	140	675	10	9,963	746	4.4	1,300	1,400	7,263	9,963
1978	12,684	100	0.75	1,018	669	8.4	2,167	2,000	4.0	140	675	10	16,009	398	1.8	1,300	1,400	13,309	16,009
1979	8,107	100	0.75	2,030	660	8.0	2,167	2,000	4.0	140	675	10	12,444	529	2.6	1,300	1,400	9,744	12,444
1980	8,925	100	0.75	2,039	660	7.9	2,167	2,000	4.0	140	675	10	13,271	502	2.5	1,300	1,400	10,571	13,271
1981	1,728	100	0.75	4,830	656	7.7	2,167	2,000	4.0	140	675	10	8,865	876	5.5	1,300	1,400	6,165	8,865
1982	5,861	100	0.75	3,693	656	7.8	2,167	2,000	4.0	140	675	10	11,861	627	3.6	1,300	1,400	9,161	11,861
1983	10,067	100	0.75	3,395	656	7.8	2,167	2,000	4.0	140	675	10	15,769	486	2.8	1,300	1,400	13,069	15,769
1984	3,647	100	0.75	4,626	656	7.8	2,167	2,000	4.0	140	675	10	10,580	740	4.6	1,300	1,400	7,880	10,580
1985	6,873	100	0.75	4,097	655	7.7	2,167	2,000	4.0	140	675	10	13,277	587	3.5	1,300	1,400	10,577	13,277
1986	4,610	100	0.75	4,712	655	7.7	2,167	2,000	4.0	140	675	10	11,629	686	4.3	1,300	1,400	8,929	11,629
1987	1,760	100	0.75	4,844	656	7.8	2,167	2,000	4.0	140	675	10	8,911	873	5.5	1,300	1,400	6,211	8,911
1988	6,477	100	0.75	3,123	659	7.9	2,167	2,000	4.0	140	675	10	11,907	599	3.3	1,300	1,400	9,207	11,907
1989	2,248	100	0.75	4,570	656	7.8	2,167	2,000	4.0	140	675	10	9,125	838	5.2	1,300	1,400	6,425	9,125
1990	2,285	100	0.75	4,854	655	7.7	2,167	2,000	4.0	140	675	10	9,446	830	5.2	1,300	1,400	6,746	9,446
1991	4,933	100	0.75	4,956	654	7.7	2,167	2,000	4.0	140	675	10	12,196	669	4.3	1,300	1,400	9,496	12,196
1992	6,227	100	0.75	4,146	654	7.7	2,167	2,000	4.0	140	675	10	12,680	612	3.7	1,300	1,400	9,980	12,680
1993	11,577	100	0.75	1,570	662	8.0	2,167	2,000	4.0	140	675	10	15,454	429	2.0	1,300	1,400	12,754	15,454
1994	3,370	100	0.75	4,988	655	7.7	2,167	2,000	4.0	140	675	10	10,665	753	4.8	1,300	1,400	7,965	10,665
1995	12,243	100	0.75	1,231	664	8.1	2,167	2,000	4.0	140	675	10	15,781	410	1.9	1,300	1,400	13,081	15,781
1996	3,763	100	0.75	4,875	655	7.7	2,167	2,000	4.0	140	675	10	10,945	731	4.6	1,300	1,400	8,245	10,945
1997	5,705	100	0.75	1,578	667	8.2	2,167	2,000	4.0	140	675	10	9,590	631	2.9	1,300	1,400	6,890	9,590
1998	11,434	100	0.75	3,322	651	7.5	2,167	2,000	4.0	140	675	10	17,063	453	2.6	1,300	1,400	14,363	17,063
1999	780	100	0.75	4,959	656	7.7	2,167	2,000	4.0	140	675	10	8,046	964	6.1	1,300	1,400	5,346	8,046
2000	3,101	100	0.75	4,983	655	7.7	2,167	2,000	4.0	140	675	10	10,391	770	4.9	1,300	1,400	7,691	10,391
2001	3,355	100	0.75	4,685	656	7.8	2,167	2,000	4.0	140	675	10	10,347	757	4.7	1,300	1,400	7,647	10,347
2002	363	100	0.75	5,135	655	7.7	2,167	2,000	4.0	140	675	10	7,805	1,003	6.4	1,300	1,400	5,105	7,805
2003	6,489	100	0.75	4,636	654	7.7	2,167	2,000	4.0	140	675	10	13,432	604	3.8	1,300	1,400	10,732	13,432
2004	4,132	100	0.75	4,748	655	7.7	2,167	2,000	4.0	140	675	10	11,187	711	4.5	1,300	1,400	8,487	11,187
2005	14,931	100	0.75	825	666	8.2	2,167	2,000	4.0	140	675	10	18,063	358	1.6	1,300	1,400	15,363	18,063
2006	3,197	100	0.75	4,831	656	7.8	2,167	2,000	4.0	140	675	10	10,335	766	4.8	1,300	1,400	7,635	10,335
2007	113	100	0.75	5,147	655	7.7	2,167	2,000	4.0	140	675	10	7,567	1,033	6.6	1,300	1,400	4,867	7,567
2008	4,753	100	0.75	3,148	659	7.9	2,167	2,000	4.0	140	675	10	10,208	683	3.8	1,300	1,400	7,508	10,208
2009	4,930	100	0.75	4,344	655	7.7	2,167	2,000	4.0	140	675	10	11,581	671	4.1	1,300	1,400	8,881	11,581
2010	5,016	100	0.75	2,888	659	7.9	2,167	2,000	4.0	140	675	10	10,211	669	3.6	1,300	1,400	7,511	10,211
2011	6,869	100	0.75	3,809	656	7.8	2,167	2,000	4.0	140	675	10	12,985	586	3.5	1,300	1,400	10,285	12,985
2012	1,090	100	0.75	5,044	655	7.7	2,167	2,000	4.0	140	675	10	8,441	929	5.9	1,300	1,400	5,741	8,441
2013	454	100	0.75	5,021	655	7.7	2,167	2,000	4.0	140	675	10	7,782	998	6.3	1,300	1,400	5,082	7,782
2014	1,343	100	0.75	5,149	655	7.7	2,167	2,000	4.0	140	675	10	8,799	902	5.8	1,300	1,400	6,099	8,799
Min	113	100	0.8	825	651	7.5	2,167	2,000	4.0	140	675	10	7,567	358	1.6	1,300	1,400	4,867	7,567
Max	14,931	100	0.8	5,425	669	8.4	2,167	2,000	4.0	140	675	10	18,063	1,033	6.6	1,300	1,400	15,363	18,063
Average	4,622	100	0.8	4,026	657	7.8	2,167	2,000	4.0	140	675	10	10,954	721	4.3	1,300	1,400	8,235	10,935

Appendix C-2
Recharge and Discharge to the Upper Temescal Valley Groundwater Management Zone
Scenario 1b

Hydrologic Year	Recharge															Discharge			
	Streambed Recharge of Stormwater Runoff			Streambed Recharge of Recycled Water			Deep Infiltration of Applied Water			Recycled Water Discharge to Ponds			Total			Groundwater Production	ET	Rising Groundwater Outflow	Total
	Q	TDS	N	Q	TDS	N	Q	TDS	N	Q	TDS	N	Q	TDS	N				
1950	1,801	100	0.75	5,425	654	7.7	2,167	2,000	4.0	140	675	10	9,533	856	5.6	4,400	1,400	2,483	8,283
1951	881	100	0.75	5,567	655	7.7	2,167	2,000	4.0	140	675	10	8,755	932	6.1	4,400	1,400	2,955	8,755
1952	9,891	100	0.75	2,588	659	7.9	2,167	2,000	4.0	140	675	10	14,786	482	2.6	4,400	1,400	8,986	14,786
1953	1,901	100	0.75	5,345	655	7.7	2,167	2,000	4.0	140	675	10	9,553	850	5.5	4,400	1,400	3,753	9,553
1954	5,000	100	0.75	4,341	656	7.8	2,167	2,000	4.0	140	675	10	11,648	668	4.1	4,400	1,400	5,848	11,648
1955	2,564	100	0.75	5,277	655	7.7	2,167	2,000	4.0	140	675	10	10,148	802	5.2	4,400	1,400	4,348	10,148
1956	3,469	100	0.75	4,220	657	7.8	2,167	2,000	4.0	140	675	10	9,996	755	4.6	4,400	1,400	4,196	9,996
1957	3,336	100	0.75	4,642	656	7.8	2,167	2,000	4.0	140	675	10	10,285	759	4.7	4,400	1,400	4,485	10,285
1958	8,922	100	0.75	5,187	654	7.7	2,167	2,000	4.0	140	675	10	16,416	531	3.4	4,400	1,400	10,616	16,416
1959	1,422	100	0.75	5,541	655	7.7	2,167	2,000	4.0	140	675	10	9,270	885	5.8	4,400	1,400	3,470	9,270
1960	2,544	100	0.75	5,537	655	7.7	2,167	2,000	4.0	140	675	10	10,388	800	5.3	4,400	1,400	4,588	10,388
1961	644	100	0.75	5,567	655	7.7	2,167	2,000	4.0	140	675	10	8,518	956	6.3	4,400	1,400	2,718	8,518
1962	5,294	100	0.75	5,383	655	7.7	2,167	2,000	4.0	140	675	10	12,984	653	4.3	4,400	1,400	7,184	12,984
1963	1,679	100	0.75	5,551	655	7.7	2,167	2,000	4.0	140	675	10	9,537	863	5.7	4,400	1,400	3,737	9,537
1964	4,125	100	0.75	4,813	656	7.8	2,167	2,000	4.0	140	675	10	11,245	711	4.5	4,400	1,400	5,445	11,245
1965	3,576	100	0.75	5,495	654	7.7	2,167	2,000	4.0	140	675	10	11,378	737	4.8	4,400	1,400	5,578	11,378
1966	8,210	100	0.75	4,049	656	7.7	2,167	2,000	4.0	140	675	10	14,566	543	3.3	4,400	1,400	8,766	14,566
1967	8,614	100	0.75	3,828	656	7.8	2,167	2,000	4.0	140	675	10	14,749	529	3.1	4,400	1,400	8,949	14,749
1968	2,952	100	0.75	5,256	655	7.7	2,167	2,000	4.0	140	675	10	10,515	777	5.0	4,400	1,400	4,715	10,515
1969	9,444	100	0.75	1,844	661	8.0	2,167	2,000	4.0	140	675	10	13,595	485	2.3	4,400	1,400	7,795	13,595
1970	2,158	100	0.75	5,567	655	7.7	2,167	2,000	4.0	140	675	10	10,032	826	5.5	4,400	1,400	4,232	10,032
1971	4,381	100	0.75	4,881	656	7.8	2,167	2,000	4.0	140	675	10	11,569	697	4.4	4,400	1,400	5,769	11,569
1972	2,966	100	0.75	5,317	655	7.7	2,167	2,000	4.0	140	675	10	10,590	775	5.0	4,400	1,400	4,790	10,590
1973	7,622	100	0.75	4,313	656	7.7	2,167	2,000	4.0	140	675	10	14,242	563	3.5	4,400	1,400	8,442	14,242
1974	5,300	100	0.75	4,230	656	7.8	2,167	2,000	4.0	140	675	10	11,837	653	4.0	4,400	1,400	6,037	11,837
