



TDS/Nitrogen Management Plan for the Santa Ana River Basin *Groundwater Monitoring Requirements*

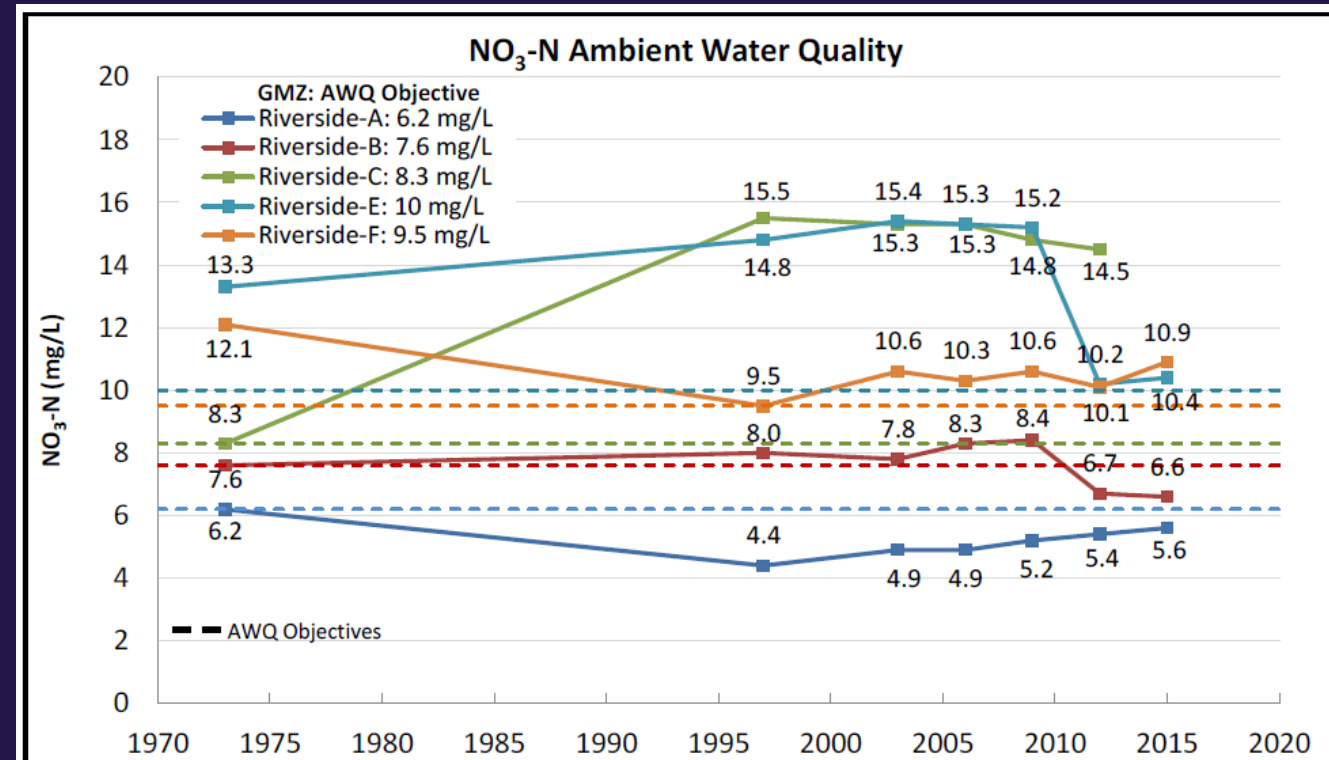
August 16, 2017



Objective

The Basin Plan requires the implementation of a watershed-wide 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.



Background

- In 1995, a Task Force was formed to study the impacts that salt and nitrate have on the long-term sustainability of groundwater supply. The Task Force including the Regional Board:
 - revised groundwater basin boundaries
 - set new water quality objectives based on a better data set
 - developed a rigorous scientific method for computing the volume-weighted ambient water quality



Groundwater Management Zone Boundaries and AWQ Objectives

Explanation

Riverside-A
560
6.2

Groundwater Management Zone
TDS Objective (mg/L)
NO₃-N Objective (mg/L)

*SWO: Surface Water Objectives Apply

N/A: Not enough data were available to calculate water quality objectives.

