Draft

Recomputation of Ambient Water Quality for the Period 1999 to 2018

for the

SAWPA – Basin Monitoring Program Task Force

4/15/2020

Water Systems Consulting, Inc.

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Glossary of Terms

AWQ	ambient water quality
BCVWD	Beaumont-Cherry Valley Water District
bgs	below ground surface
BMPTF	Basin Monitoring Program Task Force
CBWCD	Chino Basin Water Conservation District
CBWM	Chino Basin Watermaster
CCWRF	Carbon Canyon Water Recycling Facility
DBS&A	Daniel B. Stephens & Associates, Inc.
DDW	Division of Drinking Water, California Environmental Protection Agency
EC	electrical conductivity
EDD	electronic data deliverable
EMWD	Eastern Municipal Water District
EVMWD	Elsinore Valley Municipal Water District
FPW	Final Product Water
ftp	file transfer protocol
GAMA	Groundwater Ambient Monitoring and Assessment Program
GIS	geographic information system
GM	geometric mean
GMZ	groundwater management zone
GSE	geometric standard error
GWRS	Groundwater Replenishment System
HSPF	Hydrologic Simulation Program-FORTRAN
IEUA	Inland Empire Utilities Agency
IRWMP	Integrated Regional Water Management Program
IWRWG	Imported Water Recharge Work Group
JCSD	Jurupa Community Services District
MCL	maximum contaminant level
MDV	most discordant value

meq/L	milliequivalents per liter
MG	million gallons
MGD	million gallons per day
mg/L	milligrams per liter
MS	Microsoft
msl	above mean sea level
NPL	National Priorities List
OCSD	Orange County Sanitation District
OCWD	Orange County Water District
POTW	publicly-owned treatment works
QA/QC	quality assurance/quality control
RFP	request for proposal
RFQ	request for qualifications
RPD	relative percent difference
RPU	City of Riverside Public Utilities
RWQCB	Regional Water Quality Control Board, Santa Ana Region
RWQCP	Riverside Regional Water Quality Control Plant
SAT	Soil Aquifer Treatment
SAWPA	Santa Ana Watershed Project Authority
SBVWCD	San Bernardino Valley Water Conservation District
SE	standard error at student's t
SGPWA	San Gorgonio Pass Water Agency
SNMP	salt and nutrient management plan
STWMA	San Timoteo Watershed Management Authority
SWO	surface water objectives
SWRCB	State Water Resources Control Board
TDS	total dissolved solids
TIN	total inorganic nitrogen
TVWD	Temescal Valley Water District
USGS	US Geological Survey
Valley District	San Bernardino Valley Municipal Water District

WQO	water quality objective
WRCRWTP	Western Riverside County Regional Wastewater Treatment Plant
WWTF	Wastewater Treatment Facility
WWTP	Wastewater Treatment Plant
YVWD	Yucaipa Valley Water District

SECTION 1

Introduction

Water Systems Consulting, Inc. (WSC) has prepared this technical memorandum under a contract agreement with the Santa Ana Watershed Project Authority (SAWPA): Task Order No. WSC374-01 for the Triennial Recomputation of Ambient Water Quality for the Santa Ana River Watershed. Included on the WSC team are the following firms: Geo-Logic, Inc, LeClaire & Associates, and Environmental Science Solutions LLC. The Water Quality Control Plan (Basin Plan) for the Santa Ana River Basin (Region 8) (RWQCB, 2016a) requires the implementation of a watershed-wide total dissolved solids (TDS) and nitrogen groundwater monitoring program to determine ambient water quality in groundwater, assess compliance with groundwater quality objectives, and determine if assimilative capacity exists in groundwater management zones (GMZs). The current Basin Plan requires that the ambient water quality (AWQ) be computed every three years. This technical memorandum summarizes the work performed for the current recomputation for the 1999 to 2018 period. In this technical memorandum, the recomputation periods are designated by the ending year; for example, this current period is called the 2018 current AWQ recomputation period.

IN THIS SECTION

1.1 Background

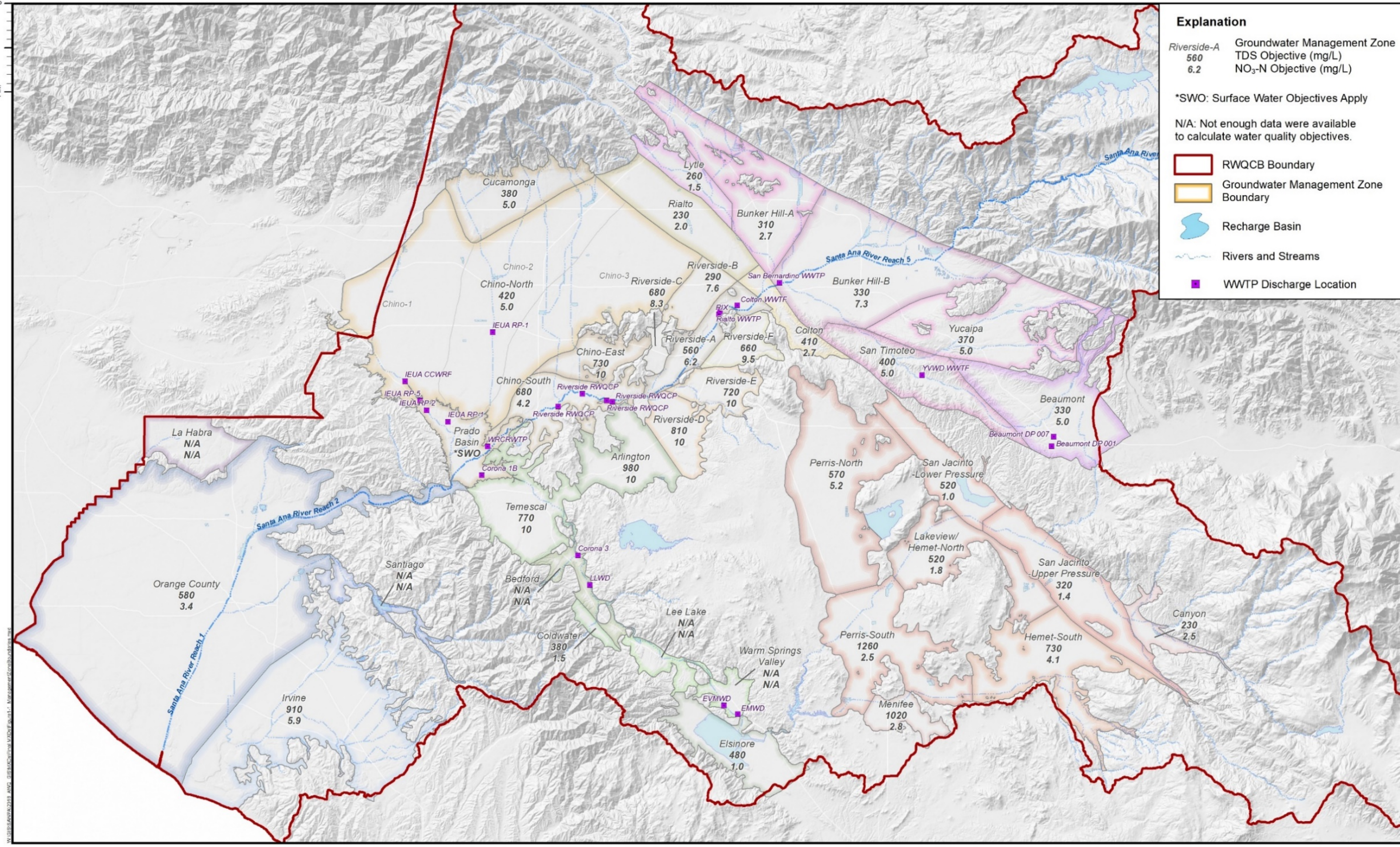
The Santa Ana River Watershed comprises portions of San Bernardino, Riverside, Los Angeles, and Orange Counties, has an area of 2,840 square miles, and is home to over 6 million residents. The Santa Ana River is the major stream draining the watershed—about 100 miles in length from its headwaters near Big Bear to its discharge location in Huntington Beach. Figure 1-1 shows the Santa Ana River

Watershed, along with the Santa Ana River and its major tributaries. The figure also depicts the Santa Ana River GMZs within sub watersheds, and the TDS and nitrate objectives associated with each GMZ that had sufficient data to make that determination. Locations of wastewater treatment plants (WWTPs) are shown in Figure 1-1.

SAWPA is a joint powers authority consisting of five member agencies: Eastern Municipal Water District, Inland Empire Utilities Agency, Orange County Water District, San Bernardino Valley Municipal Water District, and Western Municipal Water District. SAWPA's mission is to "make the Santa Ana River Watershed sustainable through fact-based planning and informed decision-making, regional and multijurisdictional coordination, and the innovative development of policies, programs, and projects (SAWPA, 2011)."

In December 1995, a Task Force consisting of 22 water resources agencies in the Santa Ana River Watershed was formed to study what effects and implications salinity—expressed as TDS—and total inorganic nitrogen (TIN) in the groundwater basins in the watershed may have on the long-term sustainability of groundwater supply. SAWPA administered all contracts pertaining to this study, including contracts with the consultants performing the study and the Santa Ana Regional Water Quality Control Board (RWQCB). The consistent input and oversight from the RWQCB were critical to the ultimate attainment of the objectives of the TIN/TDS Task Force. The ongoing participation of decision makers from each of the Task Force members was also key to reaching consensus on the scientific approach and developing an updated Salt and Nutrient Management Plan (SNMP). The process developed in the Santa Ana River Watershed was praised in a report by the Little Hoover Commission (2009). The original project was completed in mid-2003. "On January 22, 2004, the RWQCB incorporated the results of the Nitrogen TDS Task Force study into a Basin Plan Amendment for Nitrogen and TDS and adopted the Basin Plan Amendment. The Task Force agencies were named in that Basin Plan Amendment as responsible for conducting various monitoring programs and analyses to support the results defined in the Basin Plan Amendment" (Task Force, 2004). The current Basin Monitoring Program Task Force (BMPTF) members include the following:

- Santa Ana RWQCB – Advisory Member
- Beaumont-Cherry Valley Water District (BCVWD)
- Chino Basin Watermaster (CBWM)
- City of Banning
- City of Beaumont
- Colton/San Bernardino Regional Tertiary Treatment and Wastewater Reclamation
- City of Corona
- City of Redlands
- City of Rialto



Prepared by:

WSC Water Systems Consulting, Inc.

Author: EC

Date: 2/25/2020

File Name: Figure1-1_ManagementZoneBoundaries

N

1 in : 5.5 mi

0 1.75 3.5 7 Mi

0 2.75 5.5 11 Km

References:
1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for:

SAWPA

SAWPA Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality for the Period 1999 to 2018

Groundwater Management Zone Boundaries and Nitrate/TDS Objectives Santa Ana River Watershed

Figure 1-1

- City of Riverside
- Eastern Municipal Water District (EMWD)
- Elsinore Valley Municipal Water District (EVMWD)
- Inland Empire Utilities Agency (IEUA)
- Irvine Ranch Water District (IRWD)
- Jurupa Community Services District (JCSD)
- Orange County Water District (OCWD)
- San Bernardino Valley Municipal Water District (Valley District)
- San Gorgonio Pass Water Agency (SGPWA)
- Santa Ana Watershed Project Authority (SAWPA) Task Force Administrator
- Temescal Valley Water District (TVWD)
- Western Riverside County Wastewater Authority (WRCWA)
- Yucaipa Valley Water District (YVWD)

TDS and nitrate[1] objectives specified by the RWQCB in the 1975, 1984, and 1995 Basin Plans were developed using available groundwater data from the period 1968 through 1972. The initial estimates of AWQ were based on (non-volume-weighted) average concentrations in wells within each groundwater basin for that period.

The Water Quality Objectives (WQOs) in the Basin Plan are for nitrate-nitrogen because there is a primary maximum contaminant level (MCL) in drinking water for nitrate (and not TIN or total nitrogen). Effluent limits are expressed as TIN because the RWQCB had concerns about how nitrogen species may change under different environmental conditions[2] and required a safety factor. Specifying TIN for effluent discharge limits is conservative.

In Phase 2A (SAWPA Task Order 1998-W020-1616-03), the TIN/TDS Task Force revisited groundwater basin and sub-basin boundaries and the underlying dataset used to set objectives in order to determine if more rigorous methods could be employed that would yield more representative groundwater quality objectives. The TIN/TDS project team developed revised sub-basin boundaries based on a reassessment of hydrogeology and water quality to create GMZs for more effective environmental stewardship of groundwater. Historical AWQ for GMZs was based on a rigorous search for data for the 1954 to 1973 historical period; hence, the period for defining groundwater was increased from 5 years (1968 to 1972) to 20 years (1954 to 1973). The TIN/TDS Task Force developed a rigorous statistical method, along with geospatial tools, to estimate volume-weighted AWQ for the historical and current periods. These

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1 Note that, by convention, this technical memorandum expresses nitrate in terms of nitrate as nitrogen. "Nitrate," "nitrate-N," "nitrate-nitrogen," and "NO_3-N" all refer to nitrate as nitrogen, with a maximum contaminant level (MCL) of 10 milligrams per liter (mg/L). In the context of the AWQ recomputation presented in this technical memorandum, ambient nitrate and TDS refer to concentrations that are representative of a given volume of groundwater for a given period.

2 Nitrogen can be converted to various nitrogen chemical forms or species, based on environmental conditions, including oxidation reduction potential, pH, sorption sites, bacteria, etc. This phenomenon is known as the nitrogen cycle.

methodologies are described in detail in Section 2.

According to the Basin Plan (RWQCB, 2016a):

> *"TDS and nitrate-nitrogen WQOs for each management zone are based on historical concentrations of TDS and nitrate-nitrogen from 1954 through 1973 and are referred to herein as the 'antidegradation' objectives. This period brackets 1968, when the State Board adopted the state's antidegradation policy in Resolution No. 68-16, "Policy with Respect to Maintaining High Quality Waters". This Resolution establishes a benchmark for assessing and considering authorization of degradation of water quality."*

The Basin Plan requires a triennial update of AWQ; hence, in the initial TIN/TDS study, current ambient conditions were also estimated for the 1978 to 1997 period. Subsequent updates have been provided for the following periods:

- 1984 to 2003
- 1987 to 2006
- 1990 to 2009
- 1993 to 2012
- 1996 to 2015
- 1999 to 2018 (this technical memorandum)

The triennial AWQ determinations from each current period are used to assess compliance with the WQOs and to determine if assimilative capacity exists for each GMZ. By definition, assimilative capacity is determined to be the difference between the WQO and the current AWQ: if the current quality of the GMZ is better than the WQO, then assimilative capacity exists. Assimilative capacity does not exist if the current quality of a GMZ is the same as or poorer than the WQOs.

According to the Basin Plan (RWQCB, 2016a), when a GMZ has little or no assimilative capacity:

> *"The Regional Board addresses such situations by providing dischargers with the opportunity to participate in TDS offset programs, such as the use of desalters, in lieu of compliance with numerical TDS limits. These offset provisions are incorporated into waste discharge requirements . . . An alternative that dischargers might pursue in these circumstances is revision of the TDS or nitrogen objectives, through the Basin Plan amendment process. Consideration of less stringent objectives would necessitate comprehensive antidegradation review, including the demonstrations that beneficial uses would be protected and that water quality consistent with maximum benefit to the people of the State would be maintained . . . a number of dischargers have pursued this 'maximum benefit objective' approach, leading to the inclusion of 'maximum benefit' objectives and implementation strategies in this Basin Plan. Discharges to areas where*

> *the 'maximum benefit' objectives apply will be regulated in conformance with these implementation strategies."*

Implementation of certain projects and programs by specific dischargers as part of their maximum benefit demonstrations is required for the continued application of the "maximum benefit" objectives.

1.2 Contents of the Technical Memorandum

Tables 1-1 (TDS) and 1-2 (nitrate) list the historical AWQ, the WQOs—both "antidegradation" and "maximum benefit"—and the 1978 to 1997 AWQ from the TIN/TDS Phase 2A study[3]. Section 2 outlines the methodology used to develop water quality point statistics and average values for TDS and nitrate at wells. Section 3 presents the results of the AWQ determination, including an assessment of current assimilative capacity. Interpretative tools are used in Section 4 to distinguish between systemic and methodological factors that contribute to apparent changes in groundwater quality. Section 5 summarizes recommendations.

1.3 Electronic Deliverables

The request for proposal (RFP) outlined a number of deliverables in addition to the text, tables, figures, and maps provided in this technical memorandum. Because of the file format, size, and search capabilities, these files are included electronically as links to a secure file transfer protocol (ftp) site. These files comprise Appendix A (Table 1-3); links are provided below and in the table of contents.

[3] In the Prado Basin, surface water objectives (SWO) apply. This is because *"Flood control operations at the dam, coupled with an extremely shallow groundwater table and an unusually thin aquifer, significantly affect these surface flows, as well as subsurface flows in the area. Depending on how the dam is operated, surface waters may or may not percolate behind the dam. There is little or no groundwater storage in the flood plain behind the dam. Any groundwater in storage is forced to the surface because the foot of Prado Dam extends to bedrock and subsurface flows cannot pass through the barrier created by the dam and the surrounding hills. Given these characteristics, this area is designated as a surface water management zone, rather than a groundwater management zone."* (RWQCB, 2004)

Table 1-1. TIN/TDS Phase 2A Results, Total Dissolved Solids (Page 1 of 2)

Groundwater Management Zones	Total Dissolved Solids Concentration (mg/L)			
	Water Quality Objective	Historical Ambient[a]	1997 Ambient[b]	Assimilative Capacity
San Bernardino Valley and Yucaipa / Beaumont Plains				
Beaumont, "maximum benefit"	330	233	290	40
Beaumont, "antidegradation"	230	233	290	
Bunker Hill-A	310	313	350	
Bunker Hill-B	330	332	260	70
Lytle	260	264	240	20
San Timoteo, "maximum benefit"	400	303	300	100
San Timoteo, "antidegradation"	300	303	300	
Yucaipa, "maximum benefit"	370	319	330	40
Yucaipa, "antidegradation"	320	319	330	
San Jacinto Basins				
Canyon	230	234	220	10
Hemet-South	730	732	1,030	
Lakeview/Hemet North	520	519	830	
Menifee	1,020	1,021	33,60	
Perris-North	570	569	750	
Perris-South	1,260	1,258	3,190	
San Jacinto-Lower Pressure	520	520	730	
San Jacinto-Upper Pressure, "maximum benefit"	500	321	370	
San Jacinto-Upper Pressure, "antidegradation"	320	321	370	
Chino, Rialto / Colton, and Riverside Basins				
Chino-North, "maximum benefit"	420	260	300	120
Chino-1, "antidegradation"	280	280	310	
Chino-2, "antidegradation"	250	250	300	
Chino-3, "antidegradation"	260	260	280	
Chino-East	730	733	760	
Chino-South	680	676	720	
Colton	410	407	430	

[a]Data sampling period was 20 years (1954-1973) for historical ambient water quality computations.
[b]Data sampling period was 20 years (1978-1997) for the 1997 ambient water quality computations.
[c]For the purposes of regulating discharges other than those associated with projects implemented within the Orange County GMZ to facilitate remediation projects and/or to address legacy contamination, no assimilative capacity is assumed to exist.
mg/L = milligrams per liter
? = Not enough data to estimate TDS concentrations; GMZ is presumed to have no assimilative capacity. If assimilative capacity is demonstrated by an existing or proposed discharger, that discharge would be regulated accordingly.

Table 1-1. TIN/TDS Phase 2A Results, Total Dissolved Solids (Page 2 of 2)

Groundwater Management Zones	Total Dissolved Solids Concentration (mg/L)			
	Water Quality Objective	Historical Ambient[a]	1997 Ambient[b]	Assimilative Capacity
Chino, Rialto / Colton, and Riverside Basins (continued)				
Cucamonga, "maximum benefit"	380	212	260	120
Cucamonga, "antidegradation"	210	212	260	
Rialto	230	230	230	
Riverside-A	560	560	440	120
Riverside-B	290	289	320	
Riverside-C	290	289	320	
Riverside-D	680	684	760	
Riverside-E	810	812	?	
Riverside-F	720	721	720	
Prado Basin	Surface water objectives[4] apply	618	819	Surface water objectives apply
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[c]	580	585	560	
Santiago	?	?	?	

[a]Data sampling period was 20 years (1954-1973) for historical ambient water quality computations.
[b]Data sampling period was 20 years (1978-1997) for current ambient water quality computations.
[c]For the purposes of regulating discharges other than those associated with projects implemented within the Orange County GMZ to facilitate remediation projects and/or to address legacy contamination, no assimilative capacity is assumed to exist.
mg/L = milligrams per liter
? = Not enough data to estimate TDS concentrations; GMZ is presumed to have no assimilative capacity. If assimilative capacity is demonstrated by an existing or proposed discharger, that discharge would be regulated accordingly.

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Table 1-2. TIN/TDS Phase 2A Results, Nitrate (Page 1 of 2)

Groundwater Management Zones	Nitrate as Nitrogen Concentration (mg/L)			
	Water Quality Objective	Historical Ambient[a]	1997 Ambient[b]	Assimilative Capacity
San Bernardino Valley and Yucaipa / Beaumont Plains				
Beaumont, "maximum benefit"	5.0	1.5	2.6	2.4
Beaumont, "antidegradation"	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, "maximum benefit"	5.0	2.7	2.9	2.1
San Timoteo, "antidegradation"	2.7	2.7	2.9	
Yucaipa, "maximum benefit"	5.0	4.2	5.2	
Yucaipa, "antidegradation"	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 Pressure	1.0	1.0	1.9	
San Jacinto-Upper Pressure, "maximum benefit"	7.0	1.4	1.9	5.1
San Jacinto-Upper Pressure, "antidegradation"	1.4	1.4	1.9	
Chino, Rialto / Colton, and Riverside Basins				
Chino-North, "maximum benefit"	5.0	3.7	7.4	
Chino-1, "antidegradation"	5.0	5.0	8.4	
Chino-2, "antidegradation"	2.9	2.9	7.2	
Chino-3, "antidegradation"	3.5			
Chino-East	10.0	13.3	29.1	
Chino-South	4.2	4.2	8.8	
Colton	2.7	2.7	2.9	

[a]Data sampling period was 20 years (1954-1973) for historical ambient water quality computations.
[b]Data sampling period was 20 years (1978-1997) for current ambient water quality computations.
[c]For the purposes of regulating discharges other than those associated with projects implemented within the Orange County GMZ to facilitate remediation projects and/or to address legacy contamination, no assimilative capacity is assumed to exist.
mg/L = milligrams per liter
? = Not enough data to estimate TDS concentrations; GMZ is presumed to have no assimilative capacity. If assimilative capacity is demonstrated by an existing or proposed discharger, that discharge would be regulated accordingly.

Table 1-2. TIN/TDS Phase 2A Results, Nitrate (Page 2 of 2)

Groundwater Management Zones	Nitrate as Nitrogen Concentration (mg/L)			
	Water Quality Objective	Historical Ambient[a]	1997 Ambient[b]	Assimilative Capacity
Chino, Rialto / Colton, and Riverside Basins (continued)				
Cucamonga, "maximum benefit"	5.0	2.4	4.4	0.6
Cucamonga, "antidegradation"	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 objectives apply	4.3	22.0	Surface water objectives apply
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[c]	3.4	3.4	3.4	
Santiago	?	?	?	

[a]Data sampling period was 20 years (1954-1973) for historical ambient water quality computations.
[b]Data sampling period was 20 years (1978-1997) for current ambient water quality computations.
[c]For the purposes of regulating discharges other than those associated with projects implemented within the Orange County GMZ to facilitate remediation projects and/or to address legacy contamination, no assimilative capacity is assumed to exist.
mg/L = milligrams per liter
? = Not enough data to estimate TDS concentrations; GMZ is presumed to have no assimilative capacity. If assimilative capacity is demonstrated by an existing or proposed discharger, that discharge would be regulated accordingly.

Table 1-3. Contents of Appendix A.

Year	Description
A.1 AWQ Database	MS Access database
A.2 AWQ Summary Statistics Table	MS Excel workbook
A.3 Grid Files	ArcGIS shapefile
A.4 Groundwater Elevation Contours	ArcGIS shapefile
A.5 Water Quality Contours	ArcGIS shapefile
A.6 Time-Series Plots for Groundwater Elevation, TDS, and Nitrate for Wells in the AWQ Database	Adobe Acrobat Portable Document Format (PDF) files

SECTION 2

Methods for the Recomputation of Ambient Water Quality

Ambient water quality was calculated for the study period of January 1, 1999 to December 31, 2018. SAWPA provided an MS Access database containing the 2015 AWQ recomputation data, including groundwater well, water level, and groundwater quality information. With the exception of OCWD and CBWM, data for the current three year-period (2016 to 2018) were collected and uploaded to the SAWPA AWQ database. As requested by OCWD and CBWM, all of the data for those two agencies from the previous 2015 recomputation were replaced with a complete dataset from those two agencies. Following the data collection and quality control tasks, AWQ was recalculated for each GMZ in the watershed by developing water quality point statistics for TDS and nitrate, contouring, and estimating the regional volume-weighted TDS and nitrate concentrations in groundwater across the watershed. The following subsections describe the process of recomputing the AWQ for each GMZ during the 2018 current AWQ recomputation period.

IN THIS SECTION

2.1 Data Collection (Task 1a)

On April 26, 2019, the RWQCB sent letters to SAWPA member agencies and sub-agencies requesting that "each agency that collects groundwater data in the watershed to provide groundwater level and groundwater quality data to the Task Force's consultants for the three-year period of January 1, 2016 to December 31, 2018." In addition to the letter, agencies were provided a template for data collection. Subsequent to the delivery of the RWQCB letter, the following agencies were contacted:

- Beaumont Cherry Valley Water District
- Chino Basin Watermaster
- City of Corona
- City of Riverside, (Riverside Public Utilities)
- City of Banning
- City of Beaumont
- City of Colton
- City of Loma Linda
- City of Redlands
- City of Rialto
- Colton/San Bernardino Regional Tertiary Treatment and Water Reclamation Authority
- County of Riverside, Department of Waste Resources
- County of San Bernardino, Solid Waste Management Division
- East Valley Water District
- Eastern Municipal Water District
- Elsinore Valley Municipal Water District
- Home Gardens County Water District
- Inland Empire Utilities Agency
- Irvine Ranch Water District
- Jurupa Community Services District
- Muscoy Mutual Water Company
- Orange County Water District
- Riverside-Highland Water Company
- Rubidoux Community Services District
- San Bernardino Municipal Water Department
- San Bernardino Valley Municipal Water District
- San Gorgonio Pass Water Agency
- South Mesa Water Company
- Temescal Valley Water District
- West Valley Water District
- Western Heights Water Company
- Western Municipal Water District
- Western Riverside County Regional Wastewater Authority
- Yucaipa Valley Water District.