1975	3,985	100	0.75	5,520	655	7.7	2,167	2,000	4.0	140	675	10	11,812	715	4.7	4,400	1,400	6,012	11,812
1976	2,017	100	0.75	5,520	655	7.7	2,167	2,000	4.0	140	675	10	9,844	837	5.5	4,400	1,400	4,044	9,844
1977	3,996	100	0.75	5,163	655	7.7	2,167	2,000	4.0	140	675	10	11,466	716	4.6	4,400	1,400	5,666	11,466
1978	14,058	100	0.75	464	693	9.4	2,167	2,000	4.0	140	675	10	16,829	366	1.5	4,400	1,400	11,029	16,829
1979	9,125	100	0.75	2,750	658	7.9	2,167	2,000	4.0	140	675	10	14,182	504	2.7	4,400	1,400	8,382	14,182
1980	9,764	100	0.75	3,159	657	7.8	2,167	2,000	4.0	140	675	10	15,230	491	2.8	4,400	1,400	9,430	15,230
1981	1,882	100	0.75	5,435	655	7.7	2,167	2,000	4.0	140	675	10	9,624	850	5.6	4,400	1,400	3,824	9,624
1982	6,584	100	0.75	4,560	655	7.7	2,167	2,000	4.0	140	675	10	13,451	600	3.7	4,400	1,400	7,651	13,451
1983	10,295	100	0.75	3,723	656	7.8	2,167	2,000	4.0	140	675	10	16,325	484	2.9	4,400	1,400	10,525	16,325
1984	3,628	100	0.75	4,879	656	7.8	2,167	2,000	4.0	140	675	10	10,814	739	4.7	4,400	1,400	5,014	10,814
1985	8,570	100	0.75	4,331	655	7.7	2,167	2,000	4.0	140	675	10	15,208	534	3.3	4,400	1,400	9,408	15,208
1986	4,726	100	0.75	5,410	655	7.7	2,167	2,000	4.0	140	675	10	12,443	679	4.4	4,400	1,400	6,643	12,443
1987	1,760	100	0.75	5,482	655	7.7	2,167	2,000	4.0	140	675	10	9,549	858	5.6	4,400	1,400	3,749	9,549
1988	6,605	100	0.75	3,389	658	7.9	2,167	2,000	4.0	140	675	10	12,301	595	3.4	4,400	1,400	6,501	12,301
1989	2,218	100	0.75	5,404	655	7.7	2,167	2,000	4.0	140	675	10	9,929	825	5.4	4,400	1,400	4,129	9,929
1990	2,336	100	0.75	5,553	655	7.7	2,167	2,000	4.0	140	675	10	10,196	814	5.4	4,400	1,400	4,396	10,196
1991	5,225	100	0.75	5,441	654	7.7	2,167	2,000	4.0	140	675	10	12,973	656	4.3	4,400	1,400	7,173	12,973
1992	6,519	100	0.75	5,059	653	7.7	2,167	2,000	4.0	140	675	10	13,885	604	3.9	4,400	1,400	8,085	13,885
1993	13,253	100	0.75	1,289	664	8.1	2,167	2,000	4.0	140	675	10	16,849	392	1.8	4,400	1,400	11,049	16,849
1994	3,476	100	0.75	5,517	655	7.7	2,167	2,000	4.0	140	675	10	11,300	742	4.9	4,400	1,400	5,500	11,300
1995	13,395	100	0.75	779	674	8.6	2,167	2,000	4.0	140	675	10	16,481	382	1.6	4,400	1,400	10,681	16,481
1996	3,888	100	0.75	5,469	655	7.7	2,167	2,000	4.0	140	675	10	11,664	720	4.7	4,400	1,400	5,864	11,664
1997	6,606	100	0.75	2,323	661	8.0	2,167	2,000	4.0	140	675	10	11,236	590	3.0	4,400	1,400	5,436	11,236
1998	13,104	100	0.75	3,533	651	7.6	2,167	2,000	4.0	140	675	10	18,944	424	2.5	4,400	1,400	13,144	18,944
1999	782	100	0.75	5,524	655	7.7	2,167	2,000	4.0	140	675	10	8,613	943	6.2	4,400	1,400	2,813	8,613
2000	3,236	100	0.75	5,511	655	7.7	2,167	2,000	4.0	140	675	10	11,054	756	5.0	4,400	1,400	5,254	11,054
2001	3,467	100	0.75	5,499	655	7.7	2,167	2,000	4.0	140	675	10	11,273	743	4.9	4,400	1,400	5,473	11,273
2002	329	100	0.75	5,567	655	7.7	2,167	2,000	4.0	140	675	10	8,203	988	6.5	4,400	1,400	2,403	8,203
2003	6,712	100	0.75	5,364	653	7.7	2,167	2,000	4.0	140	675	10	14,383	598	3.9	4,400	1,400	8,583	14,383
2004	4,281	100	0.75	5,401	655	7.7	2,167	2,000	4.0	140	675	10	11,989	700	4.6	4,400	1,400	6,189	11,989
2005	16,812	100	0.75	732	672	8.5	2,167	2,000	4.0	140	675	10	19,851	333	1.5	4,400	1,400	14,051	19,851
2006	3,183	100	0.75	5,447	655	7.7	2,167	2,000	4.0	140	675	10	10,937	760	5.0	4,400	1,400	5,137	10,937
2007	60	100	0.75	5,567	655	7.7	2,167	2,000	4.0	140	675	10	7,934	1,019	6.7	4,400	1,400	2,134	7,934
2008	4,872	100	0.75	4,223	657	7.8	2,167	2,000	4.0	140	675	10	11,402	674	4.1	4,400	1,400	5,602	11,402
2009	6,728	100	0.75	4,637	656	7.8	2,167	2,000	4.0	140	675	10	13,672	596	3.7	4,400	1,400	7,872	13,672
2010	6,696	100	0.75	3,244	658	7.9	2,167	2,000	4.0	140	675	10	12,247	591	3.3	4,400	1,400	6,447	12,247
2011	9,140	100	0.75	4,001	656	7.8	2,167	2,000	4.0	140	675	10	15,448	516	3.1	4,400	1,400	9,648	15,448
2012	1,079	100	0.75	5,569	655	7.7	2,167	2,000	4.0	140	675	10	8,955	914	6.0	4,400	1,400	3,155	8,955
2013	435	100	0.75	5,567	655	7.7	2,167	2,000	4.0	140	675	10	8,309	977	6.4	4,400	1,400	2,509	8,309
2014	1,443	100	0.75	5,562	655	7.7	2,167	2,000	4.0	140	675	10	9,312	882	5.8	4,400	1,400	3,512	9,312
Min	60	100	0.8	464	651	7.6	2,167	2,000	4.0	140	675	10	7,934	333	1.5	4,400	1,400	2,134	7,934
Max	16,812	100	0.8	5,569	693	9.4	2,167	2,000	4.0	140	675	10	19,851	1,019	6.7	4,400	1,400	14,051	19,851
Average	5,153	100	0.8	4,574	657	7.8	2,167	2,000	4.0	140	675	10	12,035	695	4.4	4,400	1,400	6,215	12,015

Appendix C-3
Recharge and Discharge to the Upper Temescal Valley Groundwater Management Zone
Scenario 2a

Hydrologic Year	Recharge															Discharge			
	Streambed Recharge of Stormwater Runoff			Streambed Recharge of Recycled Water			Deep Infiltration of Applied Water			Recycled Water Discharge to Ponds			Total			Groundwater Production	ET	Rising Groundwater Outflow	Total
	Q	TDS	N	Q	TDS	N	Q	TDS	N	Q	TDS	N	Q	TDS	N				
1950	1,849	100	0.75	5,806	657	7.7	2,167	2,000	4.0	703	655	12	10,525	836	6.0	1,300	1,400	6,575	9,275
1951	859	100	0.75	5,269	660	7.7	2,167	2,000	4.0	703	655	12	8,998	929	6.5	1,300	1,400	6,298	8,998
1952	6,718	100	0.75	17,322	653	7.6	2,167	2,000	4.0	703	655	12	26,910	623	5.7	1,300	1,400	24,210	26,910
1953	1,870	100	0.75	4,860	661	7.8	2,167	2,000	4.0	703	655	12	9,600	854	5.9	1,300	1,400	6,900	9,600
1954	2,817	100	0.75	20,919	652	7.6	2,167	2,000	4.0	703	655	12	26,606	704	6.7	1,300	1,400	23,906	26,606
1955	1,951	100	0.75	4,535	662	7.8	2,167	2,000	4.0	703	655	12	9,356	854	5.8	1,300	1,400	6,656	9,356
1956	2,299	100	0.75	4,172	663	7.8	2,167	2,000	4.0	703	655	12	9,341	834	5.5	1,300	1,400	6,641	9,341
1957	2,869	100	0.75	3,954	663	7.8	2,167	2,000	4.0	703	655	12	9,693	795	5.2	1,300	1,400	6,993	9,693
1958	7,555	100	0.75	16,812	653	7.6	2,167	2,000	4.0	703	655	12	27,237	607	5.5	1,300	1,400	24,537	27,237
1959	1,442	100	0.75	5,268	660	7.7	2,167	2,000	4.0	703	655	12	9,580	879	6.2	1,300	1,400	6,880	9,580
1960	2,310	100	0.75	4,745	661	7.8	2,167	2,000	4.0	703	655	12	9,925	822	5.6	1,300	1,400	7,225	9,925
1961	589	100	0.75	5,240	661	7.7	2,167	2,000	4.0	703	655	12	8,699	956	6.7	1,300	1,400	5,999	8,699
1962	3,743	100	0.75	20,093	652	7.6	2,167	2,000	4.0	703	655	12	26,706	684	6.4	1,300	1,400	24,006	26,706
1963	1,132	100	0.75	22,524	652	7.5	2,167	2,000	4.0	703	655	12	26,526	739	7.1	1,300	1,400	23,826	26,526
1964	3,831	100	0.75	4,953	661	7.7	2,167	2,000	4.0	703	655	12	11,654	725	5.0	1,300	1,400	8,954	11,654
1965	3,547	100	0.75	5,199	659	7.7	2,167	2,000	4.0	703	655	12	11,616	738	5.2	1,300	1,400	8,916	11,616
1966	6,124	100	0.75	17,664	653	7.6	2,167	2,000	4.0	703	655	12	26,658	635	5.8	1,300	1,400	23,958	26,658
1967	4,905	100	0.75	19,131	652	7.6	2,167	2,000	4.0	703	655	12	26,906	660	6.1	1,300	1,400	24,206	26,906
1968	2,917	100	0.75	5,133	661	7.7	2,167	2,000	4.0	703	655	12	10,920	776	5.4	1,300	1,400	8,220	10,920
1969	8,842	100	0.75	15,093	653	7.6	2,167	2,000	4.0	703	655	12	26,805	579	5.1	1,300	1,400	24,105	26,805
1970	2,096	100	0.75	5,186	661	7.7	2,167	2,000	4.0	703	655	12	10,152	830	5.8	1,300	1,400	7,452	10,152
1971	3,363	100	0.75	4,866	660	7.7	2,167	2,000	4.0	703	655	12	11,099	752	5.2	1,300	1,400	8,399	11,099