RWQCB Boundary

Groundwater Management Zone Boundary

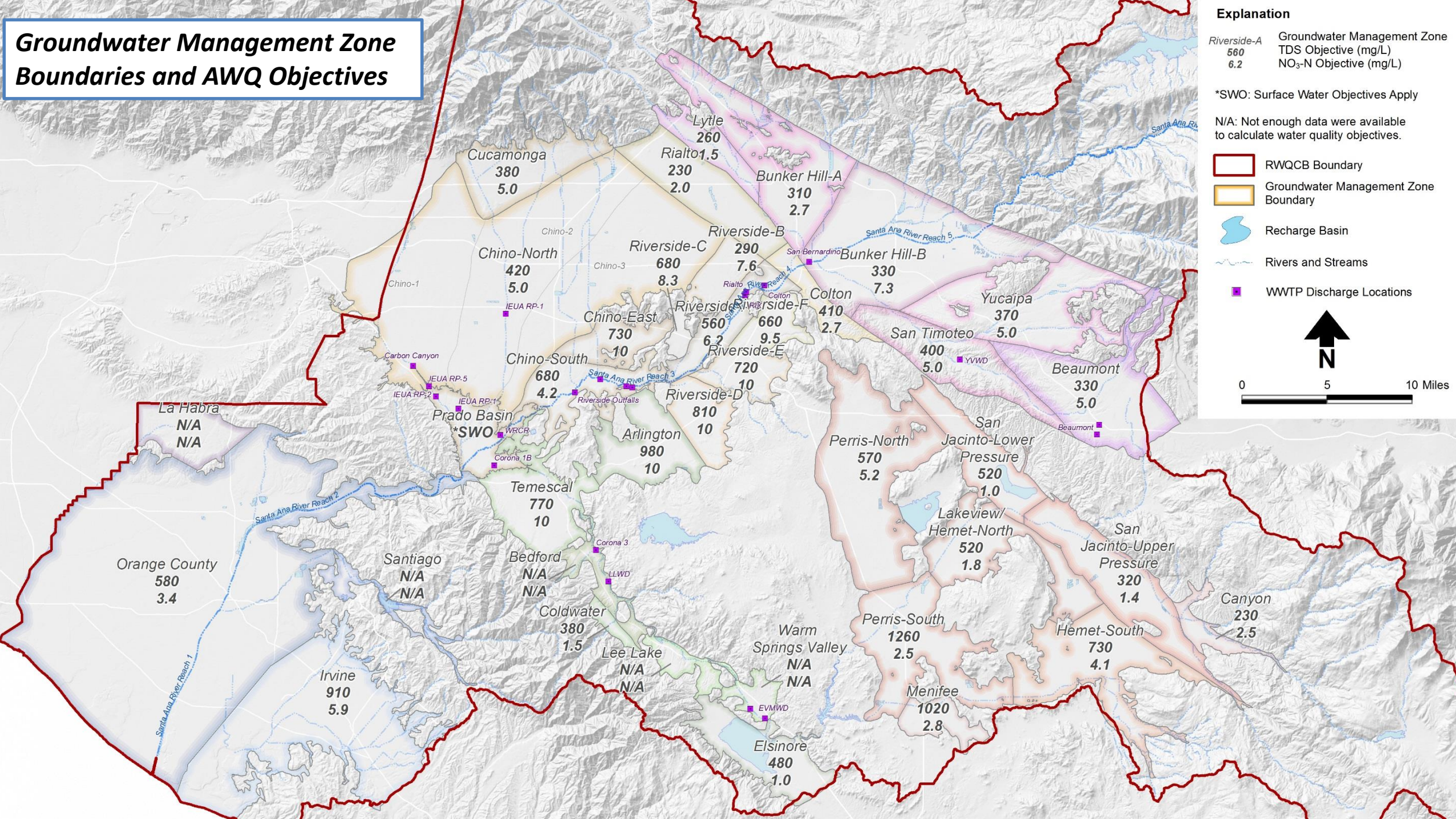
Recharge Basin

Rivers and Streams

WWTP Discharge Locations

N

0 5 10 Miles



Current - 1996 to 2015 - Recomputation

- Data compilation
- QA/QC, process, and upload recent historical data
- Calculate water quality point statistics
- Draw groundwater elevation and water quality contour maps
- Digitize contours and using geospatial tools, estimate volume-weighted ambient water quality in each groundwater management zone



Location of Wells with TDS Data

Explanation

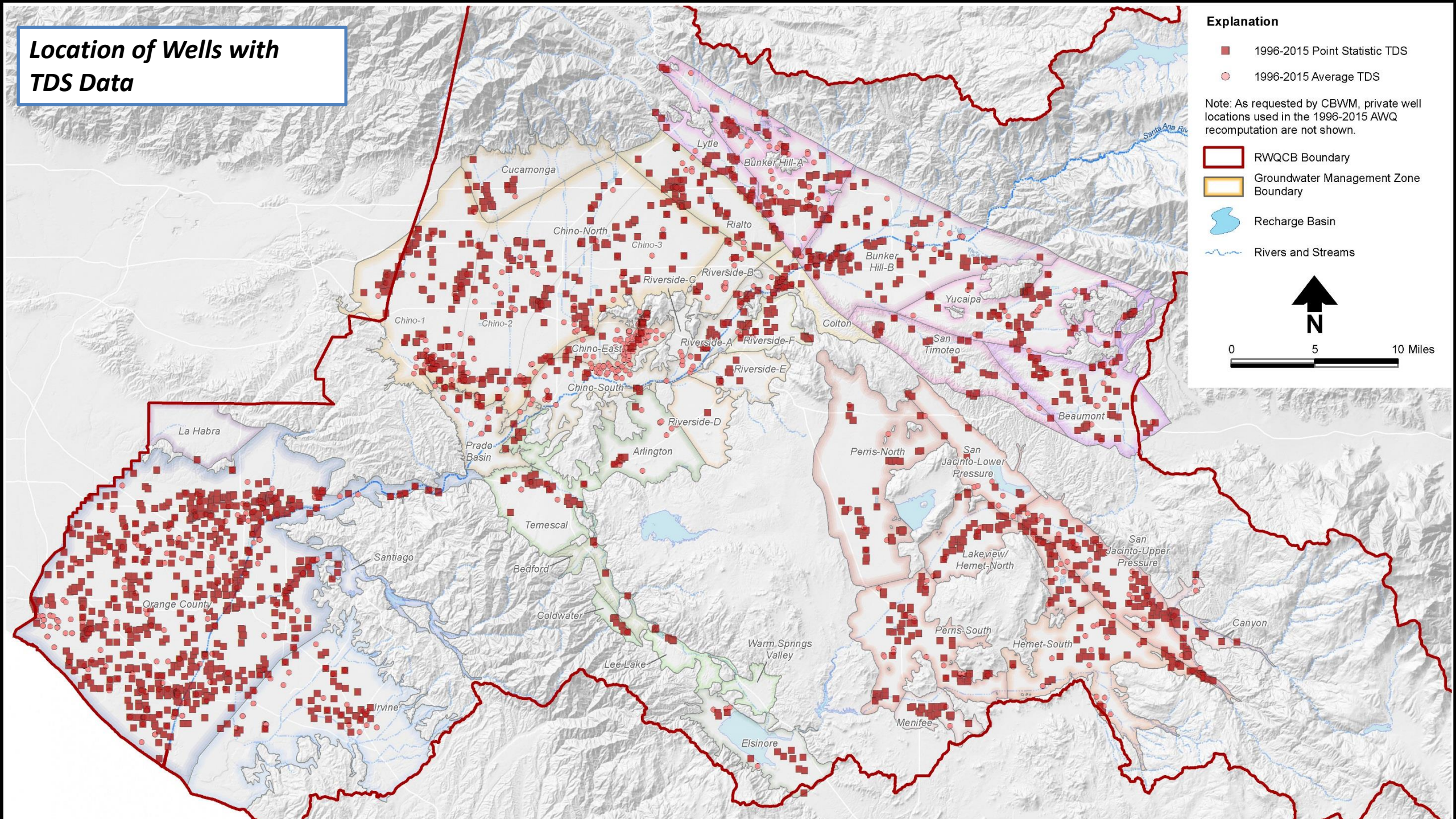
- 1996-2015 Point Statistic TDS
- 1996-2015 Average TDS

Note: As requested by CBWM, private well locations used in the 1996-2015 AWQ recomputation are not shown.

- RWQCB Boundary
- Groundwater Management Zone Boundary
- Recharge Basin
- Rivers and Streams



