BASIN PLAN AMENDMENT
REQUIRED MONITORING AND ANALYSES

Recomputation of Ambient Water Quality in the Santa Ana Watershed for the Period 1993 to 2012

Technical Memorandum

Prepared for

Santa Ana Watershed Project Authority
Basin Monitoring Program Task Force

Prepared by

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Acronyms, Abbreviations, and Initialisms

µg/L	micrograms per liter
BMPTF	Basin Monitoring Program Task Force
CBWCD	Chino Basin Water Conservation District
CBWM	Chino Basin Watermaster
CDFM	cumulative departure from the mean
DPH	State of California, Department of Public Health
EMWD	Eastern Municipal Water District
EVMWD	Elsinore Valley Municipal Water District
GIS	Geographic Information System
IEUA	Inland Empire Utilities Agency
JCSD	Jurupa Community Services District
mg/L	milligrams per liter
meq/L	milliequivalents per liter
N/TDS	nitrogen/total dissolved solids
OCSD	Orange County Sanitation District
OCWD	Orange County Water District
POTW	Publicly-Owned Treatment Works
RWQCB	Regional Water Quality Control Board
SAW DMS	Santa Ana Watershed Data Management System
SAWPA	Santa Ana Watershed Project Authority
SARWC	Santa Ana River Water Company
SBVMWD	San Bernardino Valley Municipal Water District
SBVWCD	San Bernardino Valley Water Conservation District
STWMA	San Timoteo Watershed Management Authority
TDS	total dissolved solids
TIN	total inorganic nitrogen
US EPA	United States Environmental Protection Agency
USGS	US Geological Survey
WEI	Wildermuth Environmental, Inc.
WRCRWA	Western Riverside County Regional Wastewater Authority
WMWD	Western Municipal Water District
WQ/WL	water quality/water level
YVWD	Yucaipa Valley Water District

1.1 Introduction and Background

In 1995, the TIN/TDS Task Force was formed to provide oversight, supervision, and approval of a study to evaluate the impacts of Total Inorganic Nitrogen (TIN) and Total Dissolved Solids (TDS) on water resources in the Santa Ana Watershed. Members of the TIN/TDS Task Force (later renamed the Nitrogen/TDS Task Force) included:

- California Regional Water Quality Control Board, Santa Ana Region (RWQCB) – Advisory Member
- Chino Basin Water Conservation District (CBWCD)
- Chino Basin Watermaster (CBWM)
- City of Colton
- City of Corona
- City of Redlands
- City of Rialto
- City of Riverside
- City of San Bernardino
- Eastern Municipal Water District (EMWD)
- Elsinore Valley Municipal Water District (EVMWD)
- Inland Empire Utilities Agency (IEUA)
- Jurupa Community Services District (JCSD)
- Orange County Sanitation District (OCSD)
- Orange County Water District (OCWD)
- Riverside-Highland Water Company
- San Bernardino Valley Municipal Water District (SBVMWD)
- San Bernardino Valley Water Conservation District (SBVWCD)
- San Timoteo Watershed Management Authority (STWMA)
- Santa Ana Watershed Project Authority (SAWPA) – Task Force Administrator
- US Geological Survey (USGS) – Advisory Member
- West San Bernardino County Water District
- Yucaipa Valley Water District (YVWD)

Wildermuth Environmental, Inc. (WEI) was retained by the Nitrogen/TDS Task Force, through a contract administered by SAWPA, to conduct Phase 2A of the TIN/TDS Study (Task Order 1998-W020-1616-03). Phase 2A comprised the following tasks:

- Task 1: Develop Surface Water Translator for Meeting Groundwater Objectives that Accounts for Nitrogen Losses During Percolation
- Task 2: Develop New Compliance Metric and Monitoring Plan to Replace Current

August-Only below Prado Metric

- Task 3: Develop Updated Boundary Maps for Groundwater Subbasins and New Management Zones
- Task 4: Estimate Regional TDS and Nitrogen Concentrations in Groundwater
- Task 5: Compute TDS and Nitrogen Objectives for New Groundwater Basins and Management Areas

These tasks were completed in July 2000 and documented in *TIN/TDS Study – Phase 2A Final Technical Memorandum* (WEI, 2000a). The groundwater management zones delineated in this study, with subsequent revisions, were adopted in the January 22, 2004 Basin Plan Amendment (see Figure 1-1) and replaced the groundwater subbasins of the 1995 Basin Plan (RWQCB, 2004).

Tables 1-1 and 1-2 display the ambient TDS and nitrate-nitrogen water quality determinations, respectively, for the groundwater management zones generated during the Phase 2A study for the periods of 1954-1973 and 1978-1997. The ambient water quality determinations from the "historical" period (1954-1973) were used as the basis for the new water quality objectives in the 2004 Basin Plan Amendment (RWQCB, 2004). The ambient water quality determinations from the "current" period (1978-1997) were used to assess compliance with the new water quality objectives and to determine the magnitude of assimilative capacity, if it exists, within individual management zones.

If the current quality of a management zone is the same as or poorer than the water quality objectives, assimilative capacity does not exist. If the current quality is better than the water quality objectives, assimilative capacity exists. In the latter case, the difference between the objective and current quality is the amount of assimilative capacity available.

Note that in Tables 1-1 and 1-2, a number of the water quality objectives were raised to create assimilative capacity and, thus, encourage reclamation and the maximum beneficial use of state waters. These "maximum benefit" water quality objectives for management zones are contingent on the implementation of certain projects and programs by specific dischargers as part of their maximum benefit demonstrations. Also note that the Chino Basin Management Zones, as delineated in the *TIN/TDS Study – Phase 2A Final Technical Memorandum* (with revisions), have been further revised to accompany the maximum benefit water quality objectives.

As part of the agreement to adopt the 2004 Basin Plan Amendment, the affected parties agreed to recompute ambient water quality for the individual management zones every three years. The determination of current ambient quality shall be accomplished using a methodology consistent with that employed by the Nitrogen/TDS Task Force (20-year running averages) to develop the TDS and nitrate-nitrogen water quality objectives included in the 2004 Basin Plan.

Specifically, the 2004 Basin Plan Amendment states:

> No later than (*6 months from effective date of this Basin Plan amendment*),

> Orange County Water District, Irvine Ranch Water District, Inland Empire Utilities Agency, Chino Basin Watermaster, City of Riverside, City of Corona, Elsinore Valley Municipal Water District, Eastern Municipal Water District, City of Colton, City of San Bernardino Municipal Water Department, City of Redlands, Jurupa Community Services District, Western Riverside County Regional Wastewater Authority , Lee Lake Water District, Yucaipa Valley Water District, City of Beaumont, the San Timoteo Watershed Management Authority and the City of Rialto shall submit to the Regional Board for approval, a proposed watershed-wide TDS and nitrogen monitoring program that will provide data necessary to review and update the TDS/nitrogen management plan. Data to be collected and analyzed shall address, at a minimum: (1) determination of current ambient quality in groundwater management zones; (2) determination of compliance with TDS and nitrate-nitrogen objectives for the management zones; (3) evaluation of assimilative capacity findings for groundwater management zones; and (4) assessment of the effects of recharge of surface water POTW discharges on the quality of affected groundwater management zones. The determination of current ambient quality shall be accomplished using methodology consistent with that employed by the Nitrogen/TDS Task Force (20-year running averages) to develop the TDS and nitrogen-nitrogen water quality objectives included in this Basin Plan. [Ref. 1] The determination of current ambient groundwater quality throughout the watershed must be reported by July 1, 2005, and, at a minimum, every three years thereafter.

The agencies referenced in the 2004 Basin Plan Amendment (above) formed the Basin Monitoring Program Task Force (BMPTF) to supervise and oversee the recomputation of ambient water quality, among other related tasks. The first recomputation of ambient water quality encompassed the period of 1984-2003 (reported by July 1, 2005). This recomputation of ambient water quality encompasses the period of 1993-2012 (reported by July 1, 2014). WEI was retained by the BMPTF to perform the current recomputation in June 2013.

This technical memorandum describes, in detail, the specific tasks involved in and the results derived from the recomputation of ambient water quality for all groundwater management zones listed in Tables 1-1 and 1-2 for the period of 1993 to 2012.

Table 1-1
TIN/TDS Phase 2A Results for TDS (WEI, 2000a)

Groundwater Basin	Management Zone	Total Dissolved Solids (TDS)			
		Water Quality Objective *(mg/L)*	Historical Ambient[1] *(mg/L)*	1997 Ambient[2] *(mg/L)*	Assimilative Capacity *(mg/L)*
San Bernardino Valley & Yucaipa/Beaumont Plains					
	Beaumont -- "max benefit"	330	233	290	40
	Beaumont -- "antideg"	230	233	290	
	Bunker Hill-A	310	313	350	
	Bunker Hill-B	330	332	260	70
	Lytle	260	264	240	20
	San Timoteo -- "max benefit"	400	303	300	100
	San Timoteo -- "antideg"	300	303	300	
	Yucaipa -- "max benefit"	370	319	330	40
	Yucaipa -- "antideg"	320	319	330	
San Jacinto Basins					
	Canyon	230	234	220	10
	Hemet-South	730	732	1030	
	Lakeview/Hemet-North	520	519	830	
	Menifee	1020	1021	3360	
	Perris-North	570	568	750	
	Perris-South	1260	1258	3190	
	San Jacinto-Lower	520	520	730	
	San Jacinto-Upper -- "max benefit"	500	321	370	130
	San Jacinto-Upper -- "antideg"	320	321	370	
Chino, Rialto/Colton, & Riverside Basins					
	Chino-North -- "max benefit"	420	260	300	120
	Chino 1 -- "antideg"	280	280	310	
	Chino 2 -- "antideg"	250	250	300	
	Chino 3 -- "antideg"	260	260	280	
	Chino-East	730	733	760	
	Chino-South	680	676	720	
	Colton	410	407	430	
	Cucamonga -- "max benefit"	380	212	260	120
	Cucamonga -- "antideg"	210	212	260	
	Rialto	230	230	230	
	Riverside-A	560	560	440	120
	Riverside-B	290	289	320	
	Riverside-C	680	684	760	
	Riverside-D	810	812	?	
	Riverside-E	720	721	720	
	Riverside-F	660	665	580	80
	Prado Basin	surface water objective applies	618	819	surface water objective applies
Elsinore/Temescal Valleys					
	Arlington	980	983	?	
	Bedford	?	?	?	
	Coldwater	380	381	380	
	Elsinore	480	476	480	
	Lee Lake	?	?	?	
	Temescal	770	771	780	
	Warm Springs Valley	?	?	?	
Orange County Basins					
	Irvine	910	908	910	
	La Habra	?	?	?	
	Orange County[3]	580	585	560	
	Santiago	?	?	?	

? = Not enough data to estimate TDS concentrations; management zone is presumed to have no assimilative capacity. If assimilative capacity is demonstrated by an existing or proposed discharger, that discharge would be regulated accordingly.

[1] Data sampling period was 20 years (1954-1973) for historical ambient water quality computations.

[2] Data sampling period was 20 years (1978-1997) for current ambient water quality computations.

[3] For the purposes of regulating discharges other than those associated with projects implemented within the Orange County Management Zone to facilitate remediation projects and/or to address legacy contamination, no assimilative capacity is assumed to exist.

For a detailed description of the methodologies employed to calculate ambient water quality, refer to Sections 4 & 5 of the Phase 2A Final Technical Memorandum (WEI, 2000a).

This table reflects all revisions requested and approved by the TIN/TDS Task Force since the original publication of Table 5-1 in the Phase 2A Final Technical Memorandum (WEI, 2000a).

Table 1-2
TIN/TDS Phase 2A Results for Nitrate-Nitrogen (WEI, 2000a)

Groundwater Basin	Management Zone	Nitrate-Nitrogen (NO3-N)			
		Water Quality Objective *(mg/L)*	Historical Ambient[1] *(mg/L)*	1997 Ambient[2] *(mg/L)*	Assimilative Capacity *(mg/L)*
San Bernardino Valley & Yucaipa/Beaumont Plains					
	Beaumont -- "max benefit"	5.0	1.5	2.6	2.4
	Beaumont -- "antideg"	1.5	1.5	2.6	
	Bunker Hill-A	2.7	2.7	4.5	
	Bunker Hill-B	7.3	7.3	5.5	1.8
	Lytle	1.5	1.5	2.8	
	San Timoteo -- "max benefit"	5.0	2.7	2.9	2.1
	San Timoteo -- "antideg"	2.7	2.7	2.9	
	Yucaipa -- "max benefit"	5.0	4.2	5.2	
	Yucaipa -- "antideg"	4.2	4.2	5.2	
San Jacinto Basins					
	Canyon	2.5	2.5	1.6	0.9
	Hemet-South	4.1	4.1	5.2	
	Lakeview/Hemet-North	1.8	1.8	2.7	
	Menifee	2.8	2.8	5.4	
	Perris-North	5.2	5.2	4.7	0.5
	Perris-South	2.5	2.5	4.9	
	San Jacinto-Lower	1.0	1.0	1.9	
	San Jacinto-Upper -- "max benefit"	7.0	1.4	1.9	5.1
	San Jacinto-Upper -- "antideg"	1.4	1.4	1.9	
Chino, Rialto/Colton, & Riverside Basins					
	Chino-North -- "max benefit"	5.0	3.7	7.4	
	Chino 1 -- "antideg"	5.0	5.0	8.4	
	Chino 2 -- "antideg"	2.9	2.9	7.2	
	Chino 3 -- "antideg"	3.5	3.5	6.3	
	Chino-East	10.0	13.3	29.1	
	Chino-South	4.2	4.2	8.8	
	Colton	2.7	2.7	2.9	
	Cucamonga -- "max benefit"	5.0	2.4	4.4	0.6
	Cucamonga -- "antideg"	2.4	2.4	4.4	
	Rialto	2.0	2.0	2.7	
	Riverside-A	6.2	6.2	4.4	1.8
	Riverside-B	7.6	7.6	8.0	
	Riverside-C	8.3	8.3	15.5	
	Riverside-D	10.0	19.5	?	
	Riverside-E	10.0	13.3	14.8	
	Riverside-F	9.5	12.1	9.5	
	Prado Basin	surface water objective applies	4.3	22.0	surface water objective applies
Elsinore/Temescal Valleys					
	Arlington	10.0	25.5	?	
	Bedford	?	?	?	
	Coldwater	1.5	1.5	2.6	
	Elsinore	1.0	1.0	2.6	
	Lee Lake	?	?	?	
	Temescal	10.0	11.8	13.2	
	Warm Springs Valley	?	?	?	
Orange County Basins					
	Irvine	5.9	5.9	7.4	
	La Habra	?	?	?	
	Orange County	3.4	3.4	3.4	
	Santiago	?	?	?	

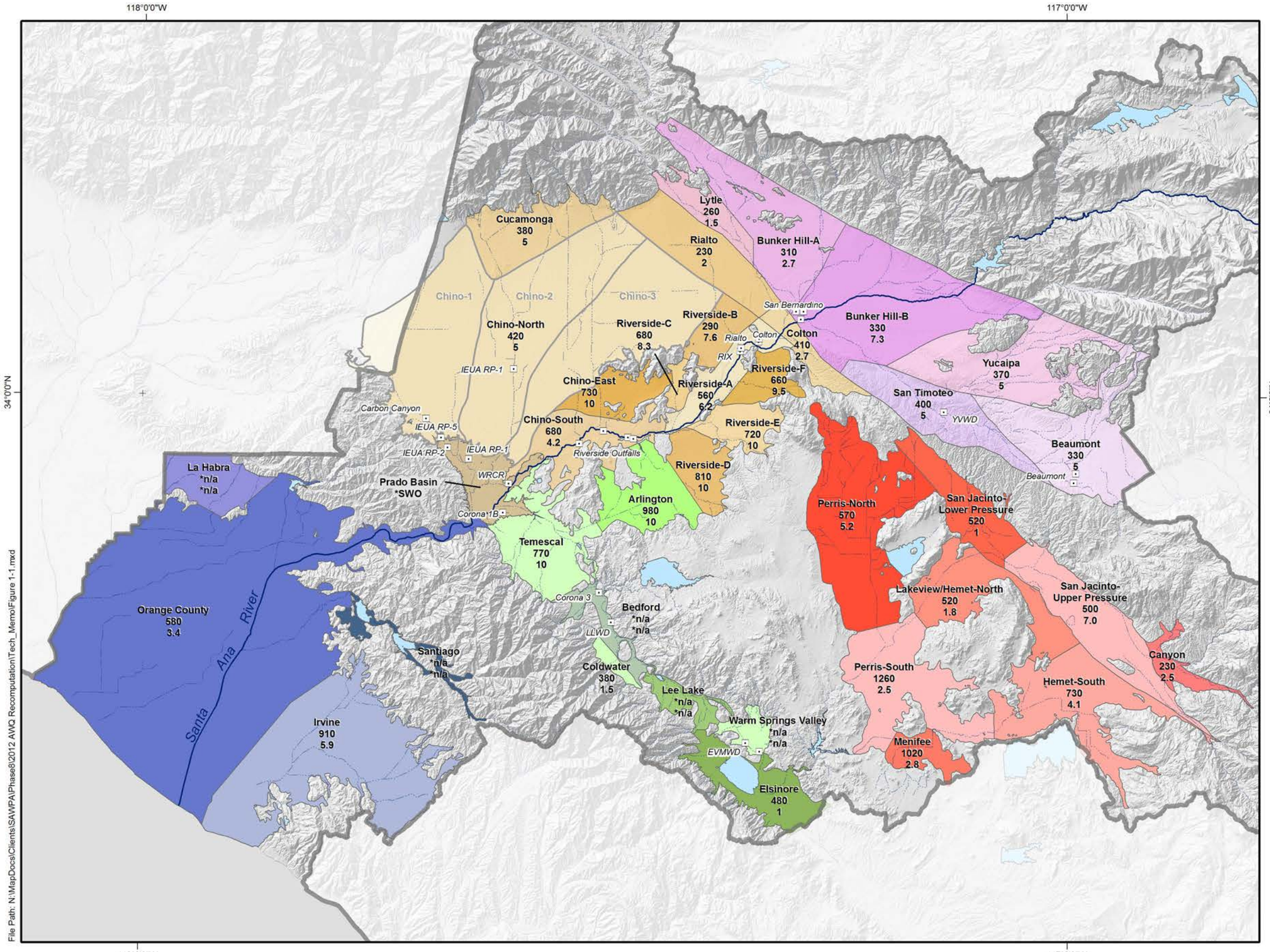
? = Not enough data to estimate nitrate-nitrogen concentrations; management zone is presumed to have no assimilative capacity. If assimilative capacity is demonstrated by an existing or proposed discharger, that discharge would be regulated accordingly.