1972	2,752	100	0.75	4,860	661	7.7	2,167	2,000	4.0	703	655	12	10,482	790	5.4	1,300	1,400	7,782	10,482
1973	5,426	100	0.75	18,432	652	7.6	2,167	2,000	4.0	703	655	12	26,728	650	6.0	1,300	1,400	24,028	26,728
1974	3,974	100	0.75	2,964	668	7.9	2,167	2,000	4.0	703	655	12	9,808	731	4.4	1,300	1,400	7,108	9,808
1975	2,871	100	0.75	20,894	652	7.6	2,167	2,000	4.0	703	655	12	26,635	702	6.6	1,300	1,400	23,935	26,635
1976	1,620	100	0.75	22,219	652	7.5	2,167	2,000	4.0	703	655	12	26,709	728	7.0	1,300	1,400	24,009	26,709
1977	3,305	100	0.75	22,384	652	7.5	2,167	2,000	4.0	703	655	12	28,559	691	6.6	1,300	1,400	25,859	28,559
1978	13,013	100	0.75	11,835	653	7.6	2,167	2,000	4.0	703	655	12	27,718	499	4.2	1,300	1,400	25,018	27,718
1979	7,315	100	0.75	16,816	653	7.6	2,167	2,000	4.0	703	655	12	27,001	611	5.5	1,300	1,400	24,301	27,001
1980	8,941	100	0.75	15,202	653	7.6	2,167	2,000	4.0	703	655	12	27,013	578	5.1	1,300	1,400	24,313	27,013
1981	1,693	100	0.75	5,150	661	7.7	2,167	2,000	4.0	703	655	12	9,713	861	6.0	1,300	1,400	7,013	9,713
1982	5,412	100	0.75	18,646	652	7.6	2,167	2,000	4.0	703	655	12	26,928	650	6.0	1,300	1,400	24,228	26,928
1983	8,574	100	0.75	15,624	653	7.6	2,167	2,000	4.0	703	655	12	27,068	586	5.2	1,300	1,400	24,368	27,068
1984	3,624	100	0.75	5,109	661	7.7	2,167	2,000	4.0	703	655	12	11,603	735	5.1	1,300	1,400	8,903	11,603
1985	6,687	100	0.75	4,443	659	7.7	2,167	2,000	4.0	703	655	12	14,000	599	4.0	1,300	1,400	11,300	14,000
1986	3,571	100	0.75	20,337	652	7.6	2,167	2,000	4.0	703	655	12	26,778	688	6.5	1,300	1,400	24,078	26,778
1987	1,757	100	0.75	4,952	661	7.7	2,167	2,000	4.0	703	655	12	9,579	861	5.9	1,300	1,400	6,879	9,579
1988	5,593	100	0.75	19,675	652	7.6	2,167	2,000	4.0	703	655	12	28,138	646	6.0	1,300	1,400	25,438	28,138
1989	2,207	100	0.75	4,796	661	7.8	2,167	2,000	4.0	703	655	12	9,873	829	5.7	1,300	1,400	7,173	9,873
1990	2,278	100	0.75	5,116	660	7.7	2,167	2,000	4.0	703	655	12	10,264	819	5.7	1,300	1,400	7,564	10,264
1991	5,226	100	0.75	18,716	652	7.6	2,167	2,000	4.0	703	655	12	26,812	654	6.1	1,300	1,400	24,112	26,812
1992	6,060	100	0.75	17,944	652	7.6	2,167	2,000	4.0	703	655	12	26,874	637	5.9	1,300	1,400	24,174	26,874
1993	11,669	100	0.75	12,323	653	7.6	2,167	2,000	4.0	703	655	12	26,862	522	4.4	1,300	1,400	24,162	26,862
1994	2,557	100	0.75	21,144	652	7.6	2,167	2,000	4.0	703	655	12	26,571	709	6.7	1,300	1,400	23,871	26,571
1995	11,515	100	0.75	12,596	653	7.6	2,167	2,000	4.0	703	655	12	26,981	525	4.5	1,300	1,400	24,281	26,981
1996	3,822	100	0.75	5,160	660	7.7	2,167	2,000	4.0	703	655	12	11,852	724	5.0	1,300	1,400	9,152	11,852
1997	5,698	100	0.75	2,010	676	8.1	2,167	2,000	4.0	703	655	12	10,578	636	3.6	1,300	1,400	7,878	10,578
1998	14,240	100	0.75	10,793	654	7.6	2,167	2,000	4.0	703	655	12	27,903	476	3.9	1,300	1,400	25,203	27,903
1999	760	100	0.75	5,306	660	7.7	2,167	2,000	4.0	703	655	12	8,936	937	6.6	1,300	1,400	6,236	8,936
2000	3,140	100	0.75	5,255	659	7.7	2,167	2,000	4.0	703	655	12	11,265	761	5.3	1,300	1,400	8,565	11,265
2001	2,325	100	0.75	21,439	652	7.6	2,167	2,000	4.0	703	655	12	26,634	714	6.8	1,300	1,400	23,934	26,634
2002	337	100	0.75	5,395	660	7.7	2,167	2,000	4.0	703	655	12	8,602	975	6.9	1,300	1,400	5,902	8,602
2003	6,687	100	0.75	17,594	653	7.6	2,167	2,000	4.0	703	655	12	27,151	624	5.7	1,300	1,400	24,451	27,151
2004	4,196	100	0.75	4,989	660	7.7	2,167	2,000	4.0	703	655	12	12,055	706	4.9	1,300	1,400	9,355	12,055
2005	14,790	100	0.75	11,412	653	7.6	2,167	2,000	4.0	703	655	12	29,072	472	3.9	1,300	1,400	26,372	29,072
2006	3,241	100	0.75	5,079	661	7.7	2,167	2,000	4.0	703	655	12	11,190	757	5.3	1,300	1,400	8,490	11,190
2007	88	100	0.75	5,464	660	7.7	2,167	2,000	4.0	703	655	12	8,422	999	7.1	1,300	1,400	5,722	8,422
2008	3,775	100	0.75	20,644	652	7.6	2,167	2,000	4.0	703	655	12	27,289	683	6.4	1,300	1,400	24,589	27,289
2009	3,907	100	0.75	19,759	652	7.6	2,167	2,000	4.0	703	655	12	26,536	681	6.4	1,300	1,400	23,836	26,536
2010	4,108	100	0.75	19,605	652	7.6	2,167	2,000	4.0	703	655	12	26,583	677	6.3	1,300	1,400	23,883	26,583
2011	5,171	100	0.75	18,688	652	7.6	2,167	2,000	4.0	703	655	12	26,729	655	6.1	1,300	1,400	24,029	26,729
2012	1,073	100	0.75	5,314	660	7.7	2,167	2,000	4.0	703	655	12	9,257	909	6.4	1,300	1,400	6,557	9,257
2013	419	100	0.75	5,341	660	7.7	2,167	2,000	4.0	703	655	12	8,630	969	6.8	1,300	1,400	5,930	8,630
2014	1,308	100	0.75	5,440	660	7.7	2,167	2,000	4.0	703	655	12	9,618	885	6.2	1,300	1,400	6,918	9,618
Min	88	100	0.8	2,010	652	7.5	2,167	2,000	4.0	703	655	12	8,422	472	3.6	1,300	1,400	5,722	8,422
Max	14,790	100	0.8	22,524	676	8.1	2,167	2,000	4.0	703	655	12	29,072	999	7.1	1,300	1,400	26,372	29,072
Average	4,313	100	0.8	11,317	657	7.7	2,167	2,000	4.0	703	655	12	18,500	728	5.7	1,300	1,400	15,781	18,481

Appendix C-4
Recharge and Discharge to the Upper Temescal Valley Groundwater Management Zone
Scenario 2b

Hydrologic Year	Recharge															Discharge			
	Streambed Recharge of Stormwater Runoff			Streambed Recharge of Recycled Water			Deep Infiltration of Applied Water			Recycled Water Discharge to Ponds			Total			Groundwater Production	ET	Rising Groundwater Outflow	Total
	Q	TDS	N	Q	TDS	N	Q	TDS	N	Q	TDS	N	Q	TDS	N				
1950	1,882	100	0.75	5,846	657	7.7	2,167	2,000	4.0	703	655	12	10,598	833	6.0	4,400	1,400	3,548	9,348
1951	894	100	0.75	5,986	659	7.7	2,167	2,000	4.0	703	655	12	9,750	906	6.6	4,400	1,400	3,950	9,750
1952	6,916	100	0.75	18,897	652	7.6	2,167	2,000	4.0	703	655	12	28,683	621	5.8	4,400	1,400	22,883	28,683
1953	1,942	100	0.75	5,637	660	7.7	2,167	2,000	4.0	703	655	12	10,449	833	5.9	4,400	1,400	4,649	10,449
1954	2,881	100	0.75	22,651	652	7.5	2,167	2,000	4.0	703	655	12	28,402	699	6.7	4,400	1,400	22,602	28,402
1955	2,212	100	0.75	5,142	661	7.7	2,167	2,000	4.0	703	655	12	10,224	823	5.7	4,400	1,400	4,424	10,224
1956	2,717	100	0.75	4,640	662	7.8	2,167	2,000	4.0	703	655	12	10,227	796	5.4	4,400	1,400	4,427	10,227
1957	3,300	100	0.75	4,942	661	7.7	2,167	2,000	4.0	703	655	12	11,112	755	5.2	4,400	1,400	5,312	11,112
1958	7,795	100	0.75	18,299	652	7.6	2,167	2,000	4.0	703	655	12	28,964	605	5.6	4,400	1,400	23,164	28,964
1959	1,450	100	0.75	5,898	659	7.7	2,167	2,000	4.0	703	655	12	10,218	864	6.2	4,400	1,400	4,418	10,218
1960	2,579	100	0.75	5,849	659	7.7	2,167	2,000	4.0	703	655	12	11,298	789	5.7	4,400	1,400	5,498	11,298
1961	666	100	0.75	5,876	660	7.7	2,167	2,000	4.0	703	655	12	9,412	928	6.7	4,400	1,400	3,612	9,412
1962	3,934	100	0.75	21,770	652	7.5	2,167	2,000	4.0	703	655	12	28,574	678	6.5	4,400	1,400	22,774	28,574
1963	1,192	100	0.75	24,070	652	7.5	2,167	2,000	4.0	703	655	12	28,132	733	7.1	4,400	1,400	22,332	28,132
1964	4,191	100	0.75	5,158	661	7.7	2,167	2,000	4.0	703	655	12	12,219	706	4.9	4,400	1,400	6,419	12,219
1965	3,646	100	0.75	5,885	658	7.7	2,167	2,000	4.0	703	655	12	12,401	728	5.2	4,400	1,400	6,601	12,401
1966	6,636	100	0.75	19,397	652	7.6	2,167	2,000	4.0	703	655	12	28,903	627	5.8	4,400	1,400	23,103	28,903
1967	4,985	100	0.75	20,743	652	7.6	2,167	2,000	4.0	703	655	12	28,598	658	6.2	4,400	1,400	22,798	28,598