0 5 10 Miles



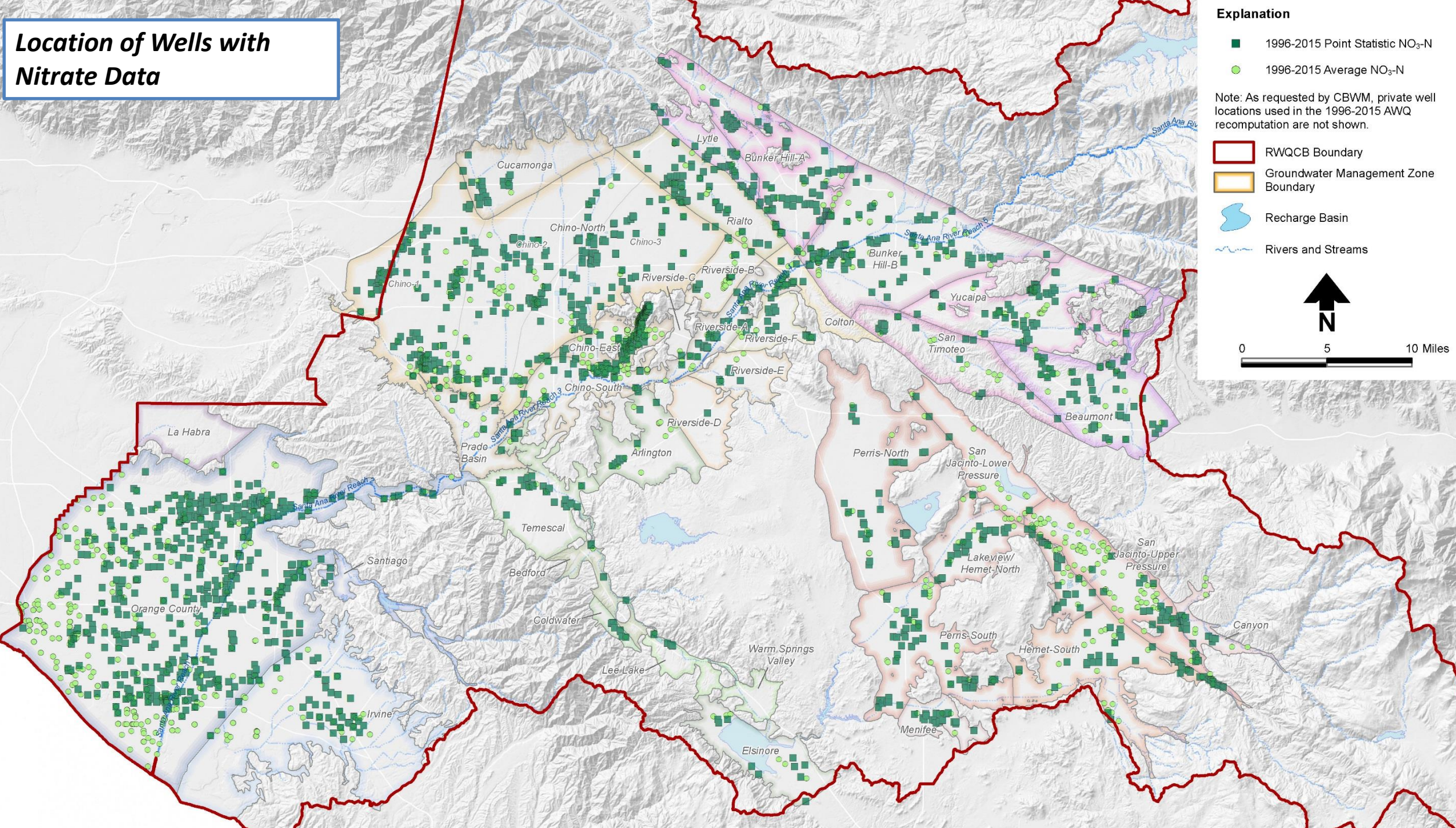
Location of Wells with Nitrate Data

Explanation

- 1996-2015 Point Statistic NO₃-N
- 1996-2015 Average NO₃-N

Note: As requested by CBWM, private well locations used in the 1996-2015 AWQ recomputation are not shown.

- RWQCB Boundary
- Groundwater Management Zone Boundary
- Recharge Basin
- Rivers and Streams



Volume Weighted Estimate of AWQ





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

where C_{avg} = the volume-weighted current ambient concentration in a GMZ
 C_i = the current ambient concentration of groundwater in the i th grid cell
 V_i = the volume of groundwater in the i th grid cell
 n = number of grid cells







Volume of Groundwater in GMZs

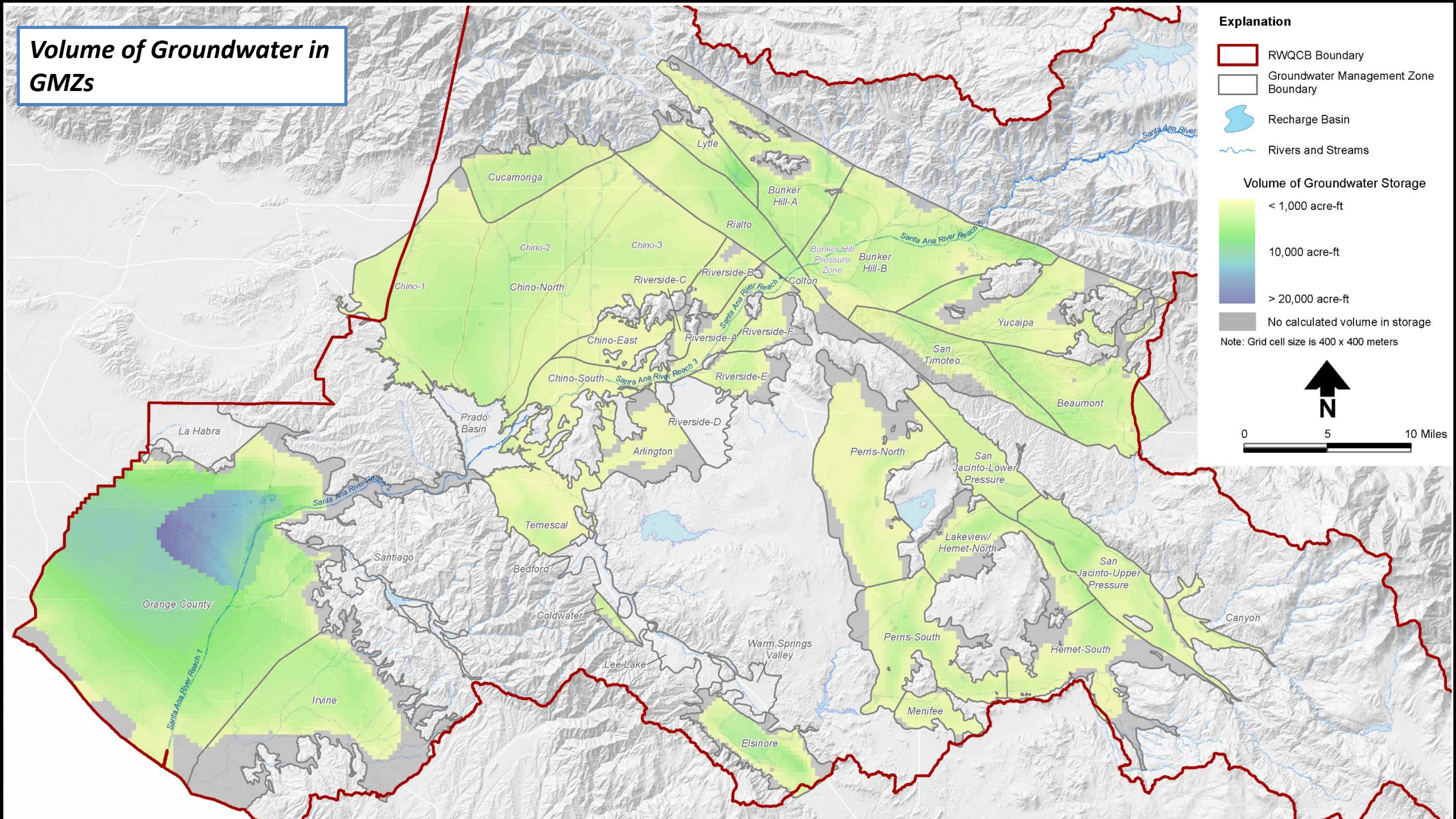
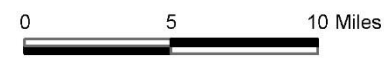
Explanation

-  RWQCB Boundary
-  Groundwater Management Zone Boundary
-  Recharge Basin
-  Rivers and Streams

Volume of Groundwater Storage

-  < 1,000 acre-ft
-  10,000 acre-ft
-  > 20,000 acre-ft
-  No calculated volume in storage