The data types and data fields that were collected are listed in Table 2-1.

Table 2-1. Requisite Data Fields

Well Information (for New Wells)	
• Well name • Well type • Well status • Well x coordinate • Well y coordinate	• Ground surface elevation • Distance from reference point to ground surface • Reference point type (e.g., top of casing) • Depth of well casing • Depth intervals of well perforations
Groundwater Level Data	
• Well name • Measurement date / time • Depth from reference point to the water table	• Activity of well during measurement (e.g., static, pumping, recovering) • Measurement method
Groundwater Quality Data	
• Well name • Sample date / time • Analyte name	• Result • Detection limit • Units
Analyte List	
• Alkalinity, total (as $CaCO_3$) • Bicarbonate • Calcium • Carbonate • Chloride • Electrical conductivity • Fluoride • Magnesium	• Nitrate as nitrate (NO_3) or nitrate as nitrogen (N) • pH • Potassium • Silica • Sodium • Sulfate • Total dissolved solids

2.2 Process and Upload Historical Data (Task 1c)

An inventory of all datasets was compiled for the data received from the various data providers. The inventory included data provider information such as contact, date received, number of records, and data format (e.g., Microsoft Access, Microsoft Excel, hardcopy), as well as a version number, which was assigned to track changes to datasets should issues arise during the data loading process and/or the statistical analysis. This living document was updated throughout the project. A data mapping document (also known as a "lookup table") was developed that translates the data providers' fields to the AWQ database fields. In addition to providing the necessary mapping, it also helped to locate missing requisite data, identify conflicting data types/sizes (e.g., text to numeric, floating point to decimal, text to numeric, text field size of 100 characters to 50 characters, etc.), and other information that may be pertinent to the migration.

Each dataset was formatted and normalized for data migration. For example, data received in a crosstab format (e.g., columns indicate chemical information, rows indicate sample information) were processed using automation tools to reformat the data into the normalized table structure required in the AWQ database. Keypunched data were entered in a controlled tool that used data validation tools including drop downs, default values, data type constraints, data value constraints, and field size constraints.

Conversions were completed on necessary reference values such as units and chemicals. Duplicate data were identified using analytical queries that filter on various parameters such as sample, date/time, and chemical name. Duplicates were flagged and reviewed to determine the appropriate course of action. In some cases, there were samples that appeared to be duplicates, but turned out to be re-analyses due to dilutions, laboratory errors, or requests from the data provider. Data were reviewed by project team members who did not participate in the processing outlined above. Keypunched data were carefully reviewed to ensure that no data entry errors occurred. Automated data processing was 10 percent randomly reviewed to ensure automation processes met the quality assurance/quality control (QA/QC) requirements. All errors were rectified before loading the data into the AWQ database.

2.3 Develop Water-Quality Point Statistics and Average Values for TDS and Nitrate at Wells (Task 1d)

Once the new data were uploaded to the AWQ database as described in Section 2.2 (Task 1c) a series of steps were executed to develop the point statistics and average water quality values that are the basis of the computation of ambient water quality. These steps include (1) review the time-series charts, (2) run the QA/QC checks, (3) annualize the water quality data, (4) use the Shapiro-Wilk test to remove potential outliers, and (5) compute averages and point statistics. These steps were defined through the Task Force process in the late 1990s as documented in the Phase 2A technical memorandum (WEI, 2000).

2.3.1 Review Time-Series Data

Once data were uploaded to the AWQ database, well location maps and time-series charts were generated for groundwater level, TDS, and nitrate for each well. The time-series charts were developed using automation tools, and PDF files were made for each of the wells with data in the database. Each PDF page contains time-series data for groundwater elevation, TDS, and nitrate. The time-series data were reviewed by staff hydrogeologists. These time-series charts are included electronically in Appendix A.7.

2.3.2 QA/QC Tests Adapted from the Methods for the Examination of Water and Wastewater

Four tests were conducted to evaluate the quality of data based on TDS, electrical conductivity (EC), and major ions. The tests were automated and applied to the data directly from the database to streamline the process. The computations were reviewed and tested to ensure that they worked properly. The test results were qualified and tied back to the primary (or unique) key. This allowed the test results to be related directly to the respective samples within the database. Any sample that failed all four tests was flagged and excluded from the dataset used for statistical analysis.

The four data quality tests include: (1) an anion-cation balance; (2) a comparison of measured and calculated TDS; (3) a comparison of measured EC and the sum of ions; and (4) TDS to EC ratios. These tests are described in Standard Methods for the Examination of Water and Wastewater (Rice et al., 1992), and are summarized in the following subsections.

2.1.1.1 Anion-Cation Balance

For this test, percent difference is calculated as follows:

$$Percent\ Difference = 100 \times \left(\frac{\sum cations - \sum anions}{\sum cations + \sum anions} \right) \qquad \text{Equation (1)}$$

Acceptance criteria are as follow:

- For an anion sum of 0 to 3 milliequivalents per liter (meq/L), an acceptable percent difference is ± 0.2 percent.
- For an anion sum of 3 to 10 meq/L, an acceptable percent difference is ± 2 percent.
- For an anion sum of 10 to 800 meq/L, an acceptable percent difference is ± 5 percent.

2.1.1.2 Measured vs. Calculated TDS

The criteria for this test are expressed as follows:

$$1.0 < \frac{Measured\ TDS}{Calculated\ TDS} < 1.2 \qquad \text{Equation (2)}$$

where Calculated TDS = 0.6 (alkalinity) + Na + K + Ca + Cl + SO_4 + SiO_3 + NO_3 + F

Na = Sodium

K = Potassium

Ca = Calcium

Cl = Chloride

SO_4 = Sulfate

SiO_3 = Silicate

NO_3 = Nitrate

F = Fluoride

2.1.1.3 Measured EC and Cation Sums

The criteria for this test are expressed as follows:

$$0.9 \times EC < 100 \times anion\ (or\ cation)\ sum < 1.1 \times EC \qquad \text{Equation (3)}$$

2.1.1.4 TDS to EC Ratios

The criteria for this test are expressed as follows:

$$0.55 < \frac{Measured\ TDS}{EC} < 0.7$$ Equation (4)

$$0.55 < \frac{Calculated\ TDS}{EC} < 0.7$$ Equation (5)

2.3.3 Define Analysis Period and Annualize the Data

The water quality point statistic for a given well is based on a 20-year moving average. For this AWQ recomputation, the 20-year period is from January 1, 1999 to December 31, 2018. When there is more than one water quality sample result for each well in a given calendar year, these values are averaged. Thus, only one value per year – the annualized average – will be used in the computation of AWQ. This technique is a form of temporal declustering. A well may have a maximum of 20 annualized averages where data exist for each year of the recomputation period, but a well must have a minimum of three annualized average values to be eligible to have a point statistic computed.

2.3.4 Shapiro-Wilk Test for Normality, Identification of Potential Outliers, and Development of Water Quality Point Statistics and Average Values

The Shapiro-Wilk test for normality and outlier testing was recommended and adopted by the Nitrogen/TDS Task Force at the June 15, 1999 meeting. For this test, the mean, standard deviation, and the statistic W were calculated. The calculated W was compared with a critical W found in reference tables to determine if the population in the dataset is normally distributed. If the dataset is not normally distributed, then the most discordant value (MDV) is discarded and a new W is calculated:

$$W = \frac{\left(\sum_{i=1}^{n} a_{i,n} \cdot x_i\right)^2}{\sum_{i=1}^{n} \left(x_i - x_{avg}\right)^2}$$ Equation (6)

Where: $a_{i,n}$ = coefficient based on the order of the observation, i, and the number of observations, n (*e.g.*, Gibbons, 1994)

x_i = i^{th} observation

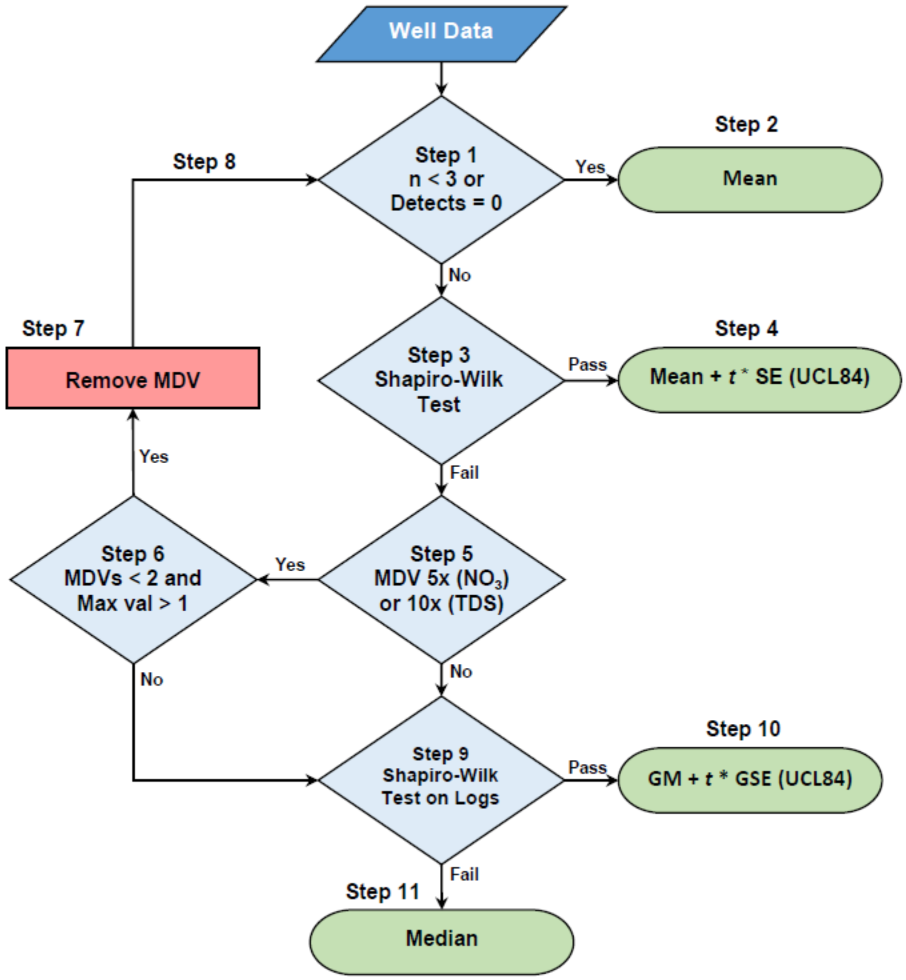
x_{avg} = mean of *n* observations

The MDV can be defined three ways: (1) the residual between the point and the corresponding y-value on the linear regression line, (2) the difference between the point and the mean value of the dataset, and (3) the difference between the point and the median value. The third method of determining the MDV was used in this study. In past AWQ recomputation efforts, the Shapiro-Wilk test was used to find and remove MDVs or outliers in an iterative fashion. In some cases, more than half of the annualized average values were removed from the dataset. In the 2018 current AWQ recomputation, the Shapiro-Wilk test was employed, but with three enhancements:

- Removal of outliers—MDVs—only occurred for values that were significantly greater than the median: 5 times (5x) for nitrate and 10x for TDS. This captures the original intent of the outlier test, which was to identify decimal placement errors or nitrate/nitrate as N conversion errors[5].
- Up to two MDVs, but not more, could be removed from a given dataset.
- If there is no MDV, but the dataset fails the Shapiro-Wilk test, or if two MDVs were removed and a third potential MDV is identified, then the dataset is log transformed and undergoes the Shapiro-Wilk test on the log-transformed data. A data transformation is the application of a mathematical function to every data point to meet an inference about the sample population. In this case, the assumption is that the data are logarithmically distributed and are transformed by taking the base-10 logarithm of each data point. The inverse logarithm is simply 10x, where x is the number undergoing inverse logarithmic transformation.

Figure 2-1 is a flow chart that depicts the outlier identification in this AWQ recomputation through the following steps:

[5] The conversion of nitrate units to nitrogen units is based on ratio of their molecular weights: MW_{NO3} / MW_N = ((14.0067 + 3*16) / (14.0067)) = 4.427



MDV = Most discordant value from median
SE = Standard error at student's t
GM = Geometric mean
GSE = Geometric standard error
UCL84 = 84% upper confidence limit of mean
For an explanation of the numbered steps, please refer to the text (Section 2.3.4).

Figure 2-1. Flow Chart for Outlier Identification and Computation of Point Statistics and Averages

1. The dataset is tested to determine if there are less than three annualized average values or there are no detected values.
2. If there are less than three annualized average values or there are no detected values, then the dataset for that well is not eligible to have a point statistic computed and a mean value is computed instead (as discussed in Section 4, point statistics are given preferences over mean values in drawing contour maps).
3. If there are three or more annualized average values, then the Shapiro-Wilk test is performed on the dataset.
4. If the dataset passes the Shapiro-Wilk test, then a point statistic is computed. The water quality point statistic is operationally defined as mean plus t times the standard error of the mean at an upper confidence level (UCL) of 0.84.
5. If the dataset fails the Shapiro-Wilk test, then the dataset is tested to see if the MDV is significantly greater than the median (5x for nitrate and 10x for TDS).

    a. If the MDV is significantly greater than the median, then the dataset moves to Step 6.
    b. If the MDV is not significantly greater than the median, then the dataset moves to Step 9.

6. If the MDV is significantly greater than the median, the dataset is checked to see if the previous MDV had been removed.

    a. Only a total of two MDVs can be removed. If there are fewer than two MDVs removed, then the dataset moves to Step 7.
    b. If two MDVs have been removed, then dataset moves to Step 9.

7. The current MDV is removed.
8. At this point, the dataset is retested beginning at Step 1.
9. The dataset is log transformed and the Shapiro-Wilk test is performed on the log-transformed dataset.
10. If the log-transformed dataset passes the Shapiro-Wilk test, then the geometric mean (GM) and the geometric standard error of the mean (GSE) are computed. A statistic, GM plus t times the GSE at an upper confidence level (UCL) of 0.84 is computed. Then the geometric statistic is inverse log transformed.
11. If the log-transformed dataset does not pass the Shapiro-Wilk test, then the geometric median is calculated, and then inverse log transformed.

Appendix A.2 contains an MS Excel file that summarizes all of the point statistics and averages that were computed in Task 1d. As stated in the RFP, “The Consultant will prepare tables that will describe (i) the results of the tests for normality, outliers, and data quality and (ii) the statistics by well for TDS and nitrate-nitrogen of the mean, standard deviation, standard error of the mean, and mean plus t times the standard error of the mean.”

2.4 Estimate Regional TDS and Nitrate in Groundwater (Task 1e)

The objective of this task is to prepare groundwater level and groundwater quality contour maps for all GMZs in the watershed. In strict accordance with procedures established by the Task Force, the steps described herein will be used to estimate regional nitrate and salinity (i.e., TDS) in groundwater.

For each GMZ (and for each GMZ with a multi-layer system), the following maps were produced (Appendix B):

- Groundwater level contours: 2018 data
- Nitrate (as N): current ambient (1999 to 2018)
- TDS: current ambient (1999 to 2018)

2.4.1 Water Quality Point Statistics and Average Values

As shown in Figure 2-1 and discussed in Section 2.3.4, the values that were computed to contour water quality are termed "water quality point statistic" and "average values." If a water quality point statistic could be computed, then these values were preferentially used in the generation of water quality maps and the development of water quality contours. If a water quality point statistic could not be computed, then the mean value (for a normal distribution) or inverse log-transformed median value were plotted but were given less weight in contouring.

- Water quality point statistic
  - The water quality point statistic, which is operationally defined as the mean plus t times the standard error of the mean at an upper confidence level (UCL) of 0.84.
  - The geometric point statistic, which is operationally defined as the geometric mean plus t times geometric standard error of the mean at an upper confidence level (UCL) of 0.84.

- Average values
  - The mean value for normally distributed data sets.
  - The inverse log-transformed median value log normally distributed data sets.

Table 2-2 summarizes analytics for each of the GMZs in the watershed, including the area of each GMZ (in square miles and acres), the volume of groundwater in storage (acre-feet [AF]) for the study period, the number of wells sampled and analyzed for TDS and nitrate, the number of wells for which point statistics could be computed, the percentage of wells with point statistics, and the TDS and nitrate well density. Note for example that the Arlington and some of the Riverside GMZs have relatively low water quality well densities, while the Riverside-A and Orange County (OC) GMZs have densities that are close to or greater than six wells per square mile. The relatively high water quality well density in Chino East is largely due to the monitoring program for the Stringfellow National Priorities List (NPL) site.

Table 2-2. Groundwater Management Zone Analytics (Page 1 of 2)

Groundwater Management Zone	Area		Volume (acre feet)	Total Dissolved Solids				Nitrate			
	Square Miles	Acres		Total Wells Sampled	Total Point Statistics	Percentage of Wells with Point Statistics	Well Density (wells per square mile)	Total Wells Sampled	Total Point Statistics	Percentage of Wells with Point Statistics	Well Density (wells per square mile)
San Bernardino Valley and Yucaipa / Beaumont Plains											
Beaumont	43	27,200	1,200,100	99	59	60%	2.3	97	66	68%	2.3
Bunker Hill-A	42	27,100	1,000,000	109	85	78%	32.6	105	85	81%	2.5
Bunker Hill-B	70	44,600	2,100,500	146	105	72%	2.1	136	99	73%	1.9
Lytle	11	6,850	400,000	38	27	71%	3.5	38	35	92%	3.5
San Timoteo	28	18,100	669,000	34	25	74%	1.2	34	21	62%	1.2
Yucaipa	40	25,500	684,000	114	72	63%	2.9	117	78	67%	2.9
San Jacinto Basins											
Canyon	7	4,390	99,800	27	24	89%	3.9	27	19	70%	3.9
Hemet-South	39	25,200	450,000	58	41	71%	1.5	58	41	71%	1.5
Lakeview/Hemet North	27	17,500	545,000	88	66	75%	3.3	88	54	61%	3.3
Menifee	9	5,630	107,000	22	19	86%	2.4	22	16	73%	2.4
Perris-North	59	38,000	453,000	42	33	79%	0.7	42	28	67%	0.7
Perris-South	39	25,200	757,000	67	54	81%	1.7	67	52	78%	1.7
San Jacinto-Lower Pressure	21	13,500	525,000	17	12	71%	0.8	17	3	18%	0.8
San Jacinto-Upper Pressure	33	20,900	1,038,400	111	81	73%	3.4	111	35	32%	3.4
Chino, Rialto / Colton, and Riverside Basins											
Chino-North	189	121,000	5,904,000	482	444	92%	2.6	975	480	49%	5.2
Chino-1/Chino North	62	39,500	2,104,500	179	102	57%	2.9	236	129	55%	3.8
Chino-2/Chino North	68	43,400	2,516,000	194	107	55%	2.9	204	107	52%	3.0
Chino-3/Chino North	60	38,500	1,283,500	109	78	72%	1.8	133	113	85%	2.2
Chino-East	12	7,950	77,000	207	33	16%	17.3	493	273	55%	41.1
Chino-South	21	13,100	187,000	59	23	39%	2.8	109	49	45%	5.2
Colton	10	6,080	169,000	10	9	90%	1.0	10	8	80%	1.0
Cucamonga	25	15,900	76,900	28	26	93%	1.1	28	23	82%	1.1
Rialto	28	17,600	980,700	91	58	64%	3.3	105	58	55%	3.8
Riverside-A	15	9,350	181,000	77	43	56%	5.1	71	42	59%	4.7
Riverside-B	11	6,710	180,700	27	10	37%	2.5	48	23	48%	4.4
Riverside-C	3	1,990	14,600	1	0	0%	0.3	4	3	75%	1.3
Riverside-D	14	8,640	?	1	1	100%	0.1	9	7	78%	0.6
Riverside-E	11	7,320	171,900	8	5	63%	0.7	9	4	44%	0.8
Riverside-F	10	6,070	127,400	27	22	81%	2.7	28	19	68%	2.8
Prado Basin	17	10,700	?	40	22	55%	2.4	40	22	55%	2.4
Elsinore / Temescal Valleys											
Arlington	21	13,700	58,100	19	6	32%	0.9	32	19	59%	1.5
Bedford	8	5,030	?	6	4	67%	0.8	6	4	67%	0.8
Coldwater	3	1,770	37,600	8	6	75%	2.7	9	6	67%	3.0
Elsinore	23	15,000	537,900	16	12	75%	0.7	16	10	63%	0.7
Lee Lake	7	4,720	?	7	6	86%	1.0	7	6	86%	1.0
Temescal	28	18,000	384,300	45	36	80%	1.6	46	38	83%	1.6
Warm Springs Valley	6	3,720	?	1	0	0%	0.2	1	0	0%	0.2

Table 2-2: Groundwater Management Zone Analytics (Page 2 of 2)

Groundwater Management Zone	Area		Volume (acre feet)	Total Dissolved Solids				Nitrate			
	Square Miles	Acres		Total Wells Sampled	Total Point Statistics	Percentage of Wells with Point Statistics	Well Density (wells per square mile)	Total Wells Sampled	Total Point Statistics	Percentage of Wells with Point Statistics	Well Density (wells per square mile)
Orange County Basins											
Irvine	84	53,900	1,800,800	119	101	85%	1.4	120	68	57%	1.4
La Habra	17	10,800	?	1	1	100%	0.1	1	0	0%	0.1
Orange County	255	163,000	23,900,400	1,710	1,320	77%	6.7	1,677	845	50%	6.6
Santiago	8	5,100	?	3	3	100%	0.4	3	3	100%	0.4

? Not enough data to estimate volume

The locations of wells for which point statistics and averages were determined are shown on Figures 2-2 and 2-3 for TDS and nitrate, respectively. Wells depicted by a square had the requisite data, passed the QA/QC steps and had a point statistic computed. Locations where only the mean or geometric median values could be computed are depicted with smaller circles. Note that, at the request of CBWM, the locations of the private wells for which point statistics and averages were determined and that were ultimately used to compute AWQ values are not shown in these figures.

2.4.2 Develop and Digitize Water Quality and Water Level Contours

The following information was used to prepare groundwater quality and groundwater elevation contour maps: (1) the computed statistics at wells, (2) the aquifer layer for the following GMZs: Chino-North, Orange County, Irvine, and Bunker Hill-A Pressure Zone and Bunker Hill-B Pressure Zone, (3) groundwater elevation measurements, and (4) contours from previous recomputation efforts. Some GMZs have multiple aquifer units. For those GMZs, information from the AWQ database or well construction data were used to identify which aquifer units a given well is screened against. Separate maps were prepared for these multi-aquifer GMZs.

Water quality and water level contours were hand-drawn by staff experienced in the hydrogeologic sciences. All groundwater level and groundwater quality contour maps were reviewed by a California certified hydrogeologist. A review of previous recomputation contours was incorporated into the contouring process to minimize subjective bias during the current contouring effort, which is especially important in areas where little data exist. Each contour was digitized and transformed into a geographic information system (GIS) shapefile.

Agency representatives were invited to review the water level and water quality contour maps; the consultants worked closely with Task Force members to perform an accurate and complete analysis of the groundwater quality within their agency's respective GMZs.

2.5 Compute Current Ambient TDS and Nitrate for Groundwater Management Zones (Task 1f)

GIS tools were used to compute the volume-weighted estimates of AWQ for the GMZs. In Task 1e, the water quality point statistics for both TDS and nitrate, as well as water levels, were contoured and reviewed by the Task Force members. The finalized contours and points were interpolated using kriging techniques in which the surrounding measured values are weighted to derive a predicted value for an unmeasured location to create a raster grid. The kriging interpolation method used is identical to prior AWQ determinations. The raster files went through a thorough QA/QC process.