1968	2,978	100	0.75	5,582	660	7.7	2,167	2,000	4.0	703	655	12	11,430	768	5.5	4,400	1,400	5,630	11,430
1969	9,071	100	0.75	16,608	653	7.6	2,167	2,000	4.0	703	655	12	28,549	579	5.2	4,400	1,400	22,749	28,549
1970	2,171	100	0.75	5,892	659	7.7	2,167	2,000	4.0	703	655	12	10,933	814	5.9	4,400	1,400	5,133	10,933
1971	4,445	100	0.75	5,214	661	7.7	2,167	2,000	4.0	703	655	12	12,529	693	4.9	4,400	1,400	6,729	12,529
1972	3,017	100	0.75	5,584	660	7.7	2,167	2,000	4.0	703	655	12	11,471	766	5.4	4,400	1,400	5,671	11,471
1973	6,395	100	0.75	20,405	652	7.6	2,167	2,000	4.0	703	655	12	29,670	632	5.9	4,400	1,400	23,870	29,670
1974	4,838	100	0.75	3,930	664	7.8	2,167	2,000	4.0	703	655	12	11,638	678	4.4	4,400	1,400	5,838	11,638
1975	2,962	100	0.75	22,495	652	7.5	2,167	2,000	4.0	703	655	12	28,327	698	6.7	4,400	1,400	22,527	28,327
1976	1,745	100	0.75	23,713	652	7.5	2,167	2,000	4.0	703	655	12	28,328	721	7.0	4,400	1,400	22,528	28,328
1977	3,310	100	0.75	23,920	652	7.5	2,167	2,000	4.0	703	655	12	30,100	688	6.6	4,400	1,400	24,300	30,100
1978	13,295	100	0.75	13,082	653	7.6	2,167	2,000	4.0	703	655	12	29,247	501	4.3	4,400	1,400	23,447	29,247
1979	7,545	100	0.75	18,405	652	7.6	2,167	2,000	4.0	703	655	12	28,820	609	5.6	4,400	1,400	23,020	28,820
1980	9,161	100	0.75	16,663	653	7.6	2,167	2,000	4.0	703	655	12	28,694	578	5.2	4,400	1,400	22,894	28,694
1981	1,758	100	0.75	5,700	660	7.7	2,167	2,000	4.0	703	655	12	10,328	845	6.0	4,400	1,400	4,528	10,328
1982	5,591	100	0.75	20,192	652	7.6	2,167	2,000	4.0	703	655	12	28,653	647	6.1	4,400	1,400	22,853	28,653
1983	8,834	100	0.75	17,249	653	7.6	2,167	2,000	4.0	703	655	12	28,953	585	5.3	4,400	1,400	23,153	28,953
1984	3,671	100	0.75	5,307	660	7.7	2,167	2,000	4.0	703	655	12	11,848	731	5.1	4,400	1,400	6,048	11,848
1985	8,272	100	0.75	4,702	659	7.7	2,167	2,000	4.0	703	655	12	15,844	550	3.8	4,400	1,400	10,044	15,844
1986	3,754	100	0.75	22,146	652	7.5	2,167	2,000	4.0	703	655	12	28,770	682	6.5	4,400	1,400	22,970	28,770
1987	1,800	100	0.75	5,722	660	7.7	2,167	2,000	4.0	703	655	12	10,392	842	6.0	4,400	1,400	4,592	10,392
1988	5,995	100	0.75	21,771	652	7.5	2,167	2,000	4.0	703	655	12	30,636	640	6.1	4,400	1,400	24,836	30,636
1989	2,269	100	0.75	5,590	660	7.7	2,167	2,000	4.0	703	655	12	10,729	812	5.8	4,400	1,400	4,929	10,729
1990	2,399	100	0.75	5,970	659	7.7	2,167	2,000	4.0	703	655	12	11,239	798	5.8	4,400	1,400	5,439	11,239
1991	5,351	100	0.75	20,340	652	7.6	2,167	2,000	4.0	703	655	12	28,561	651	6.1	4,400	1,400	22,761	28,561
1992	6,190	100	0.75	19,429	652	7.6	2,167	2,000	4.0	703	655	12	28,489	635	5.9	4,400	1,400	22,689	28,489
1993	11,890	100	0.75	13,709	653	7.6	2,167	2,000	4.0	703	655	12	28,469	525	4.6	4,400	1,400	22,669	28,469
1994	2,677	100	0.75	22,677	652	7.5	2,167	2,000	4.0	703	655	12	28,224	703	6.7	4,400	1,400	22,424	28,224
1995	11,727	100	0.75	14,012	653	7.6	2,167	2,000	4.0	703	655	12	28,609	528	4.6	4,400	1,400	22,809	28,609
1996	3,942	100	0.75	5,771	659	7.7	2,167	2,000	4.0	703	655	12	12,583	715	5.1	4,400	1,400	6,783	12,583
1997	6,193	100	0.75	2,462	671	8.0	2,167	2,000	4.0	703	655	12	11,525	613	3.6	4,400	1,400	5,725	11,525
1998	14,506	100	0.75	12,310	653	7.6	2,167	2,000	4.0	703	655	12	29,686	481	4.1	4,400	1,400	23,886	29,686
1999	786	100	0.75	5,851	660	7.7	2,167	2,000	4.0	703	655	12	9,507	918	6.6	4,400	1,400	3,707	9,507
2000	3,283	100	0.75	6,002	659	7.7	2,167	2,000	4.0	703	655	12	12,155	747	5.4	4,400	1,400	6,355	12,155
2001	2,400	100	0.75	23,037	652	7.5	2,167	2,000	4.0	703	655	12	28,307	709	6.8	4,400	1,400	22,507	28,307
2002	375	100	0.75	5,978	659	7.7	2,167	2,000	4.0	703	655	12	9,223	951	6.9	4,400	1,400	3,423	9,223
2003	6,876	100	0.75	19,333	652	7.6	2,167	2,000	4.0	703	655	12	29,079	622	5.8	4,400	1,400	23,279	29,079
2004	4,335	100	0.75	5,645	659	7.7	2,167	2,000	4.0	703	655	12	12,850	696	5.0	4,400	1,400	7,050	12,850
2005	16,299	100	0.75	12,538	653	7.6	2,167	2,000	4.0	703	655	12	31,707	461	3.9	4,400	1,400	25,907	31,707
2006	3,191	100	0.75	5,761	660	7.7	2,167	2,000	4.0	703	655	12	11,822	754	5.4	4,400	1,400	6,022	11,822
2007	97	100	0.75	6,088	659	7.7	2,167	2,000	4.0	703	655	12	9,055	974	7.1	4,400	1,400	3,255	9,055
2008	3,923	100	0.75	22,279	652	7.5	2,167	2,000	4.0	703	655	12	29,072	678	6.5	4,400	1,400	23,272	29,072
2009	4,024	100	0.75	21,219	652	7.6	2,167	2,000	4.0	703	655	12	28,113	677	6.4	4,400	1,400	22,313	28,113
2010	4,252	100	0.75	21,069	652	7.6	2,167	2,000	4.0	703	655	12	28,191	673	6.4	4,400	1,400	22,391	28,191
2011	5,282	100	0.75	20,226	652	7.6	2,167	2,000	4.0	703	655	12	28,378	652	6.1	4,400	1,400	22,578	28,378
2012	1,098	100	0.75	5,915	659	7.7	2,167	2,000	4.0	703	655	12	9,883	891	6.4	4,400	1,400	4,083	9,883
2013	491	100	0.75	5,988	659	7.7	2,167	2,000	4.0	703	655	12	9,349	940	6.8	4,400	1,400	3,549	9,349
2014	1,409	100	0.75	6,114	659	7.7	2,167	2,000	4.0	703	655	12	10,393	863	6.3	4,400	1,400	4,593	10,393
Min	97	100	0.8	2,462	652	7.5	2,167	2,000	4.0	703	655	12	9,055	461	3.6	4,400	1,400	3,255	9,055
Max	16,299	100	0.8	24,070	671	8.0	2,167	2,000	4.0	703	655	12	31,707	974	7.1	4,400	1,400	25,907	31,707
Average	4,549	100	0.8	12,404	656	7.6	2,167	2,000	4.0	703	655	12	19,823	715	5.8	4,400	1,400	14,004	19,804

Appendix C-5
Recharge and Discharge to the Upper Temescal Valley Groundwater Management Zone
Scenario 3a

Hydrologic Year	Recharge															Discharge			
	Streambed Recharge of Stormwater Runoff			Streambed Recharge of Recycled Water			Deep Infiltration of Applied Water			Recycled Water Discharge to Ponds			Total			Groundwater Production	ET	Rising Groundwater Outflow	Total
	Q	TDS	N	Q	TDS	N	Q	TDS	N	Q	TDS	N	Q	TDS	N				
1950	3,174	100	0.75	5,231	654	7.7	4,896	2,000	4.0	740	675	10	14,041	999	5.0	1,300	1,400	10,091	12,791
1951	2,242	100	0.75	4,718	656	7.8	4,896	2,000	4.0	740	675	10	12,596	1,080	5.2	1,300	1,400	9,896	12,596
1952	9,686	100	0.75	1,307	668	8.3	4,896	2,000	4.0	740	675	10	16,629	730	2.7	1,300	1,400	13,929	16,629
1953	4,038	100	0.75	4,239	656	7.8	4,896	2,000	4.0	740	675	10	13,913	969	4.5	1,300	1,400	11,213	13,913
1954	4,968	100	0.75	3,200	658	7.9	4,896	2,000	4.0	740	675	10	13,804	934	4.1	1,300	1,400	11,104	13,804
1955	3,929	100	0.75	3,759	657	7.8	4,896	2,000	4.0	740	675	10	13,324	987	4.5	1,300	1,400	10,624	13,324
1956	3,421	100	0.75	3,601	658	7.8	4,896	2,000	4.0	740	675	10	12,658	1,027	4.6	1,300	1,400	9,958	12,658
1957	4,420	100	0.75	3,245	658	7.9	4,896	2,000	4.0	740	675	10	13,301	968	4.2	1,300	1,400	10,601	13,301
1958	10,191	100	0.75	4,238	655	7.7	4,896	2,000	4.0	740	675	10	20,065	702	3.4	1,300	1,400	17,365	20,065
1959	2,792	100	0.75	4,820	656	7.8	4,896	2,000	4.0	740	675	10	13,248	1,036	5.0	1,300	1,400	10,548	13,248
1960	4,631	100	0.75	3,832	657	7.8	4,896	2,000	4.0	740	675	10	14,099	941	4.3	1,300	1,400	11,399	14,099
1961	1,466	100	0.75	4,614	656	7.8	4,896	2,000	4.0	740	675	10	11,716	1,149	5.5	1,300	1,400	9,016	11,716
1962	6,122	100	0.75	3,779	656	7.8	4,896	2,000	4.0	740	675	10	15,537	861	3.9	1,300	1,400	12,837	15,537
1963	2,616	100	0.75	5,093	655	7.7	4,896	2,000	4.0	740	675	10	13,345	1,041	5.1	1,300	1,400	10,645	13,345
1964	5,876	100	0.75	4,177	655	7.7	4,896	2,000	4.0	740	675	10	15,689	868	4.1	1,300	1,400	12,989	15,689