Note: Grid cell size is 400 x 400 meters



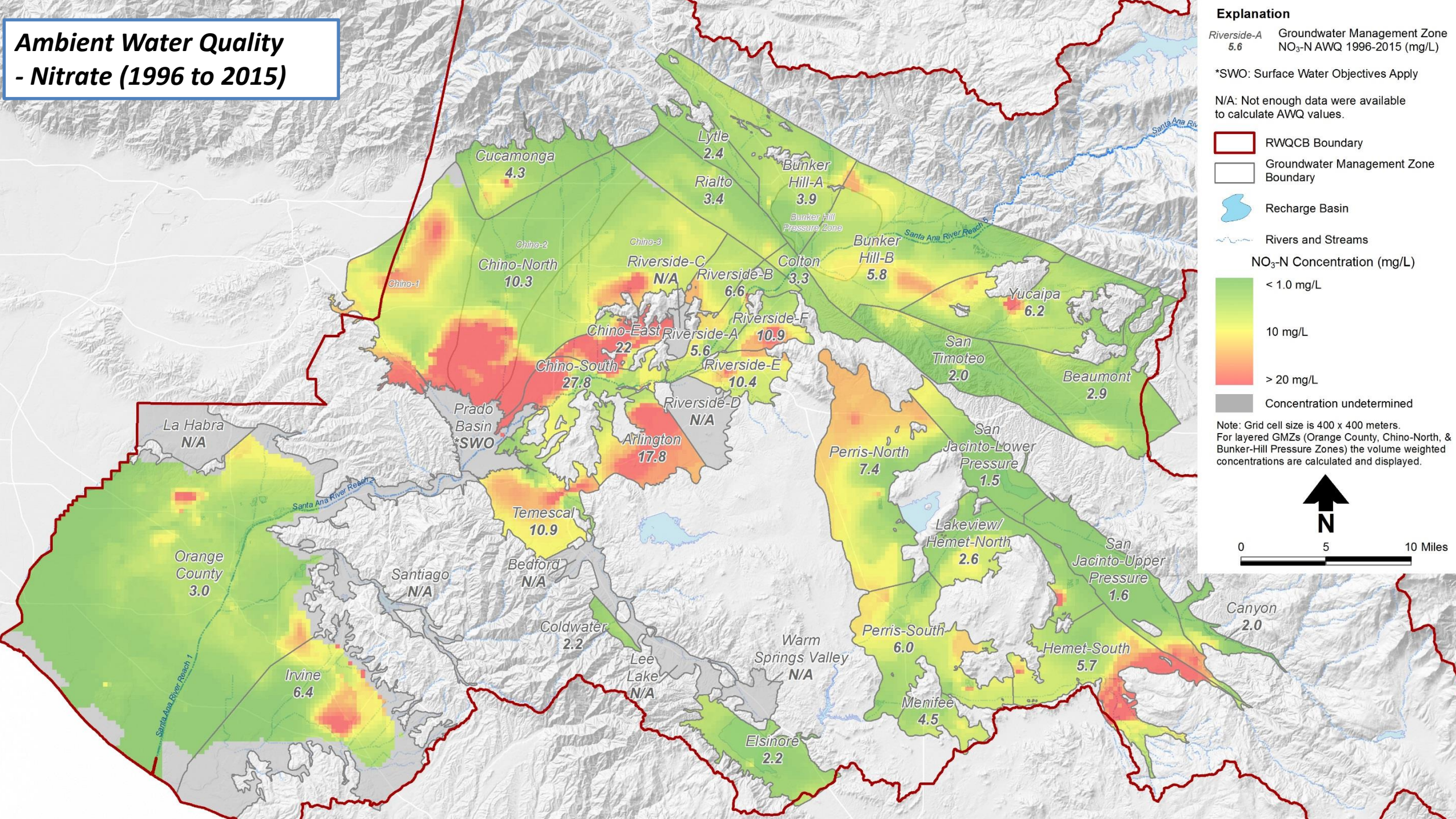
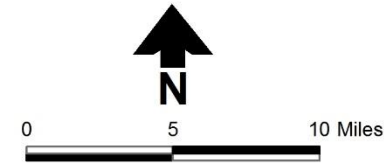
Ambient Water Quality - Nitrate (1996 to 2015)

Explanation
Riverside-A 5.6 Groundwater Management Zone
NO₃-N AWQ 1996-2015 (mg/L)
*SWO: Surface Water Objectives Apply

N/A: Not enough data were available to calculate AWQ values.

- RWQCB Boundary
- Groundwater Management Zone Boundary
- Recharge Basin
- Rivers and Streams
- NO₃-N Concentration (mg/L)**
 - < 1.0 mg/L
 - 10 mg/L
 - > 20 mg/L
 - Concentration undetermined

Note: Grid cell size is 400 x 400 meters.
For layered GMZs (Orange County, Chino-North, & Bunker-Hill Pressure Zones) the volume weighted concentrations are calculated and displayed.



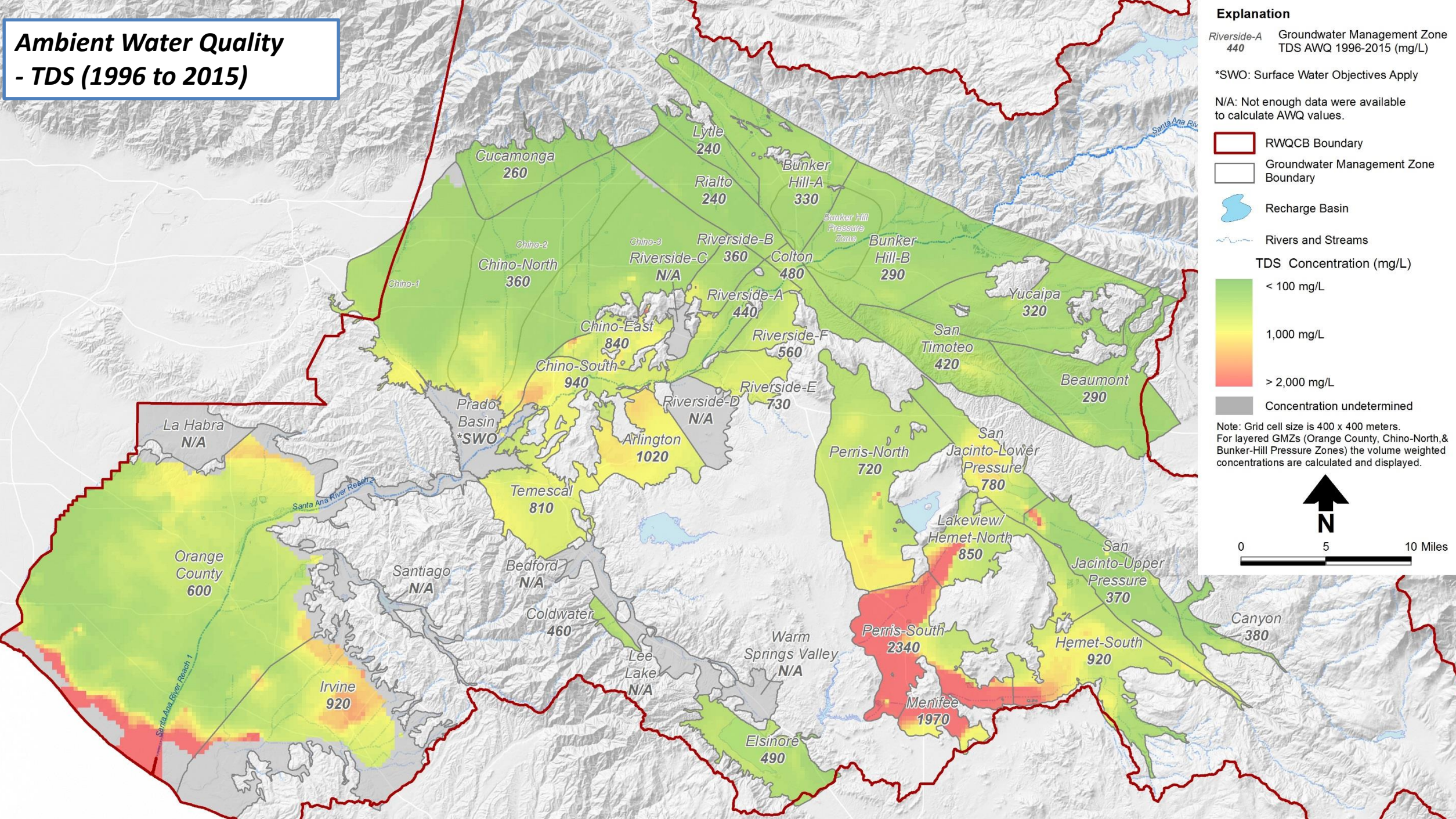
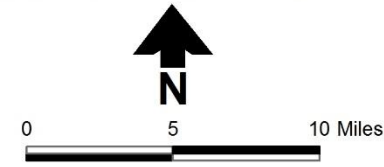
Ambient Water Quality - TDS (1996 to 2015)