[1] Data sampling period was 20 years (1954-1973) for historical ambient water quality computations.

[2] Data sampling period was 20 years (1978-1997) for current ambient water quality computations.

For a detailed description of the methodologies employed to calculate ambient water quality, refer to Sections 4 & 5 of the Phase 2A Final Technical Memorandum (WEI, 2000a).

This table reflects all revisions requested and approved by the TIN/TDS Task Force since the original publication of Table 5-1 in the Phase 2A Final Technical Memorandum (WEI, 2000a).



File Path: N:\MapDocs\Clients\SAWPA\Phase8\2012 AWQ Recomputation\Tech_Memo\Figure 1-1.mxd

Groundwater Quality Objectives

Management Zone — Orange County
TDS Objective (mg/L) — 580
NO3-N Objective (mg/L) — 3.4

Recycled Water Discharge Location

*SWO: Surface Water Objectives Apply.

*n/a: not enough data were available to calculate water quality objectives.

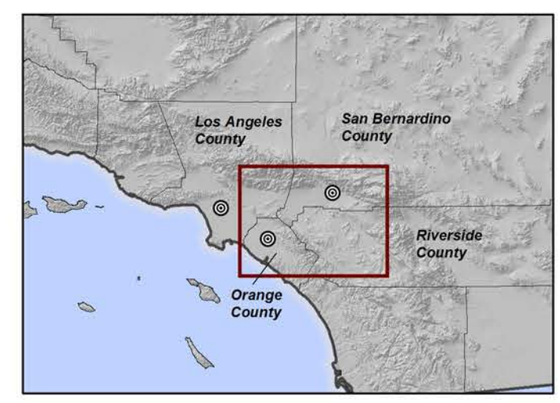
Other Features

RWQCB Boundary

Management Zone Boundary

Santa Ana River

Lakes & Reservoirs



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File: Figure 1-1

0 5 10 15 Miles
0 5 10 15 20 25 KM

Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality for the Period 1993 to 2012

SAWPA

Management Zone Boundaries

Santa Ana Watershed - 2004 Basin Plan Amendment

Figure 1-1

Section 2 – Methods to Recompute Ambient Water Quality

Ambient water quality was calculated for the 20-year period of January 1, 1993 to December 31, 2012. All data for this period were collected, processed, and stored in a central project database. With exception to OCWD data, the database used in the previous recomputation (1990-2009 [WEI, 2011]) was updated with well information, water level data, and water quality data through 2012. Moreover, the database developed for the Phase 2A study (WEI, 2000b) contained all historical groundwater data from 1954 through 1997 and was subsequently updated to include data through 2009 during the three prior recomputations (WEI, 2005; WEI, 2008; WEI, 2011). Following the completion of previous recomputation efforts, OCWD data were expunged from the database at the agencies' request. In the current recomputation effort, the OCWD delivered complete datasets encompassing the entire recomputation period (1993-2012). For all other agencies, WEI collected and appended data from 2010 through 2012 to the existing database.

After the database had been updated through 2012, WEI staff began recalculating ambient water quality for each management zone in the watershed. This technical process included:

- Development of water quality point statistics for TDS and nitrate-nitrogen at wells
- Estimation (mapping) of regional TDS and nitrate-nitrogen in groundwater across the watershed
- Computation of ambient TDS and nitrate-nitrogen for each management zone in the watershed

The tasks listed in this section describe, in detail, the process of computing ambient water quality for all management zones listed in Tables 1-1 and 1-2 for the period of 1993 to 2012.

2.1 Task 1 – Meet with Agencies and Collect Data

In July 2013, the RWQCB sent letters to SAWPA agencies and sub-agencies, asking for cooperation and participation in the recomputation of ambient water quality in the Santa Ana Watershed, as required by the Basin Plan. An outline of the data required for the analysis, based on guidelines established by the United States Environmental Protection Agency (US EPA, 1992), was included in the RWQCB letter (see Table 2-1). Following the RWQCB letter, a WEI staff scientist made initial and follow-up emails and phone calls, reminding agency data managers of the request for historical data.

A complete set of water quality and water level data through 2012 was collected from each agency. Well site information was gathered where new or revised data existed. The specific water quality analytes required for the recomputation effort are listed in Table 2-2.

Where available, copies of each agency's database or electronic archives were collected. For agencies that did not have these data available in digital format, hard copies of archived water quality lab reports were collected. In cases where data were unavailable from a particular agency, data were collected from the State of California, Department of Public Health (DPH) database. For governmental entities that perform monitoring or compile data in the watershed (i.e. the USGS, EPA, and State Water Resources Control Board), data were

downloaded from their database websites. Table 2-3 summarizes the agencies contacted and the format in which data were received.

2.2 Task 2 – Process and Upload Historical Data

The objective of this task was to process station information, water quality data, and water level data into a normalized format for upload to the database. This was accomplished in one of two ways:

- Five agencies provided data in database format, which required reformatting and normalization before it could be incorporated into the central database. This involved identifying necessary database fields in the agency databases and mapping those fields to the current database. This process often required performing chemical (e.g. nitrate to nitrate as nitrogen) and unit (e.g. μg/L to mg/L) conversions to ensure a standardized dataset.
- The remaining agencies provided archive data in customized digital spreadsheet files and/or hardcopy format. Hardcopy lab reports and water level measurements were manually entered into a normalized upload file. Digital documents were reformatted and normalized into the same digital format. This process often required performing chemical (e.g. nitrate to nitrate as nitrogen) and unit (e.g. μg/L to mg/L) conversions to ensure a standardized dataset prior to upload. The populated upload templates were checked for accuracy, and duplicate records were removed before data were assimilated into the database.

Following the data upload, a visual check of all processed data was performed using HydroDaVE^{SM}, which is capable of simultaneously displaying data spatially and temporally. Using HydroDaVE^{SM}, WEI staff scrutinized hydrographs of water level and water quality data spanning the entire period of recomputation for discrepancies. If data anomalies were identified visually, WEI staff reviewed the original data source and verified the reported values. This method identified any data inconsistencies that were introduced during processing, such as incorrect well assignment or incorrect analyte/unit assignment. As an additional data check, well-specific TDS and nitrate-nitrogen hydrographs and well location maps were prepared and submitted to each respective agency. After the agencies had visually reviewed their data using the hydrographs and maps, they provided comments and suggested edits to the data where necessary; where required, edits were made to the project database.

2.3 Task 3 – Develop Water-Quality Point Statistics for TDS/Nitrate-N at Wells

The following steps were executed to develop water-quality point statistics at wells for TDS and nitrate-nitrogen and are identical to the methods used in the TIN/TDS Phase 2A study (WEI 2000a):

- *Reviewed TDS and nitrate-nitrogen time histories.* TDS and nitrate-nitrogen time histories were developed for all wells used in the ambient water quality recomputation. Each time history includes a cumulative departure from the mean (CDFM) curve for

rainfall. The CDFM curve is useful in characterizing the occurrence and magnitude of wet and dry climatic periods. Negatively sloping segments (trending down and to the right) in CDFM curves indicate dry periods, and positively sloping segments (trending up and to the right) indicate wet periods. The time histories are included in Appendix B.

- *Defined data sampling periods.* For historical ambient water quality, the data sampling period was January 1, 1954 to December 31, 1973 (objective setting period). For current ambient water quality, the data sampling period is a 20-year period with the latest complete set of data. For the current ambient water quality recomputation, this period is January 1, 1993 to December 31, 2012. Current ambient water quality will always be computed as a rolling 20-year average.
- *Conducted a series of data quality tests and rejected data.* Four tests were conducted, based on the results of general mineral analyses if data were available. Samples that failed the data quality tests were rejected from the analysis. These tests are described in *Standard Methods for the Examination of Water and Wastewater* (Greenberg et al., 1992):

1. Anion-Cation Balance

$$\%\ difference = 100 \cdot \frac{\sum cations - \sum anions}{\sum cations + \sum anions}$$

with the following acceptance criteria:

Anion Sum (milliequivalents per liter [meq/L])	Acceptable % Difference
0 – 3	±0.2 meq/L
3 – 10	±2%
10 - 800	±5%

2. Measured TDS = Calculated TDS

$$1.0 < \frac{measured\ TDS}{calculated\ TDS} < 1.2$$

where:

calculated TDS = 0.6 (alkalinity) + Na + K + Ca + Mg + Cl + SO_4 + SiO_3 + NO_3 + F

3. Measured EC and Ion Sums

$$0.9 \cdot EC < 100 \cdot anion\ (or\ cation)\ sum,\ meq/L < 1.1 \cdot EC$$

4. TDS to EC Ratios

$$0.55 < \frac{measured\ TDS}{EC} < 0.7$$

–and–

$$0.55 < \frac{calculated\ TDS}{EC} < 0.7$$

(Note: If a sample had nitrate-nitrogen or TDS data but did not have all of the prerequisite data to perform the above listed data quality tests [e.g. well owner sampled for nitrate but not for general minerals], the sample passed to the next level of statistical tests for normality and outliers.)

- *Computed statistics.* Before performing statistical tests for normality and outliers, the *mean* and *standard deviation* statistics for each well were computed for both TDS and nitrate-nitrogen.
- *Annualized data.* TDS and nitrate-nitrogen sample results were averaged for each calendar year where more than one observation occurred during that year. Thus, only one value per year, the annual average, was used in the computation of ambient water quality. A well may have a maximum of 20 annualized averages where data exist each year of the recomputation period but must have a minimum of 3 annualized averages to continue to the statistical tests for normality and outliers. This means a statistic (*mean plus t*standard error of the mean*) cannot be computed for a well that does not have qualified data in at least three separate calendar years.
- *Applied appropriate statistical tests for normality and outliers.* The assumption of the "mean plus t*standard error of the mean" approach is that data are normally distributed or that a transformation can approximate a normal distribution. The Shapiro-Wilk test for both normality and outlier testing was recommended and adopted by the Nitrogen/TDS Task Force at the June 15, 1999 meeting. Shapiro and Wilk (1965) developed a test for normality based on normal order statistics. In the Shapiro-Wilk test, a value for the variable W is calculated with the formula below. The calculated value of W is then compared with a critical W found in reference tables (e.g. Gibbons, 1994).

$$W = \left(\sum_{i=1}^{n} a_{i,n} \cdot x_i\right)^2 \Big/ \sum_{i=1}^{n} \left(X_i - X_{avg}\right)^2$$

where: $a_{i,n}$ = coefficients based on the order of the observation, i, and the number of observations, n (see, for example, Gibbons [1994])

X_i = i^{th} observation

X_{avg} = mean of n observations

- *Computed statistics.* Statistics for both TDS and nitrate-nitrogen were computed: *standard error of the mean* and *mean plus t*standard error of the mean*. Mean plus t*standard error of the mean is the "water-quality point statistic" that was plotted on maps and used to define historical and current ambient water quality for TDS and nitrate-nitrogen.

2.4 Task 4 – Estimate Regional TDS/Nitrate-N in Groundwater

The following steps were executed to estimate regional TDS/nitrate-nitrogen in groundwater

(WEI, 2000a):

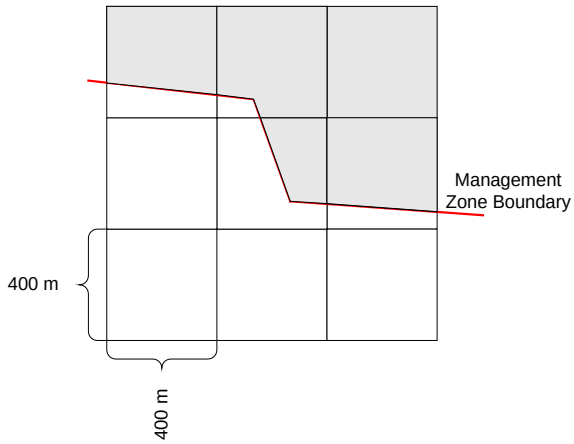
- *For both TDS and nitrate-nitrogen, mapped the location of wells where point statistics were computed.* These locations were annotated with the point statistic. In addition, wells with mean values (but where point statistics could not be computed [e.g. less than the required three annual data points]) were plotted. For each management zone, the following maps were developed and are included in Appendix B:
  - TDS point statistic – current ambient (1993 to 2012)
  - Nitrate-nitrogen point statistic – current ambient (1993 to 2012)
- *Defined relative aquifer contributions.* For regions with multi-layered aquifers, well construction data were compared to the hydrostratigraphy developed in the Phase 2A study to identify which aquifers are tributary to each well. The water quality maps listed above were developed for each aquifer.
- *Developed and digitized contours of TDS and nitrate-nitrogen point statistics.* The computed point statistics for each period, each aquifer layer (if appropriate), and each water quality constituent were carefully hand-contoured and digitized, taking into account:
  - Management zone boundaries
  - At several wells, not enough water-quality data were available to compute a point statistic (at least three annualized data points over the period from 1993 to 2012). For these wells, the mean of the available annualized data between 1993 and 2012 was calculated and plotted on the maps used in contouring. These ancillary water-quality data were given less weight when contouring than wells with point statistics. They were mainly used to help guide contours in areas with a paucity of point statistics.
  - Contours from previous recomputation efforts were plotted alongside current point statistics and used to guide the current contouring effort. This was done for two reasons: to minimize the impact of subjective contouring decisions and to identify areas with new data or areas where old data are no longer present.

2.5 Task 5 – Compute Ambient TDS/Nitrate-N for Management Zones

The final steps in the development of the ambient water quality determinations were: (1) to develop a rectangular grid (i.e. GIS polygon layer) over every management zone in the watershed, (2) to estimate the volume of groundwater in each grid cell and each management zone, (3) to estimate the mass of TDS and nitrate-nitrogen in each grid cell and each management zone, and (4) to compute the volume-weighted, ambient water quality in each management zone. If a management zone contains more than one aquifer, the volume and mass terms were computed for each aquifer layer at each grid cell during steps (2) and (3). The specific steps are outlined below:

- *Developed fine rectangular grid.* The grid resolution is the same in each management zone and is fine enough such that resulting ambient quality determinations are not significantly influenced by grid resolution. Numerical tests were done previously

(WEI, 2000a) to determine the appropriate grid resolution. The grid cell size used in the Phase 2A study was 400x400 meters. The same grid cell dimension was used in this effort. Where a grid cell is split by a management zone boundary, it is assigned parameters based on the apportionment of the grid cell in each management zone (determined by area).



- *Computed volume of groundwater in storage in each grid cell* (V_i). Groundwater-elevation contours for fall 2012 were hand-drawn and digitized. The groundwater elevations for each grid cell were estimated by an automated gridding program that interpolates between contours. The volume of groundwater in a grid cell for a single-layer aquifer is operationally defined as:

$$V_i = A_i \cdot b_i \cdot SY_i$$

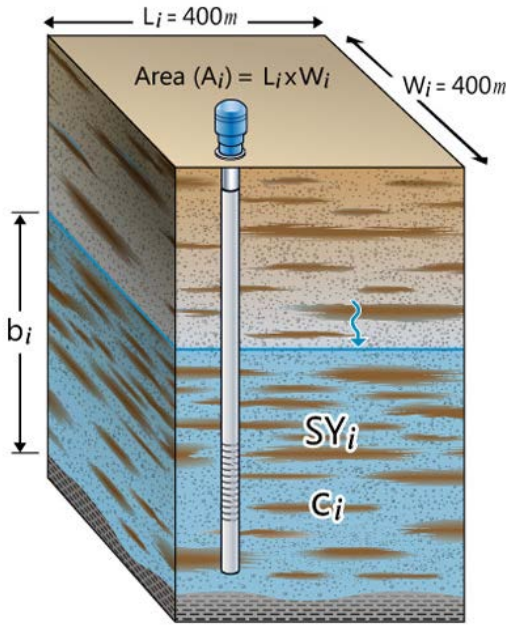
where: V_i = volume of groundwater in i^{th} grid cell (cubic meters)

A_i = grid cell area (160,000 square meters for a square grid cell)

b_i = average saturated thickness in the ith grid cell (meters), calculated as the difference between the average elevation of groundwater and the average elevation of the effective base of the aquifer in the grid cell

SY_i = specific yield of the ith grid cell (%)

GIS layers of specific yield were previously developed to estimate specific yield at each grid cell (WEI, 2000a). The use of specific yield (as opposed to porosity) causes the computed volume of groundwater to represent the volume that can be pumped, not the actual amount of water in storage.