1965	4,997	100	0.75	4,722	655	7.7	4,896	2,000	4.0	740	675	10	15,355	904	4.4	1,300	1,400	12,655	15,355
1966	7,655	100	0.75	3,745	656	7.8	4,896	2,000	4.0	740	675	10	17,036	793	3.6	1,300	1,400	14,336	17,036
1967	7,718	100	0.75	3,109	655	7.7	4,896	2,000	4.0	740	675	10	16,463	796	3.5	1,300	1,400	13,763	16,463
1968	5,015	100	0.75	4,503	656	7.8	4,896	2,000	4.0	740	675	10	15,154	907	4.3	1,300	1,400	12,454	15,154
1969	9,136	100	0.75	863	673	8.6	4,896	2,000	4.0	740	675	10	15,635	754	2.6	1,300	1,400	12,935	15,635
1970	3,698	100	0.75	4,460	656	7.7	4,896	2,000	4.0	740	675	10	13,794	985	4.7	1,300	1,400	11,094	13,794
1971	4,706	100	0.75	4,330	655	7.7	4,896	2,000	4.0	740	675	10	14,672	927	4.4	1,300	1,400	11,972	14,672
1972	3,866	100	0.75	4,340	656	7.8	4,896	2,000	4.0	740	675	10	13,842	977	4.6	1,300	1,400	11,142	13,842
1973	9,568	100	0.75	3,309	657	7.8	4,896	2,000	4.0	740	675	10	18,513	725	3.2	1,300	1,400	15,813	18,513
1974	5,940	100	0.75	2,227	662	8.0	4,896	2,000	4.0	740	675	10	13,803	895	3.6	1,300	1,400	11,103	13,803
1975	5,864	100	0.75	4,613	655	7.7	4,896	2,000	4.0	740	675	10	16,113	863	4.2	1,300	1,400	13,413	16,113
1976	3,101	100	0.75	4,979	655	7.7	4,896	2,000	4.0	740	675	10	13,716	1,011	4.9	1,300	1,400	11,016	13,716
1977	6,354	100	0.75	3,547	657	7.8	4,896	2,000	4.0	740	675	10	15,537	853	3.8	1,300	1,400	12,837	15,537
1978	14,741	100	0.75	986	668	8.3	4,896	2,000	4.0	740	675	10	21,363	582	2.2	1,300	1,400	18,663	21,363
1979	10,572	100	0.75	1,754	660	8.0	4,896	2,000	4.0	740	675	10	17,962	696	2.7	1,300	1,400	15,262	17,962
1980	9,814	100	0.75	1,601	662	8.1	4,896	2,000	4.0	740	675	10	17,051	723	2.8	1,300	1,400	14,351	17,051
1981	2,951	100	0.75	4,594	656	7.8	4,896	2,000	4.0	740	675	10	13,181	1,032	4.9	1,300	1,400	10,481	13,181
1982	7,825	100	0.75	2,956	657	7.8	4,896	2,000	4.0	740	675	10	16,417	793	3.4	1,300	1,400	13,717	16,417
1983	12,090	100	0.75	2,972	656	7.8	4,896	2,000	4.0	740	675	10	20,698	650	2.9	1,300	1,400	17,998	20,698
1984	6,054	100	0.75	4,579	656	7.8	4,896	2,000	4.0	740	675	10	16,269	854	4.1	1,300	1,400	13,569	16,269
1985	8,099	100	0.75	3,929	654	7.7	4,896	2,000	4.0	740	675	10	17,664	774	3.6	1,300	1,400	14,964	17,664
1986	6,873	100	0.75	4,485	655	7.7	4,896	2,000	4.0	740	675	10	16,994	819	3.9	1,300	1,400	14,294	16,994
1987	3,672	100	0.75	4,214	656	7.8	4,896	2,000	4.0	740	675	10	13,522	993	4.6	1,300	1,400	10,822	13,522
1988	9,277	100	0.75	2,853	659	7.9	4,896	2,000	4.0	740	675	10	17,766	737	3.2	1,300	1,400	15,066	17,766
1989	3,701	100	0.75	4,160	657	7.8	4,896	2,000	4.0	740	675	10	13,497	992	4.6	1,300	1,400	10,797	13,497
1990	3,520	100	0.75	4,460	656	7.8	4,896	2,000	4.0	740	675	10	13,616	996	4.7	1,300	1,400	10,916	13,616
1991	5,637	100	0.75	4,681	654	7.7	4,896	2,000	4.0	740	675	10	15,954	872	4.2	1,300	1,400	13,254	15,954
1992	7,686	100	0.75	3,438	654	7.7	4,896	2,000	4.0	740	675	10	16,760	794	3.5	1,300	1,400	14,060	16,760
1993	13,184	100	0.75	1,490	661	8.0	4,896	2,000	4.0	740	675	10	20,310	620	2.4	1,300	1,400	17,610	20,310
1994	4,891	100	0.75	4,742	655	7.7	4,896	2,000	4.0	740	675	10	15,269	909	4.4	1,300	1,400	12,569	15,269
1995	13,329	100	0.75	1,624	660	7.9	4,896	2,000	4.0	740	675	10	20,589	617	2.4	1,300	1,400	17,889	20,589
1996	4,706	100	0.75	4,535	655	7.7	4,896	2,000	4.0	740	675	10	14,877	923	4.4	1,300	1,400	12,177	14,877
1997	7,373	100	0.75	1,292	670	8.4	4,896	2,000	4.0	740	675	10	14,301	832	3.0	1,300	1,400	11,601	14,301
1998	13,210	100	0.75	2,939	649	7.5	4,896	2,000	4.0	740	675	10	21,785	621	2.7	1,300	1,400	19,085	21,785
1999	1,789	100	0.75	4,724	656	7.8	4,896	2,000	4.0	740	675	10	12,149	1,117	5.3	1,300	1,400	9,449	12,149
2000	3,786	100	0.75	4,790	654	7.7	4,896	2,000	4.0	740	675	10	14,212	971	4.7	1,300	1,400	11,512	14,212
2001	4,429	100	0.75	3,997	656	7.8	4,896	2,000	4.0	740	675	10	14,062	950	4.4	1,300	1,400	11,362	14,062
2002	1,081	100	0.75	4,995	656	7.7	4,896	2,000	4.0	740	675	10	11,712	1,168	5.7	1,300	1,400	9,012	11,712
2003	8,283	100	0.75	4,481	654	7.7	4,896	2,000	4.0	740	675	10	18,400	764	3.7	1,300	1,400	15,700	18,400
2004	5,341	100	0.75	4,487	655	7.7	4,896	2,000	4.0	740	675	10	15,464	890	4.2	1,300	1,400	12,764	15,464
2005	16,198	100	0.75	642	668	8.3	4,896	2,000	4.0	740	675	10	22,476	549	2.0	1,300	1,400	19,776	22,476
2006	5,304	100	0.75	4,429	656	7.7	4,896	2,000	4.0	740	675	10	15,369	893	4.2	1,300	1,400	12,669	15,369
2007	352	100	0.75	5,087	655	7.7	4,896	2,000	4.0	740	675	10	11,075	1,233	6.0	1,300	1,400	8,375	11,075
2008	6,536	100	0.75	2,270	662	8.0	4,896	2,000	4.0	740	675	10	14,442	862	3.5	1,300	1,400	11,742	14,442
2009	5,936	100	0.75	4,288	655	7.7	4,896	2,000	4.0	740	675	10	15,860	863	4.1	1,300	1,400	13,160	15,860
2010	6,345	100	0.75	2,668	660	7.9	4,896	2,000	4.0	740	675	10	14,649	866	3.6	1,300	1,400	11,949	14,649
2011	7,928	100	0.75	3,721	655	7.7	4,896	2,000	4.0	740	675	10	17,285	782	3.6	1,300	1,400	14,585	17,285
2012	2,606	100	0.75	4,792	656	7.8	4,896	2,000	4.0	740	675	10	13,034	1,051	5.1	1,300	1,400	10,334	13,034
2013	1,195	100	0.75	4,795	656	7.8	4,896	2,000	4.0	740	675	10	11,626	1,166	5.6	1,300	1,400	8,926	11,626
2014	2,051	100	0.75	5,004	655	7.7	4,896	2,000	4.0	740	675	10	12,691	1,085	5.3	1,300	1,400	9,991	12,691
Min	352	100	0.8	642	649	7.5	4,896	2,000	4.0	740	675	10	11,075	549	2.0	1,300	1,400	8,375	11,075
Max	16,198	100	0.8	5,231	673	8.6	4,896	2,000	4.0	740	675	10	22,476	1,233	6.0	1,300	1,400	19,776	22,476
Average	6,085	100	0.8	3,724	657	7.8	4,896	2,000	4.0	740	675	10	15,445	888	4.1	1,300	1,400	12,726	15,426

Appendix C-6
Recharge and Discharge to the Upper Temescal Valley Groundwater Management Zone
Scenario 3b

Hydrologic Year	Recharge															Discharge			
	Streambed Recharge of Stormwater Runoff			Streambed Recharge of Recycled Water			Deep Infiltration of Applied Water			Recycled Water Discharge to Ponds			Total			Groundwater Production	ET	Rising Groundwater Outflow	Total
	Q	TDS	N	Q	TDS	N	Q	TDS	N	Q	TDS	N	Q	TDS	N				
1950	3,223	100	0.75	5,413	654	7.7	4,896	2,000	4.0	740	675	10	14,272	992	5.0	4,400	1,400	7,222	13,022
1951	2,271	100	0.75	5,368	655	7.7	4,896	2,000	4.0	740	675	10	13,275	1,057	5.3	4,400	1,400	7,475	13,275
1952	11,701	100	0.75	1,851	663	8.1	4,896	2,000	4.0	740	675	10	19,188	661	2.6	4,400	1,400	13,388	19,188
1953	4,194	100	0.75	4,850	656	7.8	4,896	2,000	4.0	740	675	10	14,680	946	4.6	4,400	1,400	8,880	14,680
1954	6,449	100	0.75	3,720	657	7.8	4,896	2,000	4.0	740	675	10	15,805	847	3.9	4,400	1,400	10,005	15,805
1955	4,379	100	0.75	4,496	656	7.8	4,896	2,000	4.0	740	675	10	14,511	943	4.5	4,400	1,400	8,711	14,511
1956	4,027	100	0.75	3,912	656	7.8	4,896	2,000	4.0	740	675	10	13,575	977	4.5	4,400	1,400	7,775	13,575
1957	5,027	100	0.75	4,256	656	7.8	4,896	2,000	4.0	740	675	10	14,919	911	4.3	4,400	1,400	9,119	14,919
1958	10,585	100	0.75	4,714	654	7.7	4,896	2,000	4.0	740	675	10	20,935	689	3.4	4,400	1,400	15,135	20,935
1959	2,762	100	0.75	5,437	655	7.7	4,896	2,000	4.0	740	675	10	13,835	1,021	5.1	4,400	1,400	8,035	13,835
1960	5,202	100	0.75	4,998	655	7.7	4,896	2,000	4.0	740	675	10	15,836	890	4.4	4,400	1,400	10,036	15,836