Explanation
Riverside-A 440 Groundwater Management Zone
TDS AWQ 1996-2015 (mg/L)
*SWO: Surface Water Objectives Apply

N/A: Not enough data were available to calculate AWQ values.

- RWQCB Boundary
- Groundwater Management Zone Boundary
- Recharge Basin
- Rivers and Streams
- TDS Concentration (mg/L)**
 - < 100 mg/L
 - 1,000 mg/L
 - > 2,000 mg/L
 - Concentration undetermined

Note: Grid cell size is 400 x 400 meters.
For layered GMZs (Orange County, Chino-North, & Bunker-Hill Pressure Zones) the volume weighted concentrations are calculated and displayed.







Nitrate AWQ Change (2012 to 2015)





Explanation

Riverside-A 0.2 Groundwater Management Zone
NO₃-N AWQ Change (mg/L)

*SWO: Surface Water Objectives Apply
N/A: Not enough data were available
to calculate AWQ change

-  RWQCB Boundary
-  Groundwater Management Zone Boundary
-  Recharge Basin
-  Rivers and Streams

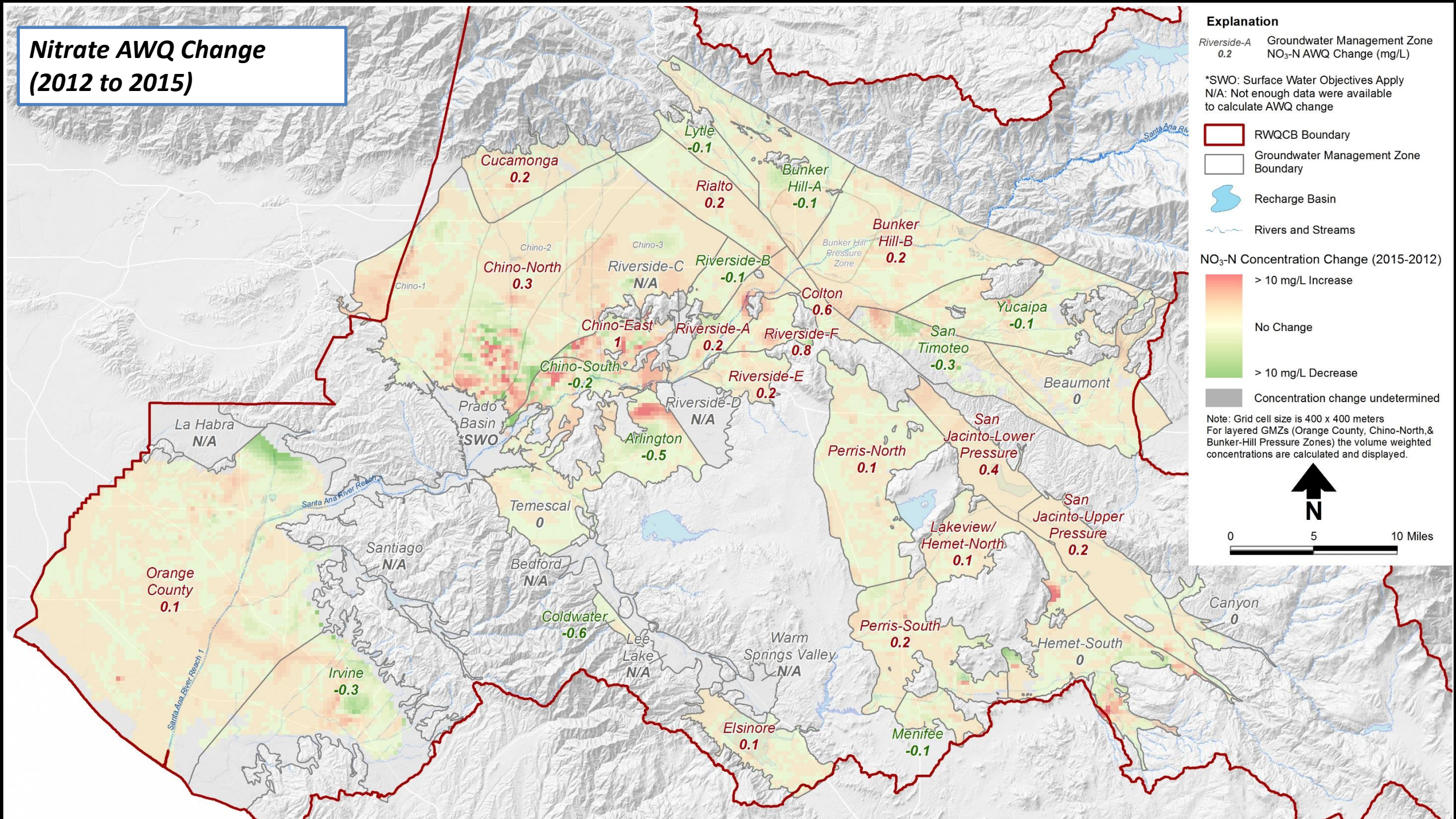
NO₃-N Concentration Change (2015-2012)

-  > 10 mg/L Increase
-  No Change
-  > 10 mg/L Decrease
-  Concentration change undetermined