- *Computed volume of groundwater in storage in each layer of a multi-layer aquifer.* Groundwater in storage for each layer in a multi-layer aquifer was computed in exactly the same fashion as in a single-layer aquifer. However, the top of a confined aquifer was used to calculate the water in storage if the groundwater level was above the top of the aquifer. The volume of groundwater in storage in each grid cell is the sum of the volume in each aquifer layer.
- *Computed volume of groundwater in each management zone.* The total volume of groundwater within the management zones was calculated by summing the volume of groundwater in all grid cells within each management zone.
- *Estimated value of the water quality statistics for each grid cell.* The values of the TDS and nitrate-nitrogen statistics for each grid cell were estimated by an automated gridding program that interpolates between the contours of the point statistics.
- *Compute volume-weighted statistic for each aquifer in each management zone.* Ambient water quality was calculated using the following formula:

$$C_{avg} = (1/V_T) \cdot \Sigma C_i \cdot V_i$$

where: C_{avg} = the ambient concentration of TDS or nitrate-nitrogen in a management zone

V_T = the total volume of groundwater within a management zone

C_i = the concentration in grid cell i

V_i = the volume of water stored in grid cell i

The methodology described above was used to compute ambient TDS and nitrate-nitrogen concentrations for the management zones. In some instances, the methodology was modified

to accommodate available data. The following is a list of details related to the computation of ambient concentrations for specific management zones:

- For the Orange County Groundwater Basin, the shallow and principal (middle) aquifers were used in the recomputation of ambient water quality. The deep aquifer was not used because relatively few wells produce from this aquifer, and water quality data are sparse; hence, ambient water quality could not be characterized.
- For the Bunker Hill Groundwater Basin, the shallow and middle aquifers within the Pressure Zone were used in the recomputation of ambient water quality. The deep aquifer was not used because relatively few wells produce from this aquifer, and water quality data are sparse; hence, ambient water quality could not be characterized.
- For the Chino Groundwater Basin, the shallow, middle, and deep aquifers were used in the recomputation of ambient water quality within the Chino-North Management Zone (Chino-1, Chino-2, and Chino-3 Management Zones combined). The confining units that separate the aquifers in Chino-North become thin or "pinch out" within the Chino-East and Chino-South Management Zones; hence, Chino-East and Chino-South were treated as single-aquifer systems in the recomputation of ambient water quality.
- For the Orange County Groundwater Basin, the OCWD provided groundwater level contour GIS shapefiles for spring 2012, which were used to estimate groundwater levels in the Orange County and Irvine Management Zones.
- For the San Jacinto Groundwater Basins, the EMWD provided groundwater level contour GIS shapefiles for 2012, which were used to estimate groundwater levels in the San Jacinto-Upper Pressure, San Jacinto-Lower Pressure, Canyon, Hemet-South, Lakeview/Hemet-North, Menifee, Perris-North, and Perris-South Management Zones.
- For the Orange County Groundwater Basin, the OCWD provided aquifer geometry data from its current groundwater model. In some areas, the model boundary did not extend to the management zone boundaries. As a result, some grid cells did not contain aquifer geometry data and were not used to recompute ambient water quality. In most cases, these grid cells were located at the periphery of the basin where saturated aquifer thickness is small or non-existent.
- In some instances, where data were insufficient, ambient concentrations were not computed for management zones, including the Bedford, Warm Springs Valley, Lee Lake, Santiago, La Habra, and Riverside-D Management Zones.

2.6 Task 6 – Prepare Technical Memorandum

A draft technical memorandum, summarizing the results of the recomputation of ambient water quality for the period of 1993 to 2012, was prepared in June 2014. The memorandum contained pertinent text, tables, and maps, describing the recomputation methods and results.

The draft technical memorandum was submitted to SAWPA, BMPTF members, the RWQCB, all other affected public agencies, and other interested parties for comment. Comments from all parties were addressed, with revisions made where applicable; the comments and responses have been included as Appendix A to this final technical memorandum.

Table 2-1
Requested Groundwater Data Descriptions by Data Type

General Well Information	Description
Well Name	Unique well name and/or identifiers used by well owner
Well Status	*e.g.* active, inactive, abandoned, destroyed
Well Location	Geographic coordinates (X,Y) and description of well location
Well Elevations	Ground surface and water level measurement point elevations
Geographic Information	Datum of coordinates, coordinate units (*e.g.* degrees, meters), name and parameters of coordinate projection, elevation units and vertical datum, method used to determine well elevations
Perforated Interval	"From" and "To" fields (depth in feet-below ground surface)
Groundwater Level Information	**Description**
Date and Time Measured	Date and time of water level measurement
Depth to Water	Distance from measurement point to groundwater level (including units)
Measurement Point Description	Physical description of water level measurement point (*e.g.* top of well casing)
Measurement Point Elevation	Elevation of water level measurement point
Well Activity at Time of Measurement	Description and comments related to the well activity at the time of measurement (*e.g.* was the well pumping or was the well turned off?)
Groundwater Quality Information	**Description**
Date and Time Sampled	Date and time water quality sample collected
Chemical Name or Code	Name or code of constituent analyzed
Detection Limit	Detection limit of the sample method used
Result	Concentration/value and units of analysis
Analytical Method	Analytical method used by laboratory
Analytical Laboratory	Laboratory used for sample analysis

Table 2-2
Analytes Required for the Computation of Ambient Water Quality

Analytes of Interest
Alkalinity, Total (as CaCO3)
Bicarbonate
Calcium
Carbonate
Chloride
Electrical Conductivity (Specific Conductance)
Fluoride
Magnesium
Nitrate as NO3 or Nitrate as N
pH
Potassium
Silica
Sodium
Sulfate
Total Dissolved Solids

Table 2-3
Summary of Data Collection Effort by Agency

Agency	Data Deliverable Format
Beaumont, City of	Database
Chino Basin Watermaster (CBWM)	Database
Colton, City of	Spreadsheets
Corona, City of	Spreadsheets
East Valley Water District	Spreadsheets
Eastern Municipal Water District (EMWD)	Database
Elsinore Valley Municipal Water District	Spreadsheets/DPH/Hardcopy
Environmental Protection Agency (EPA)	Hardcopy
Home Gardens County Water District	DPH
Lee Lake Water District	Spreadsheets
Loma Linda, City of	DPH/Hardcopy
Muscoy Mutual Water Company	DPH/Hardcopy
Orange County Water District (OCWD)	Database
Rialto, City of	Spreadsheet
Riverside, City of	Spreadsheet
Riverside-Highland Water Company	Spreadsheet
Rubidoux Community Service District	Spreadsheet/Hardcopy
San Bernardino, City of	Spreadsheet/hardcopy
San Bernardino Valley Municipal Water District	Spreadsheets/Hardcopy
State Water Resource Control Board (GeoTracker)	Spreadsheets
United States Geological Society (USGS)	USGS NWIS website
West Valley Water District	DPH
Western Municipal Water District	Spreadsheets
Yucaipa Valley Water District (YVWD)	DPH/Database/Spreadsheets/Hardcopy

CBWM Includes:
CBWM Monitoring
Chino Hills, City of
Chino, City of
Chino Basin Desalter Authority
Cucamonga Valley Water District
Fontana Water Company
Golden State Water Company
Inland Empire Utilities Agency
Jurupa Community Services District
Marygold Mutual Water Company
Monte Vista Water District
Norco, City of
Ontario, City of
Pomona, City of
San Antonio Water Company
Santa Ana River Water Company
Upland, City of

City of Beaumont[1] Includes:
Banning, City of
Beaumont Cherry Valley Water District
Redlands, City of
San Gorgonio Pass Water Agency

YVWD[2] Includes:
South Mesa Water Company
Western Heights Water Company

OCWD Includes:
Anaheim, City of
Buena Park, City of
East Orange County Water District
Fountain Valley, City of
Fullerton, City of
Garden Grove, City of
Huntington Beach, City of
Irvine Ranch Water District
Mesa Consolidated Water District
Newport Beach, City of
OCWD Monitoring
Orange, City of
Santa Ana, City of
Serrano Water District
Tustin, City of
Westminster, City of
Yorba Linda Water District

EMWD Includes:
Box Springs Mutual Water Company
Hemet, City of
Lake Hemet Municipal Water District
Nuevo Water Company
Perris, City of
San Jacinto, City of

1--The City of Beaumont provides data collected for its Maximum Benefit Monitoring Program.
2--The YVWD provides data collected for its Maximum Benefit Monitoring Program.

Section 3 – Ambient Water Quality Results (1993 to 2012)

This section summarizes the results of the ambient water quality recomputation for the period of 1993-2012, and describes the findings of assimilative capacity for all management zones in the Santa Ana River Watershed.

3.1 Current Ambient TDS and Nitrate-Nitrogen Concentrations for Management Zones (1993 to 2012)

The results of the recomputation of ambient TDS/nitrate-nitrogen concentrations for each management zone in the Santa Ana River Watershed for the period of 1993 to 2012 are presented in Tables 3-1 (TDS) and 3-2 (nitrate-nitrogen). Figures 3-1 and 3-2 show these results as map graphics.

3.2 Findings of Assimilative Capacity

The TDS and nitrate-nitrogen objectives for management zones are listed in the 2004 Basin Plan Amendment (RWQCB, 2004) and Tables 3-1 and 3-2. Ambient water quality determinations for the current period (1993-2012) are used to determine the magnitude of assimilative capacity, if it exists, within individual management zones.

The assimilative capacity findings are significant from a regulatory perspective. If the current ambient quality of a management zone is the same as or poorer than the water quality objectives, assimilative capacity does not exist. In this case, the numerical limits in discharge requirements cannot exceed the objectives for the receiving waters. This rule was expressed by the State Water Resources Control Board in Order No. 73-4, the so- called "Rancho Caballero decision." If the current quality is better than the water quality objectives, assimilative capacity exists. In this case, the difference between the objective and current quality is the magnitude of assimilative capacity. Where assimilative capacity exists, the RWQCB may, at its discretion, permit discharges containing TDS and/or nitrate-nitrogen at concentrations higher than the objective (RWQCB, 2004).

The magnitudes of assimilative capacity for TDS and nitrate-nitrogen in each management zone for the current period of recomputation are listed in Tables 3-1 and 3-2 and shown as map graphics in Figures 3-3 and 3-4. Note that in Tables 3-1 and 3-2, a number of the "anti-degradation" objectives have been raised to create assimilative capacity and, thus, encourage reclamation and the maximum beneficial use of state waters (RWQCB, 2004). These "maximum benefit" objectives for management zones are contingent upon the implementation of certain projects and programs by specific dischargers as part of their maximum benefit demonstrations. The management zones with "maximum benefit" water quality objectives are Chino-North, Cucamonga, Yucaipa, San Timoteo, Beaumont, and San Jacinto-Upper Pressure.

3.3 Changes in Ambient Water Quality

The ambient water quality of management zones in the Santa Ana River Watershed has been computed for five twenty-year periods (1978-1997 [WEI, 2000a], 1984-2003 [WEI, 2005],

1987-2006 [WEI, 2008], 1990-2009 [WEI, 2011], and 1993-2012 [this technical memorandum]) since the initial computation of historical ambient water quality (1954-1973 [WEI 2000a]). The results of these computations are shown in Tables 3-1 and 3-2.

Table 3-3 and Figures 3-5 and 3-6 show the changes in ambient TDS and nitrate-nitrogen since the last recomputation. An interpretive analysis of the trends in ambient water quality is described in *Section 4 – Interpretive Tools*.

Table 3-1
Water Quality Objectives, Ambient Water Quality, and Assimilative Capacity for Total Dissolved Solids

Groundwater Basin	Management Zone	Total Dissolved Solids (mg/L)								
		Water Quality Objective	Historical Ambient[1]	1997 Ambient[2]	2003 Ambient[3]	2006 Ambient[4]	2009 Ambient[5]	2012 Current Ambient[6]	Difference from 2009 to 2012	Assimilative Capacity
San Bernardino Valley & Yucaipa/Beaumont Plains										
	Beaumont -- "max benefit"	330	233	290	260	260	280	290	10	40
	Beaumont -- "antideg"	230	233	290	260	260	280	290	10	
	Bunker Hill-A	310	313	350	320	330	340	340	0	
	Bunker Hill-B	330	332	260	280	280	270	280	10	50
	Lytle	260	264	240	230	230	240	240	0	20
	San Timoteo -- "max benefit" [7]	400	303	300	?	?	420	410	-10	
	San Timoteo -- "antideg"	300	303	300	?	?	420	410	-10	
	Yucaipa -- "max benefit"	370	319	330	310	310	320	320	0	50
	Yucaipa -- "antideg"	320	319	330	310	310	320	320	0	0
San Jacinto Basins										
	Canyon	230	234	220	420	370	420	340	-80	
	Hemet-South	730	732	1030	850	920	910	940	30	
	Lakeview/Hemet-North	520	519	830	840	880	890	860	-30	
	Menifee	1020	1021	3360	2220	2140	2050	2030	-20	
	Perris-North	570	568	750	780	730	770	760	-10	
	Perris-South	1260	1258	3190	2200	2600	2470	2400	-70	
	San Jacinto-Lower	520	520	730	950	810	800	800	0	
	San Jacinto-Upper -- "max benefit"	500	321	370	370	350	350	350	0	150
	San Jacinto-Upper-- "antideg"	320	321	370	370	350	350	350	0	
Chino, Rialto/Colton, & Riverside Basins										
	Chino-North -- "max benefit"	420	260	300	320	340	340	350	10	70
	Chino 1 -- "antideg"	280	280	310	330	340	340	350	10	
	Chino 2 -- "antideg"	250	250	300	340	360	360	380	20	
	Chino 3 -- "antideg"	260	260	280	280	310	320	320	0	
	Chino-East	730	733	760	620	650	770	770	0	
	Chino-South	680	676	720	790	940	980	990	10	
	Colton	410	407	430	430	450	430	440	10	
	Cucamonga -- "max benefit"	380	212	260	250	250	250	260	10	120
	Cucamonga -- "antideg"	210	212	260	250	250	250	260	10	
	Rialto	230	230	230	220	230	230	230	0	0
	Riverside-A	560	560	440	440	440	430	420	-10	140
	Riverside-B	290	289	320	310	340	340	340	0	
	Riverside-C	680	684	760	750	740	740	730	-10	
	Riverside-D	810	812	?	?	?	?	?	--	--
	Riverside-E	720	721	720	700	710	700	740	40	
	Riverside-F	660	665	580	570	570	570	560	-10	100
	Prado Basin	surface water objective applies	618	819						--
Elsinore/Temescal Valleys										
	Arlington	980	983	?	1020	960	1020	1030	10	
	Bedford	?	?	?	740	?	?	?	?	--
	Coldwater	380	381	380	400	420	440	440	0	
	Elsinore	480	476	480	460	470	470	490	20	
	Lee Lake	?	?	?	?	?	?	?	?	--
	Temescal	770	771	780	700	780	790	790	0	
	Warm Springs Valley	?	?	?	?	?	?	?	?	--
Orange County Basins										
	Irvine	910	908	910	880	920	910	940	30	
	La Habra	?	?	?	?	?	?	?	?	--
	Orange County [8]	580	585	560	560	590	600	610	10	
	Santiago	?	?	?	?	?	?	?	?	--

? = Not enough data to estimate TDS concentrations; management zone is presumed to have no assimilative capacity. If assimilative capacity is demonstrated by an existing or proposed discharger, that discharge would be regulated accordingly.
[1] Data sampling period was 20 years (1954-1973) for historical ambient water quality computations.
[2] Data sampling period was 20 years (1978-1997) for 1997 ambient water quality computations.
[3] Data sampling period was 20 years (1984-2003) for 2003 ambient water quality computations.
[4] Data sampling period was 20 years (1987-2006) for 2006 ambient water quality computations.
[5] Data sampling period was 20 years (1990-2009) for 2009 ambient water quality computations.
[6] Data sampling period was 20 years (1993-2012) for current ambient water quality computations.
[7] 2009 ambient water quality computations for the San Timoteo Management Zone were not made during the 2009 recomputation; they were published in the *Preliminary Assessment of Assimilative Capacity in the San Timoteo Management Zone* (WEI, 2010), using a surrogate methodology.
[8] For the purposes of regulating discharges other than those associated with projects implemented within the Orange County Management Zone to facilitate remediation projects and/or to address legacy contamination, no assimilative capacity is assumed to exist.
For a detailed description of the methodologies employed to calculate ambient water quality, refer to Sections 4 & 5 of the Phase 2A Final Technical Memorandum (July, 2000).