A geoprocessing model in ArcGIS was used to automate the process of extracting the values from the TDS, nitrate, and groundwater elevation raster files to the SAWPA-supplied AWQ grid shapefile. Specific yield, and bottom of aquifer, and layers in multilayer GMZs were already included in the grid shapefile. The volume of groundwater for a single-layer aquifer system is simply the difference between groundwater elevation and the bottom of the aquifer, accounting for area and specific yield and summing for all grid cells or portions of grid cells in the GMZ, as follows:

$$V = \sum_{i=1}^{n} A_i \cdot \left(GWE_i - BOA_i\right) \cdot SY_i \qquad \text{Equation (7)}$$

where V = volume of groundwater in the GMZ

A_i = area of the i^{th} grid cell

GWE_i = groundwater elevation (feet above mean sea level [feet msl])

BOA_i = bottom of the aquifer of the i^{th} grid cell (feet msl)

SY = specific yield of the i^{th} grid cell

n = number of grid cells

The geoprocessing model links together sequences of geoprocessing tools, feeding the output of one tool into another tool as input to produce the desired outcome. The model documents and streamlines the process and enables efficient replication for populating the AWQ grid. The AWQ grid was exported to a Microsoft Excel spreadsheet, where the following steps were executed to compute the volume-weighted estimates of ambient TDS and nitrate for the 2015 current AWQ recomputation period:

1. Overlay the SAWPA-provided 400-meter x 400-meter grid on each GMZ.
2. Compute volume of groundwater in storage in each grid cell.
3. Compute volume of groundwater in storage in each layer of multi-layer aquifers (Chino North, Orange County, and Bunker Hill Pressure Zone).
4. Compute volume of groundwater in each GMZ.
5. Estimate the value of the water quality statistics for each grid cell.
6. Compute volume-weighted estimate of TDS and nitrate for each aquifer in each GMZ, as follows:

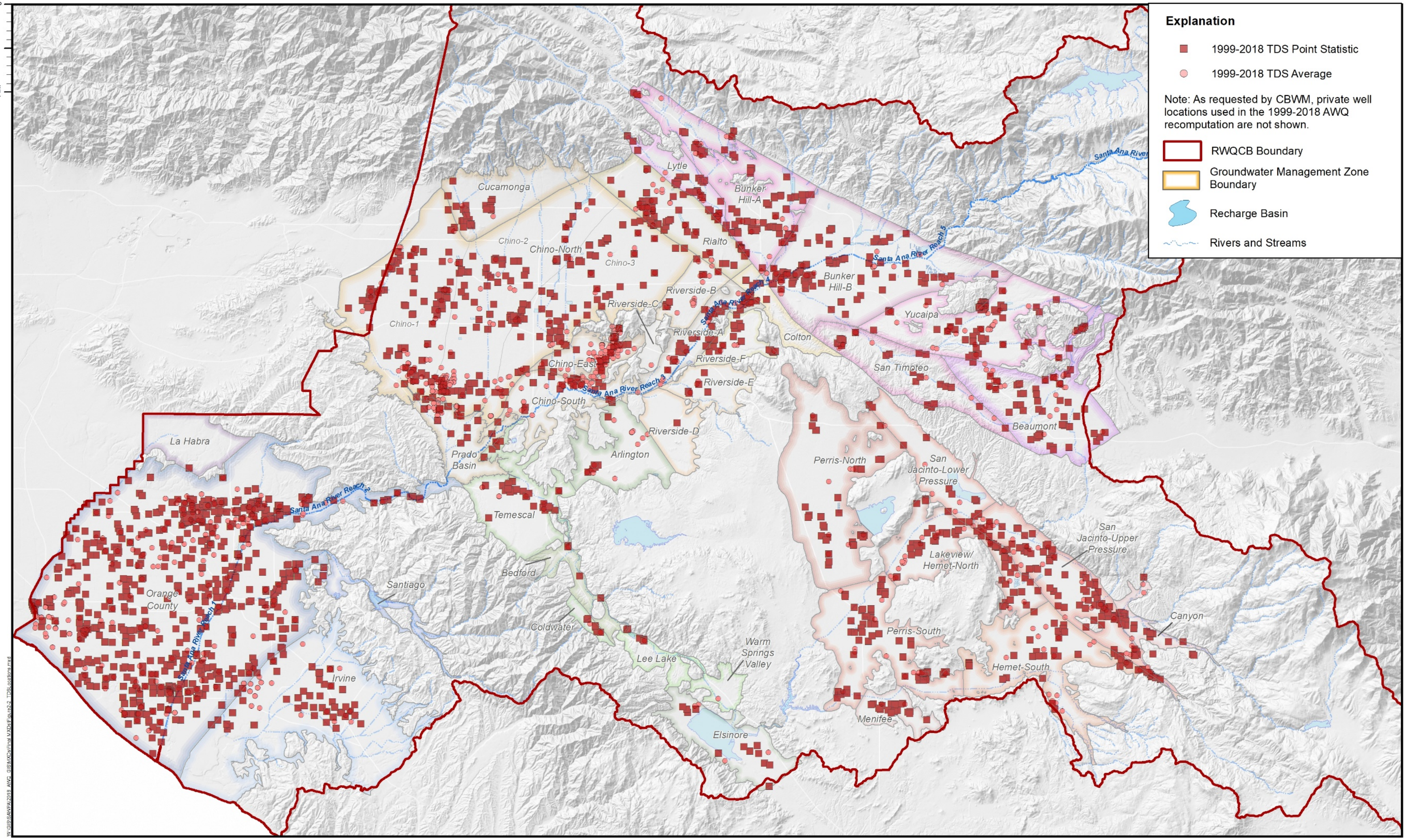
$$C_{avg} = \frac{\sum_{i=1}^{n} C_i \cdot V_i}{\sum_{i=1}^{n} V_i} \qquad (8)$$

where C_{avg} = the volume-weighted current ambient concentration in a GMZ

C_i = the current ambient concentration of groundwater in the ith grid cell

V_i = the volume of groundwater in the ith grid cell

n = number of grid cells



Prepared by:

WSC Water Systems Consulting, Inc.

Author: EC

Date: 3/5/2020

File Name: Figure2-2_TDSLocations

N

1 in : 5.5 mi

0 1.75 3.5 7 Mi

0 2.75 5.5 11 Km

References:

1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for:

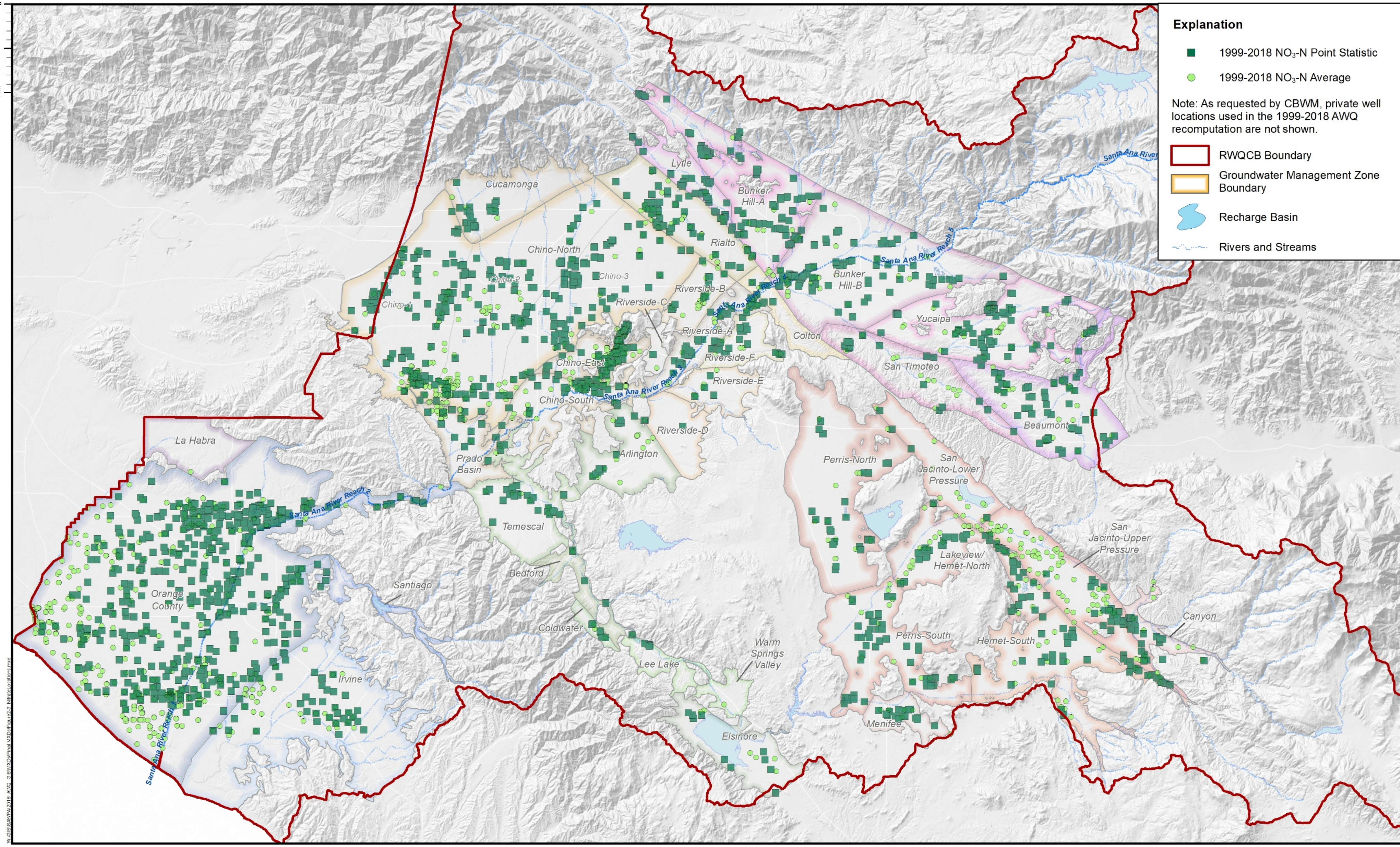
SAWPA

SAWPA Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality for the Period 1999 to 2018

Locations of TDS Point Statistics and Averages Santa Ana River Watershed

Figure 2-2



Prepared by:

WSC Water Systems Consulting, Inc.

Author: EC

Date: 3/5/2020

File Name: Figure2-3_NitrateLocations

N

1 in : 5.5 mi

0 1.75 3.5 7 Mi

0 2.75 5.5 11 Km

References:
1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for:

SAWPA

SAWPA Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality
for the Period 1999 to 2018

Locations of NO_3-N Point Statistics and Averages
Santa Ana River Watershed

Figure 2-3

SECTION 3

Ambient Water Quality Results for the 2018 Recomputation

This section presents the results of the AWQ recomputation for the current period (1999 to 2018) determination, including an assessment of current assimilative capacity. The Basin Plan requires that the AWQ be computed every three years. The triennial AWQ determinations from each current period are used to assess compliance with the WQOs and to determine if assimilative capacity exists for each GMZ. By definition, assimilative capacity is determined to be the difference between the WQO and the current AWQ: if the current quality of the GMZ is better than the WQO, then assimilative capacity exists. Assimilative capacity does not exist if the current quality of a GMZ is the same as or poorer than the WQOs.

IN THIS SECTION

3.1 2018 Current Ambient TDS and Nitrate Concentrations for Groundwater Management Zones

As described in Section 2.5, a combination of steps using analytical tools (GIS and MS Excel) was employed to compute the volume-weighted estimates of AWQ for the GMZs:

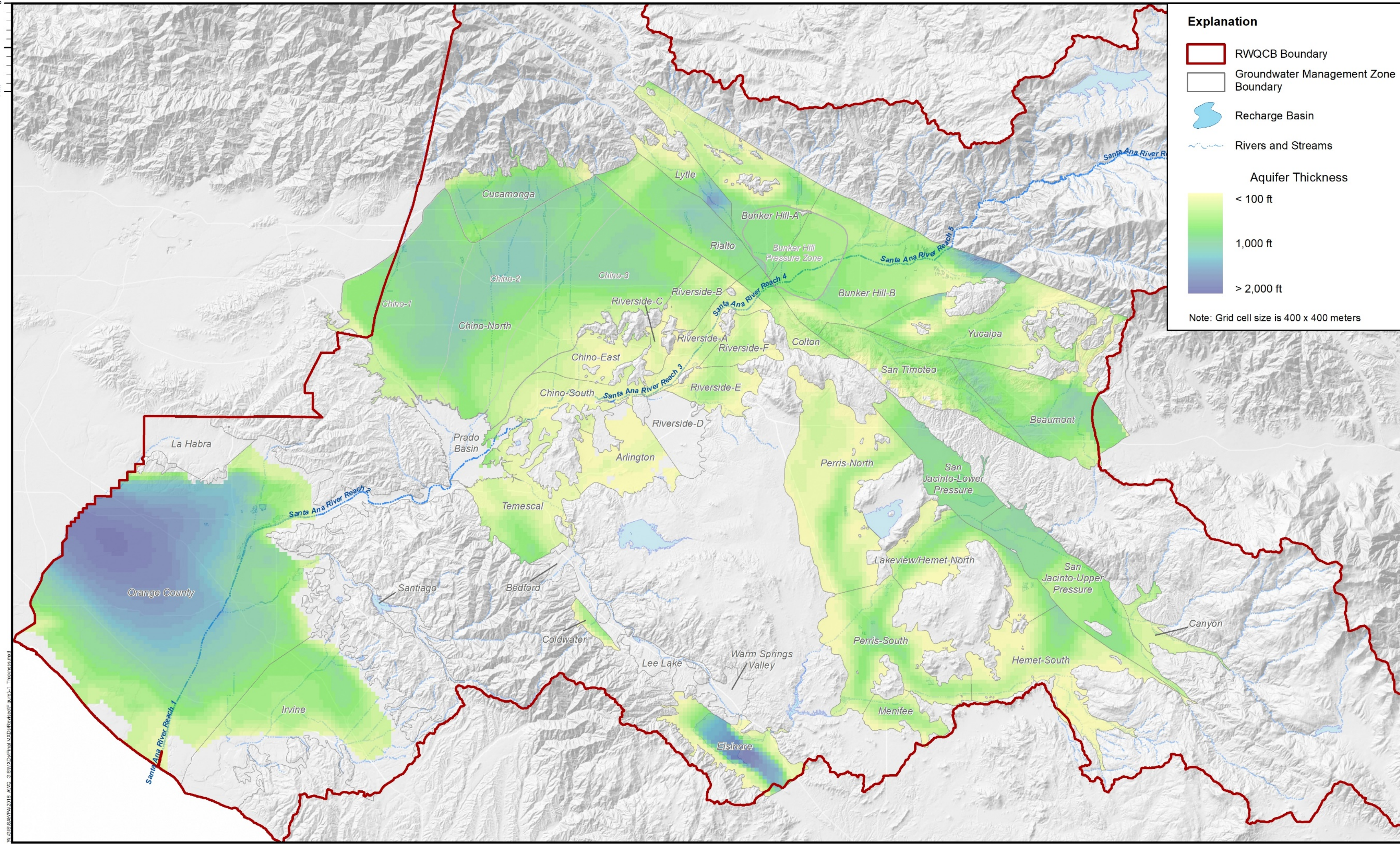
1. Water quality point statistics (and averages) for both TDS and nitrate, as well as water levels, were mapped, contoured, and reviewed by the Task Force members. The previous period's contours were used as a starting point for developing new water level and water quality contours.
2. The finalized contours and points were interpolated using kriging techniques.
3. A geoprocessing model in ArcGIS was used to automate the process of extracting the values from the TDS, nitrate, and groundwater elevation raster files to the SAWPA-supplied AWQ grid shapefile. Specific yield, bottom of aquifer, and layers in multilayer GMZs were already included in the grid shapefile.
4. The 400-meter x 400-meter grid was overlaid on each GMZ.
5. The volume of groundwater in storage in each grid cell was computed.
6. The volume of groundwater in storage in each layer of multi-layer aquifers (Chino North, Orange County, and Bunker Hill Pressure Zone) was computed.
7. The volume of groundwater in each GMZ was computed (this is the summation of water in storage for each of the grid cells or partial grid cells comprising the GMZ).
8. Water quality for each grid cell was assigned based on the kriging results.
9. The volume-weighted estimate of TDS and nitrate concentrations for each aquifer in each GMZ was computed by dividing the total mass of TDS or nitrate in each GMZ by the total volume of water in storage in each GMZ.

In Step 5, the groundwater storage in each grid cell was computed from the groundwater elevation, bottom of the aquifer, and specific yield. Figure 3-1 shows the thickness of the aquifer, by grid cell, for all of the GMZs. For multi-layered GMZs, the thickness shown is the total of all layers. Figure 3-2 displays the specific yield, by grid cell, for all of the GMZs. For multi-layered GMZs, only specific yield values for Layer 1 are shown on the map (specific yield values for each layer in a multi-layer system were used in the computation). Figure 3-3 shows the amount of groundwater in storage, which is the product of saturated volume and specific yield. Values of groundwater storage range from less than 1 AF per grid cell to more than 20,000 AF. The highest storage values occur in the OC GMZ forebay area, where the saturated thickness is greater and where specific yield values are estimated by OCWD's model to be greater than 25 percent.

Computed ambient water quality data—TDS and nitrate—are shown in Tables 3-1 and 3-2. Figures 3-4, 3-5, and 3-6 provide maps that analyze the TDS AWQ findings for the 2018 current AWQ recomputation period.

Figure 3-4 shows that the highest concentrations of TDS are along the coast in the OC GMZ, where there has been historical and ongoing seawater intrusion (Alamitos, Bolsa, and Talbert Gaps), in the Irvine GMZ, and in the Perris South and Menifee GMZs. Figure 3-5 shows the mass (in tons of salt) in each grid cell. The TDS mass per grid cell is highest in the OC GMZ—forebay area and seawater intrusion zones—and in Perris South GMZ. The high mass per grid cell in the OC GMZ forebay area reflects the high volume of groundwater storage in that area. Figure 3-6 is a map that depicts the changes in TDS concentration in groundwater between the 2015 and 2018 recomputation periods from two distinct perspectives. The grid cells on the map grade from red (1,000 mg/L increase in TDS concentration) to green (1,000 mg/L decrease in TDS concentration). Most of the grid cells in the GMZs are light yellow to light peach, indicating that there is either no change or a small increase in TDS over that period. A reduction in computed TDS concentrations has occurred in the vicinity of the boundary between Perris North and Perris South GMZs due to the method used to draw the TDS contours. Contours in previous recomputations were extended between the two GMZs, increasing the TDS in the Perris-North GMZ. The map also shows the 20-year trend in TDS concentration in the key wells using the Mann-Kendall trend analysis. For consistency, key wells identified in WEI (2014) were used in this study. This trend analysis is discussed in more detail in Section 4.3.2.

Figures 3-7, 3-8, and 3-9 are a parallel series of maps that analyze the nitrate AWQ findings for the current period. High concentrations of nitrate occur in portions of several GMZs: Irvine, Temescal, Arlington, Chino North, Chino South, Chino East, Riverside, and San Jacinto GMZs. Figure 3-8 shows the mass (in tons of nitrate) in each grid cell. The nitrate mass per grid cell is highest in the OC GMZ forebay area and in the southern portion of Chino North, Chino South, and Chino East GMZs. The high mass per grid cell in the forebay area reflects the high volume of groundwater storage in that area. Figure 3-9 depicts the changes in nitrate concentrations in groundwater between the 2012 and 2015 analyses from two distinct perspectives. The grid cells on the map grade from red (10 mg/L increase in nitrate concentrations) to green (10 mg/L decrease in nitrate concentrations). Most of the grid cells in the GMZs are light yellow to light peach, indicating that there is no change to a small increase in nitrate over that period. There are areas where nitrate concentrations are also decreasing. The map also shows the trends in nitrate concentration in the key wells using the Mann-Kendall trend analysis. This trend analysis is discussed in more detail in Section 4.3.2.



Prepared by:

WSC Water Systems Consulting, Inc.

Author: EC
Date: 3/22/2020

File Name: Figure3-1_Thickness

N

1 in : 5.5 mi

0 1.75 3.5 7 Mi

0 2.75 5.5 11 Km

References:
1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for:

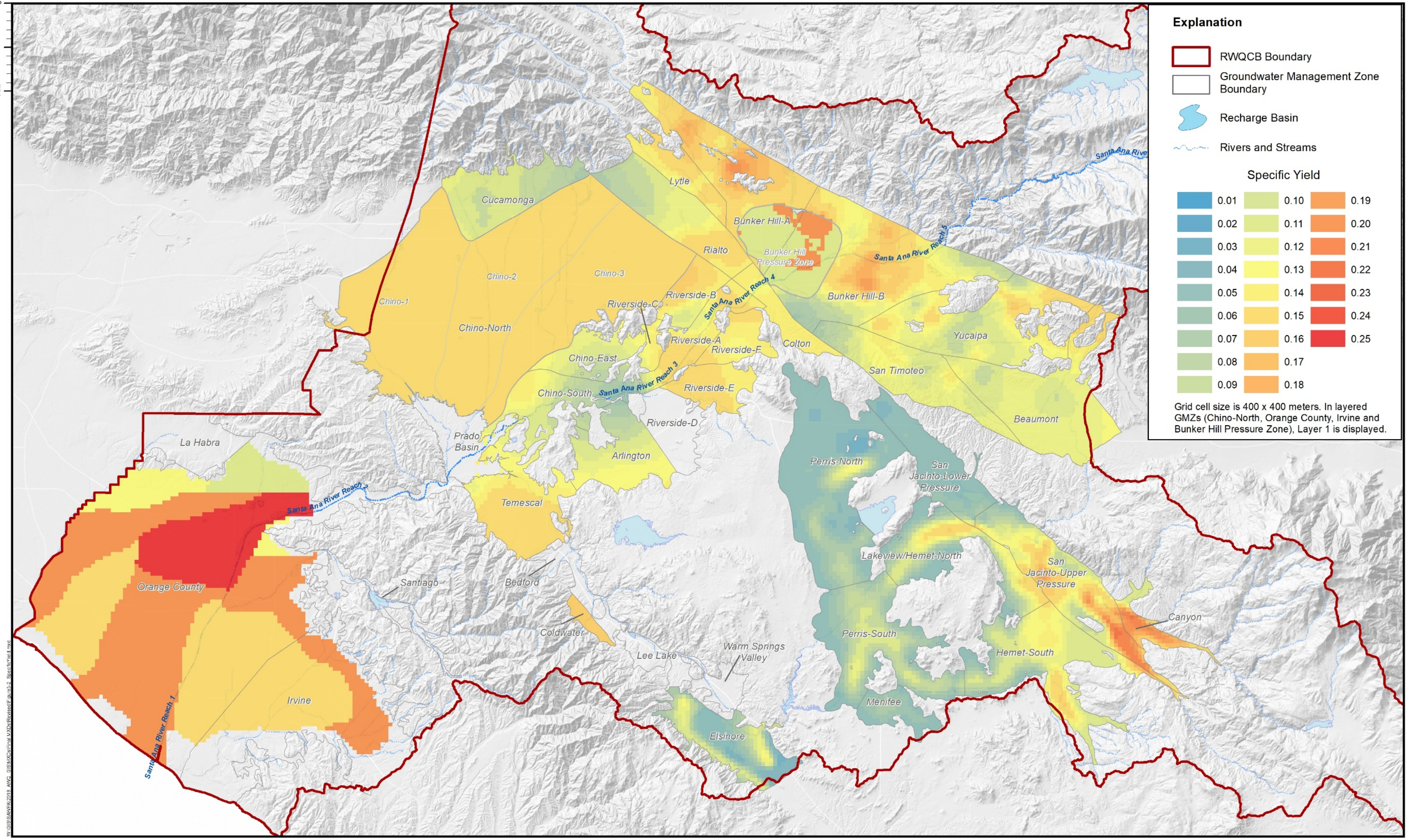
SAWPA

SAWPA Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality for the Period 1999 to 2018

Total Potential Aquifer Thickness
Santa Ana River Watershed

Figure 3-1



Prepared by:

WSC Water Systems Consulting, Inc.

Author: EC

Date: 3/20/2020

File Name: Figure3-2_SpecificYield

N

1 in : 5.5 mi

0 1.75 3.5 7 Mi

0 2.75 5.5 11 Km

References:

1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for:

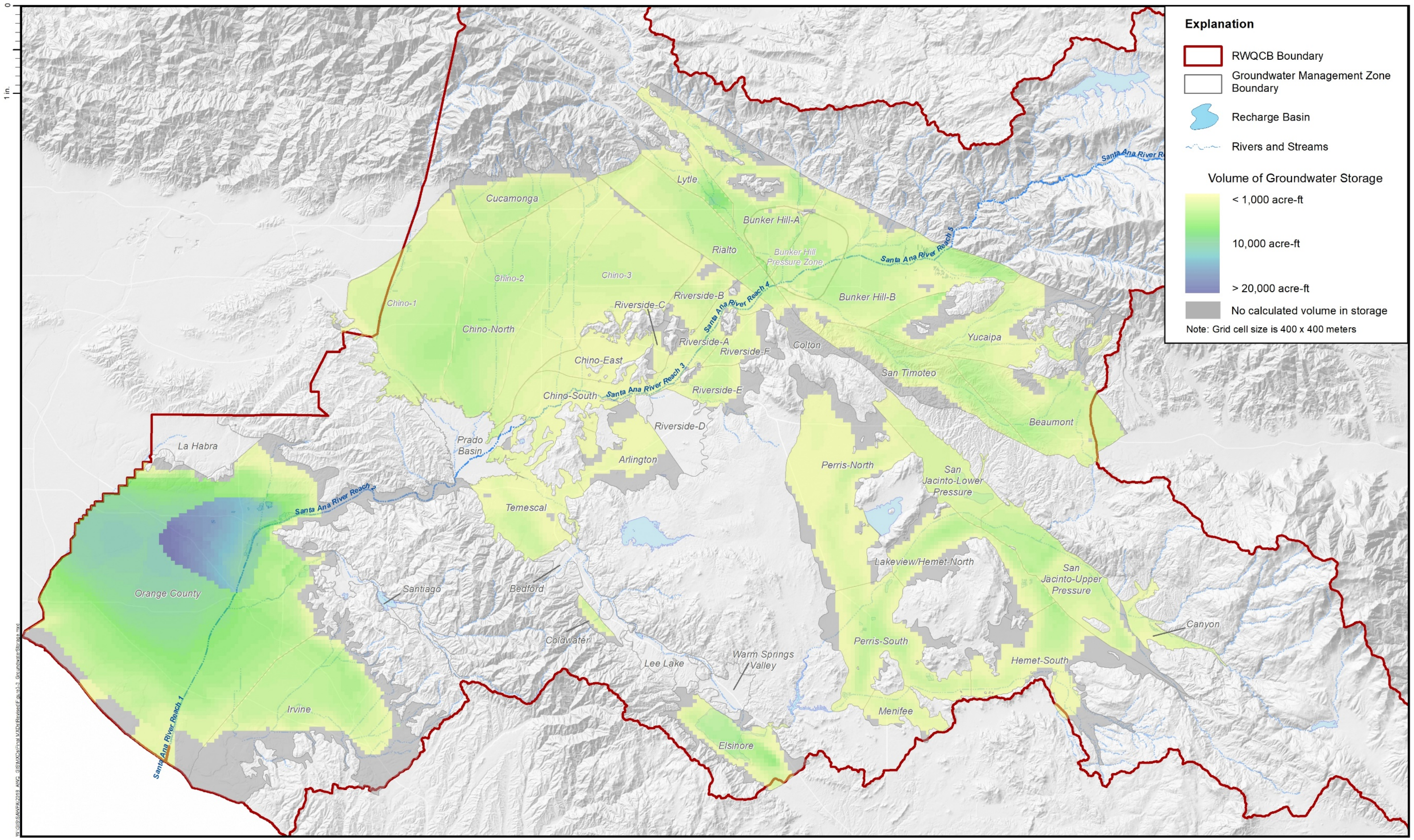
SAWPA

SAWPA Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality for the Period 1999 to 2018

Specific Yield
Santa Ana River Watershed

Figure 3-2



Prepared by:

WSC
Water Systems Consulting, Inc.