1961	1,516	100	0.75	5,163	655	7.7	4,896	2,000	4.0	740	675	10	12,315	1,123	5.5	4,400	1,400	6,515	12,315
1962	6,753	100	0.75	4,487	655	7.7	4,896	2,000	4.0	740	675	10	16,876	824	4.0	4,400	1,400	11,076	16,876
1963	2,750	100	0.75	5,509	655	7.7	4,896	2,000	4.0	740	675	10	13,895	1,020	5.1	4,400	1,400	8,095	13,895
1964	6,662	100	0.75	4,404	656	7.8	4,896	2,000	4.0	740	675	10	16,702	829	4.0	4,400	1,400	10,902	16,702
1965	5,160	100	0.75	5,383	655	7.7	4,896	2,000	4.0	740	675	10	16,179	886	4.5	4,400	1,400	10,379	16,179
1966	9,156	100	0.75	3,936	656	7.7	4,896	2,000	4.0	740	675	10	18,728	736	3.4	4,400	1,400	12,928	18,728
1967	9,995	100	0.75	3,331	656	7.8	4,896	2,000	4.0	740	675	10	18,962	711	3.2	4,400	1,400	13,162	18,962
1968	5,177	100	0.75	4,809	655	7.7	4,896	2,000	4.0	740	675	10	15,622	894	4.4	4,400	1,400	9,822	15,622
1969	10,102	100	0.75	1,632	663	8.1	4,896	2,000	4.0	740	675	10	17,370	713	2.7	4,400	1,400	11,570	17,370
1970	3,874	100	0.75	5,345	655	7.7	4,896	2,000	4.0	740	675	10	14,855	954	4.8	4,400	1,400	9,055	14,855
1971	6,243	100	0.75	4,614	656	7.8	4,896	2,000	4.0	740	675	10	16,493	845	4.1	4,400	1,400	10,693	16,493
1972	4,461	100	0.75	4,967	656	7.8	4,896	2,000	4.0	740	675	10	15,064	929	4.6	4,400	1,400	9,264	15,064
1973	10,203	100	0.75	3,517	657	7.8	4,896	2,000	4.0	740	675	10	19,356	704	3.2	4,400	1,400	13,556	19,356
1974	7,032	100	0.75	3,331	658	7.9	4,896	2,000	4.0	740	675	10	15,999	824	3.7	4,400	1,400	10,199	15,999
1975	6,064	100	0.75	5,288	654	7.7	4,896	2,000	4.0	740	675	10	16,988	845	4.3	4,400	1,400	11,188	16,988
1976	3,183	100	0.75	5,507	655	7.7	4,896	2,000	4.0	740	675	10	14,326	992	5.0	4,400	1,400	8,526	14,326
1977	7,104	100	0.75	4,097	657	7.8	4,896	2,000	4.0	740	675	10	16,837	813	3.8	4,400	1,400	11,037	16,837
1978	15,560	100	0.75	872	673	8.5	4,896	2,000	4.0	740	675	10	22,068	563	2.1	4,400	1,400	16,268	22,068
1979	11,389	100	0.75	1,965	661	8.0	4,896	2,000	4.0	740	675	10	18,990	670	2.7	4,400	1,400	13,190	18,990
1980	11,412	100	0.75	2,414	658	7.9	4,896	2,000	4.0	740	675	10	19,462	669	2.8	4,400	1,400	13,662	19,462
1981	3,284	100	0.75	5,127	655	7.7	4,896	2,000	4.0	740	675	10	14,047	995	4.9	4,400	1,400	8,247	14,047
1982	8,170	100	0.75	3,776	656	7.8	4,896	2,000	4.0	740	675	10	17,582	773	3.5	4,400	1,400	11,782	17,582
1983	13,238	100	0.75	3,191	657	7.8	4,896	2,000	4.0	740	675	10	22,065	621	2.8	4,400	1,400	16,265	22,065
1984	6,166	100	0.75	4,773	656	7.8	4,896	2,000	4.0	740	675	10	16,575	847	4.1	4,400	1,400	10,775	16,575
1985	9,833	100	0.75	4,147	654	7.7	4,896	2,000	4.0	740	675	10	19,616	713	3.4	4,400	1,400	13,816	19,616
1986	7,050	100	0.75	5,044	655	7.7	4,896	2,000	4.0	740	675	10	17,730	807	4.0	4,400	1,400	11,930	17,730
1987	3,749	100	0.75	5,194	655	7.7	4,896	2,000	4.0	740	675	10	14,579	965	4.8	4,400	1,400	8,779	14,579
1988	9,909	100	0.75	3,048	659	7.9	4,896	2,000	4.0	740	675	10	18,593	715	3.1	4,400	1,400	12,793	18,593
1989	3,789	100	0.75	5,029	656	7.7	4,896	2,000	4.0	740	675	10	14,454	966	4.8	4,400	1,400	8,654	14,454
1990	3,699	100	0.75	5,440	655	7.7	4,896	2,000	4.0	740	675	10	14,775	963	4.9	4,400	1,400	8,975	14,775
1991	5,933	100	0.75	5,392	654	7.7	4,896	2,000	4.0	740	675	10	16,961	850	4.3	4,400	1,400	11,161	16,961
1992	8,326	100	0.75	4,766	653	7.7	4,896	2,000	4.0	740	675	10	18,728	760	3.7	4,400	1,400	12,928	18,728
1993	13,887	100	0.75	1,300	664	8.1	4,896	2,000	4.0	740	675	10	20,823	602	2.3	4,400	1,400	15,023	20,823
1994	5,083	100	0.75	5,411	654	7.7	4,896	2,000	4.0	740	675	10	16,130	889	4.5	4,400	1,400	10,330	16,130
1995	14,571	100	0.75	350	698	9.7	4,896	2,000	4.0	740	675	10	20,557	583	2.0	4,400	1,400	14,757	20,557
1996	4,982	100	0.75	5,192	654	7.7	4,896	2,000	4.0	740	675	10	15,810	897	4.5	4,400	1,400	10,010	15,810
1997	7,661	100	0.75	1,640	666	8.2	4,896	2,000	4.0	740	675	10	14,937	813	3.1	4,400	1,400	9,137	14,937
1998	15,731	100	0.75	3,157	650	7.5	4,896	2,000	4.0	740	675	10	24,524	568	2.5	4,400	1,400	18,724	24,524
1999	1,875	100	0.75	5,222	655	7.7	4,896	2,000	4.0	740	675	10	12,733	1,092	5.4	4,400	1,400	6,933	12,733
2000	3,969	100	0.75	5,453	654	7.7	4,896	2,000	4.0	740	675	10	15,058	947	4.8	4,400	1,400	9,258	15,058
2001	4,907	100	0.75	5,111	655	7.7	4,896	2,000	4.0	740	675	10	15,654	903	4.5	4,400	1,400	9,854	15,654
2002	1,067	100	0.75	5,567	655	7.7	4,896	2,000	4.0	740	675	10	12,270	1,145	5.8	4,400	1,400	6,470	12,270
2003	8,546	100	0.75	5,074	653	7.7	4,896	2,000	4.0	740	675	10	19,256	751	3.8	4,400	1,400	13,456	19,256
2004	5,517	100	0.75	5,148	655	7.7	4,896	2,000	4.0	740	675	10	16,301	872	4.3	4,400	1,400	10,501	16,301
2005	17,595	100	0.75	537	675	8.6	4,896	2,000	4.0	740	675	10	23,768	522	1.9	4,400	1,400	17,968	23,768
2006	5,419	100	0.75	5,111	655	7.7	4,896	2,000	4.0	740	675	10	16,166	877	4.4	4,400	1,400	10,366	16,166
2007	303	100	0.75	5,567	655	7.7	4,896	2,000	4.0	740	675	10	11,506	1,214	6.1	4,400	1,400	5,706	11,506
2008	7,091	100	0.75	3,762	657	7.8	4,896	2,000	4.0	740	675	10	16,489	817	3.7	4,400	1,400	10,689	16,489
2009	7,251	100	0.75	4,514	655	7.7	4,896	2,000	4.0	740	675	10	17,401	803	3.9	4,400	1,400	11,601	17,401
2010	7,584	100	0.75	3,049	659	7.9	4,896	2,000	4.0	740	675	10	16,269	803	3.5	4,400	1,400	10,469	16,269
2011	10,174	100	0.75	3,913	655	7.7	4,896	2,000	4.0	740	675	10	19,723	703	3.3	4,400	1,400	13,923	19,723
2012	2,649	100	0.75	5,510	655	7.7	4,896	2,000	4.0	740	675	10	13,795	1,027	5.2	4,400	1,400	7,995	13,795
2013	1,286	100	0.75	5,414	655	7.7	4,896	2,000	4.0	740	675	10	12,336	1,132	5.7	4,400	1,400	6,536	12,336
2014	2,152	100	0.75	5,537	655	7.7	4,896	2,000	4.0	740	675	10	13,325	1,061	5.4	4,400	1,400	7,525	13,325
Min	303	100	0.8	350	650	7.5	4,896	2,000	4.0	740	675	10	11,506	522	1.9	4,400	1,400	5,706	11,506
Max	17,595	100	0.8	5,567	698	9.7	4,896	2,000	4.0	740	675	10	24,524	1,214	6.1	4,400	1,400	18,724	24,524
Average	6,709	100	0.8	4,247	657	7.8	4,896	2,000	4.0	740	675	10	16,592	853	4.1	4,400	1,400	10,772	16,572

Appendix C-7
Recharge and Discharge to the Upper Temescal Valley Groundwater Management Zone
Scenario 4a

Hydrologic Year	Recharge															Discharge			
	Streambed Recharge of Stormwater Runoff			Streambed Recharge of Recycled Water			Deep Infiltration of Applied Water			Recycled Water Discharge to Ponds			Total			Groundwater Production	ET	Rising Groundwater Outflow	Total
	Q	TDS	N	Q	TDS	N	Q	TDS	N	Q	TDS	N	Q	TDS	N				
1950	3,199	100	0.75	7,321	670	8.3	4,896	2,000	4.0	1,303	664	11	16,719	950	5.8	1,300	1,400	12,769	15,469
1951	2,187	100	0.75	7,447	676	8.5	4,896	2,000	4.0	1,303	664	11	15,833	1,005	6.2	1,300	1,400	13,133	15,833
1952	7,878	100	0.75	17,744	658	7.8	4,896	2,000	4.0	1,303	664	11	31,821	727	5.6	1,300	1,400	29,121	31,821
1953	4,126	100	0.75	7,302	676	8.5	4,896	2,000	4.0	1,303	664	11	17,627	908	5.6	1,300	1,400	14,927	17,627
1954	3,732	100	0.75	21,239	657	7.8	4,896	2,000	4.0	1,303	664	11	31,170	802	6.5	1,300	1,400	28,470	31,170
1955	3,534	100	0.75	6,774	678	8.6	4,896	2,000	4.0	1,303	664	11	16,507	945	5.7	1,300	1,400	13,807	16,507
1956	3,831	100	0.75	6,040	678	8.6	4,896	2,000	4.0	1,303	664	11	16,070	942	5.5	1,300	1,400	13,370	16,070