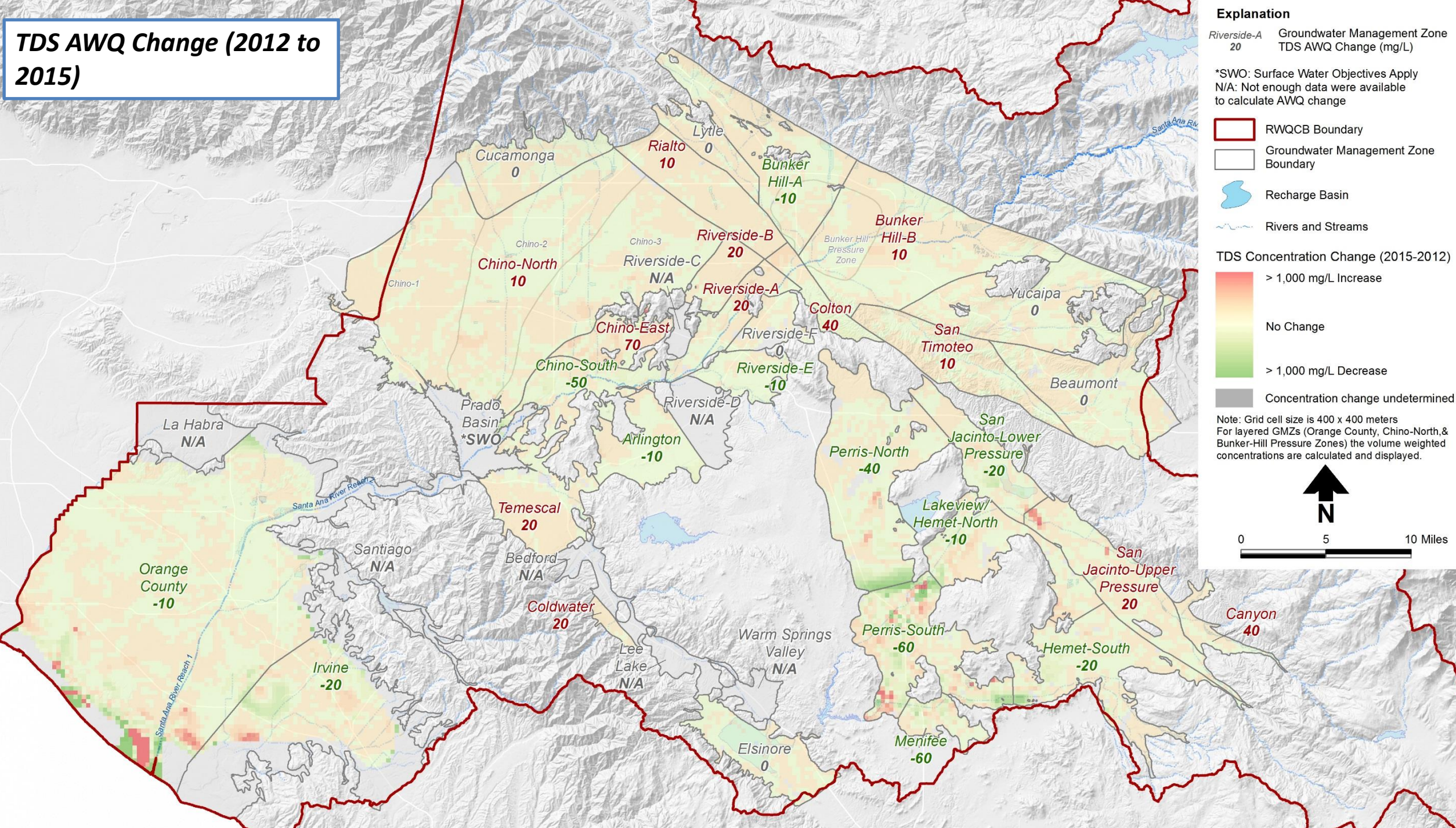
Note: Grid cell size is 400 x 400 meters
For layered GMZs (Orange County, Chino-North, & Bunker-Hill Pressure Zones) the volume weighted concentrations are calculated and displayed.



0 5 10 Miles



TDS AWQ Change (2012 to 2015)



Nitrate Well Attrition

Explanation

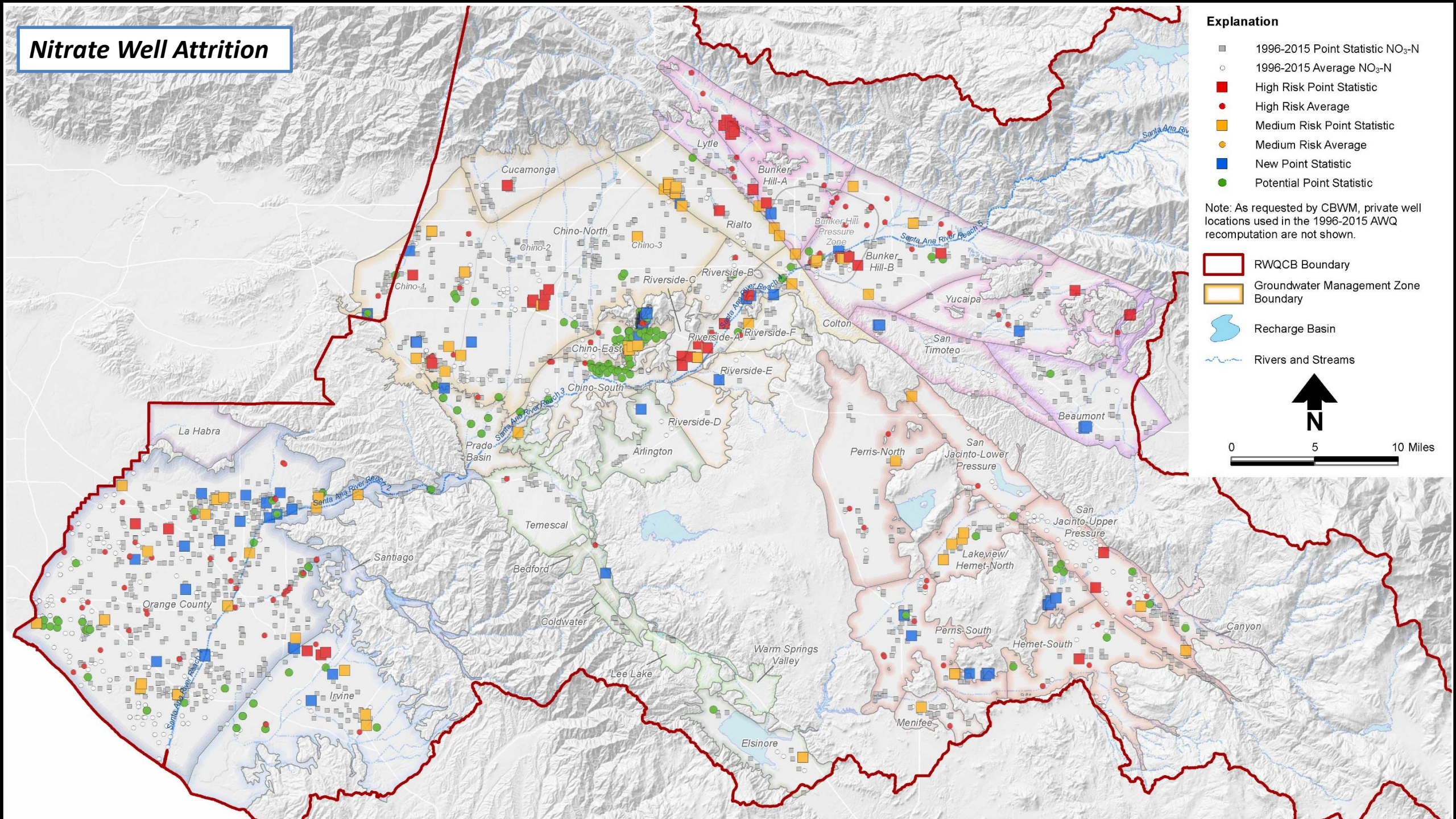
- 1996-2015 Point Statistic $\text{NO}_3\text{-N}$
- 1996-2015 Average $\text{NO}_3\text{-N}$
- High Risk Point Statistic
- High Risk Average
- Medium Risk Point Statistic
- Medium Risk Average
- New Point Statistic
- Potential Point Statistic

Note: As requested by CBWM, private well locations used in the 1996-2015 AWQ recomputation are not shown.