Author: EC
Date: 3/20/2020

File Name: Figure3-3_GroundwaterStorage

N

1 in : 5.5 mi

0 1.75 3.5 7 Mi
0 2.75 5.5 11 Km

References:
1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for:

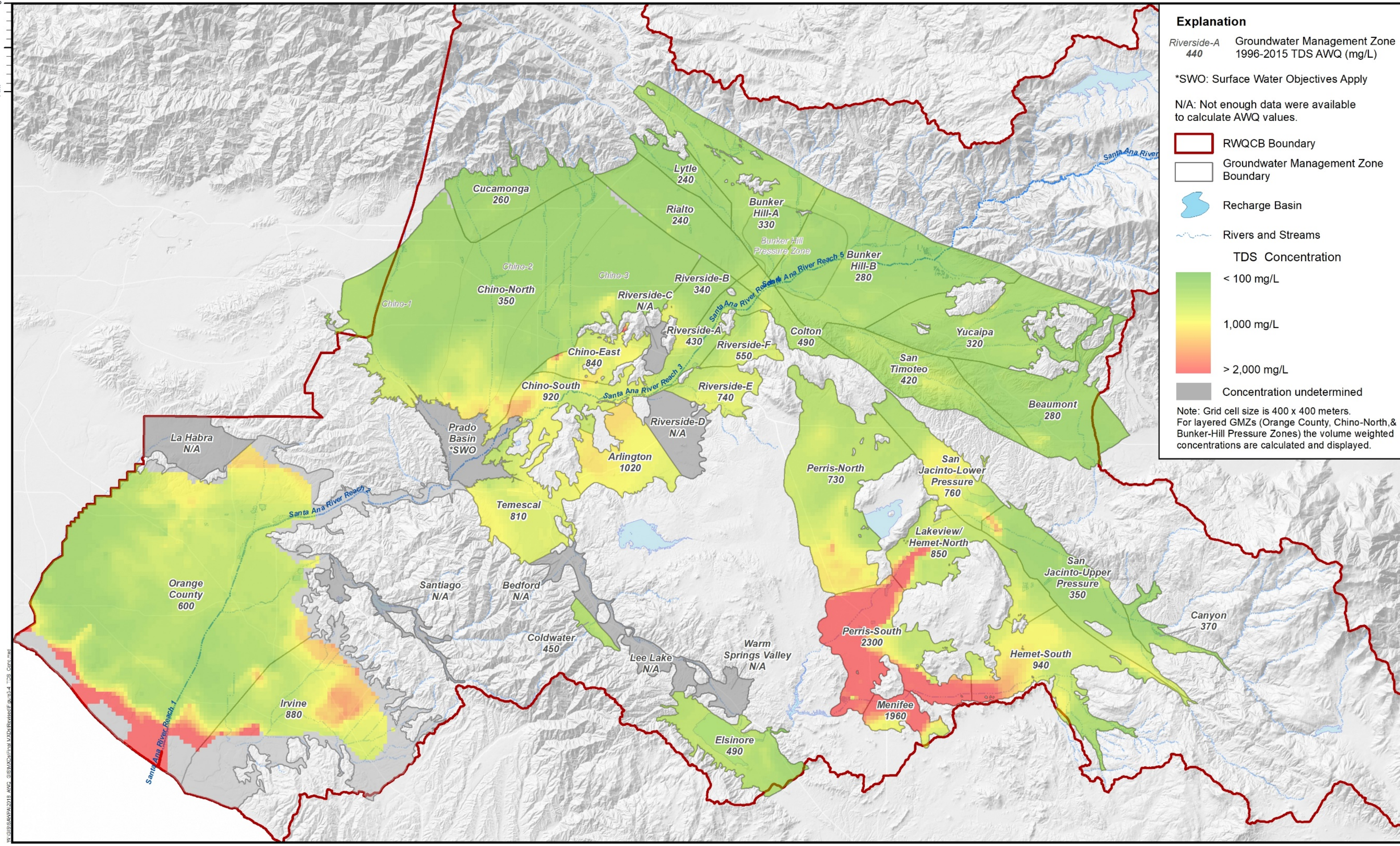
SAWPA

SAWPA Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality for the Period 1999 to 2018

Volume Groundwater in Storage - 2018
Santa Ana River Watershed

Figure 3-3



Prepared by:

WSC
Water Systems Consulting, Inc.

Author: EC
Date: 3/20/2020

File Name: Figure3-4_TDS_Conc

N

1 in : 5.5 mi

0 1.75 3.5 7 Mi

0 2.75 5.5 11 Km

References:
1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for:

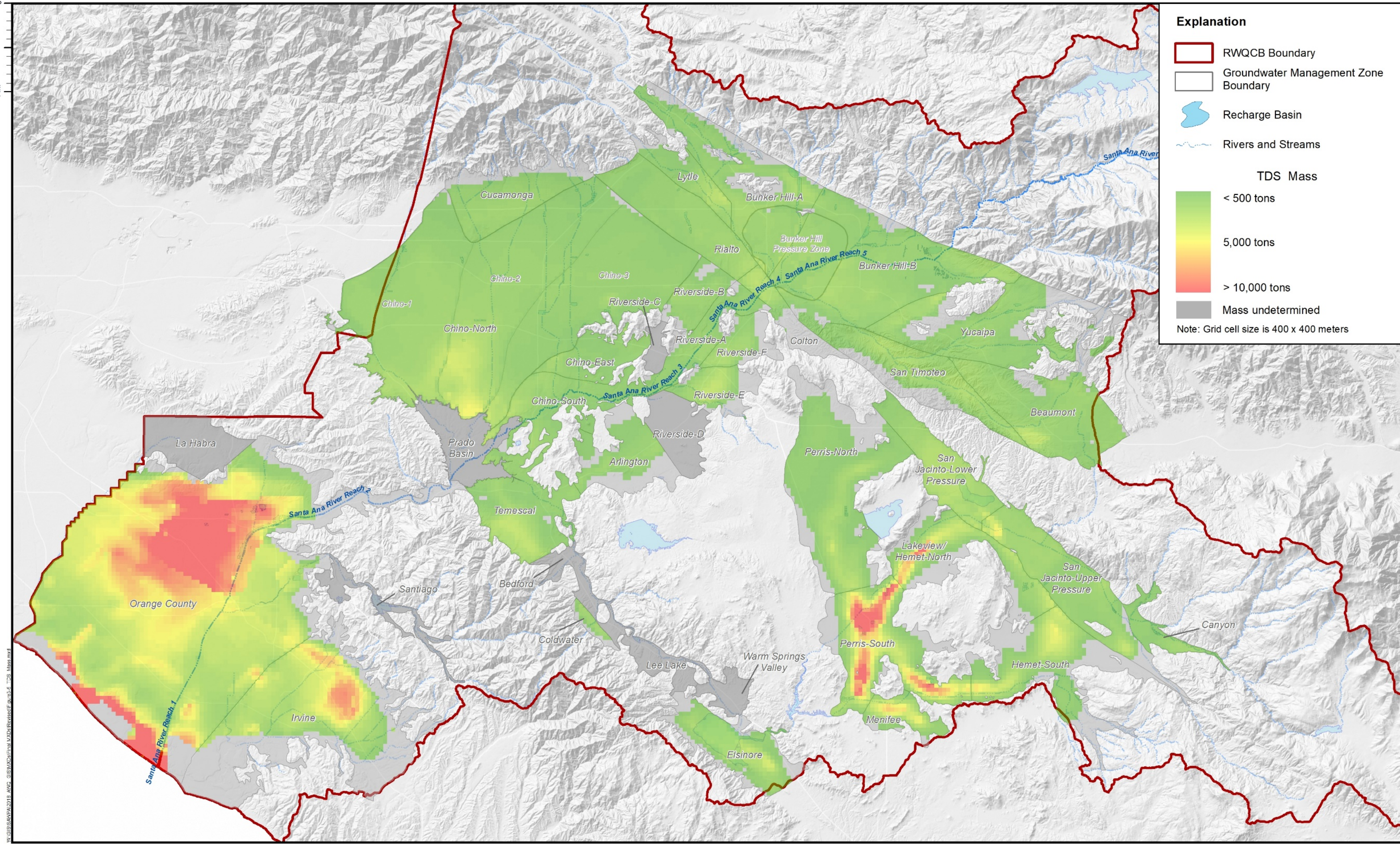
SAWPA

SAWPA Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality
for the Period 1999 to 2018

Ambient Water Quality - TDS Concentration
Santa Ana River Watershed

Figure 3-4



Prepared by:

WSC
Water Systems Consulting, Inc.

Author: EC
Date: 3/20/2020

File Name: Figure3-5_TDS_Mass

N

1 in : 5.5 mi

0 1.75 3.5 7 Mi
0 2.75 5.5 11 Km

References:
1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for:

SAWPA

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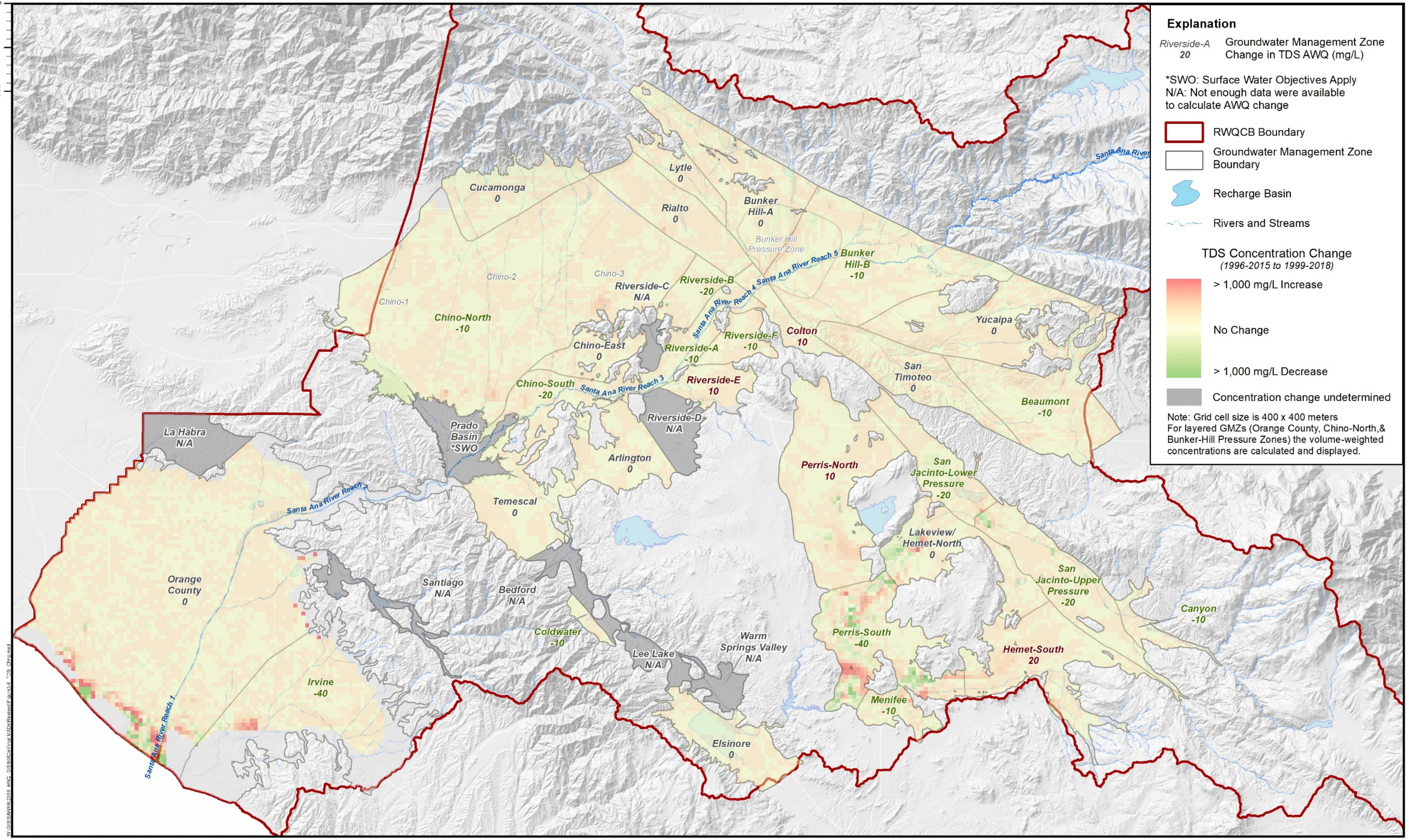
Recomputation of Ambient Water Quality
for the Period 1999 to 2018

Mass of TDS in Groundwater
Santa Ana River Watershed

Figure 3-5



Prepared by:

WSC Water Systems Consulting, Inc.

Author: EC
Date: 3/20/2020

File Name: Figure3-6_TDS_Chng

N

1 in : 5.5 mi

0 1.75 3.5 7 Mi

0 2.75 5.5 11 Km

References:
1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for:

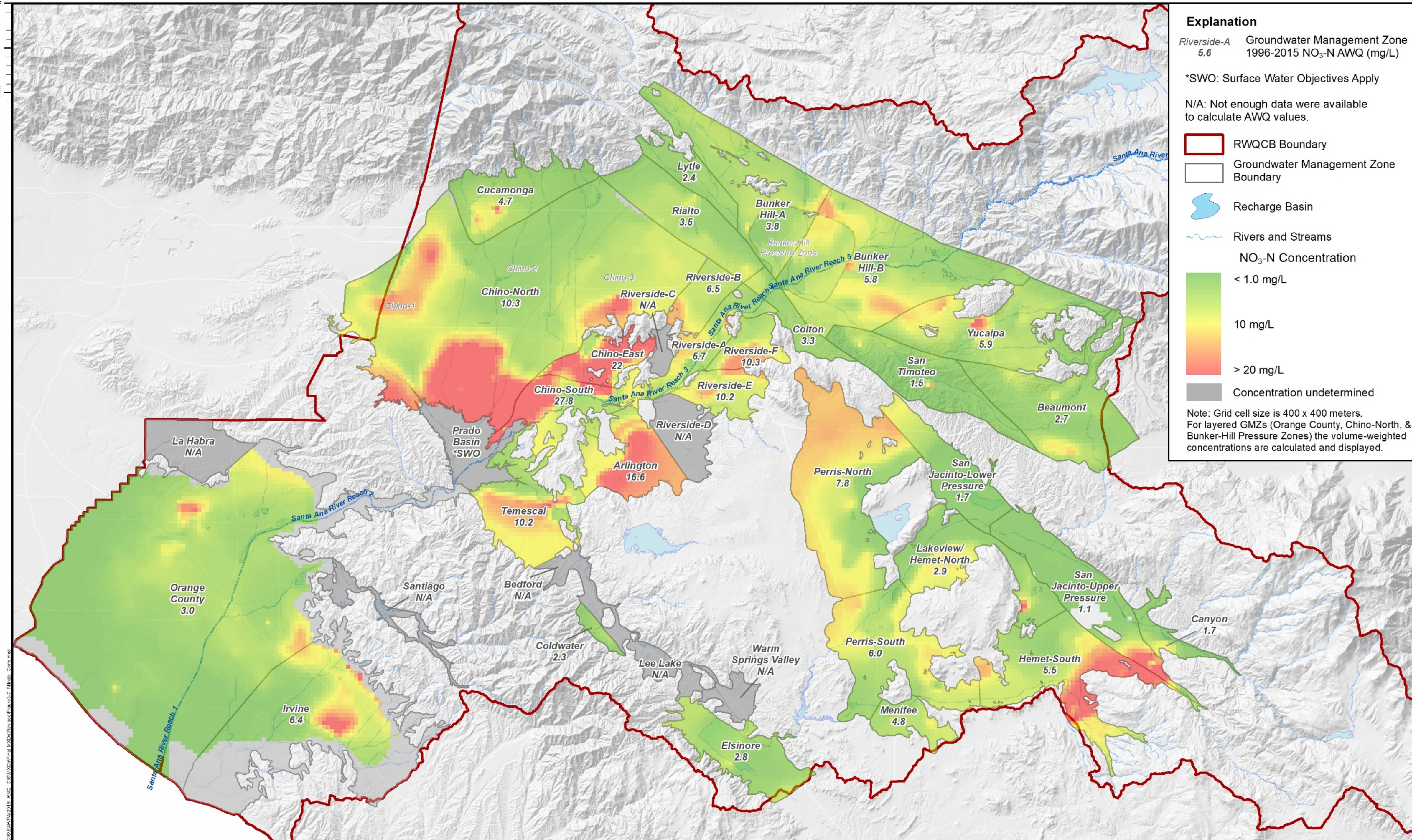
SAWPA

SAWPA Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality for the Period 1999 to 2018

TDS Concentration Change (1996-2015 to 1999-2018)
Santa Ana River Watershed

Figure 3-6



Prepared by:

WSC Water Systems Consulting, Inc.

Author: EC
Date: 3/20/2020

File Name: Figure3-7_Nitrate_Conc

N

1 in : 5.5 mi

0 1.75 3.5 7 Mi

0 2.75 5.5 11 Km

References:
1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for:

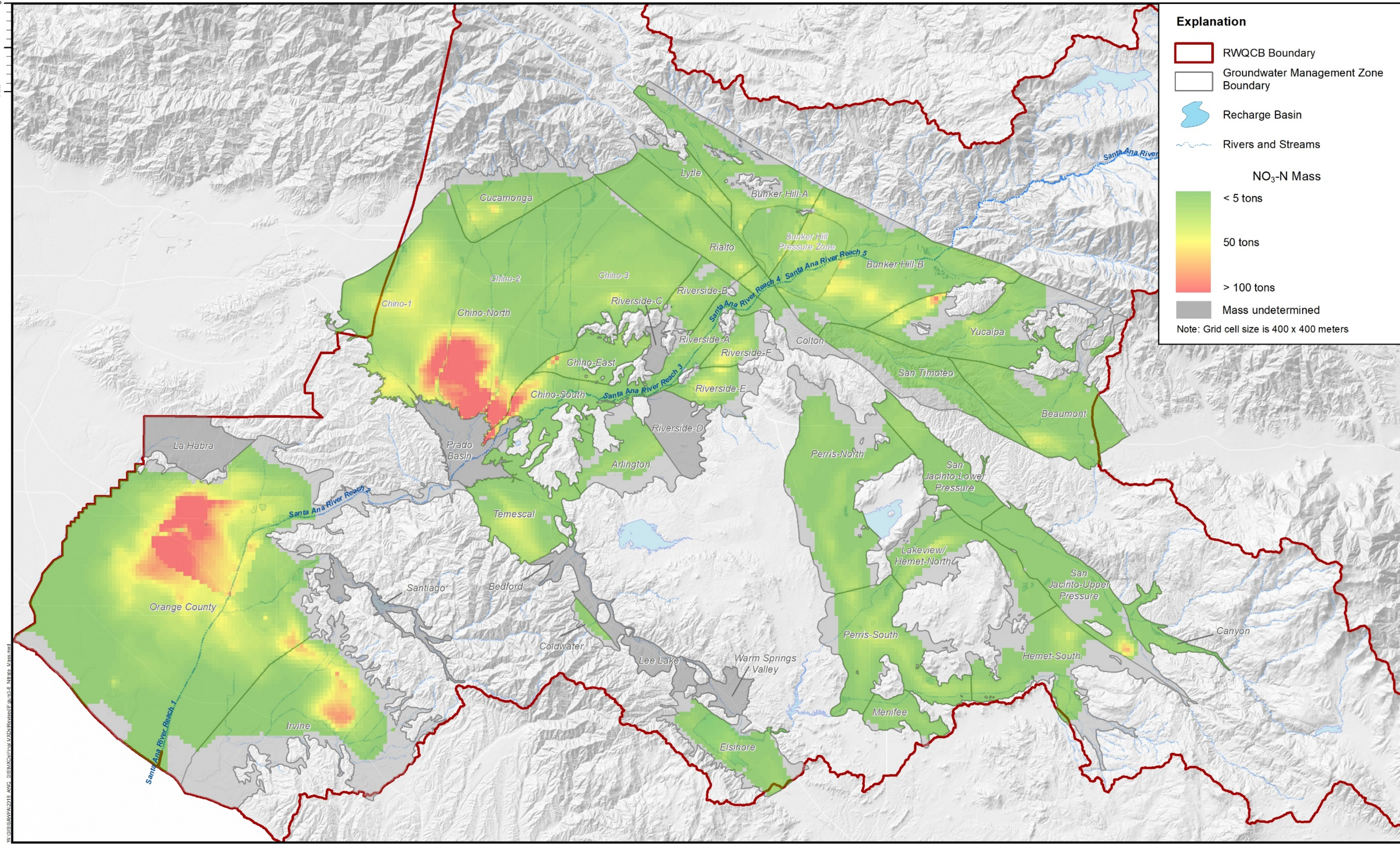
SAWPA

SAWPA Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality for the Period 1999 to 2018

Ambient Water Quality NO_3-N Concentration Santa Ana River Watershed

Figure 3-7



Prepared by:

WSC
WATER SYSTEMS CONSULTING, INC.

Author: EC
Date: 3/20/2020

File Name: Figure3-8_Nitrate_Mass

N

1 in : 5.5 mi

0 1.75 3.5 7 Mi
0 2.75 5.5 11 Km

References:
1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for:

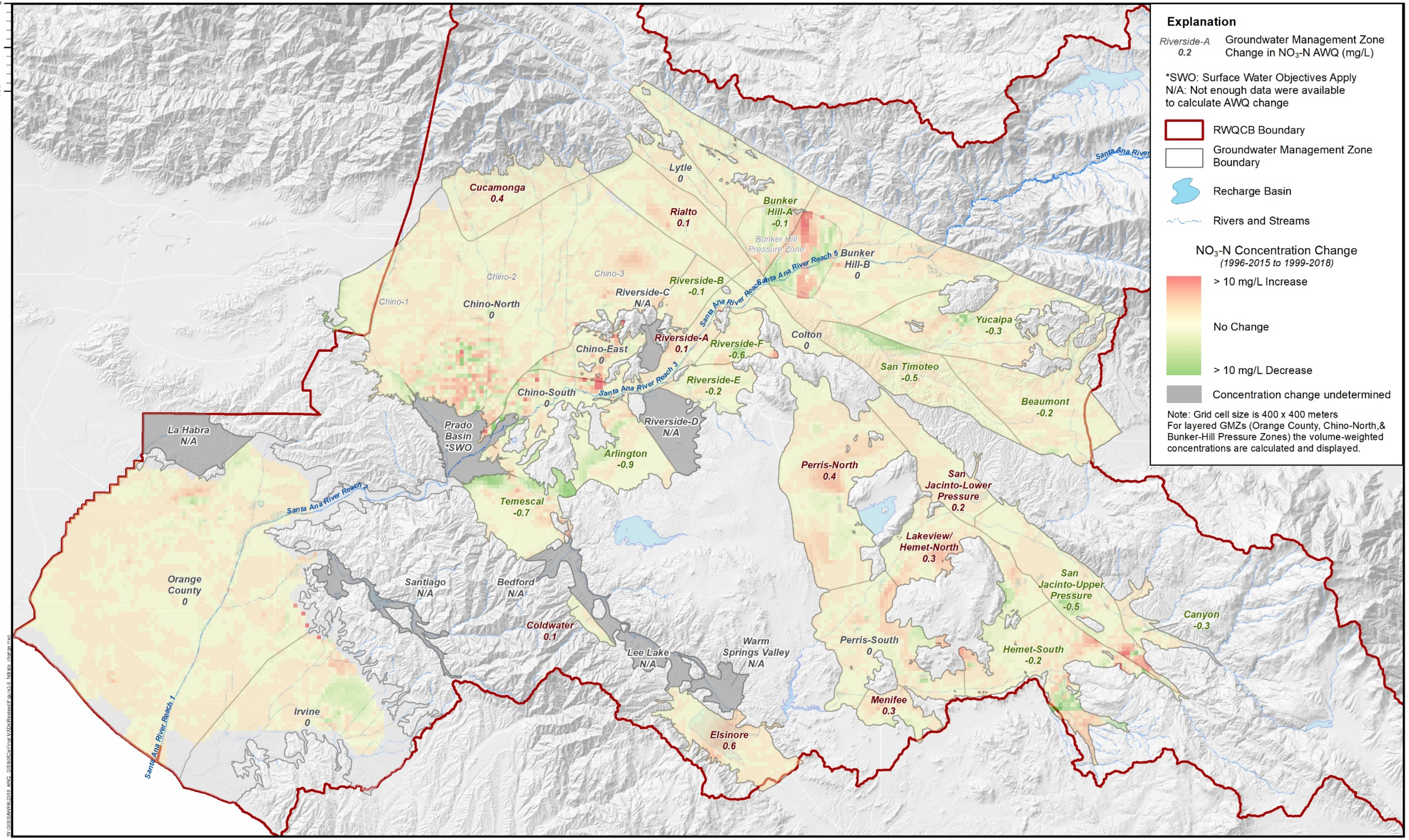
SAWPA

SAWPA Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality
for the Period 1999 to 2018

Mass of NO_3-N in Groundwater
Santa Ana River Watershed

Figure 3-8



Prepared by:

WSC Water Systems Consulting, Inc.

Author: EC

Date: 3/20/2020

File Name: Figure3-9_Nitrate_change

N

1 in : 5.5 mi

0 1.75 3.5 7 Mi

0 2.75 5.5 11 Km

References:

1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for:

SAWPA

SAWPA Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality for the Period 1999 to 2018

NO_3-N Concentration Change (1996-2015 to 1999-2018)
Santa Ana River Watershed

Figure 3-9

3.2 Assimilative Capacity Determination

The triennial AWQ determinations from each current period are used to assess compliance with the WQOs and to determine if assimilative capacity exists for each GMZ. By definition, assimilative capacity is determined to be the difference between the objective and the current AWQ: if the current quality of the GMZ is better than the water quality objective, then assimilative capacity exists. Assimilative capacity does not exist if the current quality of a GMZ is the same as or poorer than the WQOs. Allocation of assimilative capacity, or some portion of assimilative capacity, by permitting discharges containing TDS and/or nitrate at concentrations higher than their objectives is at the discretion of the RWQCB.

Certain stakeholders have petitioned the RWQCB to raise the objective of their GMZ based on a demonstration of maximum benefit to the people of the state of California. The GMZs with “maximum benefit” WQOs are Chino-North, Cucamonga, Yucaipa, San Timoteo, Beaumont, and San Jacinto-Upper Pressure. In those GMZs, both the antidegradation and maximum benefit objectives are shown in Tables 3-1 and 3-2.

GMZs that have assimilative capacity have positive values in the last column of the tables. GMZs with negative values in the assimilative capacity column of Tables 3-1 and 3-2 have no assimilative capacity; the magnitude of the negative value is simply the difference between current ambient and the WQO and is an indication of how close the GMZ is to the meeting groundwater quality objectives. Assimilative capacities for TDS and nitrate are shown in Figures 3-10 and 3-11.