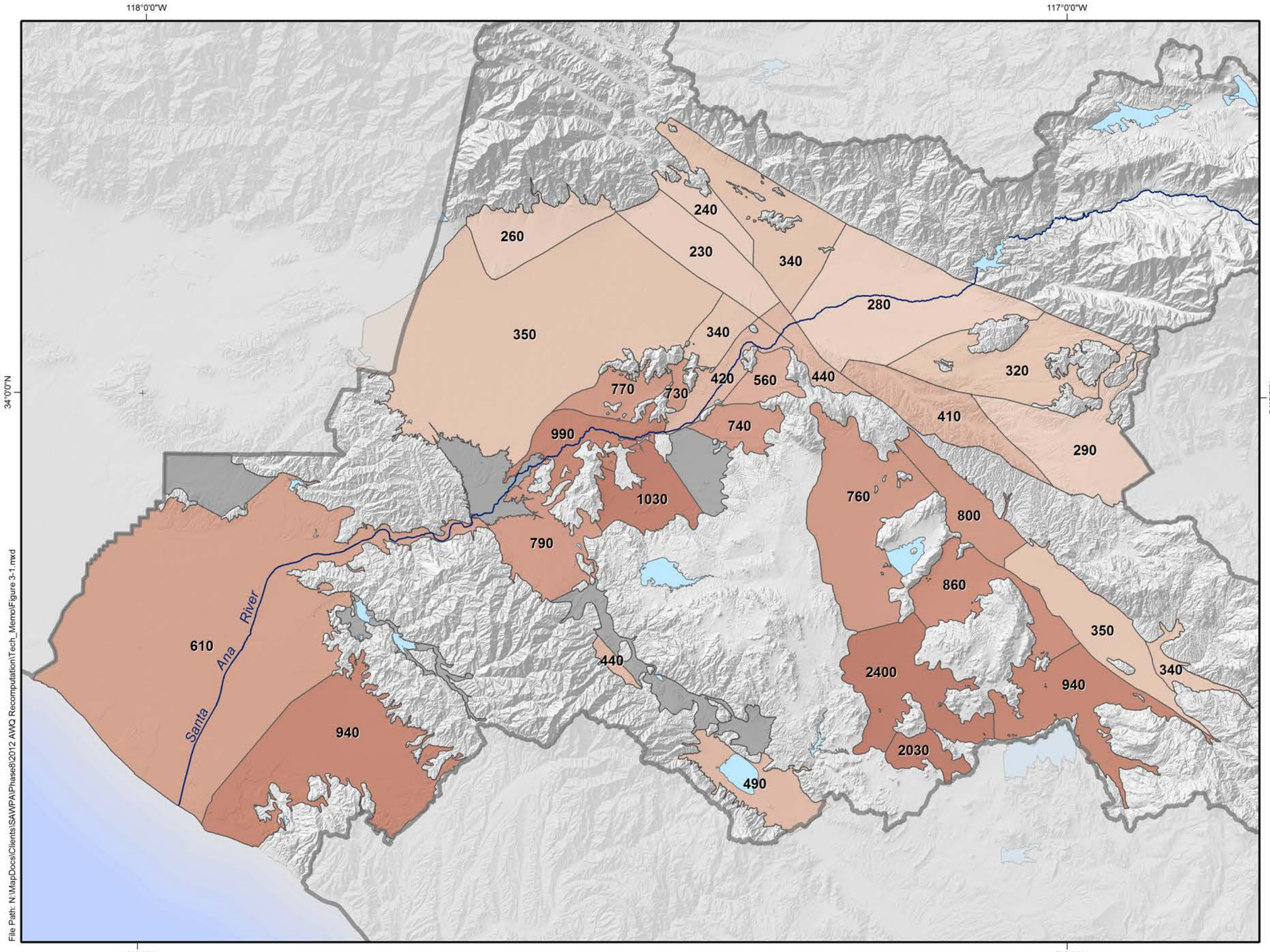
Table 3-2
Water Quality Objectives, Ambient Water Quality, and Assimilative Capacity for Nitrate-Nitrogen

Groundwater Basin	Management Zone	Nitrate-Nitrogen (mg/L)								
		Water Quality Objective	Historical Ambient[1]	1997 Ambient[2]	2003 Ambient[3]	2006 Ambient[4]	2009 Ambient[5]	2012 Current Ambient[6]	Difference from 2009 to 2012	Assimilative Capacity
San Bernardino Valley & Yucaipa/Beaumont Plains										
	Beaumont -- "max benefit"	5.0	1.5	2.6	2.0	1.6	2.5	2.9	0.4	2.1
	Beaumont -- "antideg"	1.5	1.5	2.6	2.0	1.6	2.5	2.9	0.4	
	Bunker Hill-A	2.7	2.7	4.5	4.3	4.0	4.0	4.0	0.0	
	Bunker Hill-B	7.3	7.3	5.5	5.8	5.4	5.4	5.6	0.2	1.7
	Lytle	1.5	1.5	2.8	2.7	2.7	2.6	2.5	-0.1	
	San Timoteo -- "max benefit" [7]	5.0	2.7	2.9	?	?	0.8	2.3	1.5	2.7
	San Timoteo -- "antideg"	2.7	2.7	2.9	?	?	0.8	2.3	1.5	0.4
	Yucaipa -- "max benefit"	5.0	4.2	5.2	5.4	5.3	6.2	6.3	0.1	
	Yucaipa -- "antideg"	4.2	4.2	5.2	5.8	5.3	6.2	6.3	0.1	
San Jacinto Basins										
	Canyon	2.5	2.5	1.6	2.1	1.9	2.7	2.0	-0.7	0.5
	Hemet-South	4.1	4.1	5.2	5.4	5.5	5.2	5.7	0.5	
	Lakeview/Hemet-North	1.8	1.8	2.7	3.4	2.7	2.6	2.5	-0.1	
	Menifee	2.8	2.8	5.4	6.0	4.7	4.4	4.6	0.2	
	Perris-North	5.2	5.2	4.7	6.7	6.5	7.4	7.3	-0.1	
	Perris-South	2.5	2.5	4.9	5.9	5.5	5.8	5.8	0.0	
	San Jacinto-Lower	1.0	1.0	1.9	1.8	1.2	1.1	1.1	0.0	
	San Jacinto-Upper -- "max benefit"	7.0	1.4	1.9	1.7	1.6	1.5	1.4	-0.1	5.6
	San Jacinto-Upper-- "antideg"	1.4	1.4	1.9	1.7	1.6	1.5	1.4	-0.1	0.0
Chino, Rialto/Colton, & Riverside Basins										
	Chino-North -- "max benefit"	5.0	3.7	7.4	8.7	9.7	9.5	10.0	0.5	
	Chino 1 -- "antideg"	5.0	5.0	8.4	8.9	9.3	9.1	10.0	0.9	
	Chino 2 -- "antideg"	2.9	2.9	7.2	9.5	10.7	10.3	10.7	0.4	
	Chino 3 -- "antideg"	3.5	3.5	6.3	6.8	8.2	8.4	8.5	0.1	
	Chino-East	10.0	13.3	29.1	9.6	12.7	15.7	21.0	5.3	
	Chino-South	4.2	4.2	8.8	15.3	25.7	26.8	28.0	1.2	
	Colton	2.7	2.7	2.9	2.9	2.9	2.8	2.7	-0.1	0.0
	Cucamonga -- "max benefit"	5.0	2.4	4.4	4.3	4.0	4.1	4.1	0.0	0.9
	Cucamonga -- "antideg"	2.4	2.4	4.4	4.3	4.0	4.1	4.1	0.0	
	Rialto	2.0	2.0	2.7	2.6	2.9	3.1	3.2	0.1	
	Riverside-A	6.2	6.2	4.4	4.9	4.9	5.2	5.4	0.2	0.8
	Riverside-B	7.6	7.6	8.0	7.8	8.3	8.4	6.7	-1.7	0.9
	Riverside-C	8.3	8.3	15.5	15.3	15.3	14.8	14.5	-0.3	
	Riverside-D	10.0	19.5	?	?	?	?	?	--	--
	Riverside-E	10.0	13.3	14.8	15.4	15.3	15.2	10.2	-5.0	
	Riverside-F	9.5	12.1	9.5	10.6	10.3	10.6	10.1	-0.5	
	Prado Basin	surface water objective applies	4.3	22.0	--	--	--	--	--	--
Elsinore/Temescal Valleys										
	Arlington	10.0	25.5	?	26.0	20.4	18.1	18.3	0.2	
	Bedford	?	?	?	2.8	?	?	?	--	--
	Coldwater	1.5	1.5	2.6	2.4	2.6	2.8	2.8	0.0	
	Elsinore	1.0	1.0	2.6	2.4	2.4	2.2	2.1	-0.1	
	Lee Lake	?	?	?	?	?	?	?	--	--
	Temescal	10.0	11.8	13.2	12.8	12.6	12.0	10.9	-1.1	
	Warm Springs Valley	?	?	?	?	?	?	?	--	--
Orange County Basins										
	Irvine	5.9	5.9	7.4	6.5	6.5	6.7	6.7	0.0	
	La Habra	?	?	?	?	?	?	?	--	--
	Orange County	3.4	3.4	3.4	3.1	3.0	3.0	2.9	-0.1	0.5
	Santiago	?	?	?	?	?	?	?	--	--

? = Not enough data to estimate NO3-N concentrations; management zone is presumed to have no assimilative capacity. If assimilative capacity is demonstrated by an existing or proposed discharger, that discharge would be regulated accordingly.
[1] Data sampling period was 20 years (1954-1973) for historical ambient water quality computations.
[2] Data sampling period was 20 years (1978-1997) for 1997 ambient water quality computations.
[3] Data sampling period was 20 years (1984-2003) for 2003 ambient water quality computations.
[4] Data sampling period was 20 years (1987-2006) for 2006 ambient water quality computations.
[5] Data sampling period was 20 years (1990-2009) for 2009 ambient water quality computations.
[6] Data sampling period was 20 years (1993-2012) for current ambient water quality computations.
[7] 2009 ambient water quality computations for the San Timoteo Management Zone were not made during the 2009 recomputation; they were published in the *Preliminary Assessment of Assimilative Capacity in the San Timoteo Management Zone* (WEI, 2010), using a surrogate methodology.
For a detailed description of the methodologies employed to calculate ambient water quality, refer to Sections 4 & 5 of the Phase 2A Final Technical Memorandum (July, 2000).

Table 3-3
Change in Ambient Water Quality by Management Zone

Management Zone	Change in Ambient Water Quality (2009 to 2012)	
	TDS *mg/L*	Nitrate-N *mg/L*
Arlington	10	0.2
Beaumont	10	0.4
Bedford	--	--
Bunker Hill-A	0	0.0
Bunker Hill-B	10	0.2
Canyon	-80	-0.7
Chino 1	10	0.9
Chino 2	20	0.4
Chino 3	0	0.1
Chino-East	0	5.3
Chino-North	10	0.5
Chino-South	10	1.2
Coldwater	0	0.0
Colton	10	-0.1
Cucamonga	10	0.0
Elsinore	20	-0.1
Hemet-South	30	0.5
Irvine	30	0.0
La Habra	--	--
Lakeview/Hemet-North	-30	-0.1
Lee Lake	--	--
Lytle	0	-0.1
Menifee	-20	0.2
Orange County	10	-0.1
Perris-North	-10	-0.1
Perris-South	-70	0.0
Prado Basin	--	--
Rialto	0	0.1
Riverside-A	-10	0.2
Riverside-B	0	-1.7
Riverside-C	-10	-0.3
Riverside-D	--	--
Riverside-E	40	-5.0
Riverside-F	-10	-0.5
San Jacinto-Lower	0	0.0
San Jacinto-Upper	0	-0.1
San Timoteo	-10	1.5
Santiago	--	--
Temescal	0	-1.1
Warm Springs Valley	--	--
Yucaipa	0	0.1



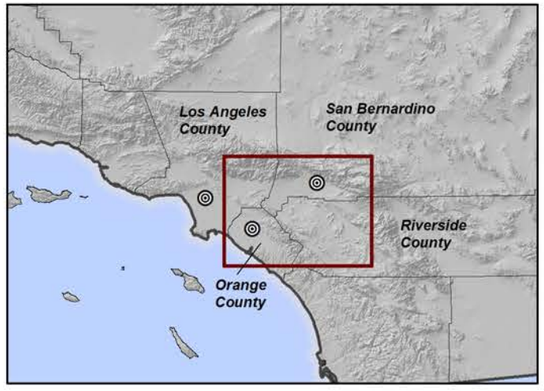
Ambient Water Quality - TDS

Water Quality
Increasing Concentration (mg/L)

- > 1000
- 901 to 1000
- 801 to 900
- 701 to 800
- 601 to 700
- 501 to 600
- 401 to 500
- 301 to 400
- < 300
- Insufficient Data

Other Features

- RWQCB Boundary
- Management Zone Boundary
- Santa Ana River
- Lakes & Reservoirs



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0 5 10 15 Miles
0 5 10 15 20 25 KM

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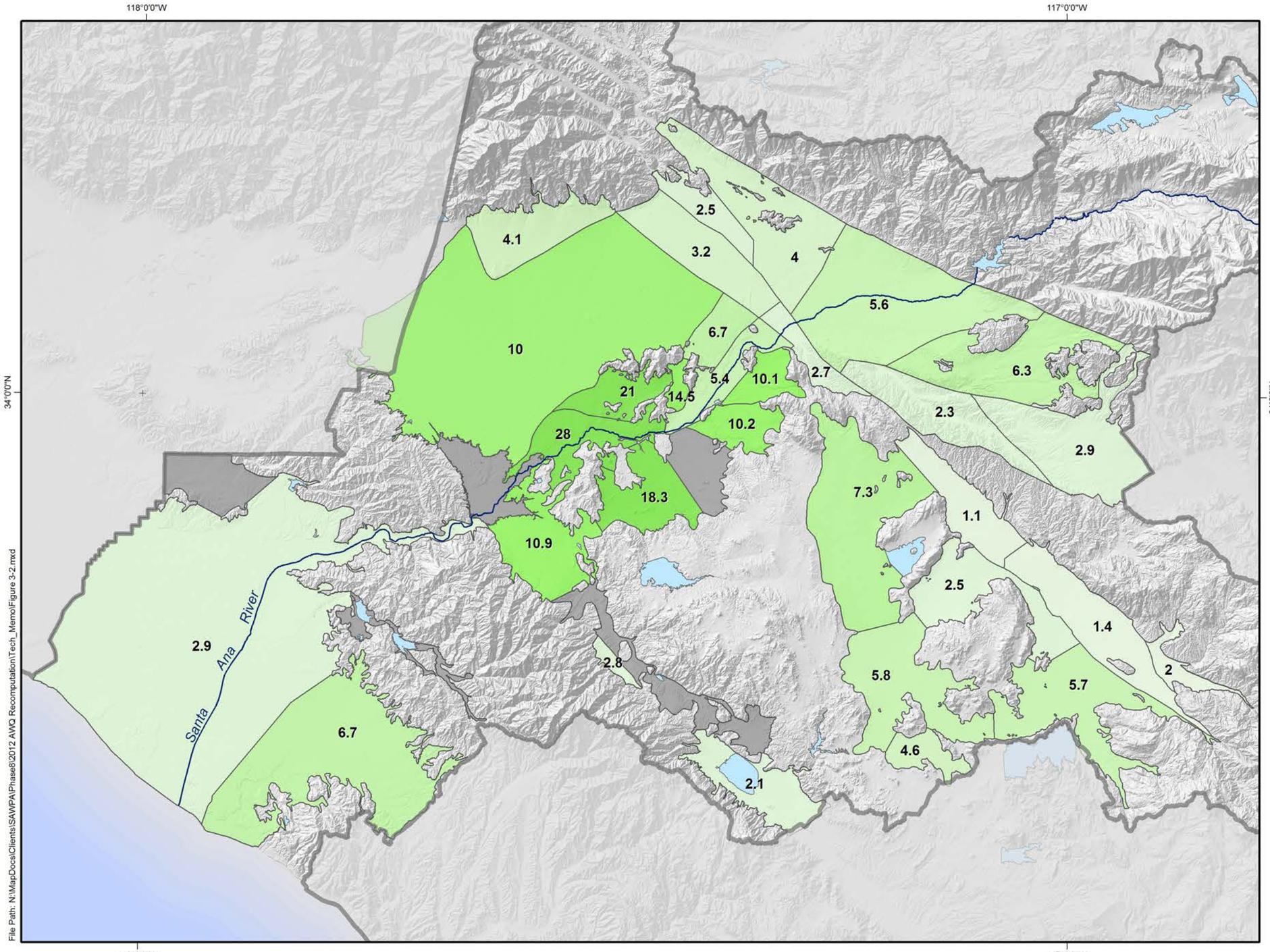
Recomputation of Ambient Water Quality for the Period 1993 to 2012

SAWPA

Ambient Water Quality - TDS

Santa Ana Watershed - 1993-2012

Figure 3-1



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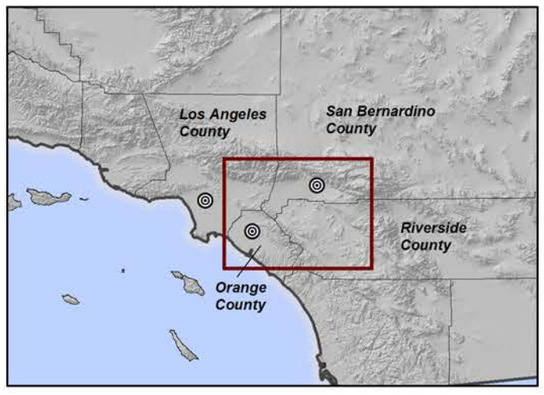
Ambient Water Quality - Nitrate-N

Water Quality
Increasing Concentration (mg/L)

- > 15.0
- 10.0 to 15.0
- 9.0 to 9.9
- 8.0 to 8.9
- 7.0 to 7.9
- 6.0 to 6.9
- 5.0 to 5.9
- 4.0 to 4.9
- 3.0 to 3.9
- 2.0 to 2.9
- < 2.0
- Insufficient Data

Other Features

- RWQCB Boundary
- Management Zone Boundary
- Santa Ana River
- Lakes & Reservoirs



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0 5 10 15 Miles
0 5 10 15 20 25 KM