- RWQCB Boundary
- Groundwater Management Zone Boundary
- Recharge Basin
- Rivers and Streams



0 5 10 Miles



TDS Well Attrition

Explanation

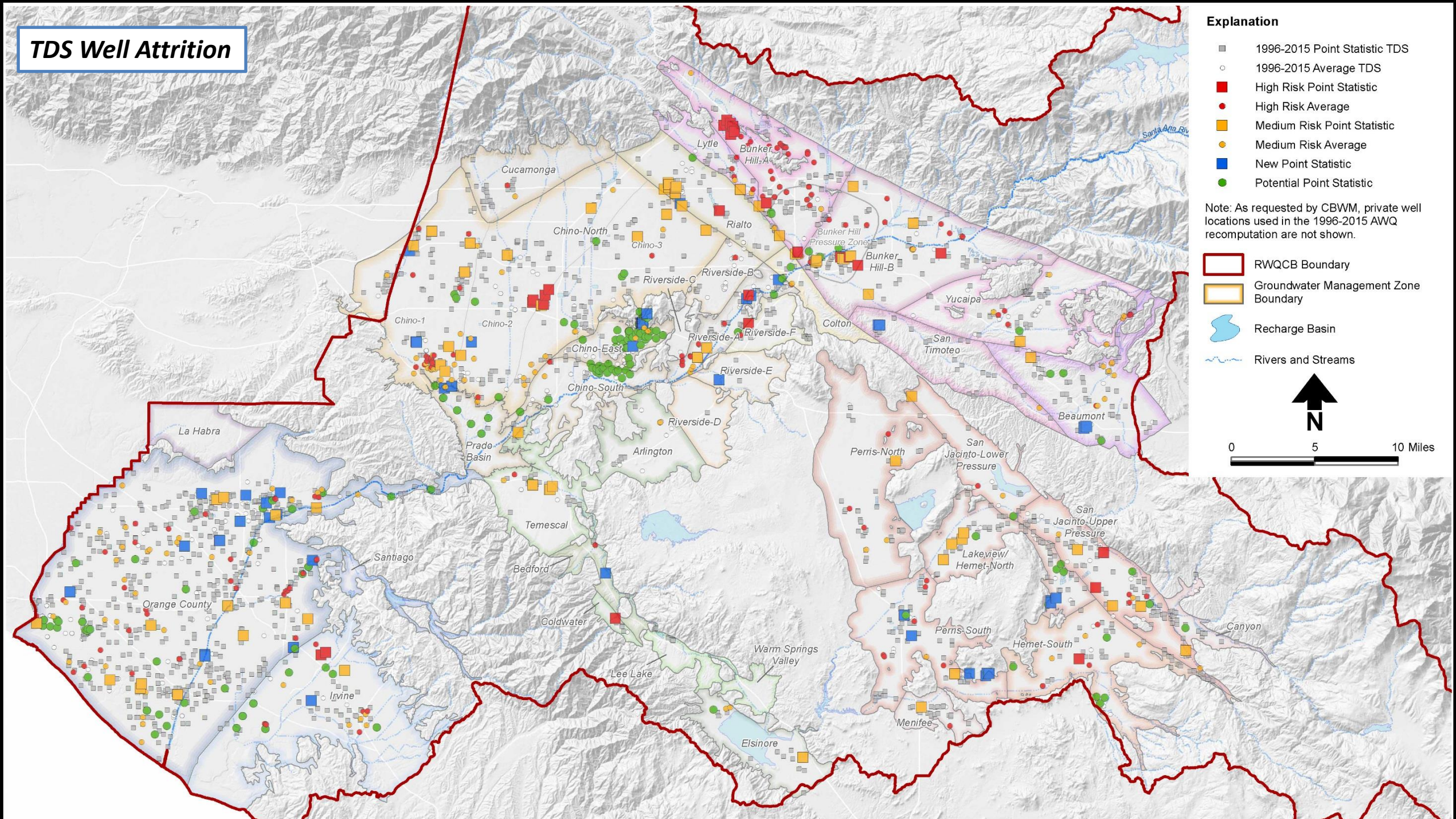
- 1996-2015 Point Statistic TDS
- 1996-2015 Average TDS
- High Risk Point Statistic
- High Risk Average
- Medium Risk Point Statistic
- Medium Risk Average
- New Point Statistic
- Potential Point Statistic

Note: As requested by CBWM, private well locations used in the 1996-2015 AWQ recomputation are not shown.

- RWQCB Boundary
- Groundwater Management Zone Boundary
- Recharge Basin
- Rivers and Streams