Table 3-1. TDS Water Quality Objectives, Ambient Water Quality, and Assimilative Capacity (Page 1 of 2)

Groundwater Management Zones	Total Dissolved Solids Concentration (mg/L)										
	Water Quality Objective	Historical Ambient[1]	1997 Ambient	2003 Ambient	2006 Ambient	2009 Ambient	2012 Ambient	2015 Ambient	2018 Ambient	Difference from 2015 to 2018	Assimilative Capacity
San Bernardino Valley and Yucaipa / Beaumont Plains											
Beaumont, “maximum benefit”	330	233	290	260	260	280	290	290	280	-10	50
Beaumont, “antidegradation”	230	233	290	260	260	280	290	290	280	-10	None (-50)
Bunker Hill-A	310	313	350	320	330	340	340	330	330	0	None (-20)
Bunker Hill-B	330	332	260	280	280	270	280	290	280	-10	50
Lytle	260	264	240	230	230	240	240	240	240	0	20
San Timoteo, “maximum benefit”	400	303	300	?	?	420	410	420	420	0	None (-20)
San Timoteo, “antidegradation”	300	303	300	?	?	420	410	420	420	0	None (-120)
Yucaipa, “maximum benefit”	370	319	330	310	310	320	320	320	320	0	50
Yucaipa, “antidegradation”	320	319	330	310	310	320	320	320	320	0	0
San Jacinto Basins											
Canyon	230	234	220	420	370	420	340	380	370	-10	None (-140)
Hemet-South	730	732	1030	850	920	910	940	920	940	20	None (-210)
Lakeview/Hemet North	520	519	830	840	880	890	860	850	850	0	None (-330)
Menifee	1020	1021	3360	2220	2140	2050	2030	1970	1960	-10	None (-940)
Perris-North	570	568	750	780	730	770	760	720	730	10	None (-160)
Perris-South	1260	1258	3190	2200	2600	2470	2400	2340	2300	-40	None (-1040)
San Jacinto-Lower Pressure	520	520	730	950	810	800	800	780	760	-20	None (-240)
San Jacinto-Upper Pressure, “maximum benefit”	500	321	370	370	350	350	350	370	350	-20	150
San Jacinto-Upper Pressure, “antidegradation”	320	321	370	370	350	350	350	370	350	-20	None (-30)
Chino, Rialto / Colton, and Riverside Basins											
Chino-North, “maximum benefit”	420	260	300	320	340	340	350	360	350	-10	70
Chino-1, “antidegradation”	280	280	310	330	340	340	350	350	340	-10	None (-60)
Chino-2, “antidegradation”	250	250	300	340	360	360	380	380	380	0	None (-130)
Chino-3, “antidegradation”	260	260	280	280	310	320	320	320	320	0	None (-60)
Chino-East	730	733	760	620	650	770	770	840	840	0	None (-110)
Chino-South	680	676	720	790	940	980	990	940	920	-20	None (-240)
Colton	410	407	430	430	450	430	440	480	490	10	None (-80)
Cucamonga, “maximum benefit”	380	212	260	250	250	250	260	260	260	0	120
Cucamonga, “antidegradation”	210	212	260	250	250	250	260	260	260	0	None (-50)
Rialto	230	230	230	220	230	230	230	240	240	0	None (-10)
Riverside-A	560	560	440	440	440	430	420	440	430	-10	130
Riverside-B	290	289	320	310	340	340	340	360	340	-20	None (-50)
Riverside-C	680	684	760	750	740	740	730	?	?	?	?
Riverside-D	810	812	?	?	?	?	?	?	?	?	?
Riverside-E	720	721	720	700	710	700	740	730	740	10	None (-20)
Riverside-F	660	665	580	570	570	570	560	560	550	-10	110
Prado Basin	SWO applies	618	—	—	—	—	—	—	—	—	—

Table 3-1. TDS Water Quality Objectives, Ambient Water Quality, and Assimilative Capacity (Page 2 of 2)

Groundwater Management Zones	Total Dissolved Solids Concentration (mg/L)										
	Water Quality Objective	Historical Ambient[1]	1997 Ambient	2003 Ambient	2006 Ambient	2009 Ambient	2012 Ambient	2015 Ambient	2018 Ambient	Difference from 2015 to 2018	Assimilative Capacity
Elsinore / Temescal Valleys											
Arlington	980	983	?	1020	960	1020	1030	1020	1020	0	None (-40)
Bedford	?	?	?	740	?	?	?	?	?	?	?
Coldwater	380	381	380	400	420	440	440	460	450	-10	None (-70)
Elsinore	480	476	480	460	470	470	490	490	490	0	None (-10)
Lee Lake	?	?	?	?	?	?	?	?	?	?	?
Temescal	770	771	780	700	780	790	790	810	810	0	None (-40)
Warm Springs Valley	?	?	?	?	?	?	?	?	?	?	?
Orange County Basins											
Irvine	910	908	910	880	920	910	940	920	880	-40	30
La Habra	?	?	?	?	?	?	?	?	?	?	?
Orange County	580	585	560	560	590	600	610	600	600	0	None (-20)
Santiago	?	?	?	?	?	?	?	?	?	?	?

? - Not enough data to estimate TDS concentrations

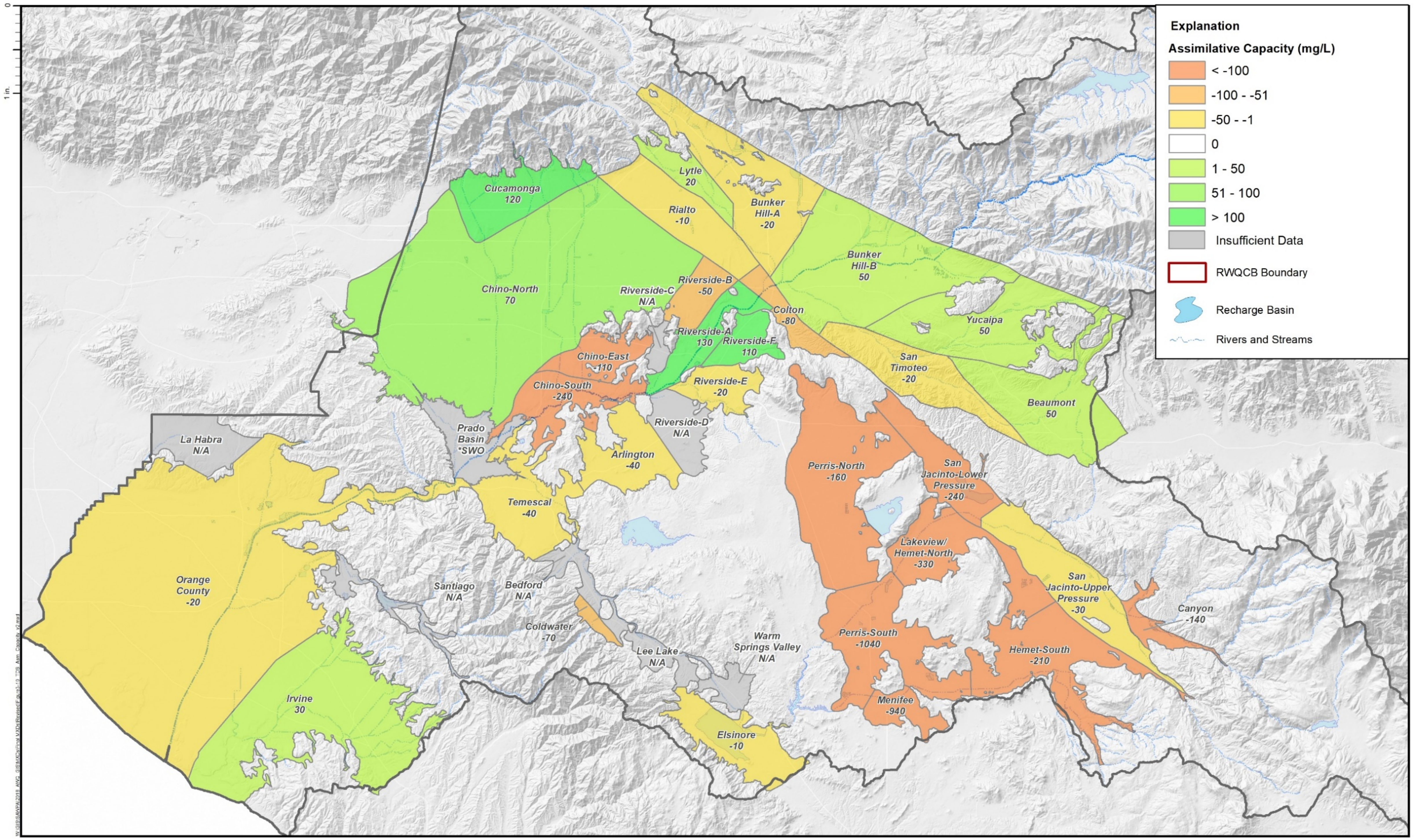
1Data sampling period for all ambient water quality computations was 20 years

Table 3-2. Nitrate Water Quality Objectives, Ambient Water Quality, and Assimilative Capacity (Page 1 of 2)

Groundwater Management Zones	Nitrate Concentration (mg/L)										
	Water Quality Objective	Historical Ambient[1]	1997 Ambient	2003 Ambient	2006 Ambient	2009 Ambient	2012 Ambient	2015 Ambient	2018 Ambient	Difference from 2015 to 2018	Assimilative Capacity
San Bernardino Valley and Yucaipa / Beaumont Plains											
Beaumont, “maximum benefit”	5.0	1.5	2.6	2.0	1.6	2.5	2.9	2.9	2.7	-0.2	2.3
Beaumont, “antidegradation”	1.5	1.5	2.6	2.0	1.6	2.5	2.9	2.9	2.7	-0.2	None (-1.2)
Bunker Hill-A	2.7	2.7	4.5	4.3	4.0	4.0	4.0	3.9	3.8	-0.1	None (-1.1)
Bunker Hill-B	7.3	7.3	5.5	5.8	5.4	5.4	5.6	5.8	5.8	0.0	1.5
Lytle	1.5	1.5	2.8	2.7	2.7	2.6	2.5	2.4	2.4	0.0	None (-0.9)
San Timoteo, “maximum benefit”	5.0	2.7	2.9	?	?	0.8	2.3	2.0	1.5	-0.5	3.5
San Timoteo, “antidegradation”	2.7	2.7	2.9	?	?	0.8	2.3	2.0	1.5	-0.5	1.2
Yucaipa, “maximum benefit”	5.0	4.2	5.2	5.4	5.3	6.2	6.3	6.2	5.9	-0.3	None (-0.9)
Yucaipa, “antidegradation”	4.2	4.2	5.2	5.8	5.3	6.2	6.3	6.2	5.9	-0.3	None (-1.7)
San Jacinto Basins											
Canyon	2.5	2.5	1.6	2.1	1.9	2.7	2.0	2.0	1.7	-0.3	0.8
Hemet-South	4.1	4.1	5.2	5.4	5.5	5.2	5.7	5.7	5.5	-0.2	None (-1.4)
Lakeview/Hemet North	1.8	1.8	2.7	3.4	2.7	2.6	2.5	2.6	2.9	0.3	None (-1.1)
Menifee	2.8	2.8	5.4	6.0	4.7	4.4	4.6	4.5	4.8	0.3	None (-2)
Perris-North	5.2	5.2	4.7	6.7	6.5	7.4	7.3	7.4	7.8	0.4	None (-2.6)
Perris-South	2.5	2.5	4.9	5.9	5.5	5.8	5.8	6.0	6.0	0.0	None (-3.5)
San Jacinto-Lower Pressure	1.0	1.0	1.9	1.8	1.2	1.1	1.1	1.5	1.7	0.2	None (-0.7)
San Jacinto-Upper Pressure, “maximum benefit”	7.0	1.4	1.9	1.7	1.6	1.5	1.4	1.6	1.1	-0.5	5.9
San Jacinto-Upper Pressure, “antidegradation”	1.4	1.4	1.9	1.7	1.6	1.5	1.4	1.6	1.1	-0.5	None (0.3)
Chino, Rialto / Colton, and Riverside Basins											
Chino-North, “maximum benefit”	5.0	3.7	7.4	8.7	9.7	9.5	10.0	10.3	10.3	0	None (-5.3)
Chino-1, “antidegradation”	5.0	5.0	8.4	8.9	9.3	9.1	10.0	10.5	10.4	-0.1	None (-5.4)
Chino-2, “antidegradation”	2.9	2.9	7.2	9.5	10.7	10.3	10.7	10.9	10.9	0	None (-8)
Chino-3, “antidegradation”	3.5	3.5	6.3	6.8	8.2	8.4	8.5	8.9	9.2	0.3	None (-5.7)
Chino-East	10.0	13.3	29.1	9.6	12.7	15.7	21.0	22.0	22.0	0.0	None (-12)
Chino-South	4.2	4.2	8.8	15.3	25.7	26.8	28.0	27.8	27.6	-0.2	None (-23.4)
Colton	2.7	2.7	2.9	2.9	2.9	2.8	2.7	3.3	3.3	0.0	None (-0.6)
Cucamonga, “maximum benefit”	5.0	2.4	4.4	4.3	4.0	4.1	4.1	4.3	4.7	0.4	0.3
Cucamonga, “antidegradation”	2.4	2.4	4.4	4.3	4.0	4.1	4.1	4.3	4.7	0.4	None (-2.3)
Rialto	2.0	2.0	2.7	2.6	2.9	3.1	3.2	3.4	3.5	0.1	None (-1.5)
Riverside-A	6.2	6.2	4.4	4.9	4.9	5.2	5.4	5.6	5.7	0.1	0.5
Riverside-B	7.6	7.6	8.0	7.8	8.3	8.4	6.7	6.6	6.5	-0.1	1.1
Riverside-C	8.3	8.3	15.5	15.3	15.3	14.8	14.5	?	?	?	?
Riverside-D	10.0	19.5	?	?	?	?	?	?	?	?	?
Riverside-E	10.0	13.3	14.8	15.4	15.3	15.2	10.2	10.4	10.2	-0.2	None (-0.19)
Riverside-F	9.5	12.1	9.5	10.6	10.3	10.6	10.1	10.9	10.3	-0.6	None (-0.8)
Prado Basin	SWQO applies	4.3	—	—	—	—	—	—			

Table 3-2: Nitrate Water Quality Objectives, Ambient Water Quality, and Assimilative Capacity (Page 2 of 2)

Groundwater Management Zones	Nitrate Concentration (mg/L)										
	Water Quality Objective	Historical Ambient[1]	1997 Ambient	2003 Ambient	2006 Ambient	2009 Ambient	2012 Ambient	2015 Ambient	2018 Ambient	Difference from 2015 to 2018	Assimilative Capacity
Elsinore / Temescal Valleys											
Arlington	10.0	25.5	?	26.0	20.4	18.1	18.3	17.8	16.6	-1.2	None (-6.6)
Bedford	?	?	?	2.8	?	?	?	?	?	?	?
Coldwater	1.5	1.5	2.6	2.4	2.6	2.8	2.8	2.2	2.3	0.1	None (-0.8)
Elsinore	1.0	1.0	2.6	2.4	2.4	2.2	2.1	2.2	2.8	0.6	None (-1.8)
Lee Lake	?	?	?	?	?	?	?	?	?	?	?
Temescal	10.0	11.8	13.2	12.8	12.6	12.0	10.9	10.9	10.2	-0.7	None (-0.2)
Warm Springs Valley	?	?	?	?	?	?	?	?	?	?	?
Orange County Basins											
Irvine	5.9	5.9	7.4	6.5	6.5	6.7	6.7	6.4	6.4	0	None (-0.5)
La Habra	?	?	?	?	?	?	?	?	?	?	?
Orange County	3.4	3.4	3.4	3.1	3.0	3.0	2.9	3.0	3.0	0	0.4
Santiago	?	?	?	?	?	?	?	?	?	?	?



Prepared by:

WSC Water Systems Consulting, Inc.

Author: EC
Date: 3/20/2020

File Name: Figure3-10_TDS_Asm_Capacity_v2

N

1 in : 5.5 mi

0 1.75 3.5 7 Mi

0 2.75 5.5 11 Km

References:
1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for:

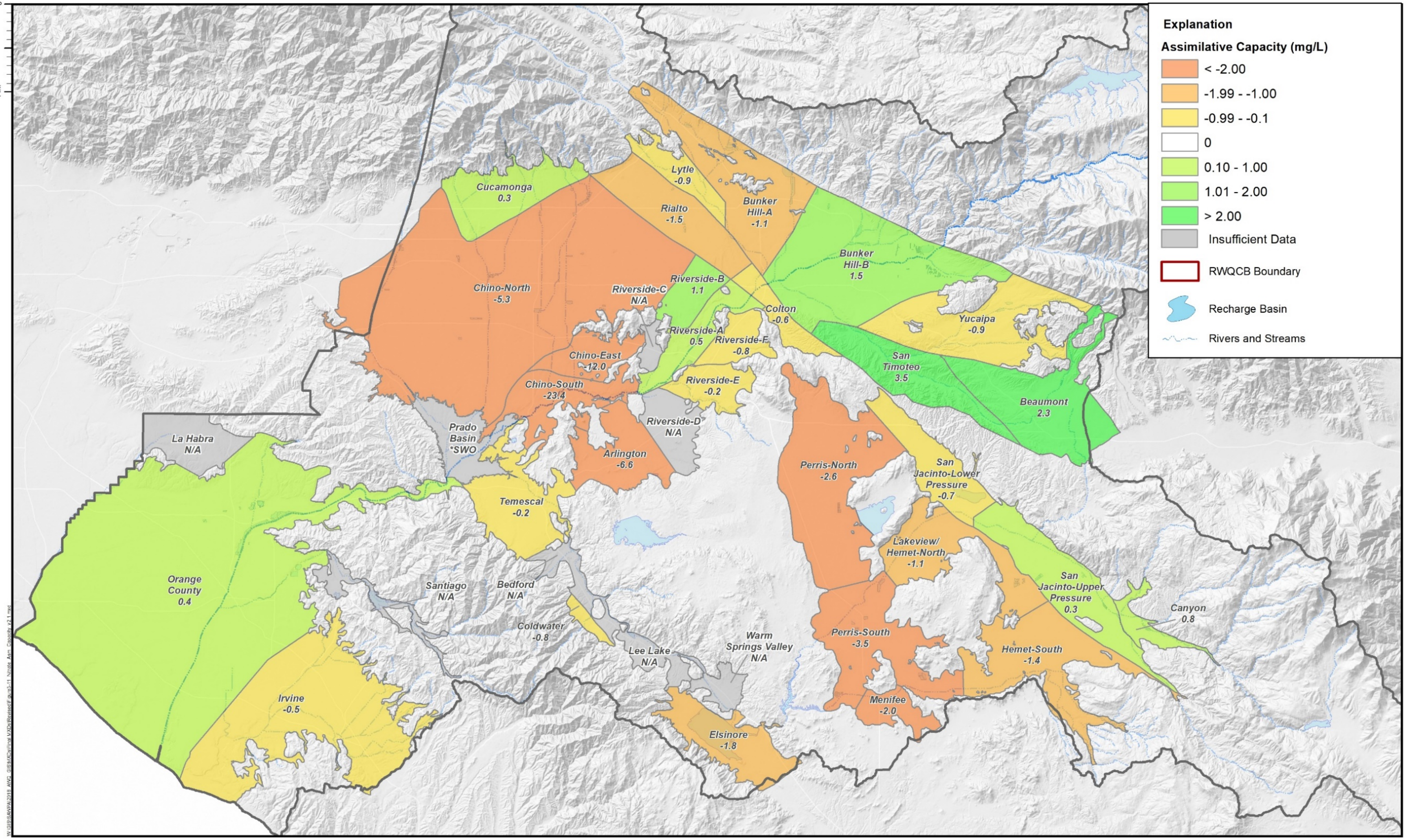
SAWPA

SAWPA Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality for the Period 1999 to 2018

Assimilative Capacity - TDS
Santa Ana River Watershed

Figure 3-10



Prepared by:

WSC Water Systems Consulting, Inc.

Author: EC

Date: 3/20/2020

File Name: Figure3-11_Nitrate_Asm_Capacity_v2.1

N

1 in : 5.5 mi

0 1.75 3.5 7 Mi

0 2.75 5.5 11 Km

References:

1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for:

SAWPA

SAWPA Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality for the Period 1999 to 2018

Assimilative Capacity - NO_3-N
Santa Ana River Watershed

Figure 3-11

SECTION 4

Interpretive Tools

The genesis of the AWQ interpretive tools occurred during the 1990 to 2009 recomputation effort, when unexpected changes in salinity were observed in the recomputation results for the OC and other GMZs. It was clear to the Task Force that the change in ambient TDS concentrations in the OC GMZ was caused by improvements in the monitoring network and not by any real regional changes in groundwater chemistry. Specifically, new data were incorporated into the AWQ analysis via new wells that had been installed in areas that were previously not well monitored. The purpose of the interpretive tools is to attempt to characterize the factors that may have influenced changes in AWQ over time, and to determine whether the changes are real (systemic factors) or are artifacts of the methodology (methodological factors). Changes in computed groundwater quality can be caused by the factors listed in Table 4-1. In most cases, both systemic and methodological factors play a role in the computed changes in ambient water quality for a GMZ. However, the relative roles of each factor for each GMZ are not easily quantified.

IN THIS SECTION

Table 4-1. Systemic and Methodological Factors Affecting Groundwater Quality.

Category	Factor
Systemic Change	The movement of solutes from the vadose zone to the saturated zone.
Systemic Change	Changes in water levels that affect groundwater storage in a GMZ
Systemic Change	Revised understanding of hydrogeologic physical models, which may change aquifer geometry and aquifer properties.
Systemic Change	Pumping/recharge stresses and/or groundwater flow within or between GMZs that can add, remove, and/or transport TDS and nitrate constituents in groundwater.
Methodological Change	The addition or loss of wells within GMZs.
Methodological Change	The geographic distribution of added or lost wells within GMZs.
Methodological Change	Differences in the techniques employed to contour and interpolate water quality data.
Methodological Change	The elimination of three years of data from the analysis (1996 to 1998).
Methodological Change	The addition of three years of data to the analysis (2016 to 2018).

The objective of the Interpretative tools task is to compare the current AWQ determinations with previous recomputations. More specifically, the interpretive tools will attempt to show how and why the 2018 estimates of current AWQ changed from the 2015 estimates of current AWQ for each GMZ.

The BMPTF envisions a multi-faceted approach, where the interpretive tools would include the following:

- A spatial analysis of groundwater quality change comparing the distribution of AWQ statistics across GMZs. (Section 4.2)
- A temporal analysis of groundwater quality change comparing basin-level trends to trends observed in individual “key” well locations. (Section 4.3)
- Appendix B contains subwatershed analyses with the data depicted in a map-atlas or infographics format (Section 4.4)
- A forward-looking analysis of AWQ statistics lost over time, as wells are decommissioned, destroyed, or are otherwise no longer monitored (well attrition analysis, Section 4.5).

A cloud-based mapping tool has been developed to allow the BMPTF members to drill into the data behind the interpretive tools.

4.1 GIS On-Line AWQ Data Explorer

The project team developed an interactive, web-accessible, GIS toolbox using ArcGIS Online, which is a cloud-based mapping and analysis solution. The BMPTF members will be enabled to make their own maps, analyze AWQ data, and can share and collaborate within their organizations and/or with other parties.

ArcGIS Online provides a convenient way to explore data collected and data that was computed for the 1999 – 2018 Ambient Water Quality. Currently there are several interactive web maps available online where each individual well point whether it is a point statistic, average, groundwater elevation, etc. may be inspected. Each online map may have one or more "slides," which are map views with various layers displayed. The user can pan and zoom and obtain metadata by selecting GMZs or wells. The legend can be displayed by clicking this symbol in the upper right hand corner of the map.

Ctrl + click to follow the links (blue + underline) to the AWQ Data Explorer websites.

1. AWQ Draft TDS Nitrate Data Loss Risk – Two slides: Nitrate Data Loss Risk and TDS Data Loss Risk. Both symbolize well points by new and potential well point statistics, wells that are at risk of data loss if not sampled by the year listed for both point statistics and averages, and point statistics and averages for all other well points.
2. AWQ Draft TDS and Nitrate Well Attrition Analysis – This web map contains 13 slides:

    a. Groundwater Elevations – Symbolized all well points with a GWE.
    b. Nitrate Well Attrition Analysis – Nitrate well points by point statistics and averages symbolized by high or medium risk, new or potential point statistics, and all other point statistic and average well points not classified by risk, new, or potential point statistics.
    c. TDS Well Attrition Analysis – TDS well points by point statistics and averages symbolized by high or medium risk, new or potential point statistics, and all other point statistic and average well points not classified by risk, new, or potential point statistic.
    d. The rest of the slides show each individual data grouping (e.g. point statics) from b and c

3. AWQ Draft Nitrate Key Well Trends – One slide: key well points symbolized by very significantly increasing to very significantly decreasing trend in nitrate at the well over the computation period.
4. AWQ Draft TDS Key Well Trends – One slide: key well points symbolized by very significantly increasing to very significantly decreasing trend in TDS at the well over the computation period.
5. AWQ Draft Nitrate Well Trends – One slide: well points symbolized by very significantly increasing to very significantly decreasing trend in nitrate at the well over the computation period.
6. AWQ Draft TDS Well Trends – One slide: well points symbolized by very significantly increasing to very significantly decreasing trend in TDS at the well over the computation period.
7. AWQ Draft Point Statistics Percent Rank – four slides:

    a. Nitrate Point Statistics and Averages – well point stats and averages are symbolized by nitrate concentration in a range.
    b. TDS Point Statistics and Averages - well point stats and averages are symbolized by TDS concentration in a range.
    c. Nitrate Point Statistics and Averages Percent Difference from 2015 – 2018 – nitrate well points stats and averages are symbolized by their percent difference and ranked.

d. TDS Point Statistics and Averages Percent Difference from 2015 – 2018 – TDS well points stats and averages are symbolized by their percent difference and ranked.

4.2 Change in the Spatial Distribution of TDS and Nitrate in Groundwater at the Santa Ana River Watershed Scale

The objective of this sub-task was to perform a spatial analysis of water quality changes from the previous recomputation effort to the current recomputation effort at the Santa Ana River Watershed scale. Maps showing the AWQ for nitrate and TDS are provided in Figures 3-4 and 3-7. Color-ramped change maps were also prepared that show a grid-level comparison between prior and current estimates of regional nitrate and TDS concentrations in groundwater for each GMZ (Figures 4-1 and 4-2). These maps include adjacent GMZs to provide both a local and a regional context for the changes in nitrate and TDS estimates. They show the changes in TDS and nitrate concentration from two distinct perspectives:

- Changes in concentration by grid cell, where the magnitude of the concentration grid is depicted by color.
- 20-year trends of groundwater quality at key wells using the Mann-Kendall test.

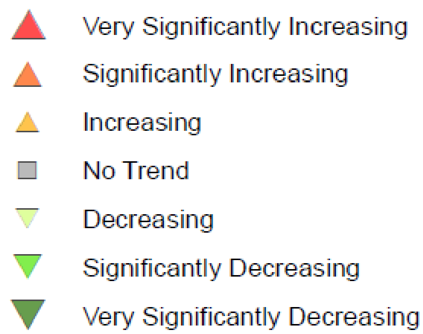
Note that as these maps show two temporal/spatial comparisons, care should be taken so as not to conflate the two analyses. The first map analysis of change is concentration-based and is a comparison of the 2018 current ambient estimates at each grid cell with the 2015 current ambient estimates. The Mann-Kendall test—performed on each key well—determines if there is a significant trend in water quality (increasing, no trend, or decreasing) for up to 20 annualized average values within the 2018 AWQ recomputation dataset. A very significant increasing trend does not necessarily mean that the trend has a high positive slope or that the concentrations are high; it means only that the trend is monotonically increasing.