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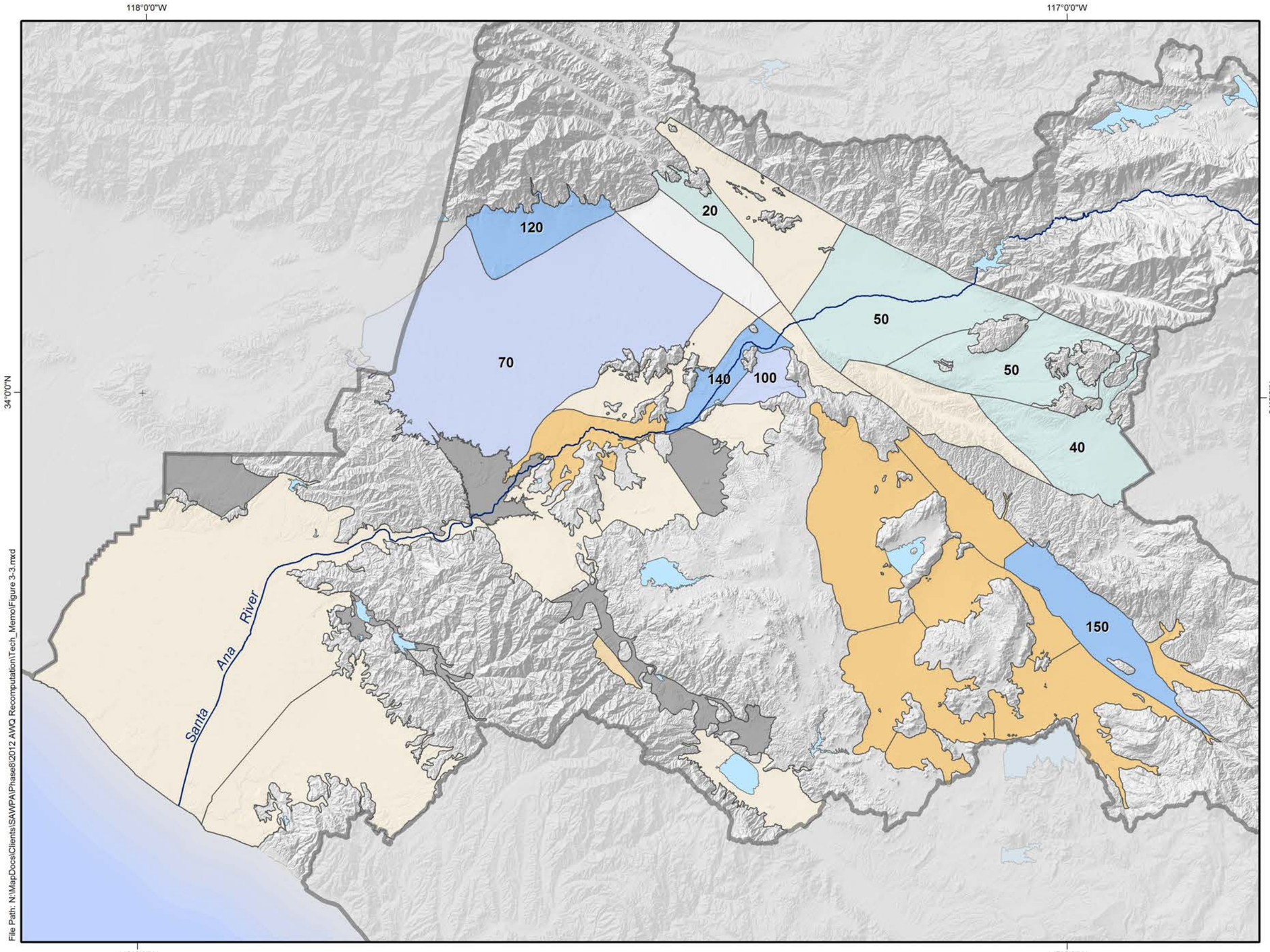
Recomputation of Ambient Water Quality for the Period 1993 to 2012

SAWPA

Ambient Water Quality - Nitrate-N

Santa Ana Watershed - 1993-2012

Figure 3-2



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Assimilative Capacity for TDS

- < -100 mg/L
- -51 to -100
- -1 to -50
- 0
- 1 to 50
- 51 to 100
- >100
- Insufficient Data

Note: A negative value means that the current ambient quality is worse than the water quality objective, and no assimilative capacity exists for that management zone.

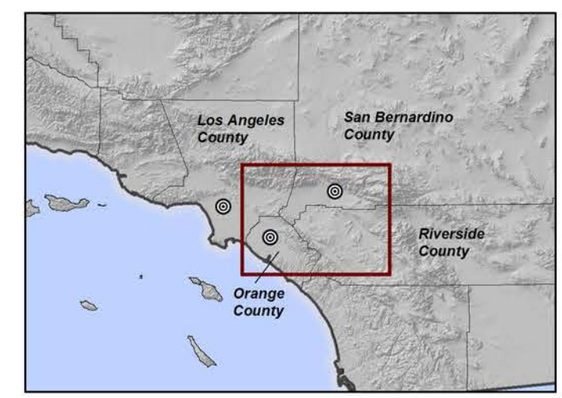
A positive value means that the current ambient quality is better than the water quality objective, and assimilative capacity exists for that management zone.

Each management zone in this figure is symbolized and labeled by the difference between the current ambient water quality and the water quality objective.

Where assimilative capacity exists, the RWQCB may, at its discretion, permit wastewater discharges containing TDS and/or nitrate-nitrogen at concentrations higher than the basin objective.

Other Features

- RWQCB Boundary
- Management Zone Boundary
- Santa Ana River
- Lakes & Reservoirs



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0 5 10 15 Miles
0 5 10 15 20 25 KM

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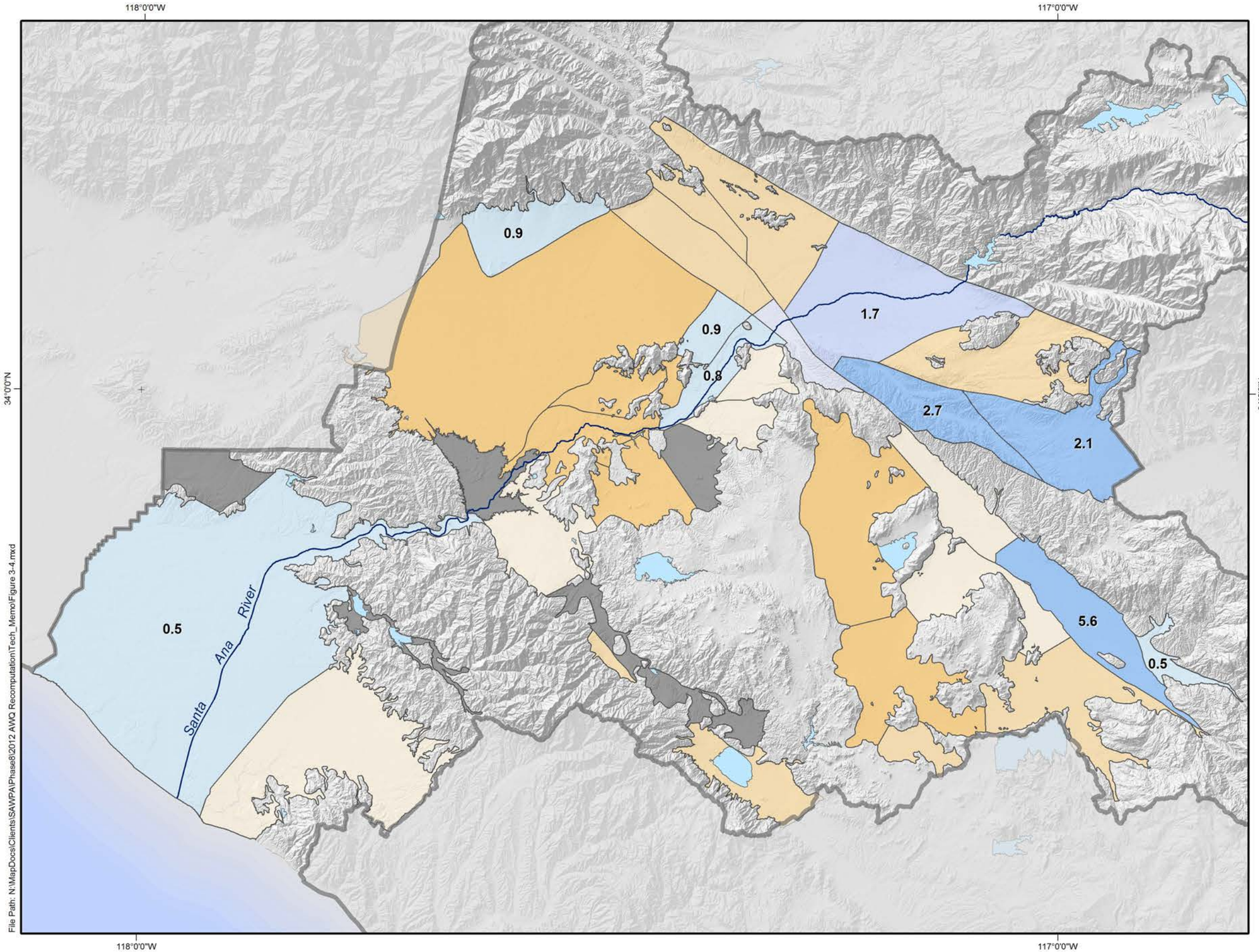
Recomputation of Ambient Water Quality for the Period 1993 to 2012

SAWPA

Assimilative Capacity for TDS

Santa Ana Watershed - 1993-2012

Figure 3-3



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Assimilative Capacity for Nitrate-N

- < -2 mg/L
- -1.1 to -2
- -0.1 to -1
- 0
- 0.1 to 1
- 1.1 to 2
- > 2
- Insufficient Data

Note: A negative value means that the current ambient quality is worse than the water quality objective, and no assimilative capacity exists for that management zone.

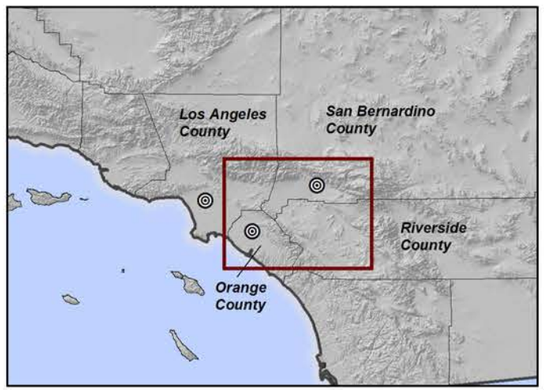
A positive value means that the current ambient quality is better than the water quality objective, and assimilative capacity exists for that management zone.

Each management zone in this figure is symbolized and labeled by the difference between the current ambient water quality and the water quality objective.

Where assimilative capacity exists, the RWQCB may, at its discretion, permit wastewater discharges containing TDS and/or nitrate-nitrogen at concentrations higher than the basin objective.

Other Features

- RWQCB Boundary
- Management Zone Boundary
- Santa Ana River
- Lakes & Reservoirs



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0 5 10 15 Miles
0 5 10 15 20 25 KM

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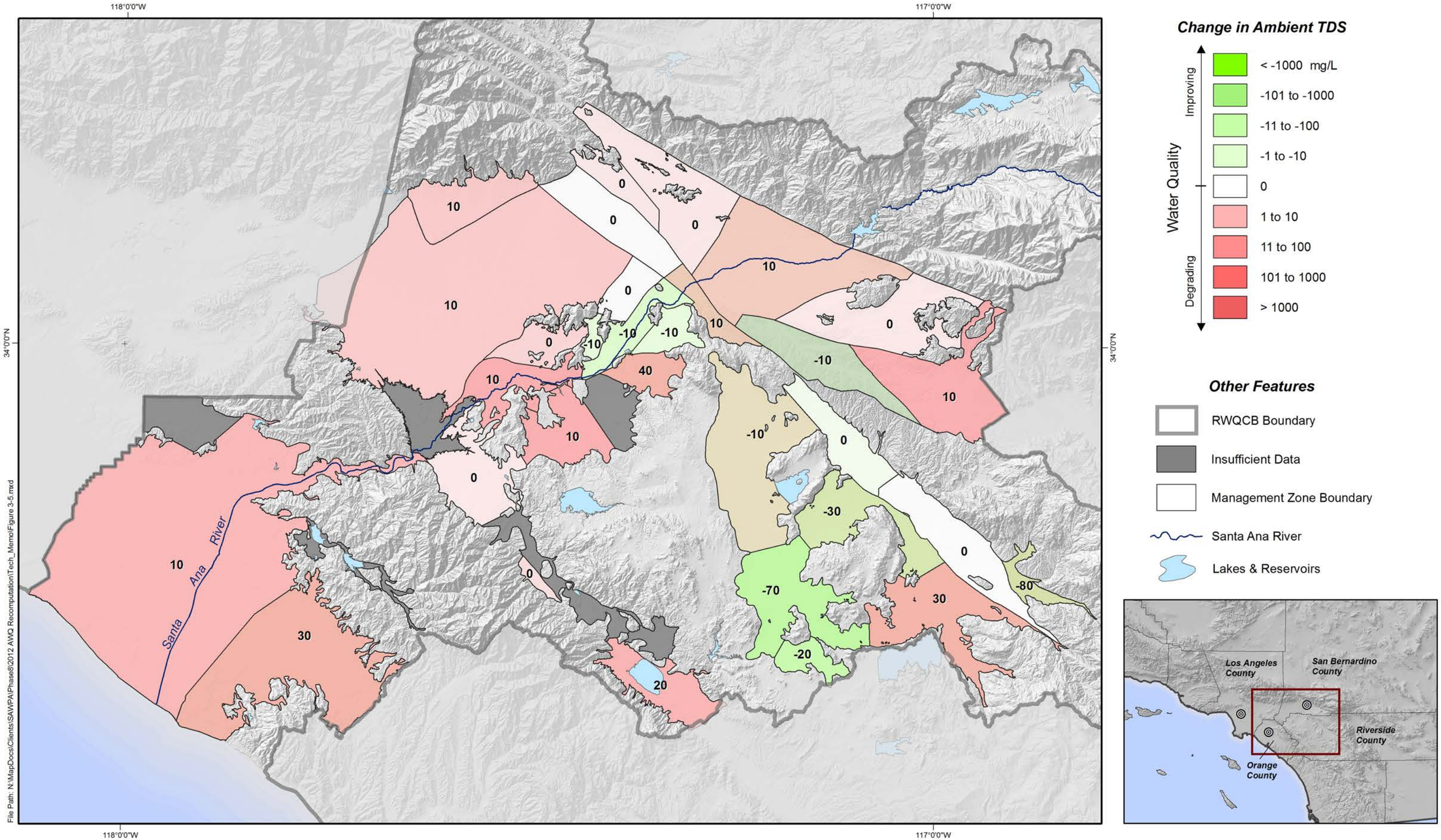
Recomputation of Ambient Water Quality for the Period 1993 to 2012

SAWPA

Assimilative Capacity for Nitrate-N

Santa Ana Watershed - 1993-2012

Figure 3-4



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0 5 10 15 Miles
0 5 10 15 20 25 KM

Basin Monitoring Program Task Force

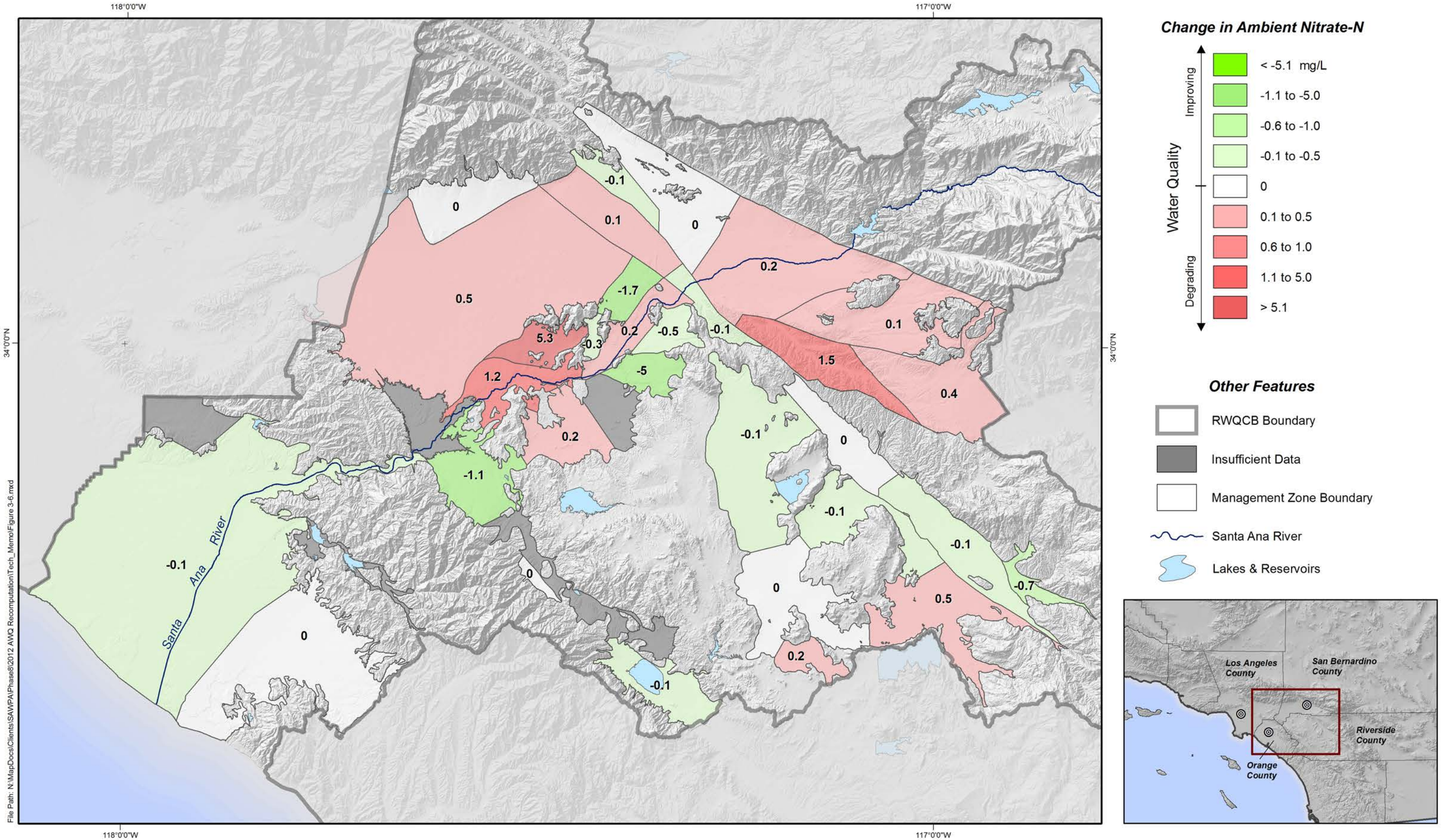
Recomputation of Ambient Water Quality for the Period 1993 to 2012

SAWPA

Change in Ambient TDS

Santa Ana Watershed - 2009 to 2012

Figure 3-5



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0 5 10 15 Miles
0 5 10 15 20 25 KM

Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality for the Period 1993 to 2012

SAWPA

Change in Ambient Nitrate-N

Santa Ana Watershed - 2009 to 2012

Figure 3-6

The results of the ambient water quality computations indicate that groundwater quality has changed over time in most management zones. Listed below are a number of factors that can influence the estimation of ambient water quality:

1. The discharge of solutes from the vadose zone to the saturated zone
2. Changes in water levels that affect groundwater storage in a management zone
3. Pumping/recharge stresses and/or groundwater flow within or between management zones that can add, remove, and/or transport TDS and nitrate-nitrogen constituents in groundwater
4. The gain/loss of wells with point statistics within management zones
5. The geographic distribution of gained/lost wells with point statistics within management zones
6. Differences in the techniques employed to contour and interpolate water-quality point statistics
7. The elimination of three years of data from the analysis (1990-1992 for this computation)
8. The addition of three years of data to the analysis (2010-2012 for this computation)

Changes in ambient water quality that result from the first three factors are measurable hydrologic and water chemistry changes that occur within the aquifer system. These changes are referred to as *systemic* factors. Changes in ambient water quality that result from the last five factors are driven by the methods and techniques employed in the recomputation. These changes are referred to as *methodological* factors. Note that the elimination and addition of data to the analysis (7 and 8) are intentional factors that were designed to account for temporal water quality changes.