1957	4,005	100	0.75	5,744	682	8.7	4,896	2,000	4.0	1,303	664	11	15,948	939	5.5	1,300	1,400	13,248	15,948
1958	8,897	100	0.75	17,187	659	7.8	4,896	2,000	4.0	1,303	664	11	32,283	708	5.4	1,300	1,400	29,583	32,283
1959	2,679	100	0.75	7,146	677	8.5	4,896	2,000	4.0	1,303	664	11	16,024	984	6.0	1,300	1,400	13,324	16,024
1960	4,743	100	0.75	6,702	677	8.5	4,896	2,000	4.0	1,303	664	11	17,644	888	5.4	1,300	1,400	14,944	17,644
1961	1,517	100	0.75	7,552	675	8.5	4,896	2,000	4.0	1,303	664	11	15,268	1,042	6.5	1,300	1,400	12,568	15,268
1962	4,957	100	0.75	20,249	658	7.8	4,896	2,000	4.0	1,303	664	11	31,405	779	6.2	1,300	1,400	28,705	31,405
1963	2,075	100	0.75	22,865	657	7.8	4,896	2,000	4.0	1,303	664	11	31,139	831	6.8	1,300	1,400	28,439	31,139
1964	5,334	100	0.75	6,782	674	8.4	4,896	2,000	4.0	1,303	664	11	18,315	861	5.2	1,300	1,400	15,615	18,315
1965	5,252	100	0.75	7,313	674	8.4	4,896	2,000	4.0	1,303	664	11	18,764	859	5.3	1,300	1,400	16,064	18,764
1966	7,323	100	0.75	17,916	658	7.8	4,896	2,000	4.0	1,303	664	11	31,438	737	5.7	1,300	1,400	28,738	31,438
1967	6,214	100	0.75	18,960	658	7.8	4,896	2,000	4.0	1,303	664	11	31,373	757	5.9	1,300	1,400	28,673	31,373
1968	4,481	100	0.75	7,277	674	8.4	4,896	2,000	4.0	1,303	664	11	17,957	892	5.5	1,300	1,400	15,257	17,957
1969	9,633	100	0.75	15,649	659	7.8	4,896	2,000	4.0	1,303	664	11	31,481	697	5.2	1,300	1,400	28,781	31,481
1970	3,739	100	0.75	7,194	675	8.5	4,896	2,000	4.0	1,303	664	11	17,132	927	5.7	1,300	1,400	14,432	17,132
1971	4,369	100	0.75	6,859	674	8.4	4,896	2,000	4.0	1,303	664	11	17,427	902	5.4	1,300	1,400	14,727	17,427
1972	2,908	100	0.75	7,063	675	8.4	4,896	2,000	4.0	1,303	664	11	16,170	972	5.9	1,300	1,400	13,470	16,170
1973	7,013	100	0.75	18,161	658	7.8	4,896	2,000	4.0	1,303	664	11	31,373	743	5.8	1,300	1,400	28,673	31,373
1974	5,401	100	0.75	4,880	687	8.9	4,896	2,000	4.0	1,303	664	11	16,480	883	5.0	1,300	1,400	13,780	16,480
1975	4,291	100	0.75	20,764	658	7.8	4,896	2,000	4.0	1,303	664	11	31,254	792	6.4	1,300	1,400	28,554	31,254
1976	2,517	100	0.75	22,685	657	7.8	4,896	2,000	4.0	1,303	664	11	31,401	822	6.8	1,300	1,400	28,701	31,401
1977	5,007	100	0.75	22,635	656	7.7	4,896	2,000	4.0	1,303	664	11	33,841	769	6.3	1,300	1,400	31,141	33,841
1978	13,891	100	0.75	12,617	660	7.9	4,896	2,000	4.0	1,303	664	11	32,707	623	4.4	1,300	1,400	30,007	32,707
1979	9,288	100	0.75	16,740	658	7.8	4,896	2,000	4.0	1,303	664	11	32,227	702	5.3	1,300	1,400	29,527	32,227
1980	9,780	100	0.75	15,698	659	7.8	4,896	2,000	4.0	1,303	664	11	31,677	694	5.2	1,300	1,400	28,977	31,677
1981	2,993	100	0.75	7,119	676	8.5	4,896	2,000	4.0	1,303	664	11	16,311	967	5.9	1,300	1,400	13,611	16,311
1982	7,124	100	0.75	18,565	658	7.8	4,896	2,000	4.0	1,303	664	11	31,888	740	5.8	1,300	1,400	29,188	31,888
1983	10,212	100	0.75	15,399	659	7.8	4,896	2,000	4.0	1,303	664	11	31,810	686	5.1	1,300	1,400	29,110	31,810
1984	5,557	100	0.75	7,469	674	8.4	4,896	2,000	4.0	1,303	664	11	19,225	845	5.3	1,300	1,400	16,525	19,225
1985	8,592	100	0.75	6,065	672	8.3	4,896	2,000	4.0	1,303	664	11	20,856	748	4.4	1,300	1,400	18,156	20,856
1986	5,229	100	0.75	19,876	658	7.8	4,896	2,000	4.0	1,303	664	11	31,304	775	6.2	1,300	1,400	28,604	31,304
1987	3,709	100	0.75	7,193	676	8.5	4,896	2,000	4.0	1,303	664	11	17,101	929	5.7	1,300	1,400	14,401	17,101
1988	8,296	100	0.75	19,588	658	7.8	4,896	2,000	4.0	1,303	664	11	34,083	715	5.7	1,300	1,400	31,383	34,083
1989	3,401	100	0.75	6,994	676	8.5	4,896	2,000	4.0	1,303	664	11	16,594	948	5.8	1,300	1,400	13,894	16,594
1990	3,643	100	0.75	7,146	676	8.5	4,896	2,000	4.0	1,303	664	11	16,988	933	5.7	1,300	1,400	14,288	16,988
1991	5,868	100	0.75	19,305	658	7.8	4,896	2,000	4.0	1,303	664	11	31,372	763	6.0	1,300	1,400	28,672	31,372
1992	7,531	100	0.75	18,032	658	7.8	4,896	2,000	4.0	1,303	664	11	31,762	733	5.7	1,300	1,400	29,062	31,762
1993	12,777	100	0.75	12,831	660	7.9	4,896	2,000	4.0	1,303	664	11	31,807	642	4.6	1,300	1,400	29,107	31,807
1994	3,937	100	0.75	21,085	658	7.8	4,896	2,000	4.0	1,303	664	11	31,221	798	6.4	1,300	1,400	28,521	31,221
1995	12,731	100	0.75	12,925	660	7.9	4,896	2,000	4.0	1,303	664	11	31,855	642	4.6	1,300	1,400	29,155	31,855
1996	4,998	100	0.75	7,064	674	8.4	4,896	2,000	4.0	1,303	664	11	18,261	872	5.3	1,300	1,400	15,561	18,261
1997	7,138	100	0.75	4,306	692	9.1	4,896	2,000	4.0	1,303	664	11	17,643	813	4.4	1,300	1,400	14,943	17,643
1998	16,222	100	0.75	10,997	662	7.9	4,896	2,000	4.0	1,303	664	11	33,418	585	4.0	1,300	1,400	30,718	33,418
1999	1,833	100	0.75	7,507	675	8.5	4,896	2,000	4.0	1,303	664	11	15,539	1,024	6.4	1,300	1,400	12,839	15,539
2000	4,014	100	0.75	7,185	673	8.4	4,896	2,000	4.0	1,303	664	11	17,398	914	5.6	1,300	1,400	14,698	17,398
2001	3,498	100	0.75	21,603	657	7.8	4,896	2,000	4.0	1,303	664	11	31,300	805	6.5	1,300	1,400	28,600	31,300
2002	1,116	100	0.75	7,746	675	8.5	4,896	2,000	4.0	1,303	664	11	15,061	1,062	6.7	1,300	1,400	12,361	15,061
2003	7,951	100	0.75	17,412	658	7.8	4,896	2,000	4.0	1,303	664	11	31,562	726	5.6	1,300	1,400	28,862	31,562
2004	5,643	100	0.75	6,793	675	8.5	4,896	2,000	4.0	1,303	664	11	18,635	848	5.1	1,300	1,400	15,935	18,635
2005	15,197	100	0.75	12,177	659	7.8	4,896	2,000	4.0	1,303	664	11	33,573	602	4.2	1,300	1,400	30,873	33,573
2006	5,421	100	0.75	7,216	675	8.5	4,896	2,000	4.0	1,303	664	11	18,836	853	5.3	1,300	1,400	16,136	18,836
2007	373	100	0.75	7,785	675	8.5	4,896	2,000	4.0	1,303	664	11	14,357	1,111	7.0	1,300	1,400	11,657	14,357
2008	5,349	100	0.75	20,802	658	7.8	4,896	2,000	4.0	1,303	664	11	32,350	769	6.2	1,300	1,400	29,650	32,350
2009	4,736	100	0.75	20,238	658	7.8	4,896	2,000	4.0	1,303	664	11	31,173	784	6.3	1,300	1,400	28,473	31,173
2010	5,082	100	0.75	19,939	658	7.8	4,896	2,000	4.0	1,303	664	11	31,220	778	6.2	1,300	1,400	28,520	31,220
2011	6,514	100	0.75	18,989	658	7.8	4,896	2,000	4.0	1,303	664	11	31,702	751	5.9	1,300	1,400	29,002	31,702
2012	2,693	100	0.75	7,635	675	8.5	4,896	2,000	4.0	1,303	664	11	16,527	973	6.1	1,300	1,400	13,827	16,527
2013	1,266	100	0.75	7,574	675	8.5	4,896	2,000	4.0	1,303	664	11	15,039	1,057	6.6	1,300	1,400	12,339	15,039
2014	2,207	100	0.75	7,615	674	8.4	4,896	2,000	4.0	1,303	664	11	16,021	999	6.2	1,300	1,400	13,321	16,021
Min	373	100	0.8	4,306	656	7.7	4,896	2,000	4.0	1,303	664	11	14,357	585	4.0	1,300	1,400	11,657	14,357
Max	16,222	100	0.8	22,865	692	9.1	4,896	2,000	4.0	1,303	664	11	34,083	1,111	7.0	1,300	1,400	31,383	34,083
Average	5,641	100	0.8	12,472	667	8.2	4,896	2,000	4.0	1,303	664	11	24,312	835	5.7	1,300	1,400	21,593	24,293

Appendix C-8
Recharge and Discharge to the Upper Temescal Valley Groundwater Management Zone
Scenario 4b

Hydrologic Year	Recharge															Discharge			
	Streambed Recharge of Stormwater Runoff			Streambed Recharge of Recycled Water			Deep Infiltration of Applied Water			Recycled Water Discharge to Ponds			Total			Groundwater Production	ET	Rising Groundwater Outflow	Total
	Q	TDS	N	Q	TDS	N	Q	TDS	N	Q	TDS	N	Q	TDS	N				
1950	3,198	100	0.75	7,557	669	8.2	4,896	2,000	4.0	1,303	664	11	16,954	946	5.8	4,400	1,400	9,904	15,704