The Mann-Kendall test was employed to analyze data collected over time to determine whether there are consistently increasing or decreasing trends. The Mann-Kendall test is non-parametric and allows for missing data, irregularly spaced measurement periods, and non-detect values (Gibbons and Coleman, 2001). In the test, the values are ordered by sample date and the signs (+/–) are recorded for all of the possible differences between a given value and every value that preceded it in the time series. The Mann-Kendall statistic "S" is defined as the number of positive differences (+) minus the number of negative differences (–). S and n, the number of sample dates, together define a probability (p-value) that defines possible trends as one of the following:

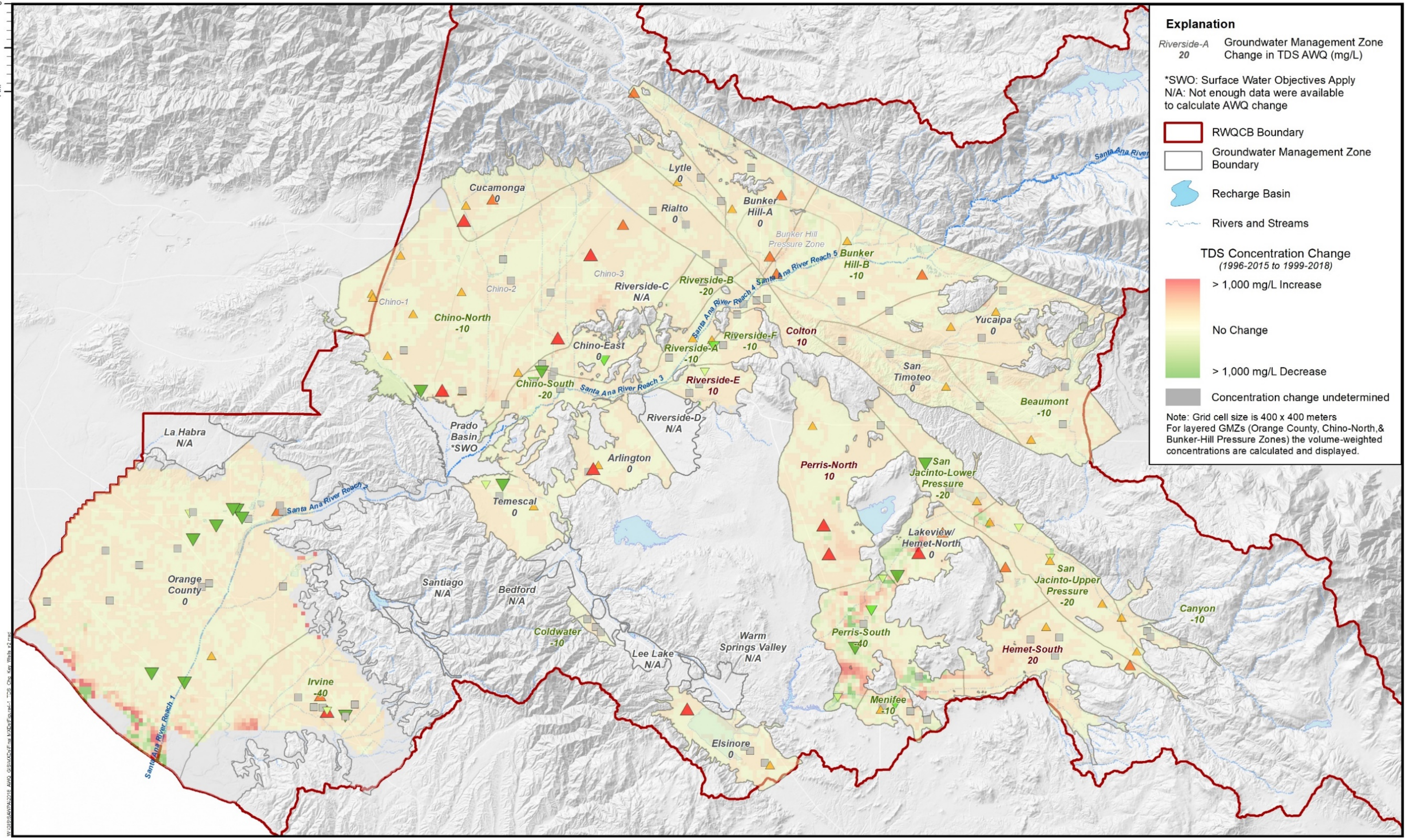
- Not calculated (either p-value = 0 or n =1)
- Very significantly increasing (p-value ≤ 0.001, positive slope)
- Significantly increasing (p-value ≤ 0.01, positive slope)
- Increasing (p-value ≤ 0.1, positive slope)
- No trend (p-value > 0.1 or slope = 0)

- Decreasing (p-value ≤ 0.1, negative slope)
- Significantly decreasing (p-value ≤ 0.01, negative slope)
- Very significantly decreasing (p-value ≤ 0.001, negative slope)

The following symbology was used to represent the estimated trends in Figures 4-1 and 4-2:



More detailed discussions at the subwatershed scale are provided in Section 4.3.



Prepared by:

WSC Water Systems Consulting, Inc.

Author: EC
Date: 3/20/2020

File Name: Figure4-1_TDS_Chg_Key_Wells_v2

N

1 in : 5.5 mi

0 1.75 3.5 7 Mi
0 2.75 5.5 11 Km

References:
1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for:

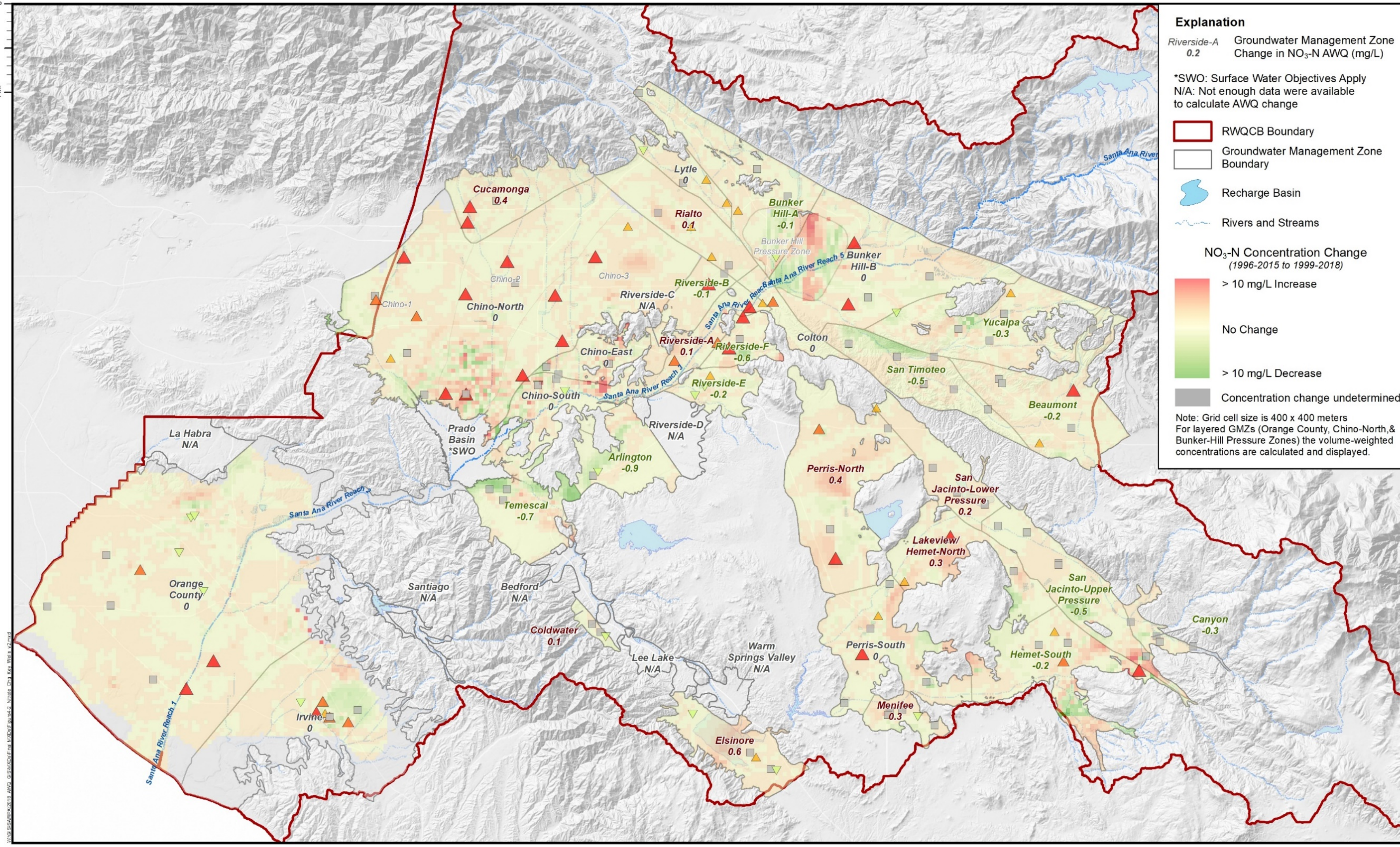
SAWPA

SAWPA Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality for the Period 1999 to 2018

TDS Change (1996-2015 to1999-2018) and Key Well Trends
Santa Ana River Watershed

Figure 4-1



Prepared by:

WSC Water Systems Consulting, Inc.

Author: EC
Date: 3/2/2020

File Name: Figure4-2_Nitrate_Chg_Key_Wells_v2

N

1 in : 5.5 mi

0 1.75 3.5 7 Mi

0 2.75 5.5 11 Km

References:

1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for:

SAWPA

SAWPA Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality for the Period 1999 to 2018

NO_3-N Change (1996-2015 to1999-2018) and Key Well Trends
Santa Ana River Watershed

Figure 4-2

4.3 Temporal Trends in TDS and Nitrate Concentrations

The objective of this sub-task was to perform a temporal analysis of water quality changes from the previous recomputation effort to the current recomputation effort. Time-series charts of groundwater elevation, TDS, and nitrate concentrations were generated for all 6,756 wells in the 2018 AWQ database that contained data. These plots are provided electronically in Appendix A.7. Data from the previous period are depicted with dark blue dots, while data collected for the current (2016 through 2018) period are shown as orange dots. In addition, the point selected to represent Fall 2018 groundwater elevation (closest date to October 15, 2018) is shown with a black dot. The statistics table included in Appendix A.2 provides a lookup table to identify each of the time-series plots by the unique Well ID. Each interested stakeholder can identify a well of interest by GMZ, owner, and local well name, which is linked in a 1:1 relationship to the Well ID.

A number of key wells have previously been selected for each GMZ based on location, perforated intervals, the density and period of available water quality data, and the quality of the dataset, and have been part of two iterations of this project to date (WEI, 2014). In this technical memorandum, the data from the same key wells were analyzed to ensure continuity with previous recomputation efforts. Key well data are meant to describe how groundwater quality is changing in certain areas (and depth intervals) within each GMZ. Key well trends for each GMZ are provided in Tables 4-2 and 4-3 for TDS and nitrate, respectively. These tables summarize the number of key wells in each GMZ, as well as the number of wells in categories of significance in the Mann-Kendall trend analyses. The net trend of all key wells in each GMZ is also estimated and shown in Tables 4-2 and 4-3. For each GMZ, further analyses of key well trend data are provided in Appendix B.

Table 4-2: Key Well Trends for TDS, 1999-2018 (Page 1 of 2)

Groundwater Management Zone	No. of Key Wells	Total Dissolved Solids							
		Very Significantly Decreasing	Significantly Decreasing	Decreasing	No Trend	Increasing	Significantly Increasing	Very Significantly Increasing	Net Trend
San Bernardino Valley and Yucaipa / Beaumont Plains									
Beaumont	6	—	—	—	6	1	—	—	—
Bunker Hill-A	5	—	—	—	1	1	3	—	Increasing
Bunker Hill-B	5	—	—	—	2	1	2	—	Increasing
Lytle	4	—	—	—	3	1	—	—	—
San Timoteo	6	—	—	—	6	—	—	—	—
Yucaipa	5	—	—	—	3	2	—	—	Increasing
San Jacinto Basins									
Canyon	4	—	—	—	3	1	—	—	—
Hemet-South	5	—	—	—	3	1	1	—	Increasing
Lakeview/Hemet North	4	1	—	—	—	—	2	1	Increasing
Menifee	5	—	1	—	3	1	—	—	—
Perris-North	4	—	—	—	1	1	—	2	Increasing
Perris-South	6	1	1	2	2	—	—	—	Decreasing
San Jacinto-Lower Pressure	4	1	—	—	2	1	—	1	Decreasing
San Jacinto-Upper Pressure	6	—	—	2	—	4	—	—	Increasing
Chino, Rialto / Colton, and Riverside Basins									
Chino-North	22	1	—	1	7	8	1	3	Increasing
Chino-1/Chino North	9	1	—	1	1	5	—	—	Increasing
Chino-2/Chino North	7	—	—	—	4	2	—	1	—
Chino-3/Chino North	6	—	—	—	2	1	1	2	Increasing
Chino-East	4	—	1	—	3	—	—	—	Decreasing
Chino-South	5	1	1	—	3	—	—	—	—
Colton	2	—	—	1	1	—	—	—	—
Cucamonga	3	—	—	—	—	1	1	1	Increasing
Rialto	4	—	—	—	4	—	—	—	Increasing
Riverside-A	5	—	—	—	3	2	—	—	—
Riverside-B	2	—	—	—	2	—	—	—	—
Riverside-C[a]	0	—	—	—	—	—	—	—	—
Riverside-D[a]	0	—	—	—	—	—	—	—	—
Riverside-E	3	—	—	1	2	—	—	—	—
Riverside-F	4	—	1	—	3	—	—	—	—
Prado Basin[b]	N/A	—	—	—	—	—	—	—	N/A
Elsinore / Temescal Valleys									
Arlington	3	—	—	—	1	1	—	—	Increasing
Bedford*	N/A	—	—	—	—	—	—	—	N/A
Coldwater	3	—	—	—	3	—	—	—	—
Elsinore	5	—	—	—	3	1	—	1	—
Lee Lake[a]	N/A	—	—	—	—	—	—	—	N/A
Temescal	4	1	—	1	1	1	—	—	—
Warm Springs Valley[a]	N/A	—	—	—	—	—	—	—	N/A

Table 4-2: Key Well Trends for TDS, 1999-2018 (Page 2 of 2)

Groundwater Management Zone	No. of Key Wells	Total Dissolved Solids							
		Very Significantly Decreasing	Significantly Decreasing	Decreasing	No Trend	Increasing	Significantly Increasing	Very Significantly Increasing	Net Trend
Orange County Basins									
Irvine	9	1	—	1	5	—	1	1	Decreasing
La Habra[a]	N/A	—	—	—	—	—	—	—	N/A
Orange County	22	7	—	1	12	1	1	—	—
Santiago[a]	N/A	—	—	—	—	—	—	—	N/A

Note: Mann-Kendall trend analyses were performed on annualized average concentrations for each well between 1996 and 2015.

No trend: p-value >0.1 or slope = 0; Increasing/Decreasing: p-value ≤0.1; Significant trend: p-value ≤0.01; Very significant trend: p-value ≤0.001

[a] 1999-2018 ambient water quality not calculated

[b] Surface water objectives

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Table 4-3: Key Well Trends for Nitrate, 1999-2018 (Page 1 of 2)

Groundwater Management Zone	No. of Key Wells	Total Dissolved Solids							
		Very Significantly Decreasing	Significantly Decreasing	Decreasing	No Trend	Increasing	Significantly Increasing	Very Significantly Increasing	Net Trend
San Bernardino Valley and Yucaipa / Beaumont Plains									
Beaumont	6	—	—	—	5	1	—	1	—
Bunker Hill-A	5	—	—	1	3	1	—	—	—
Bunker Hill-B	5	—	1	—	2	—	—	2	Increasing
Lytle	4	—	—	1	1	2	—	—	—
San Timoteo	6	—	—	—	6	—	—	—	—
Yucaipa	5	—	—	1	2	1	—	—	Increasing
San Jacinto Basins									
Canyon	4	—	—	—	4	—	—	—	—
Hemet-South	5	—	—	—	2	1	1	1	Increasing
Lakeview/Hemet North	4	1	—	—	1	1	—	1	—
Menifee	5	—	—	1	4	—	—	—	—
Perris-North	4	—	—	—	2	—	1	1	Increasing
Perris-South	6	—	—	—	4	1	—	1	—
San Jacinto-Lower Pressure	4	—	—	—	3	1	—	—	—
San Jacinto-Upper Pressure	6	—	1	—	5	—	—	—	—
Chino, Rialto / Colton, and Riverside Basins									
Chino-North	22	1	—	—	6	3	2	9	Increasing
Chino-1/Chino North	9	—	—	—	4	1	2	1	Increasing
Chino-2/Chino North	7	—	—	—	2	1	—	4	Increasing
Chino-3/Chino North	6	1	—	—	—	1	—	4	—
Chino-East	4	—	1	—	3	—	—	—	—
Chino-South	5	1	—	2	2	—	—	—	—
Colton	2	—	1	—	—	—	1	—	—
Cucamonga	3	—	—	—	1	—	—	2	Increasing
Rialto	4	—	—	—	2	2	—	—	Increasing
Riverside-A	5	—	—	—	1	1	2	1	Increasing
Riverside-B	2	—	—	—	1	—	—	1	—
Riverside-C[a]	0	—	—	—	—	—	—	—	—
Riverside-D[a]	0	—	—	—	—	—	—	—	—
Riverside-E	3	—	—	2	—	1	—	—	Decreasing
Riverside-F	4	1	—	—	1	—	—	2	—
Prado Basin[b]	N/A	—	—	—	—	—	—	—	N/A
Elsinore / Temescal Valleys									
Arlington	3	1	—	1	1	—	—	—	—
Bedford*	N/A	—	—	—	—	—	—	—	N/A
Coldwater	3	—	—	1	2	—	—	—	—
Elsinore	5	—	—	2	2	1	—	—	Decreasing
Lee Lake[a]	N/A	—	—	—	—	—	—	—	N/A
Temescal	4	—	1	—	3	—	—	—	—
Warm Springs Valley[a]	N/A	—	—	—	—	—	—	—	N/A

Table 4-3: Key Well Trends for Nitrate, 1999-2018 (Page 2 of 2)

Groundwater Management Zone	No. of Key Wells	Total Dissolved Solids							
		Very Significantly Decreasing	Significantly Decreasing	Decreasing	No Trend	Increasing	Significantly Increasing	Very Significantly Increasing	Net Trend
Orange County Basins									
Irvine	9	—	1	1	2	1	3	1	Decreasing
La Habra[a]	N/A	—	—	—	—	—	—	—	N/A
Orange County	22	9	2	4	4	—	1	2	Decreasing
Santiago[a]	N/A	—	—	—	—	—	—	—	N/A

Note: Mann-Kendall trend analyses were performed on annualized average concentrations for each well between 1996 and 2015.

No trend: p-value >0.1 or slope = 0; Increasing/Decreasing: p-value ≤0.1; Significant trend: p-value ≤0.01; Very significant trend: p-value ≤0.001

[a] 1999-2018 ambient water quality not calculated

[b] Surface water objectives

4.4 Interpretative Tools Summary by Subwatershed

The body of this technical memorandum describes the spatial and temporal distributions of nitrate and TDS and trend analyses on a watershed-wide basis (Sections 4.1 and 4.2). Also included in this technical memorandum are a series of packets that provide a more detailed and focused analysis of TDS and nitrate (Appendix B). These packets follow a map-atlas or infographics format. A packet is provided in Appendix B for each subwatershed area (e.g., the Riverside GMZs [Appendix B13]). Each packet contains the following:

- **Cover Page.** The cover page includes a subwatershed location map, list of maps in each subwatershed package, a summary table displaying the WQO, historical AWQ determinations, and assimilative capacity, and a time series chart displaying the TDS and Nitrate be GMZ.
- ***2018 Groundwater storage and elevation contour map.*** This map shows the Fall 2018 groundwater elevation at each well, along with the hand-drawn contour maps of groundwater elevation, with the exception of the San Jacinto, Orange County, and Irvine GMZs, where Spring 2018 elevation contour maps were provided by EMWD and OCWD. This map also shows groundwater storage (AF) in each grid cell, based on the thickness of the saturated zone and the specific yield.
- ***Nitrate concentration and contour map.*** This map shows the water quality point statistic and average nitrate concentration for the wells that were used in the AWQ determination. Nitrate concentration contours and concentration values per grid cell are also shown on this map.
- ***TDS concentration and contour map.*** This map shows the water quality point statistic and average TDS concentration for the wells that were used in the AWQ determination. TDS concentration contours and concentration values per grid cell are also shown on this map.
-

Nitrate change map and key wells. On this map, the change in computed nitrate AWQ from the 2012 to the 2015 recomputation period is shown for each grid cell. Small gray dots represent wells for which point statistics could be computed for the 2015 recomputation period. The results of the trend analyses for each of the key wells is shown with the following symbology:

▲ Very Significantly Increasing
▲ Significantly Increasing
▲ Increasing
■ No Trend
▼ Decreasing
▼ Significantly Decreasing
▼ Very Significantly Decreasing

A map-graphic summary of well attrition (Section 4.4) is also provided on the maps. The well attrition analyses were added to the change maps was to assist in informing the changes in concentration between the 2015 and the 2018 recomputation periods.

1996-2015 Point Statistic TDS

1996-2015 Average TDS

High Risk Point Statistic

High Risk Average

Medium Risk Point Statistic

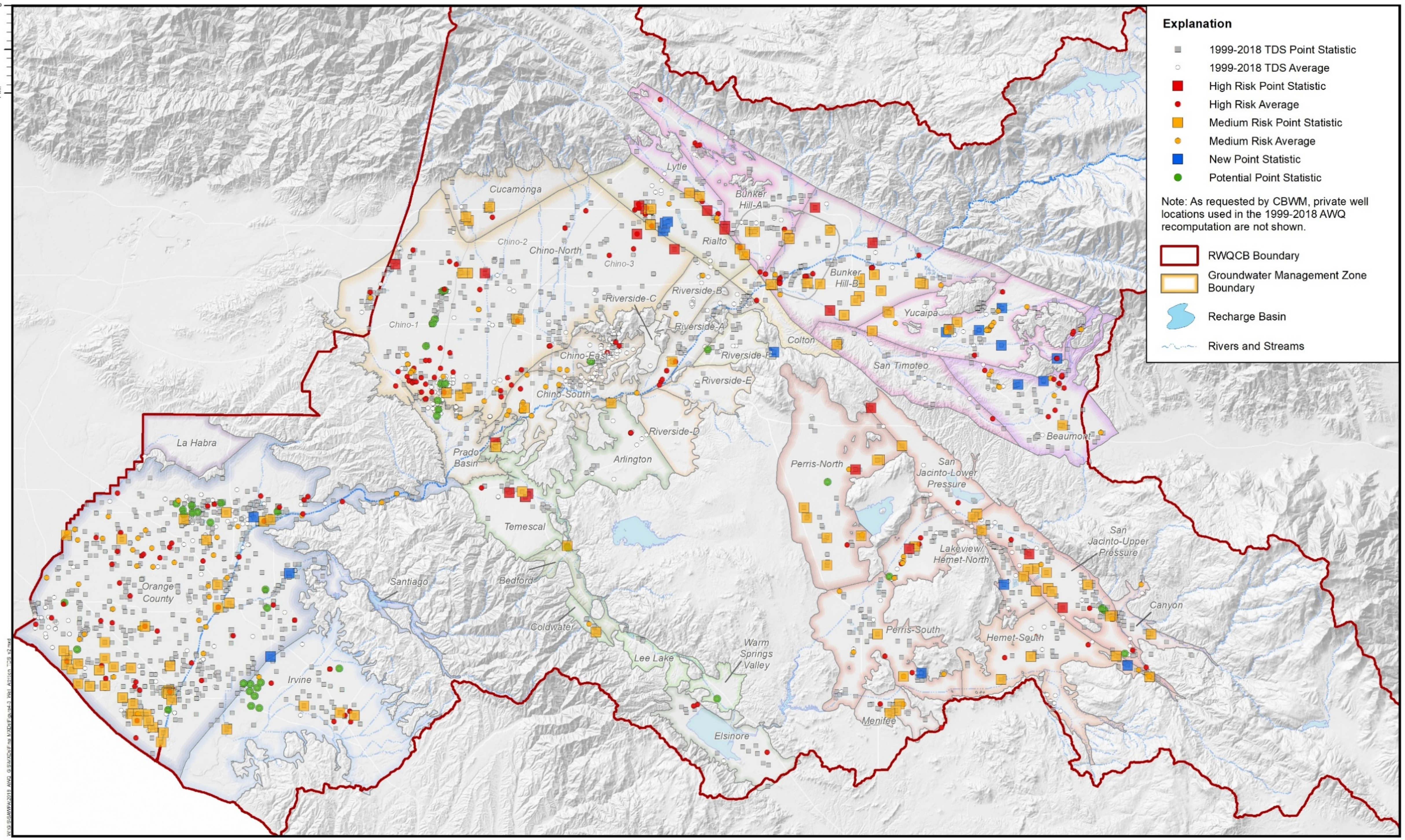
Medium Risk Average

New Point Statistic

Potential Point Statistic

- 2002-2021 point statistic TDS or nitrate: See Section 2.4.1
- 2002-2021 average TDS or nitrate: See Section 2.4.1
- High-risk statistic: will not be eligible to have a water quality point statistic computed if the well is not sampled and analyzed in the 2019 to 2021 period.
- Medium-risk statistic: will not be eligible to have a water quality point statistic computed if the well is not sampled and analyzed in the 2022 to 2024 period.
- New statistic: wells that are now eligible to have a water quality point statistic computed for the 2018 current AWQ recomputation period.
- Potential statistic: wells that will be eligible to have a water quality point statistic computed for the next period (2006 to 2024), if a sample is collected and analyzed in the 2022 to 2024 period.

• *TDS change map and key wells*. This map contains similar data to the nitrate change map and key wells.



Prepared by:

WSC Water Systems Consulting, Inc.