In most instances, both systemic and methodological factors play a role in computed changes in ambient water quality for a management zone. The relative roles of each factor for each management zone, however, are not easily quantified, and rigorous analyses have not been scoped in past recomputation efforts.

In the comments submitted on the technical memorandum for the 1987-2006 recomputation effort (WEI, 2008), BMPTF members posed the following questions (paraphrased):

- What can be done to minimize the methodological factors that influence ambient water quality?
- When the recomputation indicates a significant change in ambient water quality in a management zone, how can we distinguish between the methodological and systemic factors that may have influenced this change?
- Is there a method to characterize current groundwater-quality trends in management

zones that could be compared against the ambient water quality results?

To address these questions, the following Interpretive Tools were prepared and are described below:

- *Well-Attrition Analysis*. This is an effort to minimize the methodological factors that influence the computation of ambient water quality.

- *Interpretive Tools Maps*. These exhibits are meant to (i) distinguish between the methodological and systemic factors that may have influenced the recomputation of ambient water quality in management zones and (ii) characterize the current measured groundwater-quality trends within each management zone.

4.1 Well-Attrition Analysis

The well-attrition analysis is a forward-looking tool that provides an opportunity for the BMPTF to prevent the loss of water-quality point statistics at wells in the next triennial recomputation of ambient water quality. The next triennial recomputation will involve the analysis of water-quality data for the period of 1996-2015. The objective of this analysis is to identify wells that will be lost from the next recomputation if no water-quality data are collected during 2013-2015. Table 4-1 lists these wells, and Figure 4-1shows their locations. The well attrition analysis consisted of the following steps:

- Develop water-quality point statistics for 1996-2015 using the 1993-2012 database. In effect, this removes three years of data from the backend of the study period, while no new data is added to the front end, as data from 2013-2015 have not yet been collected. This is considered the 'worst case' scenario, simulating a condition with no sampling and analysis after 2012.

- Compare wells that have point statistics in the 1993-2012 period to those that have point statistics in the 1996-2015 'worst case' scenario to identify wells that will be lost from the ambient water quality recomputation if no new data are obtained. Table 4-1 lists these wells. Wells that may be lost were categorized using the following criteria:
  - Wells that are known to be destroyed or have a status of "undetermined" are listed as such and are shown in grey. It is assumed that these wells cannot be sampled. The BMPTF and local agencies may wish to pursue the replacement of destroyed wells that are deemed to be critical to the recomputation effort.
  - Wells with statuses of active, inactive, standby, or abandoned have been considered potentially able to be sampled. Of these wells, a small subset of "high priority" wells was selected based on the estimated impact of their loss to the contouring effort. In Table 4-1, these wells are shown in red. Sampling the remaining wells is considered a lower priority.

The well-attrition analysis identified 131 wells and 133 wells that may be lost from the recomputation for nitrate-nitrogen and TDS if no water-quality data are collected during 2013-2015. In total, 185 unique wells are at risk of losing one or both of their ambient water quality statistics. These wells were plotted on watershed maps alongside the nearly 3,200 wells

that will not be lost (see Figure 4-1). Of the potentially lost wells, 69 are assumed to be destroyed or cannot otherwise be sampled (shown in grey in Table 4-1). Of the 116 wells that can be sampled, 12 are considered "high priority" and must be sampled in 2014 and 2015 in order to continue to produce water-quality point statistics (shown in red in Table 4-1). The loss of these 12 "high priority" wells from future studies would adversely affect the mapping of regional groundwater quality and, thus, the ambient water quality determination for the management zones in which they are located (methodological factor).

WEI recommends that, wherever possible, "high priority" wells be sampled for TDS, nitrate-nitrogen, and the general minerals listed in Table 2-2 during both calendar years 2014 and 2015.

4.2 Interpretive Tools Maps

Twenty-eight exhibits were prepared to (i) distinguish between the methodological and systemic factors that may have influenced the recomputation of ambient water quality in management zones and (ii) characterize the current measured groundwater-quality trends within each management zone (see Exhibits C-1 through C-28). Where appropriate, an exhibit was prepared for each aquifer layer. The exhibits include:

- A map of change in the regional mapping of TDS and nitrate-nitrogen concentrations in groundwater from the prior (2009) to current (2012) recomputation. The maps include the locations of wells and their TDS and nitrate point statistics used to perform regional groundwater quality mapping.
- Time-series charts of (i) the computed ambient water quality for the management zones and (ii) measured TDS and nitrate concentrations at key wells located within the management zones.
- Text that provides interpretation of the changes and trends shown in the exhibits.

4.2.1 Change in the Regional Mapping of TDS and Nitrate-Nitrogen Concentrations in Groundwater (2009-2012)

Exhibits C-1 through C-28 are maps that include a two-dimensional color-ramp that shows the difference between the prior (2009) and current (2012) mapping of regional TDS and nitrate-nitrogen concentrations in groundwater. Shades of red indicate areas where TDS and nitrate-nitrogen concentrations increased between the two periods. Shades of green indicate areas where TDS and nitrate-nitrogen concentrations decreased.

The exhibits also display wells with the point-statistic values that were used in one or both recomputation periods. A well symbolized by a black dot indicates that it had a point statistic in the 2009 recomputation only, a well symbolized by a hollow square indicates that it had a point statistic for the first time in the 2012 recomputation, and a well symbolized by a hollow square with a black dot in the middle indicates that it had a point statistic for both the 2009 and 2012 recomputations.

The most common factor that results in a significant change in the regional mapping of ambient TDS and nitrate-nitrogen concentrations in groundwater is the addition of wells with point statistics (hollow squares) in areas where few or no wells with point statistics previously existed.

Changes in the regional mapping of TDS and nitrate-nitrogen concentrations in groundwater in areas where many persistent wells exist are likely due to measured trends in water quality at those wells. Time-history plots of TDS and nitrate-nitrogen at Interpretative Wells can demonstrate these trends, as further described below.

4.2.2 Trends in TDS and Nitrate-Nitrogen Concentration at Interpretive Wells

The methodological factors discussed above can have a significant influence on the determination of ambient water quality in management zones. As a result, the methodological factors can mask the real trends in groundwater quality that might be occurring in management zones or in certain portions of management zones. This section describes the historical and current trends in groundwater quality in each management zone and, if possible, how these trends have influenced past and current estimates of ambient water quality.

A number of Interpretive Wells were selected for each management zone. These wells were selected based on location, perforated depths, the density and period of available water quality data, and the quality of the dataset. Since the management zones were designed as hydrologic units with defined areas of recharge and discharge, the locations of the Interpretive Wells were typically aligned along groundwater flow paths. The water-quality trends at each Interpretive Well were compared to water-quality data at surrounding wells in an effort to choose Interpretive Wells that are generally representative of groundwater quality within their respective portions of each management zone. The exact number of Interpretive Wells chosen was based on the size and complexity of each management zone. The Interpretive Wells are symbolized and labeled on the Interpretative Tools Maps in Exhibits C-1 through C-28.

Time-history charts of TDS and nitrate-nitrogen at these Interpretive Wells for the period of 1954 to 2012 are displayed in Exhibits 4-2 through 4-29. The charts display measured groundwater-quality data along with the six ambient water quality estimates for the management zone exhibited (1973, 1997, 2003, 2006, 2009, and 2012). The charts also indicate the twenty-year time period where data was included for this current recomputation (1993-2012) and the three years of data that will be lost in the next recomputation (1993-1996). The charts illustrate how groundwater quality has changed over time in certain areas within each management zone and how these changes are influencing ambient water quality recomputations with emphasis on trends within the current 20-year period (1993-2012).

Table 4-1
Well Attrition (1996-2015)

Management Zone	Well ID or XRef ID	Status	Well Name	Well Owner[1]	Potential Loss of Statistic for 1996-2015		Sampling Priority
					TDS	NO_3-N	
Orange County	1004947	Abandoned	COR 18	City of Corona	Yes	Yes	Low
Chino-3/Chino-North	1201164	Abandoned	MIL M-02	County of San Bernardino	Yes	Yes	Low
Chino-2/Chino-North	1203717	Abandoned	MIL M-11	County of San Bernardino	Yes	Yes	Low
Chino-3/Chino-North	1203729	Abandoned	MIL M-02C	County of San Bernardino	Yes	Yes	Low
Not Applicable	1002584	Abandoned	P-07(OLD)	City of Pomona	Yes	No	Low
Not Applicable	1002619	Abandoned	P-33 (OGT-4)	City of Pomona	Yes	Yes	Low
Orange County	1213527	Abandoned	EMA-AH2/1	Orange County Water District	Yes	Yes	Low
Chino-2/Chino-North	99	Active	Private	Private	Yes	Yes	Low
Chino-2/Chino-North	1207334	Active	RIVERSIDE DR (NR ELY BASIN)	Inland Empire Utilities Agency	Yes	Yes	Low
San Jacinto Upper Pressure	1211285	Active	EMWD 12 Mountain	Eastern Municipal Water District	Yes	Yes	Low
Lakeview/Hemet-North	1211390	Active	Motte West	Eastern Municipal Water District	Yes	Yes	Low
North Perris	1211584	Active	EMWD 52 Follico	Eastern Municipal Water District	Yes	Yes	Low
Canyon	1211731	Active	EMWD 05 Cienega	Eastern Municipal Water District	Yes	Yes	Low
San Jacinto Upper Pressure	1211946	Active	EMWD 24 Howard	Eastern Municipal Water District	Yes	Yes	Low
South Hemet	1212109	Active	Seven Hills	Eastern Municipal Water District	Yes	Yes	High
Orange County	1213631	Active	FVM-1/1/WB1/MP1	Orange County Water District	Yes	Yes	Low
Orange County	1213632	Active	FVM-1/1/WB1/MP10	Orange County Water District	Yes	Yes	Low
Orange County	1213633	Active	FVM-1/1/WB1/MP11	Orange County Water District	Yes	Yes	Low
Orange County	1213634	Active	FVM-1/1/WB1/MP12	Orange County Water District	Yes	Yes	Low
Orange County	1213635	Active	FVM-1/1/WB1/MP13	Orange County Water District	Yes	Yes	Low
Orange County	1213636	Active	FVM-1/1/WB1/MP14	Orange County Water District	Yes	Yes	Low
Orange County	1213637	Active	FVM-1/1/WB1/MP15	Orange County Water District	Yes	Yes	Low
Orange County	1213638	Active	FVM-1/1/WB1/MP16	Orange County Water District	Yes	Yes	Low
Orange County	1213639	Active	FVM-1/1/WB1/MP17	Orange County Water District	Yes	Yes	Low
Orange County	1213640	Active	FVM-1/1/WB1/MP18	Orange County Water District	Yes	Yes	Low
Orange County	1213641	Active	FVM-1/1/WB1/MP2	Orange County Water District	Yes	Yes	Low
Orange County	1213642	Active	FVM-1/1/WB1/MP3	Orange County Water District	Yes	Yes	Low
Orange County	1213643	Active	FVM-1/1/WB1/MP4	Orange County Water District	Yes	Yes	Low
Orange County	1213644	Active	FVM-1/1/WB1/MP5	Orange County Water District	Yes	Yes	Low
Orange County	1213645	Active	FVM-1/1/WB1/MP6	Orange County Water District	Yes	Yes	Low
Orange County	1213646	Active	FVM-1/1/WB1/MP7	Orange County Water District	Yes	Yes	Low
Orange County	1213647	Active	FVM-1/1/WB1/MP8	Orange County Water District	Yes	Yes	Low
Orange County	1213648	Active	FVM-1/1/WB1/MP9	Orange County Water District	Yes	Yes	Low
Irvine	1213834	Active	IDM-1/1/WB1/MP10	Orange County Water District	Yes	Yes	Low
Irvine	1213837	Active	IDM-1/1/WB1/MP4	Orange County Water District	Yes	Yes	Low
Irvine	1213838	Active	IDM-1/1/WB1/MP5	Orange County Water District	Yes	Yes	Low
Irvine	1213839	Active	IDM-1/1/WB1/MP6	Orange County Water District	Yes	Yes	Low
Irvine	1213840	Active	IDM-1/1/WB1/MP7	Orange County Water District	Yes	Yes	Low
Irvine	1213841	Active	IDM-1/1/WB1/MP8	Orange County Water District	Yes	Yes	Low
Irvine	1213842	Active	IDM-1/1/WB1/MP9	Orange County Water District	Yes	Yes	Low
Irvine	1213876	Active	IDP-4/1	Orange County Water District	Yes	Yes	Low
Orange County	1214727	Active	SAR-4/1/WB1/MP1	Orange County Water District	Yes	Yes	Low
Orange County	1214856	Active	SC-2/1/WB1/MP10	Orange County Water District	Yes	Yes	Low
Orange County	1214857	Active	SC-2/1/WB1/MP11	Orange County Water District	Yes	Yes	Low
Orange County	1214858	Active	SC-2/1/WB1/MP2	Orange County Water District	Yes	Yes	Low
Orange County	1214859	Active	SC-2/1/WB1/MP3	Orange County Water District	Yes	Yes	Low
Orange County	1214860	Active	SC-2/1/WB1/MP4	Orange County Water District	Yes	Yes	Low
Orange County	1214861	Active	SC-2/1/WB1/MP5	Orange County Water District	Yes	Yes	Low
Orange County	1214862	Active	SC-2/1/WB1/MP6	Orange County Water District	Yes	Yes	Low
Orange County	1214863	Active	SC-2/1/WB1/MP7	Orange County Water District	Yes	Yes	Low
Orange County	1214865	Active	SC-2/1/WB1/MP9	Orange County Water District	Yes	Yes	Low
Orange County	1215580	Active	YLCC-35C2/1	Orange County Water District	Yes	Yes	Low
Bunker Hill A	1000151	Active	SBWD Paperboard	City of San Bernardino	Yes	Yes	High
Bunker Hill A	1001402	Active	CITY 6	City of Rialto	Yes	No	Low
Chino-1/Chino-North	1002315	Active	SAWC 12	San Antonio Water Company	Yes	No	Low
Beaumont	1002895	Active	BCVWD 18	Beaumont Cherry Valley Water District	Yes	No	Low
Chino-1/Chino-North	1203158	Active	CH HIL 19	City of Chino Hills	Yes	No	Low
Bunker Hill A	1203804	Active	SBWD MW-06A	City of San Bernardino	Yes	Yes	Low
Bunker Hill A	1203805	Active	SBWD MW-06B	City of San Bernardino	Yes	Yes	Low
Bunker Hill A	1203809	Active	SBWD MW-08B	City of San Bernardino	Yes	Yes	High
Bunker Hill A	1203811	Active	SBWD MW-09B	City of San Bernardino	Yes	Yes	Low
Chino-1/Chino-North	1206780	Active	MW-5	State of California, California Institution for Men	Yes	No	Low
Chino-1/Chino-North	1206784	Active	MW-9	State of California, California Institution for Men	Yes	No	Low
Orange County	1213738	Active	GRIM-A/1	Orange County Water District	Yes	Yes	Low
Irvine	1213875	Active	IDP-3/1	Orange County Water District	Yes	No	High
Orange County	1215126	Active	TMIX-O/1	Orange County Water District	Yes	No	Low
Bunker Hill A	1000336	Active	3	Baseline Gardens Mutual Water Company	Yes	Yes	High
Riverside B	1002121	Active	WVWD 29	West Valley Water District	Yes	Yes	High
Chino-East	1003582	Active	03	Santa Ana River Water Company	Yes	Yes	Low
Chino-1/Chino-North	1004268	Active	CH HIL 13	City of Chino Hills	Yes	Yes	Low
Chino-1/Chino-North	1206782	Active	MW-7	State of California, California Institution for Men	Yes	Yes	Low
Chino-1/Chino-North	1206783	Active	MW-8	State of California, California Institution for Men	Yes	Yes	Low
Chino-East	1208932	Active	OW-94D	State of California, Department of Toxic Substances Control	Yes	Yes	Low
Canyon	1211783	Active	LHMWD 03	Eastern Municipal Water District	Yes	Yes	Low
South Perris	1212456	Active	Agri 74/Briggs	Eastern Municipal Water District	No	Yes	Low
Orange County	1213215	Active	AMD-1/1/WB1/MP6	Orange County Water District	No	Yes	Low
Orange County	1214535	Active	OCWD-SA3/1	Orange County Water District	No	Yes	Low
Orange County	1214801	Active	SAR-7/1/WB1/MP8	Orange County Water District	No	Yes	Low
Chino-1/Chino-North	1220064	Active	B4B	State of California, California Institution for Men	Yes	Yes	Low
Irvine	1215604	Active	IDP-1/1	Orange County Water District	Yes	Yes	Low
Irvine	1213872	Active	IDP-2/1	Orange County Water District	Yes	No	Low
Irvine	1214564	Active	OSUM-T/1	Orange County Water District	Yes	Yes	High
Irvine	1215110	Active	TIC-56/1	Orange County Water District	Yes	Yes	Low
Orange County	1215523	Active	WM-8/1	Orange County Water District	Yes	No	Low
Orange County	1214986	Active	SCWC-SCER/1	Orange County Water District	Yes	Yes	Low
Orange County	1215009	Active	SID-1/1	Orange County Water District	Yes	Yes	Low
Orange County	1215516	Active	WM-124/1	Orange County Water District	Yes	Yes	Low
Orange County	1215569	Active	WM-OC2/1	Orange County Water District	Yes	Yes	Low
Orange County	1215646	Active	KSSE-A/1	Orange County Water District	Yes	Yes	Low