1951	2,192	100	0.75	7,770	675	8.5	4,896	2,000	4.0	1,303	664	11	16,161	997	6.3	4,400	1,400	10,361	16,161
1952	8,007	100	0.75	19,070	658	7.8	4,896	2,000	4.0	1,303	664	11	33,276	721	5.7	4,400	1,400	27,476	33,276
1953	4,072	100	0.75	7,486	676	8.5	4,896	2,000	4.0	1,303	664	11	17,757	908	5.7	4,400	1,400	11,957	17,757
1954	3,905	100	0.75	22,713	657	7.8	4,896	2,000	4.0	1,303	664	11	32,817	792	6.5	4,400	1,400	27,017	32,817
1955	3,917	100	0.75	6,959	677	8.6	4,896	2,000	4.0	1,303	664	11	17,075	923	5.6	4,400	1,400	11,275	17,075
1956	3,454	100	0.75	6,720	678	8.6	4,896	2,000	4.0	1,303	664	11	16,373	950	5.8	4,400	1,400	10,573	16,373
1957	4,290	100	0.75	6,308	680	8.6	4,896	2,000	4.0	1,303	664	11	16,797	915	5.5	4,400	1,400	10,997	16,797
1958	9,145	100	0.75	18,511	658	7.8	4,896	2,000	4.0	1,303	664	11	33,855	702	5.5	4,400	1,400	28,055	33,855
1959	2,784	100	0.75	7,845	675	8.4	4,896	2,000	4.0	1,303	664	11	16,828	964	6.1	4,400	1,400	11,028	16,828
1960	4,686	100	0.75	6,961	677	8.5	4,896	2,000	4.0	1,303	664	11	17,846	887	5.4	4,400	1,400	12,046	17,846
1961	1,419	100	0.75	7,744	675	8.5	4,896	2,000	4.0	1,303	664	11	15,362	1,043	6.5	4,400	1,400	9,562	15,362
1962	5,099	100	0.75	21,755	657	7.8	4,896	2,000	4.0	1,303	664	11	33,053	771	6.3	4,400	1,400	27,253	33,053
1963	2,121	100	0.75	24,386	657	7.8	4,896	2,000	4.0	1,303	664	11	32,706	822	6.9	4,400	1,400	26,906	32,706
1964	6,083	100	0.75	7,122	674	8.4	4,896	2,000	4.0	1,303	664	11	19,404	828	5.1	4,400	1,400	13,604	19,404
1965	5,300	100	0.75	7,550	673	8.4	4,896	2,000	4.0	1,303	664	11	19,049	854	5.3	4,400	1,400	13,249	19,049
1966	7,497	100	0.75	19,298	658	7.8	4,896	2,000	4.0	1,303	664	11	32,994	731	5.8	4,400	1,400	27,194	32,994
1967	6,457	100	0.75	20,704	658	7.8	4,896	2,000	4.0	1,303	664	11	33,360	747	6.0	4,400	1,400	27,560	33,360
1968	5,125	100	0.75	7,687	674	8.4	4,896	2,000	4.0	1,303	664	11	19,011	860	5.4	4,400	1,400	13,211	19,011
1969	9,938	100	0.75	17,033	659	7.8	4,896	2,000	4.0	1,303	664	11	33,170	689	5.3	4,400	1,400	27,370	33,170
1970	3,778	100	0.75	7,428	675	8.4	4,896	2,000	4.0	1,303	664	11	17,405	922	5.7	4,400	1,400	11,605	17,405
1971	4,945	100	0.75	7,321	674	8.4	4,896	2,000	4.0	1,303	664	11	18,465	871	5.4	4,400	1,400	12,665	18,465
1972	3,625	100	0.75	7,384	674	8.4	4,896	2,000	4.0	1,303	664	11	17,208	930	5.8	4,400	1,400	11,408	17,208
1973	7,253	100	0.75	19,596	658	7.8	4,896	2,000	4.0	1,303	664	11	33,048	735	5.8	4,400	1,400	27,248	33,048
1974	5,548	100	0.75	5,131	686	8.9	4,896	2,000	4.0	1,303	664	11	16,878	873	5.0	4,400	1,400	11,078	16,878
1975	4,370	100	0.75	22,313	657	7.8	4,896	2,000	4.0	1,303	664	11	32,882	783	6.4	4,400	1,400	27,082	32,882
1976	2,642	100	0.75	24,160	657	7.8	4,896	2,000	4.0	1,303	664	11	33,001	812	6.8	4,400	1,400	27,201	33,001
1977	5,520	100	0.75	24,140	657	7.8	4,896	2,000	4.0	1,303	664	11	35,859	755	6.3	4,400	1,400	30,059	35,859
1978	14,730	100	0.75	13,764	660	7.9	4,896	2,000	4.0	1,303	664	11	34,693	611	4.4	4,400	1,400	28,893	34,693
1979	9,498	100	0.75	17,925	658	7.8	4,896	2,000	4.0	1,303	664	11	33,622	696	5.4	4,400	1,400	27,822	33,622
1980	10,042	100	0.75	17,204	659	7.8	4,896	2,000	4.0	1,303	664	11	33,445	687	5.3	4,400	1,400	27,645	33,445
1981	3,026	100	0.75	7,629	674	8.4	4,896	2,000	4.0	1,303	664	11	16,854	956	6.0	4,400	1,400	11,054	16,854
1982	7,207	100	0.75	19,957	658	7.8	4,896	2,000	4.0	1,303	664	11	33,363	734	5.8	4,400	1,400	27,563	33,363
1983	10,627	100	0.75	16,666	659	7.8	4,896	2,000	4.0	1,303	664	11	33,492	678	5.1	4,400	1,400	27,692	33,492
1984	6,071	100	0.75	7,744	674	8.4	4,896	2,000	4.0	1,303	664	11	20,014	824	5.2	4,400	1,400	14,214	20,014
1985	8,898	100	0.75	6,382	672	8.3	4,896	2,000	4.0	1,303	664	11	21,479	737	4.4	4,400	1,400	15,679	21,479
1986	5,553	100	0.75	21,418	657	7.8	4,896	2,000	4.0	1,303	664	11	33,170	763	6.2	4,400	1,400	27,370	33,170
1987	3,649	100	0.75	7,377	676	8.5	4,896	2,000	4.0	1,303	664	11	17,225	929	5.8	4,400	1,400	11,425	17,225
1988	8,355	100	0.75	20,846	658	7.8	4,896	2,000	4.0	1,303	664	11	35,400	712	5.7	4,400	1,400	29,600	35,400
1989	3,575	100	0.75	7,283	676	8.5	4,896	2,000	4.0	1,303	664	11	17,057	934	5.8	4,400	1,400	11,257	17,057
1990	3,624	100	0.75	7,492	675	8.5	4,896	2,000	4.0	1,303	664	11	17,315	928	5.8	4,400	1,400	11,515	17,315
1991	6,010	100	0.75	20,732	658	7.8	4,896	2,000	4.0	1,303	664	11	32,941	756	6.1	4,400	1,400	27,141	32,941
1992	7,670	100	0.75	19,446	658	7.8	4,896	2,000	4.0	1,303	664	11	33,315	727	5.7	4,400	1,400	27,515	33,315
1993	13,010	100	0.75	14,169	660	7.9	4,896	2,000	4.0	1,303	664	11	33,378	638	4.7	4,400	1,400	27,578	33,378
1994	4,115	100	0.75	22,502	657	7.8	4,896	2,000	4.0	1,303	664	11	32,816	788	6.5	4,400	1,400	27,016	32,816
1995	12,900	100	0.75	14,365	660	7.9	4,896	2,000	4.0	1,303	664	11	33,464	640	4.7	4,400	1,400	27,664	33,464
1996	5,059	100	0.75	7,350	673	8.4	4,896	2,000	4.0	1,303	664	11	18,608	866	5.3	4,400	1,400	12,808	18,608
1997	7,456	100	0.75	4,523	690	9.1	4,896	2,000	4.0	1,303	664	11	18,178	799	4.4	4,400	1,400	12,378	18,178
1998	16,457	100	0.75	12,229	661	7.9	4,896	2,000	4.0	1,303	664	11	34,885	584	4.1	4,400	1,400	29,085	34,885
1999	1,773	100	0.75	7,877	674	8.4	4,896	2,000	4.0	1,303	664	11	15,849	1,019	6.4	4,400	1,400	10,049	15,849
2000	4,151	100	0.75	7,608	672	8.4	4,896	2,000	4.0	1,303	664	11	17,958	901	5.6	4,400	1,400	12,158	17,958
2001	3,501	100	0.75	23,217	657	7.8	4,896	2,000	4.0	1,303	664	11	32,917	798	6.6	4,400	1,400	27,117	32,917
2002	1,081	100	0.75	8,077	674	8.4	4,896	2,000	4.0	1,303	664	11	15,357	1,055	6.7	4,400	1,400	9,557	15,357
2003	8,412	100	0.75	19,075	658	7.8	4,896	2,000	4.0	1,303	664	11	33,686	714	5.6	4,400	1,400	27,886	33,686
2004	5,707	100	0.75	7,194	674	8.4	4,896	2,000	4.0	1,303	664	11	19,100	842	5.2	4,400	1,400	13,300	19,100
2005	16,363	100	0.75	13,380	659	7.8	4,896	2,000	4.0	1,303	664	11	35,942	587	4.2	4,400	1,400	30,142	35,942
2006	5,442	100	0.75	7,465	675	8.4	4,896	2,000	4.0	1,303	664	11	19,106	850	5.3	4,400	1,400	13,306	19,106
2007	348	100	0.75	8,225	674	8.4	4,896	2,000	4.0	1,303	664	11	14,772	1,099	7.0	4,400	1,400	8,972	14,772
2008	5,386	100	0.75	22,345	657	7.8	4,896	2,000	4.0	1,303	664	11	33,930	763	6.2	4,400	1,400	28,130	33,930
2009	4,811	100	0.75	21,700	657	7.8	4,896	2,000	4.0	1,303	664	11	32,710	777	6.3	4,400	1,400	26,910	32,710
2010	5,179	100	0.75	21,396	657	7.8	4,896	2,000	4.0	1,303	664	11	32,774	770	6.2	4,400	1,400	26,974	32,774
2011	6,596	100	0.75	20,397	658	7.8	4,896	2,000	4.0	1,303	664	11	33,192	745	6.0	4,400	1,400	27,392	33,192
2012	2,597	100	0.75	7,888	675	8.4	4,896	2,000	4.0	1,303	664	11	16,684	973	6.1	4,400	1,400	10,884	16,684
2013	1,208	100	0.75	7,926	674	8.4	4,896	2,000	4.0	1,303	664	11	15,333	1,052	6.6	4,400	1,400	9,533	15,333
2014	2,172	100	0.75	8,009	673	8.4	4,896	2,000	4.0	1,303	664	11	16,380	993	6.3	4,400	1,400	10,580	16,380
Min	348	100	0.8	4,523	657	7.8	4,896	2,000	4.0	1,303	664	11	14,772	584	4.1	4,400	1,400	8,972	14,772
Max	16,457	100	0.8	24,386	690	9.1	4,896	2,000	4.0	1,303	664	11	35,942	1,099	7.0	4,400	1,400	30,142	35,942
Average	5,825	100	0.8	13,345	667	8.1	4,896	2,000	4.0	1,303	664	11	25,369	825	5.7	4,400	1,400	19,550	25,350