Author: EC

Date: 3/2/2020

File Name: Figure4-3_Well_Attrition_TDS_v2

N

1 in : 5.5 mi

0 1.75 3.5 7 Mi

0 2.75 5.5 11 Km

References:

1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for:

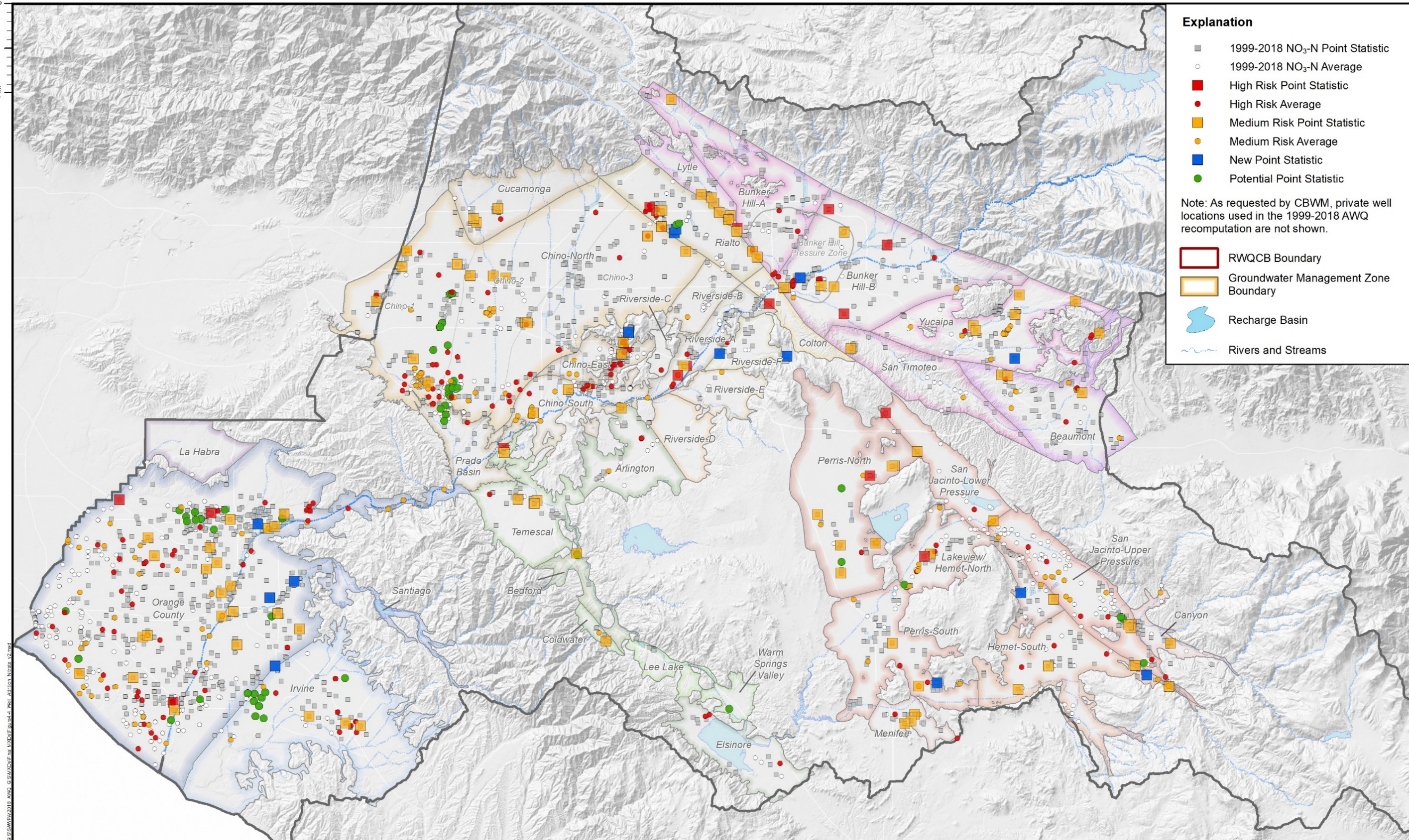
SAWPA

SAWPA Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality for the Period 1999 to 2018

Well Attrition Analysis - TDS
Santa Ana River Watershed

Figure 4-3



Prepared by:

WSC Water Systems Consulting, Inc.

Author: EC
Date: 3/2/2020

File Name: Figure4-4_Well_Attrition_Nitrate_v2

N

1 in : 5.5 mi

0 1.75 3.5 7 Mi

0 2.75 5.5 11 Km

References:

1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for:

SAWPA

SAWPA Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality
for the Period 1999 to 2018

Well Attrition Analysis - NO_3-N
Santa Ana River Watershed

Figure 4-4

4.5 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 objective of this task is to identify the following:

- *High Risk for Point Statistics*. Wells with computed water quality point statistics that will not qualify for inclusion in the next recomputation (2002 to 2021) of AWQ if no data are collected during 2019-2021.
- *Medium Risk for Point Statistics*. Wells with computed water quality point statistics that will not qualify for inclusion in the following recomputation (2005 to 2024) of AWQ if no data are collected during 2022-2024.
- *High Risk for Average Values*. Wells with average values that will not qualify for inclusion in the next recomputation (2002 to 2021) of AWQ if no data are collected during 2019-2021.
- *Medium Risk for Average Values*. Wells with average values that will not qualify for inclusion in the following recomputation (2005 to 2024) of AWQ if no data are collected during 2022-2024.

The well attrition analyses are summarized in Tables 4-4 and 4-5 for TDS and nitrate, respectively. For each GMZ, these tables provide the number of the total wells, wells with water quality point statistics, high- and medium-risk wells for water quality point statistics, newly eligible wells with point statistics, high- and medium-risk wells for average values, and potentially eligible wells for point statistics. Lists of wells that are at high risk and medium risk for TDS and nitrate and for water quality point statistics and averages are included as a spreadsheet Appendix A. The well attrition analysis is also shown in Figures 4-3 and 4-4 for TDS and nitrate, respectively. The wells have the symbology described in Section 4.3 for the change maps/well attrition maps included in Appendix B.

In addition, analyses were performed to parse the high and medium risk wells for point statistics and average, based on each of the three years in the 2019, 2020, and 2021 period. Tables 4-6 and 4-7 list the number of wells that will not be included in AWQ program unless those wells are sampled in 2019, 2020, and 2021. This table includes data for both TDS and nitrate and includes a summary of this information for each GMZ and for the entire watershed. Note that wells listed for '2019' are already out of the AWQ program unless they were sampled in the last calendar year. This analysis provides more detail on precisely which year of the three between 2019 through 2021 wells will need to be sampled to preserve their status and inclusion in the AWQ program.

Table 4-4: Well Attrition/Well Additions for TDS, 1999-2018 (Page 1 of 2)

Groundwater Management Zone	Total Dissolved Solids							
	Basin Totals		Point Statistics			Averages		
	Total Wells	Total Statistics	High Risk [a]	Medium Risk [b]	New Stat [c]	High Risk [a]	Medium Risk [b]	Potential Stat [d]
San Bernardino Valley and Yucaipa / Beaumont Plains								
Beaumont	99	59	—	1	2	14	8	—
Bunker Hill-A	109	85	3	5	—	9	1	—
Bunker Hill-B	146	105	2	18	—	17	3	—
Lytle	38	27	1	2	—	2	2	—
San Timoteo	34	25	—	1	—	1	—	—
Yucaipa	114	72	—	5	13	5	14	—
San Jacinto Basins								
Canyon	27	24	—	1	—	—	1	—
Hemet-South	58	41	—	4	1	3	2	—
Lakeview/Hemet North	88	66	1	3	1	3	4	1
Menifee	22	19	—	3	—	2	1	—
Perris-North	42	33	—	1	7	1	2	1
Perris-South	67	54	—	2	1	2	4	—
San Jacinto-Lower Pressure	17	12	1	4	—	1	—	—
San Jacinto-Upper Pressure	111	81	2	9	—	4	2	3
Chino, Rialto / Colton, and Riverside Basins								
Chino-North	482	287	4	7	—	45	16	16
Chino-1/Chino North	179	102	1	—	—	27	10	14
Chino-2/Chino North	194	107	1	6	—	7	5	2
Chino-3/Chino North	109	78	2	1	—	11	1	—
Chino-East	207	33	—	—	—	3	2	6
Chino-South	59	33	—	2	—	1	11	—
Colton	10	9	—	—	—	1	—	—
Cucamonga	28	26	—	3	—	1	—	—
Rialto	91	58	2	4	6	6	1	—
Riverside-A	77	43	—	1	1	5	1	—
Riverside-B	27	10	—	—	—	—	2	—
Riverside-C	1	0	—	—	—	1	—	—
Riverside-D	1	1	—	—	—	—	—	—
Riverside-E	8	5	—	—	—	—	—	—
Riverside-F	27	22	—	—	1	—	—	—
Prado Basin	40	22	—	—	—	—	—	4
Elsinore / Temescal Valleys								
Arlington	19	6	—	—	—	3	—	—
Bedford	6	4	—	1	—	—	—	2
Coldwater	8	6	—	1	—	—	1	—
Elsinore	16	12	—	—	—	3	—	—
Lee Lake	7	6	—	—	—	—	—	—
Temescal	45	36	5	2	—	1	—	—
Warm Springs Valley	1	—	—	—	—	—	—	1

Table 4-4: Well Attrition/Well Additions for TDS, 1999-2018 (Page 2 of 2)

Groundwater Management Zone	Total Dissolved Solids							
	Basin Totals		Point Statistics			Averages		
	Total Wells	Total Statistics	High Risk [a]	Medium Risk [b]	New Stat [c]	High Risk [a]	Medium Risk [b]	Potential Stat [d]
Orange County Basins								
Irvine	119	101	—	4	—	8	1	—
La Habra	1	1	—	—	—	—	—	—
Orange County	1,710	1,320	2	112	3	54	33	49
Santiago	3	3	—	—	—	—	—	—

a High risk wells will be lost during the 1999-2018 study period if not sampled before 2018.
b Medium risk wells will be lost during the 2002-2021 study period if not sampled before 2021.
c New stats are wells with the first sample collected 2010-2013, which meets the minimum number of annualized averages to become a point statistic.
d Potential stats are wells with the first sample collected 2014-2015; it is highly recommended that these wells continue to be sampled for the upcoming AWQ recomputation.
e 1999-2018 AWQ not calculated.
f Surface water objectives.

Table 4-5: Well Attrition/Well Additions for Nitrate, 1999-2018 (Page 1 of 2)

Groundwater Management Zone	Nitrate							
	Basin Totals		Point Statistics			Averages		
	Total Wells	Total Statistics	High Risk [a]	Medium Risk[b]	New Stat [c]	High Risk [a]	Medium Risk[b]	Potential Stat [d]
San Bernardino Valley and Yucaipa / Beaumont Plains								
Beaumont	97	66	—	4	—	8	7	—
Bunker Hill-A	105	85	2	4	—	7	1	—
Bunker Hill-B	136	99	3	7	1	11	2	—
Lytle	38	35	—	6	—	—	1	—
San Timoteo	34	21	—	1	—	—	1	—
Yucaipa	117	78	—	5	2	2	12	—
San Jacinto Basins								
Canyon	27	19	—	1	—	—	1	—
Hemet-South	58	41	—	4	1	3	2	—
Lakeview/Hemet North	88	54	1	2	1	3	6	—
Menifee	22	16	—	3	—	2	1	—
Perris-North	42	28	1	6	—	1	3	—
Perris-South	67	52	—	2	1	2	4	—
San Jacinto-Lower Pressure	17	3	1	2	—	1	2	—
San Jacinto-Upper Pressure	111	35	—	3	—	6	8	—
Chino, Rialto / Colton, and Riverside Basins								
Chino-North	573	349	—	13	—	34	34	—
Chino-1/Chino North	236	129	—	6	—	17	21	—
Chino-2/Chino North	204	107	—	4	—	7	12	—
Chino-3/Chino North	133	113	—	3	—	10	1	—
Chino-East	493	273	—	2	2	18	5	—
Chino-South	109	49	—	3	—	5	13	—
Colton	10	8	1	—	—	—	—	—
Cucamonga	28	23	—	3	—	1	—	—
Rialto	105	58	2	4	4	6	—	—
Riverside-A	71	42	2	1	—	3	2	—
Riverside-B	48	53	—	—	—	—	1	—
Riverside-C	4	3	—	—	—	1	—	—
Riverside-D	9	7	—	—	—	—	—	—
Riverside-E	9	4	—	—	—	—	1	—
Riverside-F	28	19	—	—	1	1	—	—
Prado Basin	40	22	—	—	—	—	—	—
Elsinore / Temescal Valleys								
Arlington	32	19	—	—	—	3	1	—
Bedford	6	4	—	1	—	—	—	—
Coldwater	9	6	—	1	—	—	—	—
Elsinore	16	10	—	—	—	3	—	—
Lee Lake	7	6	—	—	—	—	—	—
Temescal	46	38	1	5	—	1	—	—
Warm Springs Valley	1	—	—	—	—	—	—	—

Table 4-5:Well Attrition/Well Additions for Nitrate, 1999-2018 (Page 2 of 2)

Groundwater Management Zone	Nitrate							
	Basin Totals		Point Statistics			Averages		
	Total Wells	Total Statistics	High Risk [a]	Medium Risk[b]	New Stat [c]	High Risk [a]	Medium Risk[b]	Potential Stat [d]
Orange County Basins								
Irvine	120	68	—	3	—	9	2	—
La Habra	1	—	—	—	—	—	—	—
Orange County	1,677	845	3	31	4	57	52	—
Santiago	3	3	—	—	—	—	—	—

[a] High risk wells will be lost during the 1999-2018 study period if not sampled before 2018.
[b] Medium risk wells will be lost during the 2002-2021 study period if not sampled before 2021.
[c] New stats are wells with the first sample collected 2010-2013, which meets the minimum number of annualized averages to become a point statistic.
[d] Potential stats are wells with the first sample collected 2014-2015; it is highly recommended that these wells continue to be sampled for the upcoming AWQ recomputation.
[e] 1999-2018 AWQ not calculated.
f Surface water objectives.

Table 4-6: Well Attrition/Wells at Risk for TDS, 1999-2018 (Page 1 of 2)

Groundwater Management Zone	Total Dissolved Solids							
	Basin Totals		Point Statistics			Averages		
	Total Wells	Total Statistics	2019	2020	2021	2019	2020	2021
San Bernardino Valley and Yucaipa / Beaumont Plains								
Beaumont	99	59	—	—	1	—	12	3
Bunker Hill-A	109	85	3	1	1	—	8	2
Bunker Hill-B	146	105	2	9	7	—	16	3
Lytle	38	27	1	—	2	—	2	1
San Timoteo	34	25	—	—	1	—	1	—
Yucaipa	114	72	—	1	2	—	5	—
San Jacinto Basins								
Canyon	27	24	—	—	—	—	—	—
Hemet-South	58	41	—	1	—	—	1	2
Lakeview/Hemet North	88	66	1	1	1	—	2	2
Menifee	22	19	—	—	1	—	2	1
Perris-North	42	33	1	3	2	—	1	1
Perris-South	67	54	—	—	1	—	2	2
San Jacinto-Lower Pressure	17	12	1	2	1	—	1	—
San Jacinto-Upper Pressure	111	81	2	3	4	—	3	1
Chino, Rialto / Colton, and Riverside Basins								
Chino-North	482	287	4	2	3	—	41	16
Chino-1/Chino North	179	102	1	—	—	—	25	11
Chino-2/Chino North	194	107	1	1	3	—	6	2
Chino-3/Chino North	109	78	2	1	—	—	10	2
Chino-East	207	33	—	—	—	—	3	—
Chino-South	59	33	—	1	1	—	1	7
Colton	10	9	—	—	—	—	1	—
Cucamonga	28	26	—	3	—	—	1	—
Rialto	91	58	2	1	3	—	4	2
Riverside-A	77	43	—	—	1	—	3	2
Riverside-B	27	10	—	—	—	—	—	—
Riverside-C	1	0	—	—	—	—	—	—
Riverside-D	1	1	—	—	—	—	—	—
Riverside-E	8	5	—	—	—	—	—	—
Riverside-F	27	22	—	—	—	—	—	—
Prado Basin	40	22	—	—	—	—	—	—
Elsinore / Temescal Valleys								
Arlington	19	6	—	—	—	—	3	—
Bedford	6	4	—	1	—	—	—	—
Coldwater	8	6	—	—	1	—	—	—
Elsinore	16	12	—	—	—	—	3	—
Lee Lak	7	6	—	—	—	—	—	—
Temescal	45	36	5	2	—	—	1	—
Warm Springs Valley	1	—	—	—	—	—	—	—

Table 4 6: Well Attrition/Wells at Risk for TDS, 1999-2018 (Page 2 of 2)

Groundwater Management Zone	Total Dissolved Solids							
	Basin Totals		Point Statistics			Averages		
	Total Wells	Total Statistics	2019	2020	2021	2019	2020	2021
Orange County Basins								
Irvine	119	101	—		1	—	8	—
La Habra	1	1	—	—	—	—	—	—
Orange County	1,710	1,320	2	59	22	—	48	19
Santiago	3	3	—	—	—	—	—	—

Table 4-7: Well Attrition/Wells at Risk for Nitrate, 1999-2018 (Page 1 of 2)

Groundwater Management Zone	Nitrate							
	Basin Totals		Point Statistics			Averages		
	Total Wells	Total Statistics	2019	2020	2021	2019	2020	2021
San Bernardino Valley and Yucaipa / Beaumont Plains								
Beaumont	97	66	—	—	4	—	8	2
Bunker Hill-A	105	85	2	2	1	—	7	1
Bunker Hill-B	136	99	2	6	1	—	11	2
Lytle	38	35	—	3	3	—	—	—
San Timoteo	34	21	—	—	1	—	—	—
Yucaipa	117	78	—	—	3	—	2	—
San Jacinto Basins								
Canyon	27	19	—	—	—	—	—	—
Hemet-South	58	41	—	1	—	—	3	—
Lakeview/Hemet North	88	54	1	1	1	—	3	2
Menifee	22	16	—	—	1	—	2	1
Perris-North	42	28	1	3	1	—	1	1
Perris-South	67	52	—	—	1	—	2	2
San Jacinto-Lower Pressure	17	3	1	1	—	—	1	1
San Jacinto-Upper Pressure	111	35	—	—	1	—	6	3
Chino, Rialto / Colton, and Riverside Basins								
Chino-North	573	349	—	4	5	—	34	10
Chino-1/Chino North	236	129	—	—	4	—	17	5
Chino-2/Chino North	204	107	—	2	1	—	7	4
Chino-3/Chino North	133	113	—	2	—	—	10	1
Chino-East	493	273	—	—	1	—	18	1
Chino-South	109	49	—	1	1	—	5	10
Colton	10	8	1	—	—	—	—	—
Cucamonga	28	23	—	3	—	—	1	—
Rialto	105	58	2	1	3	—	6	—
Riverside-A	71	42	2	—	1	—	3	1
Riverside-B	48	23	—	—	—	—	—	—
Riverside-C	4	3	—	—	—	—	1	—
Riverside-D	9	7	—	—	—	—	—	—
Riverside-E	9	4	—	—	—	—	—	—
Riverside-F	28	19	—	—	—	—	1	—
Prado Basin	40	22	—	—	—	—	—	—
Elsinore / Temescal Valleys								
Arlington	32	19	—	—	—	—	3	—
Bedford	6	4	—	1	—	—	—	—
Coldwater	9	6	—	—	1	—	—	—
Elsinore	16	10	—	—	—	—	3	—
Lee Lake	6	4	—	—	—	—	—	—
Temescal	46	38	1	5	—	—	1	—
Warm Springs Valley	1	—	—	—	—	—	—	—

WSC
Water Systems Consulting, Inc.

Table 4-7: Well Attrition/Wells at Risk for Nitrate, 1999-2018 (Page 2 of 2)

Groundwater Management Zone	Nitrate							
	Basin Totals		Point Statistics			Averages		
	Total Wells	Total Statistics	2019	2020	2021	2019	2020	2021
Orange County Basins								
Irvine	120	68	—	—	1	—	9	—
La Habra	1	—	—	—	—	—	—	—
Orange County	1,677	845	3	8	8	—	57	20
Santiago	3	3	—	—	—	—	—	—

4.6 Interpretive Tools Analysis

Recall that the purpose of the interpretive tools is to attempt to characterize the factors that may have influenced changes in AWQ over time, and to determine whether the changes are real (systemic factors) or are artifacts of the methodology (methodological factors). One example from the 2009 AWQ recomputation is an apparent increase in TDS concentrations in the OC GWMZ from 2003 to 2009). However, further analyses showed that the increase in TDS concentrations was due to methodological factors (increased monitoring in areas of higher TDS that were not historically monitored).

"The ambient TDS concentration for the Orange County Groundwater Management Zone has increased from 560 mg/L (2003) to 590 mg/L (2006) to 600 mg/L (2009).[6] This increase in ambient TDS concentrations is…mainly due to the increased monitoring of seawater intrusion in the coastal regions of the management zone (see the Change Maps in Figures 4-10 and 4-11)." (WEI, 2011) The accessibility of on-line maps allows BMPTF members to readily confirm (or not) hypotheses about the root causes of changes in groundwater quality. In addition to the example provided above, additional data exploration is provided in this section.

4.6.1 Orange County Groundwater Management Zone

Groundwater in the Anaheim Forebay is under the influence of surface water diverted from the Santa Ana River (WEI, 2011), as well as water from the Groundwater Replenishment System (GWRS) that is spread in recharge basins in the forebay. From 2008 through 2018, almost 504,000 AF of GWRS final product water (FPW) has been recharged in the Anaheim Forebay (See Table 4-8). The FPW has a TDS concentration around 50 mg/L and a nitrate-nitrogen concentration around 0.8 mg/L. [7]

The interpretative tools analyses showed that five of the six key wells downgradient of the Anaheim forebay recharge locations showed very significant decreasing trends in TDS concentrations. Figure 4-5 shows a time-series chart that depicts the historical TDS concentrations in these wells (AM-13/1 , AM-23/1, AM-37/1, AM-8/1, AM-11/2, SCWC-PLJ2/1) and shows the overall trend of decreasing TDS concentrations in groundwater downgradient of the recharge facilities. The trends are not as obvious in the change maps for TDS in the Orange County GMZ. This is because the data have been spatially and temporally averaged, while the key well trends reflect annualized averages (with no spatial averaging).

The time series in Figure 4-5 also depicts the amount of FPW water recharged in the forebay area in million gallons per day (MGD). There were periods where no FPW water was recharged for several days at a time, including a period from June 9, 2014 through July 1, 2014 – a period of 23 days – which preceded a portion of the time series when there was a 350 to 400 mg/L increase in TDS (e.g., well number 1213206). There was no recharge of FPW between August 8, 2018 and October 2, 2018. One can discern the beginnings of an increase in TDS through 2018. TDS data from 2019 will be analyzed to

[6] The trend generally continued over time with TDS concentrations leveling off at 600 mg/L. TDS ambient concentrations in the OC GMZ was estimated to be 610 mg/L in 2012, 600 mg/L in 2015; and 600 mg/L in 2018.

[7] "During 2018, GWRS Final Product Water (FPW) had an average total dissolved solids (TDS) of 53 mg/L and Nitrogen (NO_3-N) of 0.81 mg/L. These results should be representative of all GWRS water throughout its operation." Kevin O'Toole / OCWD [Via email: Mon 3/16/2020 3:00 PM]

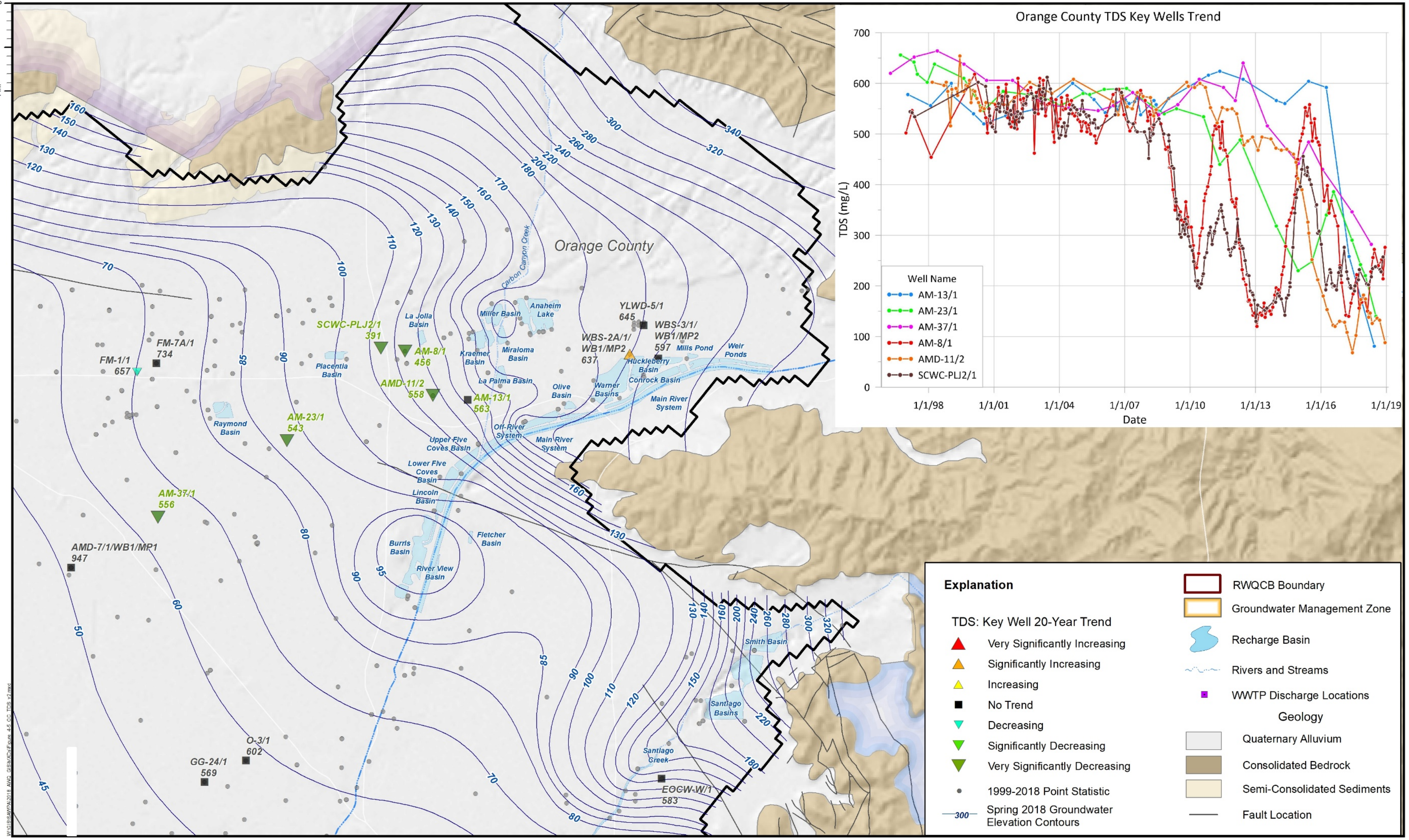
determine if this trend continues. The general pattern in the forebay is one of dramatic improvement in groundwater due to recharge of FPW water. The changes in TDS concentrations are important and real and are another example of systemic changes in the ambient groundwater quality.