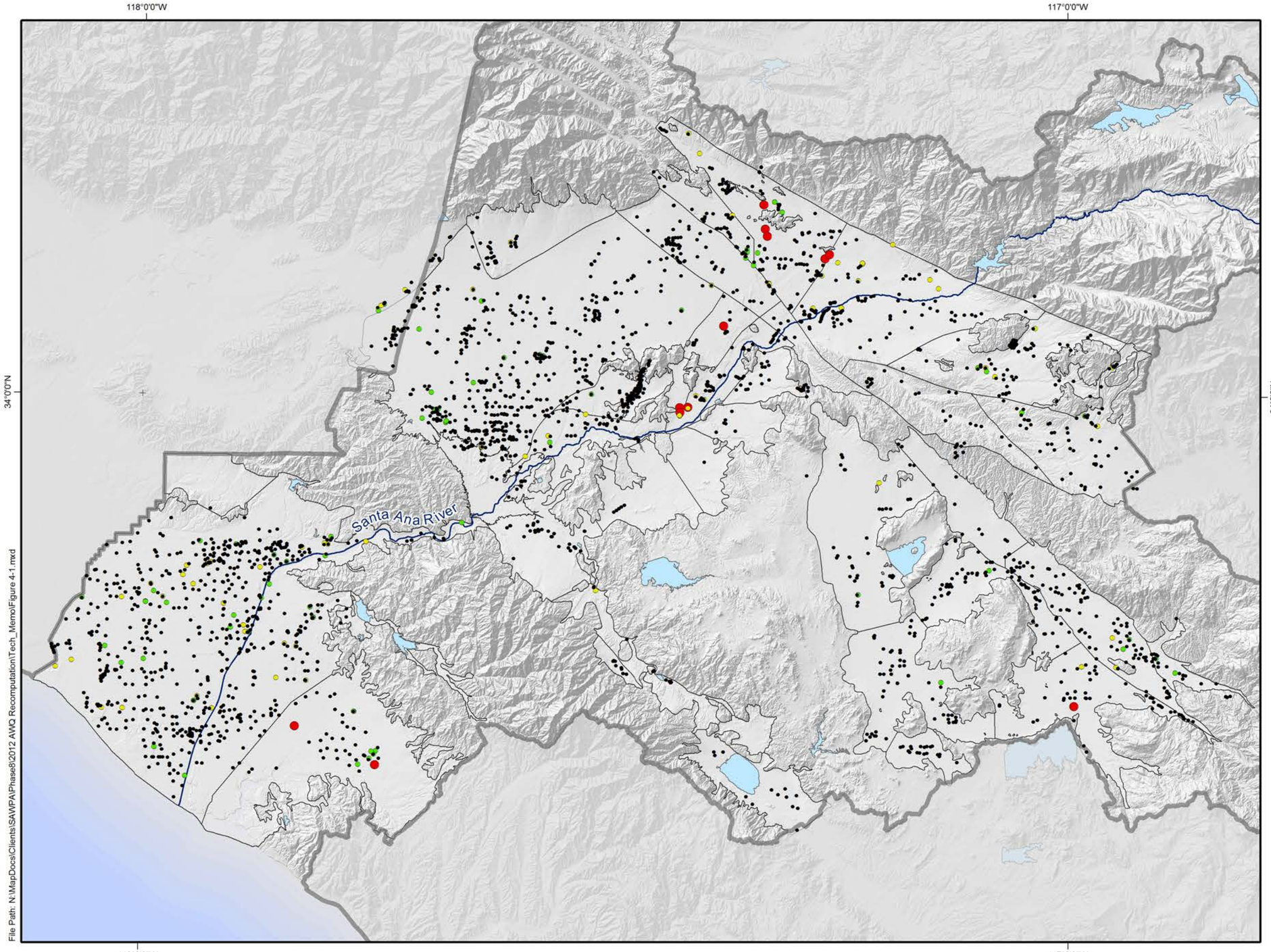
Table 4-1
Well Attrition (1996-2015)

Management Zone	Well ID or XRef ID	Status	Well Name	Well Owner[1]	Potential Loss of Statistic for 1996-2015		Sampling Priority
					TDS	NO_3-N	
Chino-1/Chino-North	1002301	Destroyed	Upland 07	City of Upland	Yes	Yes	Unable to be Sampled
Chino-1/Chino-North	1002651	Destroyed	P-05(OLD)	City of Pomona	Yes	Yes	Unable to be Sampled
Chino-South	4586	Destroyed	Private	Private	Yes	Yes	Unable to be Sampled
Chino-South	4645	Destroyed	Private	Private	Yes	Yes	Unable to be Sampled
Bedford	1005345	Destroyed	COR 04	City of Corona	Yes	Yes	Unable to be Sampled
South Hemet	1212012	Destroyed	City of Hemet 05	Eastern Municipal Water District	Yes	Yes	Unable to be Sampled
Lytle	1000510	Destroyed	WVWD 08	West Valley Water District	Yes	No	Unable to be Sampled
Beaumont	1002898	Destroyed	BCVWD 09	Beaumont Cherry Valley Water District	Yes	No	Unable to be Sampled
Beaumont	1002939	Destroyed	NA_1002939	Beaumont Irrigation District	Yes	No	Unable to be Sampled
Riverside A	1003387	Destroyed	RCSD #16 Hunter 2	Rubidoux Community Services District	Yes	No	Unable to be Sampled
Not Applicable	1201223	Destroyed	P-01B	City of Pomona	Yes	No	Unable to be Sampled
North Perris	1210632	Destroyed	Sunnymead Poultry Cottonwood	Eastern Municipal Water District	Yes	Yes	Unable to be Sampled
San Jacinto Upper Pressure	1211255	Destroyed	City of San Jacinto Mistletoe	Eastern Municipal Water District	Yes	Yes	Unable to be Sampled
Bunker Hill B	1001570	Destroyed	#3 WELL	Victoria Farms Mutual Water Co.	Yes	Yes	Unable to be Sampled
Bunker Hill B	1001572	Destroyed	2	Victoria Farms Mutual Water Co.	Yes	Yes	Unable to be Sampled
Yucaipa	1002990	Destroyed	WHWC 05A	Western Heights Water Company	Yes	Yes	Unable to be Sampled
Chino-South	1003630	Destroyed	07	Santa Ana River Water Company	Yes	Yes	Unable to be Sampled
Orange County	1213518	Destroyed	DINK-A/1	Orange County Water District	Yes	Yes	Unable to be Sampled
Orange County	1213741	Destroyed	HARR-FV/1	Orange County Water District	Yes	Yes	Unable to be Sampled
Orange County	1214557	Destroyed	OM-5/1	Orange County Water District	Yes	Yes	Unable to be Sampled
Orange County	1214996	Destroyed	SCWC-YLBA/1	Orange County Water District	Yes	Yes	Unable to be Sampled
Orange County	1214999	Destroyed	SEA-HB/1	Orange County Water District	Yes	Yes	Unable to be Sampled
Orange County	1215067	Destroyed	SPNO-HB/1	Orange County Water District	Yes	Yes	Unable to be Sampled
Orange County	1212998	Destroyed	A-129/1	Orange County Water District	Yes	No	Unable to be Sampled
Orange County	1213001	Destroyed	A-16/1	Orange County Water District	Yes	No	Unable to be Sampled
Orange County	1214834	Destroyed	SB-7/1	Orange County Water District	Yes	No	Unable to be Sampled
Orange County	1214997	Destroyed	SCWC-YLCO/1	Orange County Water District	Yes	No	Unable to be Sampled
Orange County	1215128	Destroyed	T-MS2/1	Orange County Water District	Yes	No	Unable to be Sampled
Orange County	1215595	Destroyed	YLWD-9/1	Orange County Water District	Yes	No	Unable to be Sampled
Orange County	1215609	Destroyed	CALT-A/1	Orange County Water District	Yes	No	Unable to be Sampled
Orange County	1212994	Destroyed	A-106/1	Orange County Water District	Yes	Yes	Unable to be Sampled
Orange County	1213007	Destroyed	A-23/1	Orange County Water District	Yes	Yes	Unable to be Sampled
Orange County	1213018	Destroyed	A-35/1	Orange County Water District	Yes	Yes	Unable to be Sampled
Orange County	1213036	Destroyed	A-9/1	Orange County Water District	Yes	Yes	Unable to be Sampled
Orange County	1213389	Destroyed	BP-LARW/1	Orange County Water District	Yes	Yes	Unable to be Sampled
Orange County	1213516	Destroyed	DICE-SA/1	Orange County Water District	Yes	Yes	Unable to be Sampled
Orange County	1213539	Destroyed	F-3/1	Orange County Water District	Yes	Yes	Unable to be Sampled
Orange County	1213628	Destroyed	FV-7/1	Orange County Water District	Yes	Yes	Unable to be Sampled
Orange County	1213816	Destroyed	HELL-SB2/1	Orange County Water District	No	Yes	Unable to be Sampled
Orange County	1214079	Destroyed	MIDT-APAR/1	Orange County Water District	Yes	Yes	Unable to be Sampled
Orange County	1214199	Destroyed	O-13/1	Orange County Water District	Yes	Yes	Unable to be Sampled
Orange County	1214619	Destroyed	SA-22/1	Orange County Water District	Yes	Yes	Unable to be Sampled
Riverside A	1003396	Inactive	RCSD #12 Airport	Rubidoux Community Services District	Yes	Yes	High
Chino-South	4606	Inactive	Private	Private	Yes	Yes	Low
Orange County	1214196	Inactive	O-1/1	Orange County Water District	Yes	Yes	Low
Irvine	1215095	Inactive	TIC-111/1	Orange County Water District	Yes	Yes	Low
Bunker Hill A	1000249	Inactive	SBWD Colima	City of San Bernardino	Yes	Yes	High
Lytle	1000264	Inactive	LC 1	Riverside Highland Water Company	Yes	No	Low
Lytle	1000267	Inactive	LC 8	Riverside Highland Water Company	Yes	No	Low
Bunker Hill A	1000269	Inactive	SBWD State St.	City of San Bernardino	Yes	Yes	Low
Lytle	1000512	Inactive	SBWD Lytle Creek 03-1	City of San Bernardino	Yes	Yes	Low
Chino-1/Chino-North	1002646	Inactive	MVWD 08	Monte Vista Water District	Yes	No	Low
Beaumont	1003059	Inactive	YVWD 34	Yucaipa Valley Water District	Yes	Yes	Low
Riverside C	1003378	Inactive	RCSD #14 46th St	Rubidoux Community Services District	Yes	No	High
Riverside A	1003384	Inactive	RCSD #13 Hunter 1	Rubidoux Community Services District	Yes	Yes	High
Orange County	1214573	Inactive	PINE-O/1	Orange County Water District	Yes	No	Low
Bunker Hill B	1000365	Inactive	PS & B 2	Baseline Gardens Mutual Water Company	Yes	Yes	High
Chino-3/Chino-North	1002113	Inactive	MMWC 05	Marygold Mutual Water Company	Yes	Yes	Low
Beaumont	1208431	Inactive	Well 2	Cherry Valley Mutual Water Company	Yes	Yes	Low
Orange County	1213360	Inactive	BAST-F/1	Orange County Water District	No	Yes	Low
Orange County	1214517	Inactive	OCWD-P10/1	Orange County Water District	No	Yes	Low
Orange County	1215083	Inactive	T868-S1/1	Orange County Water District	Yes	Yes	Low
Orange County	1215084	Inactive	T868-S2/1	Orange County Water District	Yes	Yes	Low
Chino-1/Chino-North	1220059	Inactive	B1A	State of California, California Institution for Men	Yes	Yes	Low
Chino-1/Chino-North	1220060	Inactive	B1B	State of California, California Institution for Men	Yes	Yes	Low
Orange County	1213570	Inactive	F-FS13/1	Orange County Water District	Yes	No	Low
Orange County	1214970	Inactive	SCWC-LABL/1	Orange County Water District	Yes	Yes	Low
Yucaipa	1002991	Standby	WHWC 04	Western Heights Water Company	Yes	No	Low
Yucaipa	1002992	Standby	WHWC 09	Western Heights Water Company	Yes	No	Low
Not Applicable	1000008	Undetermined	PL 134/CC3	East Valley Water District	Yes	Yes	Unable to be Sampled
Bunker Hill B	1000885	Undetermined	NA_1000885	Unknown	Yes	Yes	Unable to be Sampled
Bunker Hill B	1000888	Undetermined	NA_1000888	Unknown	Yes	Yes	Unable to be Sampled
Bunker Hill B	1000889	Undetermined	NA_1000889	Unknown	Yes	Yes	Unable to be Sampled
Bunker Hill B	1000962	Undetermined	NA_1000962	Unknown	Yes	Yes	Unable to be Sampled
Bunker Hill B	1000992	Undetermined	NA_1000992	Dept Of The Air Force	Yes	Yes	Unable to be Sampled
Bunker Hill B	1000994	Undetermined	NA_1000994	Unknown	Yes	Yes	Unable to be Sampled
Bunker Hill B	1001347	Undetermined	PL 11A	East San Bernardino Cwd	Yes	Yes	Unable to be Sampled
Yucaipa	1003003	Undetermined	NA_1003003	Unknown	Yes	Yes	Unable to be Sampled
Riverside A	1003386	Undetermined	NA_1003386	Unknown	Yes	Yes	Unable to be Sampled
Chino-2/Chino-North	1004026	Undetermined	NA_1004026	State of California, California Institution for Women	Yes	Yes	Unable to be Sampled
San Jacinto Upper Pressure	1212040	Undetermined	13117	Eastern Municipal Water District	Yes	Yes	Unable to be Sampled
Cucamonga	1000542	Undetermined	HELLMAN AVE#2	Unknown	Yes	No	Unable to be Sampled
Yucaipa	1000766	Undetermined	NA_1000766	Unknown	Yes	No	Unable to be Sampled
Bunker Hill A	1001427	Undetermined	NA_1001427	Terrace Water Co.	Yes	No	Unable to be Sampled
Bunker Hill A	1001429	Undetermined	NA_1001429	Terrace Water Co.	Yes	No	Unable to be Sampled
Riverside A	1003351	Undetermined	NA_1003351	Unknown	Yes	No	Unable to be Sampled
Riverside A	1003361	Undetermined	NA_1003361	Unknown	Yes	No	Unable to be Sampled
Riverside A	1003397	Undetermined	NA_1003397	Rubidoux Community Services District	Yes	No	Unable to be Sampled
Orange County	1214601	Undetermined	RHWC-W/1	Orange County Water District	Yes	No	Unable to be Sampled

Table 4-1
Well Attrition (1996-2015)

Management Zone	Well ID or XRef ID	Status	Well Name	Well Owner[1]	Potential Loss of Statistic for 1996-2015		Sampling Priority
					TDS	NO_3-N	
Lytle	1000453	Undetermined	NA_1000453	Unknown	Yes	Yes	Unable to be Sampled
Bunker Hill B	1001254	Undetermined	NA_1001254	Unknown	Yes	Yes	Unable to be Sampled
Bunker Hill B	1001590	Undetermined	NA_1001590	Unknown	Yes	Yes	Unable to be Sampled
Chino-3/Chino-North	8757	Undetermined	Private	Private	No	Yes	Unable to be Sampled
Not Applicable	1002513	Undetermined	NA_1002513	Unknown	Yes	Yes	Unable to be Sampled
Bunker Hill A	1002878	Undetermined	NA_1002878	Unknown	Yes	Yes	Unable to be Sampled
Bunker Hill A	1002889	Undetermined	NA_1002889	Unknown	Yes	Yes	Unable to be Sampled

[1] Orange County Water District and Eastern Municipal Water District are shown as owners of all wells for which they provide data.



File Path: N:\MapDocs\Clients\SAWPA\Phase8\2012 AWQ Recomputation\Tech_Memo\Figure 4-1.mxd

Well Attrition

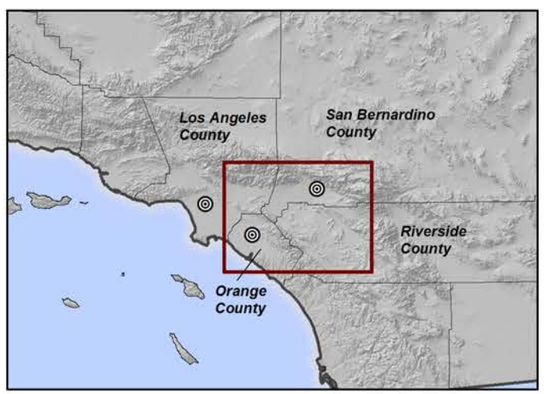
Wells that may lose AWQ Stats in 2015

- High Priority Wells
- Low Priority Wells
- Destroyed Wells

- Wells that will have AWQ Stats in 2015

Other Features

- RWQCB Boundary
- Management Zone Boundary
- Santa Ana River
- Lakes & Reservoirs



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File: Figure 4-1

0 5 10 15 Miles
0 5 10 15 20 25 KM

Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality for the Period 1993 to 2012

SAWPA

Well Attrition in the 2015 Recomputation of Ambient Water Quality

Santa Ana Watershed - 1993-2012

Figure 4-1

Section 5 – Recommendations

As described in the Basin Plan, the watershed-wide, groundwater monitoring and surveillance program is meant to provide Regional Board with the information necessary to review and update the TDS/nitrogen management plan. The groundwater monitoring and surveillance program must periodically provide an accurate depiction of current ambient groundwater quality and the trends that are occurring in groundwater quality. This information is used by the Regional Board to:

1. determine compliance with TDS and nitrate-nitrogen objectives for the management zones
2. determine the existence and magnitude of assimilative capacity for groundwater management zones
3. assist in decisions to allocate assimilative capacity
4. evaluate the efficacy of existing and/or proposed nitrogen-loss coefficients
5. evaluate the efficacy of wasteload allocations
6. perform and/or evaluate anti-degradation analyses

Optimally, the program should include:

1. groundwater sampling locations (wells) that are spatially distributed across the management zones
2. consistent sampling frequency at all wells
3. a centralized database of groundwater information that is continually updated and includes rigorous QA/QC protocols
4. a database interface that allows for data viewing and data export in understandable and useable formats
5. a standardized method of computing the current ambient quality of management zones with minimal influence from the methodological factors.

The following recommendations for future ambient water quality recomputations are based on the objectives listed above, WEI's observations from current and past recomputation efforts, and comments and concerns raised by the BMPTF.

5.1 Improve the Spatial Distribution of Monitoring

The Well-Attrition Analysis identified wells where point statistics will be lost if groundwater samples are not collected and analyzed in 2014 and 2015. There also are areas in certain management zones that need additional point statistics to compute a more accurate estimate of current ambient TDS and nitrate-nitrogen. Additional groundwater monitoring at appropriate locations and/or depths within these management zones will increase the number of wells with point statistics, better constrain TDS and nitrate-nitrogen contouring, and ultimately make the management zones less susceptible to methodological factors that

influence the computation of ambient water quality. The most important of these areas are:

- The down-gradient portion of Riverside-A near the Riverside Narrows. There are few wells with data in this area. Riverside-A is an important management zone that is receiving water for POTW discharge.
- The central and eastern portions of the Arlington Management Zone. There are few wells with data in these areas of a management zone that is considering recycled water reuse projects.
- The central and western portions of Riverside-B. There are very few wells with data in these areas that are representative of regional groundwater quality. Most wells in these areas are shallow monitoring wells associated with point-source releases.
- The management zones in the upper Temescal Valley (Warm Springs Valley, Lee Lake, and Bedford). These management zones did not have enough data to compute the "anti-degradation" objective nor do they have enough data currently to compute ambient water quality. These management zones are important receiving waters for POTW discharge.

5.2 Increase the Frequency of Groundwater Monitoring

At many wells within the watershed, groundwater sampling and analysis occurs at a frequency of once every three years or less often. A low frequency of monitoring has the potential to increase the standard error associated with the computation of TDS and nitrate point statistics at wells, which can then increase the ambient water quality concentrations for management zones. In addition, a low frequency of monitoring may "miss" the short-term effects of hydrologic events on groundwater quality, such as the dilution effect of storm-water recharge on water quality at wells located near areas of storm-water recharge.

WEI recommends the following:

1. The BMPTF should conduct a study to characterize the influence of sample size on the standard error and the point statistic. This study will provide guidance as to whether to implement the second recommendation.
2. To the extent possible, the BMPTF should make efforts to collect and analyze groundwater samples at all wells in the watershed at a minimum frequency of once per year.

5.3 Update the Physical Characterization of Management Zones

The BMPTF should consider periodically updating the physical model used to compute ambient water quality. The physical model consists of aquifer properties (i.e. the specific yield of the sediments) and aquifer geometry (i.e. depth to bedrock and aquifer-system layering). Updates to the physical model would be based on the incremental improvements in the understanding of aquifer properties and aquifer geometry that have occurred since the late

1990s (when the physical model was developed). The improvements in understanding include new borehole and well information, new hydrogeologic studies, and the development of groundwater models. The objective here is to improve the accuracy of ambient water quality determinations. Based on our professional experience in the upper Santa Ana River Watershed since the 1990s, we believe there is enough new information that has been derived to justify a re-characterization of the physical model for most management zones in this area of the watershed.

California Regional Water Quality Control Board, Santa Ana Region. (2004). *Resolution No. R8-2004-0001— Resolution Amending the Water Quality Control Plan for the Santa Ana River Basin to Incorporate an Updated Total Dissolved Solids (TDS) and Nitrogen Management Plan for the Santa Ana Region Including Revised Groundwater Subbasin Boundaries, Revised TDS and Nitrate-Nitrogen Quality Objectives for Groundwater, Revised TDS and Nitrogen Wasteload Allocations, and Revised Reach Designations, TDS and Nitrogen Objectives and Beneficial Uses for Specific Surface Waters.*

California Regional Water Quality Control Board, Santa Ana Region. (2005). *Resolution No. R8-2005-0065—Resolution Approving the San Timoteo and Yucaipa Management Zones Maximum Benefit Surface Water and Groundwater Monitoring Program Proposals as Required in the Total Dissolved Solids and Nitrogen Management Plan Specified in the Water Quality Control Plan for the Santa Ana River Basin.*

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Greenberg, A. E., L. S. Clesceri, and A. D. Eaton. (1992). *Standard Methods for the Examination of Water and Wastewater.* 18th Edition. American Public Health Association/American Water Works Association/Water Environment Federation.

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US EPA. (1992). *Definitions for the Minimum Set of Data Elements for Ground Water Quality.* Office of Water (WH55OG)EPA 813/B-92-002. July 1992.

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Wildermuth Environmental, Inc. (2000b). *TIN/TDS Phase 2A: MS Access Database for TIN/TDS Study of the Santa Ana Watershed.* Technical Memorandum. July 2000. Appendix A

Wildermuth Environmental, Inc. (2005). *TIN/TDS Phase 4: Recomputation of Ambient Water Quality in the Santa Ana Watershed for the Period 1984 to 2003.* Technical Memorandum. November 2005.

Wildermuth Environmental, Inc. (2008a). *Maximum Benefit Monitoring Program – 2007 Annual Report.* Prepared for Yucaipa Valley Water District. April 2008.

Wildermuth Environmental, Inc. (2008b). *Maximum Benefit Monitoring Program – 2007 Annual Report.* Prepared for San Timoteo Watershed Management Authority and City of Beaumont. April 2008.

Wildermuth Environmental, Inc. (2008). *TIN/TDS Phase 6: Recomputation of Ambient Water Quality in the Santa Ana Watershed for the Period 1987 to 2006*. Technical Memorandum. August 2008.

Wildermuth Environmental, Inc. (2009). *Draft Phase 2 Feasibility Study for the Expansion of the Arlington Desalter System*. Prepared for Western Municipal Water District. October 2009.

Wildermuth Environmental, Inc. (2010). *Preliminary Assessment of Assimilative Capacity in the San Timoteo Management Zone*. Prepared for Yucaipa Valley Water District and City of Beaumont. November 2010.

Wildermuth Environmental, Inc. (2011). *Recomputation of Ambient Water Quality in the Santa Ana Watershed for the Period 1990 to 2009*. Technical Memorandum. August 2011.

Appendix A

Comments and Responses

A-1 REGIONAL BOARD COMMENTS AND RESPONSES

Comment Number	Reference	Comment	Response
1	Page 2-5	Under the process to develop TDS and nitrate estimates, the report indicates "ancillary water quality data" is used. Please provide an explanation of what constitutes "ancillary data" and how these types of data differs from other evaluated water quality data.	Ancillary data refers to the mean TDS or nitrate-nitrogen concentration over the period from 1993 to 2012 for wells with not enough data to compute a point statistic. Additional explanation has been added to the text.
2	Page 2-6	To determine the volume of groundwater in each grid cell, groundwater elevations from the fall of 2006 were utilized. A discussion of why the fall of 2006 was used would be useful.	This was a typographical error. The text has been updated to indicate that groundwater elevations for fall 2012 were utilized.
3	Section 5	I note that WEI provides a number of recommendations. Does SAWPA envision a plan for Task Force review and action on the Report recommendations? Board staff is particularly concerned with the loss of some wells that could potentially affect future 20 year data collection periods.	The recommendations in Section 5 come from WEI and are based on our understanding of the objectives of the Salt Management Plan for the region, our observations from current and past recomputation efforts, and comments and concerns raised by the BMPTF. They are meant to stimulate discussion at BMPTF meetings and, potentially, direct future BMPTF efforts.

A-2 SAWPA COMMENTS AND RESPONSES

Comment Number	Reference	Comment	Response
1	Table 3-1and Table 3-2	As recommended and agreed to in our last BMP TF meeting, show only the assimilative capacity values that are positive and remove all negative values similar to what is presented in your Table 1-1.	Tables 3-1 and 3-2 were revised as suggested.
2	Table 3-1	The first footnote, ?, should be revised to say not enough data to estimate TDS concentrations instead of NO3.	Table revised as suggested.
3	Figures 3-3 and 3-4	As recommended and agreed to in our last BMP TF meeting, show only the assimilative capacity values that are positive and remove all the negative values.	Figures revised as suggested.
4	Sections 5-2 and 5-3	Please indicate more specific tasks that should be undertaken to increase monitoring frequency and updating the physical characterization of management zones. Do the recommendations apply to the whole watershed or can we pinpoint specific management zones similar to the recommendations shown in Section 5.1?	*5.2 – Increase the Frequency of Groundwater Monitoring*. The recommendation is to conduct a study to characterize the problem and provide guidance for additional recommendations to address the problem. The study would describe the management zones and wells where this problem is most acute. *5.3 – Update the Physical Characterization of Management Zones*. Based on our professional experience in the upper Santa Ana River Watershed since the 1990s, we believe that enough new information has been derived to justify a re-characterization of the physical model for most management zones in this area of the watershed. Text has been added to Section 5.3 to reflect this technical opinion.

A-3 OCWD COMMENTS AND RESPONSES

Comment Number	Reference	Comment	Response
1	Exhibits C-11, C-13, C-15, and C-17	The exhibits that discuss the Irvine Management Zone have text such as 'impacted by return flows form agricultural land uses and point-source contamination' – we concur with the part of this text regarding agricultural land uses; not sure what is implied by 'point-source contamination'; is this meant to refer to diffuse sources of contamination? (in which case it would be 'non-point sources'); if you meant individual point-sources, are there specific ones that are more significant sources? Suggest rewording for each discussion of the Irvine Management Zone	"Point-source contamination" was not intended to highlight specific sources of contamination and has been removed from the text.
2	Exhibit C-13, C-15 and C-17	On Exhibit C-11 (map 'OC_T1'), add to the text that recharge includes surface recharge of recycled water in the Forebay (use similar wording as on Exhibit C-12). Also, revise the text to note that some groundwater outflow occurs to the 'Central Basin' in Los Angeles County. Text says 'See Exhibit 4-13 for …' – should that be Exhibit C-12? On Exhibit C-13, text says 'See Exhibit 4-15 for …' - should that be Exhibit C-14? Same comment as on Exhibit C-11 regarding recharge includes surface recharge of recycled water in the Forebay. On Exhibit C-15, same comment about 'See Exhibit 4-17'; same comment as on Exhibit C-11 regarding recharge includes surface recharge of recycled water in the Forebay. On Exhibit C-17, same comment about 'See Exhibit 4-19'; same comment as on Exhibit C-11 regarding recharge includes surface recharge of recycled water in the Forebay.	Additional text has been added to the Interpretive Tools maps text as suggested. Exhibits C-11, -13, -15, and -17 have been revised as suggested.

Appendix B

Attachments

APPENDIX B – ATTACHMENTS

Folder	Folder Contents	File Type
Database	Microsoft Access 2010 database containing the well information, water quality data, and water level data used in the development of ambient water quality estimates. Please note that all stations obtained from the EMWD and OCWD databases have the "Owner" listed as EMWD or OCWD.	MS Access database
Grids	Point shapefiles of the ambient water quality grid (centroids of 400 x 400 meter grid cells) across all management zones. Attributes include ground surface elevation, Fall 2012 water level, bottom of aquifer/layer, specific yield, nitrate-nitrogen concentration, and TDS concentration at each grid cell.	ArcGIS shapefiles
WL_GIS_Contours	Polyline shapefiles of fall 2012 water level elevation contours (feet above mean sea level) in all management zones.	ArcGIS shapefiles
WQ_Maps	Groundwater quality maps for current (1993-2012) time period.	Adobe Acrobat files (PDF)
WQ_GIS_Contours	Polyline shapefiles of water quality contours for the current (1993-2012) time period	ArcGIS shapefiles
WQ_Final Statistics Tables	Summary of computed ambient water quality statistics at wells, in separate files for TDS and nitrate-nitrogen data.	MS Excel file
WQ_TimeSeries	Time series charts of TDS and nitrate-nitrogen for all wells where data were available in the Santa Ana Watershed.	Adobe Acrobat files (PDF)

Appendix C

Interpretive Tools

APPENDIX C – INTERPRETIVE TOOLS

List of Exhibits

Exhibit C-1	Interpretive Tools for TDS in the Beaumont, Yucaipa, and San Timoteo Management Zones.
Exhibit C-2	Interpretive Tools for Nitrate-Nitrogen in the Beaumont, Yucaipa, and San Timoteo Management Zones.
Exhibit C-3	Interpretive Tools for TDS in the Bunker Hill Management Zones.
Exhibit C-4	Interpretive Tools for Nitrate-Nitrogen in the Bunker Hill Management Zones.
Exhibit C-5	Interpretive Tools for TDS in the Chino-North (Layer 1), Chino-South, Chino-East, and Cucamonga Management Zones
Exhibit C-6	Interpretive Tools for Nitrate-Nitrogen in the Chino-North (Layer 1), Chino-South, Chino-East, and Cucamonga Management Zones
Exhibit C-7	Interpretive Tools for TDS in the Chino-North Management Zone (Layer 2)
Exhibit C-8	Interpretive Tools for Nitrate-Nitrogen in the Chino-North Management Zone (Layer 2)
Exhibit C-9	Interpretive Tools for TDS in the Chino-North Management Zone (Layer 3)
Exhibit C-10	Interpretive Tools for Nitrate-Nitrogen in the Chino-North Management Zone (Layer 3)
Exhibit C-11	Interpretive Tools for TDS in the Orange County and Irvine Management Zones (Layer 1)
Exhibit C-12	Interpretive Tools for TDS in the Orange County Management Zone (Layer 1) in the Vicinity of the Recharge Facilities.
Exhibit C-13	Interpretive Tools for Nitrate-Nitrogen in the Orange County and Irvine Management Zones (Layer 1)
Exhibit C-14	Interpretive Tools for Nitrate-Nitrogen in the Orange County Management Zone (Layer 1) in the Vicinity of the Recharge Facilities
Exhibit C-15	Interpretive Tools for TDS in the Orange County and Irvine Management Zones (Layer 2)
Exhibit C-16	Interpretive Tools for TDS in the Orange County Management Zone (Layer 2) in the Vicinity of the Recharge Facilities
Exhibit C-17	Interpretive Tools for Nitrate-Nitrogen in the Orange County and Irvine Management Zones (Layer 2)

List of Exhibits

Exhibit C-18	Interpretive Tools for Nitrate-Nitrogen in the Orange County Management Zone (Layer 2) in the Vicinity of the Recharge Facilities
Exhibit C-19	Interpretive Tools for TDS in the Rialto, Colton, and Lytle Management Zones
Exhibit C-20	Interpretive Tools for Nitrate-Nitrogen in the Rialto, Colton, and Lytle Management Zones
Exhibit C-21	Interpretive Tools for TDS in the Riverside Management Zones
Exhibit C-22	Interpretive Tools for Nitrate-Nitrogen in the Riverside Management Zones
Exhibit C-23	Interpretive Tools for TDS in the San Jacinto Area Management Zones
Exhibit C-24	Interpretive Tools for Nitrate-Nitrogen in the San Jacinto Area Management Zones
Exhibit C-25	Interpretive Tools for TDS in the San Jacinto-Lower Pressure, San Jacinto-Lower Pressure, and Canyon Management Zones.
Exhibit C-26	Interpretive Tools for Nitrate-Nitrogen in the San Jacinto-Lower Pressure, San Jacinto-Lower Pressure, and Canyon Management Zones.
Exhibit C-27	Interpretive Tools for TDS in the Temescal Valley Management Zones
Exhibit C-28	Interpretive Tools for Nitrate-Nitrogen in the Temescal Valley Management Zones

To obtain copies of Appendix B and/or Appendix C, please contact:

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