Table 4-8. Production of GWRS FPW and Injection and Spreading Locations

Year	Historical Injection at Talbert Barrier		Historical Injection at Mid-Basin Demonstration Project in Santa Ana		Historical Spreading Water in Anaheim Forebay		Combined Total	
	MG*	AF	MG	AF	MG	AF	MG	AF
2008	7,247	22,237			7,370	21,307	1,4617	43,544
2009	11,011	33,787			9,347	27,023	2,0358	60,810
2010	12,465	38,249			10,195	29,473	22,660	67,722
2011	8,385	25,728			14,626	42,283	23,011	68,011
2012	7,978	24,480			16,211	46,865	24,189	71,345
2013	9,804	30,084			14,693	42,478	24,498	72,562
2014	10,734	32,937			11,446	33,091	22,180	66,028
2015	11,820	36,269	377	1,156	19,188	55,472	31,385	92,897
2016	11,289	34,639	496	1,523	21,808	63,048	33,593	99,210
2017	8,555	26,250	506	1,553	25,063	72,458	34,124	100,261
2018	8,097	24,844	496	1,521	24,319	70,307	32,912	96,672
Total	**107,386**	**32,9505**	**1875**	**5,753**	**99,289**	**503,805**	**283,526**	**839,063**

*Million gallons

Data provided courtesy of Kevin O'Toole / OCWD. [Via email on Mon 3/16/2020 12:37 PM]



Prepared by: WSC Water Systems Consulting, Inc.

Author: EC
Date: 3/30/2020
File Name: Figure_4-5_OC_TDS_v2

N

1 in : 1 mi
0 0.325 0.65 1.3 Mi
0 0.5 1 2 Km

References:
1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for: SAWPA

SAWPA Basin Monitoring Program Task Force
Recomputation of Ambient Water Quality for the Period 1999 to 2018

TDS Key Wells Change in Trend
Orange County and Irvine GMZs
Santa Ana River Watershed

Figure 4-5

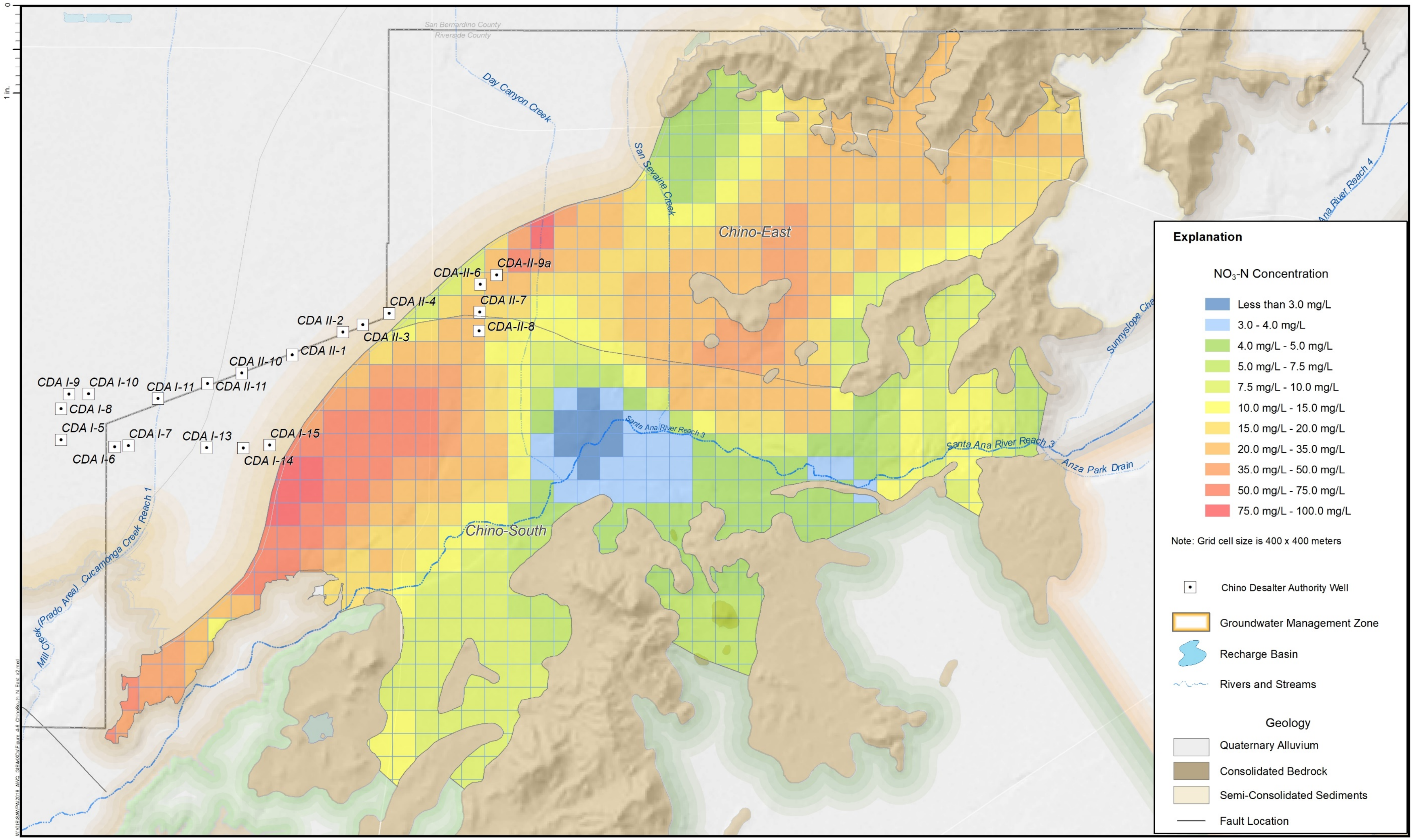
4.6.2 Chino South GMZ

In 2004, Regional Board amended the Basin Plan to better control the discharge of nitrogen and total dissolved solids (TDS) to local surface waterbodies and groundwater. Resolution Number R8-2004-0001 established new groundwater management zones (GMZ), revised nitrate-nitrogen and TDS objectives, revised TDS and nitrogen Waste Load Allocations (WLAs) for discharges of wastewater to the Santa Ana River and its tributaries, and revised reach designations for selected waterbodies. A water quality objective of 4.2 mg/L for nitrate-nitrogen was adopted in the Chino-South GMZ. The objective was computed as the volume-weighted average concentration of nitrate-nitrogen based on all sampling data collected for the period beginning in 1954 and ending in 1973 (e.g., objective setting period). In the Chino-South GMZ, the current ambient groundwater concentrations of nitrate-nitrogen and TDS for the most recent recomputation period are well above the water quality objectives of 4.2 mg/L, and 680 mg/L, respectively, and thus there is no assimilative capacity. The basin plan amendment that is currently in development proposes to amend Table 4-1 in the Basin Plan to revise the water quality objective for nitrate-nitrogen in the Chino-South GMZ from its current value of 4.2 mg/L to a new value of 5.0 mg/L. In developing the economic analysis for this amendment, it was demonstrated that high quality Santa Ana River water was being diverted into the Chino-South GMZ. In addition, the groundwater appears to be undergoing further soil aquifer treatment (SAT); see Figure 4-6. There is a substantial area (numbers of grid cells) of the Chino-South GMZ where nitrate-nitrogen concentrations are less than 3 or 4 mg/L, which is contributing to slight decreases in AWQ nitrogen concentrations in the Chino-South GMZ since the 2012 AWQ recomputation:

- 1954: 4.2 mg/L
- 1997: 8.8 mg/L
- 2003: 15.3 mg/L
- 2006: 25.7 mg/L
- 2009: 26.8 mg/L
- 2012: 28.0 mg/L
- 2015: 27.8 mg/L
- 2018: 27.6 mg/L

TDS in groundwater in the Chino South GMZ shows a similar trend, where the influx of higher quality water from the Santa Ana River into the Chino South GMZ has resulted in an area of groundwater with TDS concentrations less than 600 mg/L (Figure 4-7).

The movement of high quality surface water (low concentrations of TDS and nitrate) into the Chino South GMZ is another example of a systemic change to ambient groundwater quality and an example of using the interpretive tool for data exploration.



Prepared by:

WSC Water Systems Consulting, Inc.

Author: EC
Date: 4/6/2020

File Name: Figure_4-6_ChinoSouth_N_East_v2

N

1 in : 0.9 mi

0 0.325 0.65 1.3 Mi

0 0.5 1 2 Km

References:

1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for:

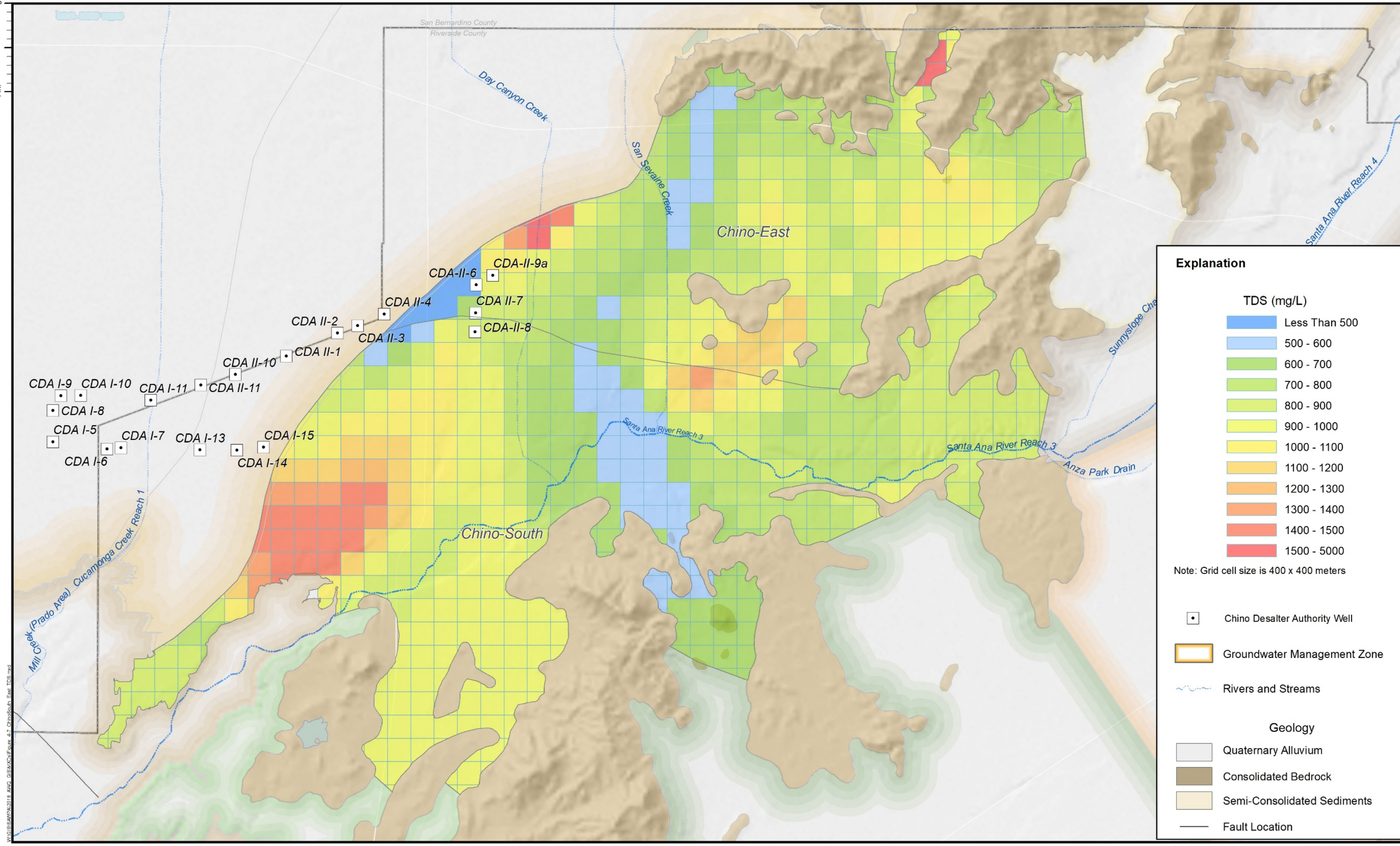
SAWPA

SAWPA Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality
for the Period 1999 to 2018

Spatial Distribution of Nitrate Concentrations in Chino South

Figure 4-6



Prepared by:

WSC
Water Systems Consulting, Inc.

Author: EC
Date: 4/6/2020

File Name: Figure_4-7_ChinoSouth_East_TDS

N

1 in : 0.9 mi

0 0.325 0.65 1.3 Mi

0 0.5 1 2 Km

References:
1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for:

SAWPA

SAWPA Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality
for the Period 1999 to 2018

Spatial Distribution of TDS Concentrations in Chino South

Figure 4-7

4.6.3 Riverside-A GMZ

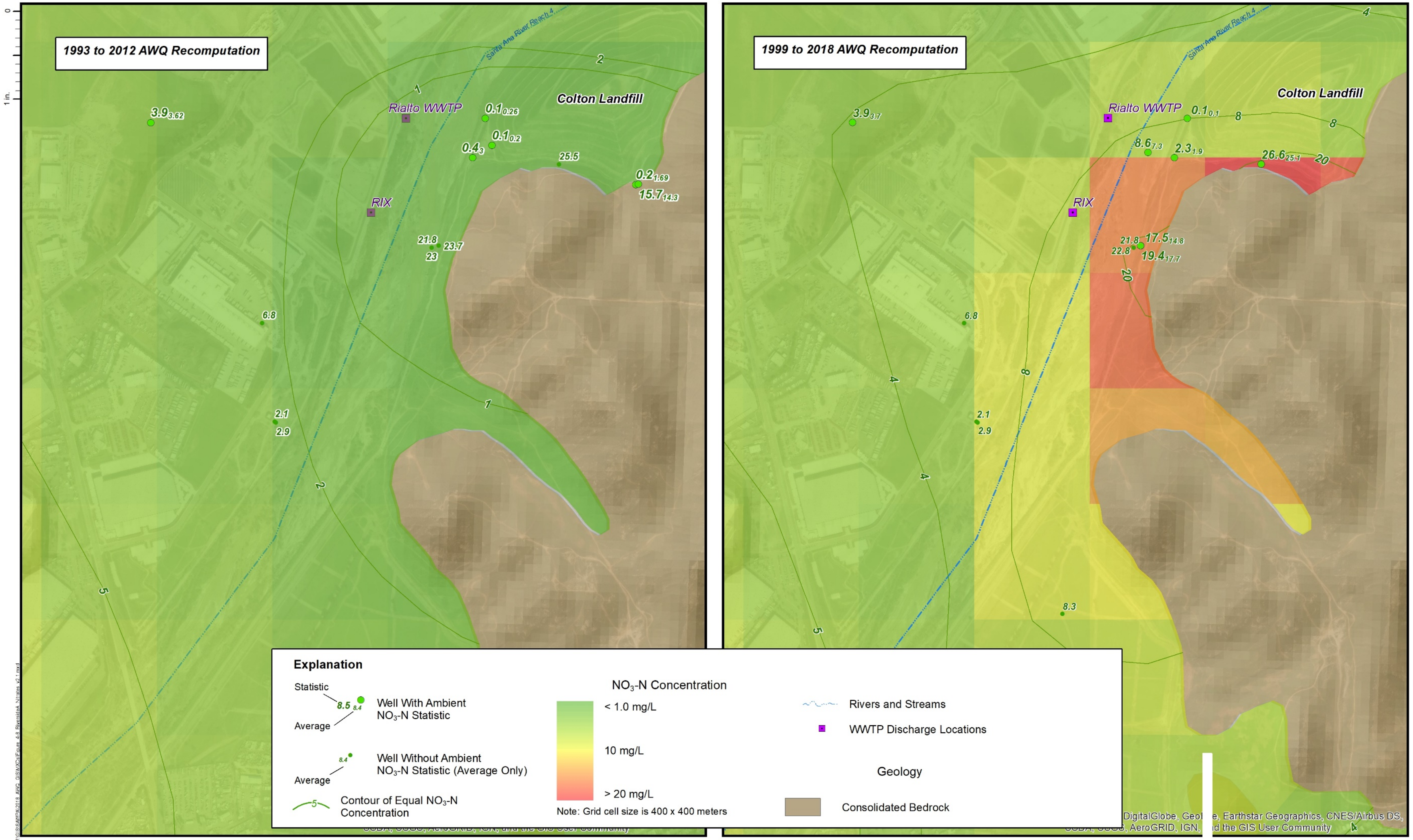
In the Riverside-A GMZ, the current ambient concentrations of nitrogen and TDS for the most recent recomputation period remains below the WQOs. Thus, there is assimilative capacity for TIN and TDS in the Riverside-A GMZ. Absent a revised Nitrogen-Loss Coefficient, the incidental recharge of recycled water is likely to degrade existing water quality in the Riverside-A GMZ, but it is not likely to cause or contribute to an exceedance of the WQO for TIN (6.2 mg/L).

However, the Colton Landfill appears to be contributing nitrate into Riverside-A GMZ above the WQOs and above MCLs. Locations of selected Colton Landfill monitoring wells are shown in Figure 4-8. Nitrate concentrations in monitoring wells have been increasing over time in several wells, beginning in about 2004. The saturated volume of groundwater in grid cells near the Colton Landfill is relatively small in comparison with the rest of the grid cells in Riverside-A GMZ; indeed some of the wells would be dry based on the elevation of the perforated intervals and bedrock elevation[8]. Hence, while the mass of nitrate contributed by the Colton Landfill is relatively small compared with the rest of the Riverside-A GMZ, the concentrations are locally significant.

In developing contour maps for nitrate in groundwater, all existing data were honored. A well southeast of the Rialto WWTP now has the requisite number of samples to become a point statistic with a computed point statistic value of 8.6 mg/L. The addition of this one well to the AWQ Recomputation has resulted in the 4 mg/L contour line being located further to the west and northwest, changing the estimated AWQ for this portion of the Riverside-A GMZ.

Interestingly, the change in nitrate in the Riverside-A GMZ is both systemic and methodological. There are real increases in nitrate in groundwater due to contributions from the Colton Landfill. Recent increases in nitrate in grid cells near the landfill can also be attributed in part to wells that became eligible to be point statistics or averages during the 2015 AWQ Recomputation (Figure 4-4 from the 2015 AWQ; DBS&A. 2017).

[8] This is an area where the aquifer geometry should be re-analyzed and perhaps updated.



Prepared by:

WSC Water Systems Consulting, Inc.

Author: EC

Date: 4/6/2020

File Name: Figure_4-8_RiversideA_Nitrates_v2.1

N

1 in : 0.2 mi

0 0.05 0.1 0.2 Mi

0 0.1 0.2 0.4 Km

References:
1. Coordinate System: NAD 1983 UTM Zone 11N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
2.
3.

Prepared for:

SAWPA

SAWPA Basin Monitoring Program Task Force

Recomputation of Ambient Water Quality for the Period 1999 to 2018

Location of Selected Monitoiring Wells Associated with the Colton Landfill
2012 to 2018 NO_3-N Riverside A GMZ

Figure 4-8

SECTION 5

Recommendations

The Basin Plan (RWQCB, 2016a) requires the "Implementation of a watershed-wide TDS/nitrogen groundwater monitoring program" to address:

- Determination of current ambient quality in GMZs
- Determination of compliance with TDS and nitrate-nitrogen objectives for the GMZs
- Evaluation of assimilative capacity findings for GMZs
- Assessment of the effects of recharge of surface water POTW discharges on the quality of affected GMZs

5.1 Objective of the Triennial Ambient Water Quality Recomputation

The Basin Plan (RWQCB, 2016a) states:

> *"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 WQOs included in this Basin Plan."*

The Basin Plan (RWQCB, 2016a) further states that groundwater monitoring should be expanded to *"fill data gaps for those management zones with insufficient data to calculate TDS and nitrate-nitrogen historical quality and current quality."*

Task Force members are required to perform the recomputation of AWQ every three years, either through the coordinated monitoring plan outlined in the BMPTF agreement, as an individual agency, or as a group of agencies.

5.2 Change the AWQ Recomputation Period

The BMPTF should explore the possibility of revising Chapter 5 of the Basin Plan (Implementation) to merge requirements of Imported Water Recharge Work Group (IWRWG) and the Waste Load Allocation model (WLAM) with the BMPTF. The BMPTF could consider performing the AWQ Recomputation every five years rather than every three years, beginning with the 2025 AWQ Recomputation. There are advantages to modifying the AWQ to a five-year cycle:

1. A five-year cycle will allow for the alignment of the major regional watershed programs, including the modeling tasks performed by the IWRWG.
2. A five-year funding and analysis period could potentially save about $46,000 per recomputation ($350,000 divided by 5 years rather than 3 years). Contract issuance and data request letters would occur in Spring 2025. Henceforth the AWQ Recomputation would be for years that end in "0" or "5."
3. More significantly, a five-year cycle would allow the BMPTF members to have more time to effective manage the watershed, evaluate SNMP activities, and fulfill the requirements of the 2018 Recycled Water Policy.[9] This plan would allow two additional years in each cycle to perform the following:

> "**6.2.6. Data assessment**. The regional water boards, in consultation with stakeholders, shall assess and review monitoring data generated from these plans every five years, unless an alternate timeline has been established in a basin plan amendment. This assessment shall include an evaluation of:
>
> - observed trends in water quality data as compared with trends predicted in the salt and nutrient management plan;
> - the ability of the monitoring network to adequately characterize groundwater quality in the basin;
> - potential new data gaps;
> - groundwater quality impacts predicted in the salt and nutrient management plan based on most recent trends and any relied-upon models, including an evaluation of the ability of the model to simulate groundwater quality;
> - available assimilative capacity based on observed trends and most recent water quality data; and
> - projects that are reasonably foreseeable at the time of this data assessment but may not have been when the salt and nutrient management was prepared or last updated.
>
> "6.2.7. The regional water boards, in consultation with stakeholders, shall use the results of these periodic assessments to update basin evaluations of available assimilative capacity, projected trends, and concentrations of salts and nutrients in groundwater, and then determine whether potential updates or revisions to the salt and nutrient management plan may be warranted as a result of the data assessment or to make the plan consistent with the Policy."

5.3 Improve the Data Compilation, Formatting, and QA/QC Process

On any data-intensive project, data compilation, formatting, and QA/QC are difficult and time-

[9]https://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/2018/121118_7_final_amendment_oal.pdf

consuming work elements. The following are recommendations to streamline the workflow and improve the processes, resulting in a high-quality AWQ database. These were suggestions posed in the 2015 AWQ Recomputation. An assessment of how well these recommendations were administered is provided below:

2015 Recommendation	Outcome and Refined Recommendations
Realign the request for proposal (RFP) and proposal due date so that the selected consultant begins work on the data compilation task on April 1, 2019 instead of July 1, 2019, with a goal of collecting all of the data from all of the agencies by June 1, 2019. This will still provide the agencies with time to acquire and load data up through December 31, 2018 and will allow the consultant to begin analyzing all of the data in June of each year, rather than August or September.	Outcome: The 2015 recommendations were mostly followed. The data compilation request to agencies went out on April 24, 2019. It took the majority of agencies two months to provide the requested data. Refined recommendations: Realign the data request to notify agencies the following week after the consultant is awarded the project in order to give agencies an early start to begin work on the data compilation task. A follow up notification for the data request will be provided 30 days after the initial data request with a June 1 deadline. This should provide the agencies adequate time to compile the data, ask questions, and allow the consultant to verify the formatting of the data provided.
Each agency is provided a template that defines the data format in order to automate/facilitate the data upload into the AWQ database. Because the submitted data do not always follow the template, it is recommended that the agency staff responsible for fulfilling data requests meet with SAWPA staff prior to the next AWQ determination with a goal of being able to produce a high-quality electronic data deliverable (EDD) by June 1, 2019.	Outcome: The primary challenge faced was more than a third of agencies provided data in a format that didn't comply with the data request's accompanying EDD and guidance. As a result, it took longer than anticipated to format and compile the data into the database to begin analyzing the data. Data didn't get analyzed until September 2019, later than anticipated from the 2015 recommendation. Refined recommendations: Since the data request doesn't substantially change over time, the same data request files and guidance can be used in each data request. An alternative recommendation to improve the quality of the formatted data provided and speed up the delivery data process in addition to providing more time for the agencies to compile the data would be for the consultant to develop an online web tool where data can be uploaded. This web tool will parse the data provided and if the data is not in the format requested, it will provide feedback automatically to the data uploader to assist them in formatting the data correctly. This

	web tool would be used for all future data uploads and may allow for further integration of other useful tools (e.g. interactive interpretative tools) to be fully online.
As part of the EDD template, data providers are encouraged to complete the lookup table that links the WELL_ID with the owner/local name. Any changes to the WELL_INFO_Table, including well status (active, inactive, destroyed, etc.), should be carefully updated.	Outcome: A lookup table was not provided in the EDD for the 2018 data request. However, in most cases, agencies did provide updated well status information for the wells that they provided data. Refined recommendations: Update the EDD template to include the lookup table and functions that will link the Well_ID with the owner/local name. An alternative solution is mentioned above using a web tool instead of a spreadsheet.

5.4 Review AWQ Conceptual Models

The BMPTF may wish to continue funding the AWQ Recomputation at its current annual level. These funds and the period from June 30, 2020 through Spring 2025 could be used to further assess hydrogeological conceptual models, aquifer properties, and groundwater basin management plans and strategies.

5.5 Consider Pursuing Grant Funding to Perform Supplemental AWQ Tasks

The BMPTF may wish to pursue grant funding for supplemental work that has been identified in previous AWQ recomputations by identifying grant programs that might be applicable, e.g., Proposition 1 IRWMP. Such work may include:

- The sampling of existing wells in key locations that fulfill the requirements of the AWQ monitoring program and allow for the continued recomputation of AWQ and AC.
- To the extent that portions of the GMZs do not have adequate spatial coverage, even with the inclusion of data from existing wells, the BMPTF may consider the siting and installation of new monitoring wells.
- Update conceptual models (Section 5.4)
- Work with the State Water Board to align the AWQ database with requirements from the Recycled Water Policy, including reporting periods.
- Work with the State Water Board to develop and potentially implement Water Board methodologies for determining "at-risk" public water systems, domestic wells, and state small water systems 9Safe and Affordable Funding for Equity and Resilience [SAFER] Program).

SECTION 6

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IN THIS SECTION

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APPENDIX A

Electronic Deliverables

Appendix A files are provided online hosted on a FTP site located at WEBLINK. This FTP also contains an electronic version of this report.

APPENDIX B

Packets for Subwatershed Areas