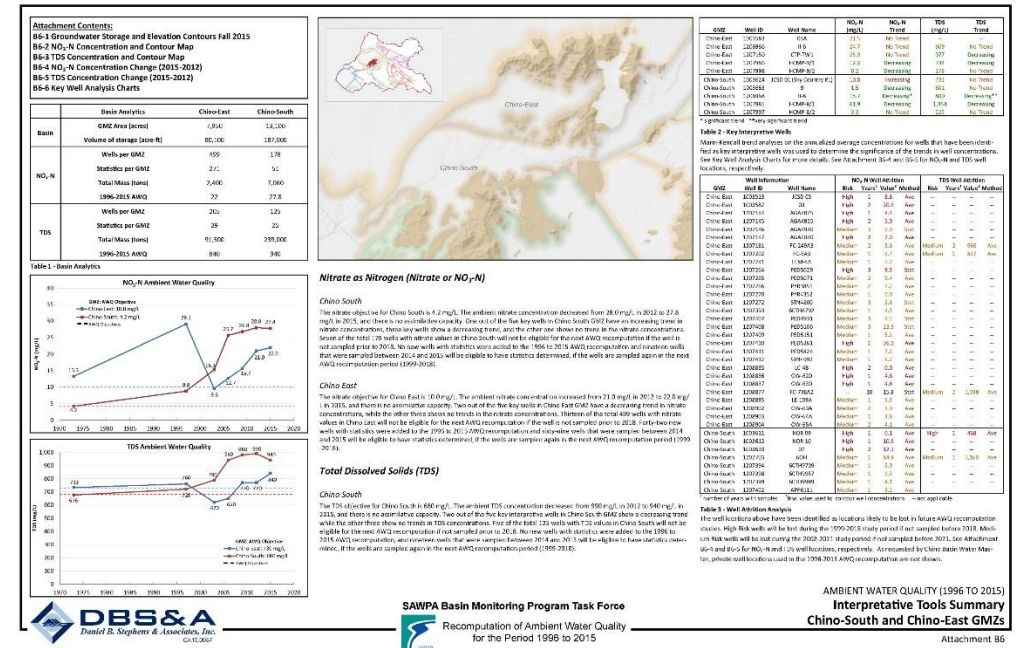


0 5 10 Miles



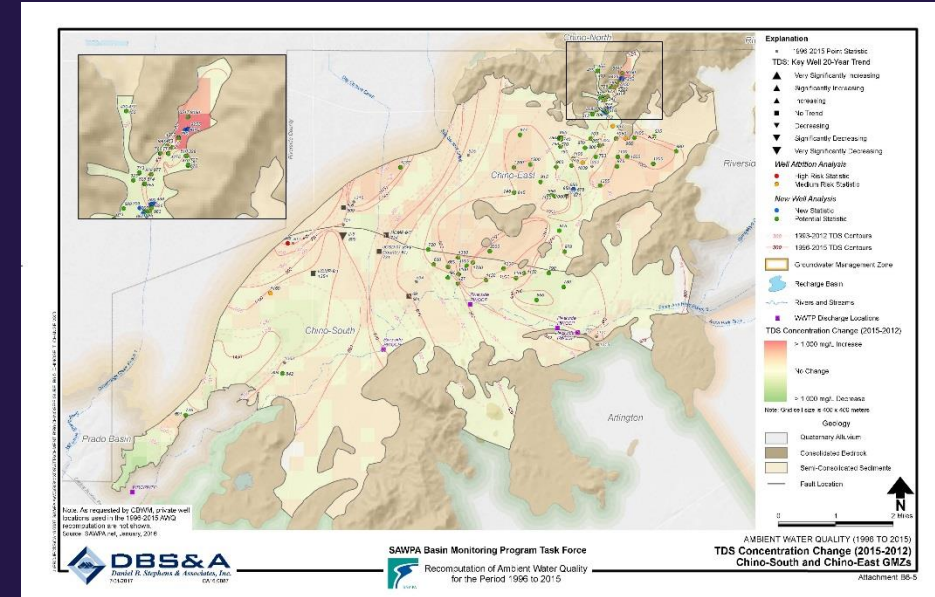
- Atlas Style Map Package
 - Cover Page

- Basin Analytics (area, volume, point statistics, mass)
- AWQ Trend Charts
- Key Interpretive Wells
- Well Attrition
- Well Addition



Interpretive Tools

- Atlas Style Map Package
 - Maps
 - Groundwater Elevation Contours Fall 2015
 - NO₃-N Concentration and Contour Map
 - TDS Concentration and Contour Map
 - NO₃-N Concentration Change (2015-2012) Map
 - TDS Change Concentration (2015-2012) Map
 - Charts
 - Key Well Analysis Charts



Attachment Contents:

B6-1 Groundwater Storage and Elevation Contours Fall 2015

B6-2 NO₃-N Concentration and Contour Map

B6-3 TDS Concentration and Contour Map

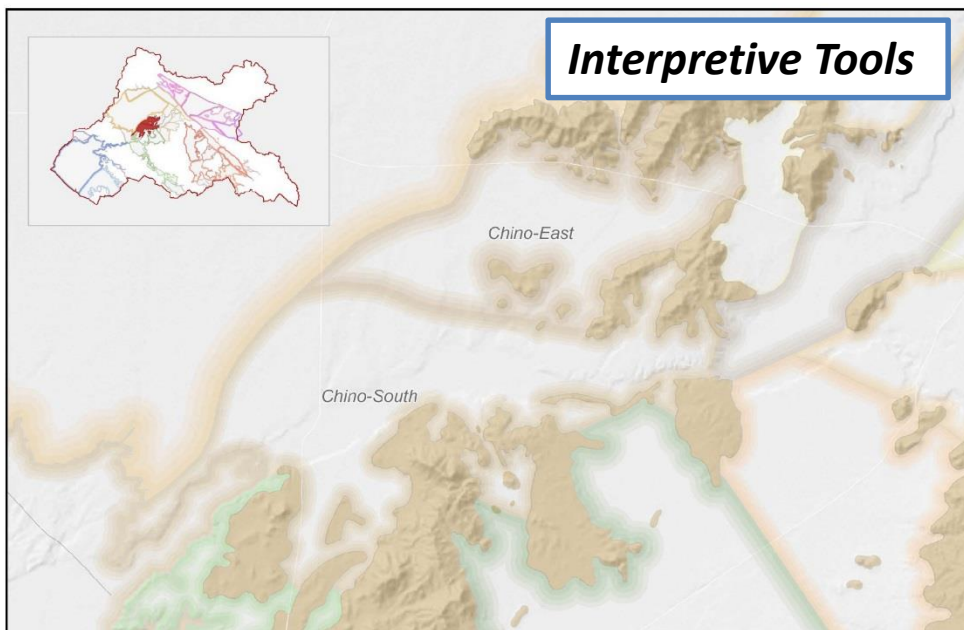
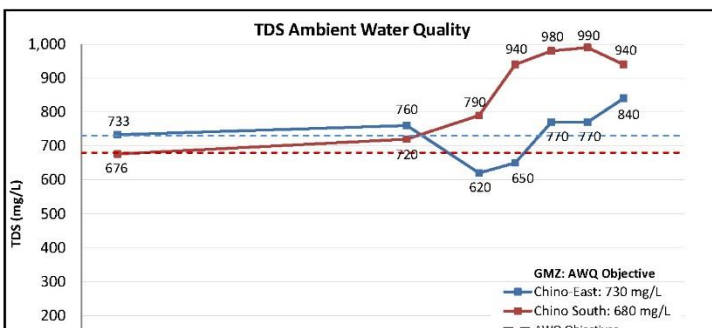
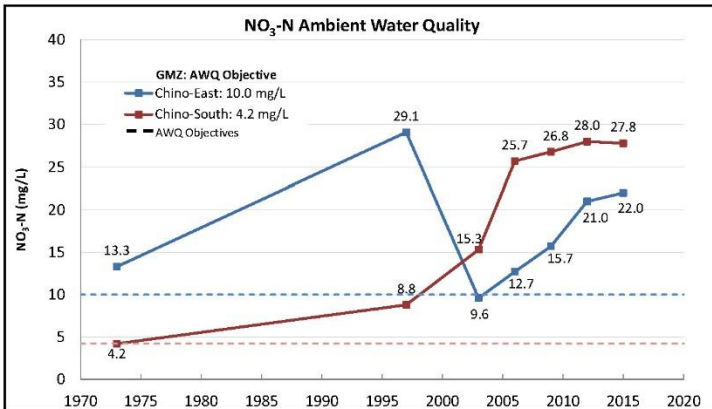
B6-4 NO₃-N Concentration Change (2015-2012)

B6-5 TDS Concentration Change (2015-2012)

B6-6 Key Well Analysis Charts

	Basin Analytics	Chino-East	Chino-South
Basin	GMZ Area (acres)	7,950	13,100
	Volume of storage (acre-ft)	80,100	187,000
NO ₃ -N	Wells per GMZ	499	178
	Statistics per GMZ	271	51
	Total Mass (tons)	2,400	7,060
	1996-2015 AWQ	22	27.8
TDS	Wells per GMZ	205	125
	Statistics per GMZ	29	25
	Total Mass (tons)	91,500	239,000
	1996-2015 AWQ	840	940

Table 1 - Basin Analytics

**Nitrate as Nitrogen (Nitrate or NO₃-N)****Chino South**

The nitrate objective for Chino South is 4.2 mg/L. The ambient nitrate concentration decreased from 28.0 mg/L in 2012 to 27.8 mg/L in 2015, and there is no assimilative capacity. One out of the five key wells in Chino South GMZ have an increasing trend in nitrate concentrations, three key wells show a decreasing trend, and the other one shows no trend in the nitrate concentrations. Seven of the total 178 wells with nitrate values in Chino South will not be eligible for the next AWQ recomputation if the well is not sampled prior to 2018. No new wells with statistics were added to the 1996 to 2015 AWQ recomputation and nineteen wells that were sampled between 2014 and 2015 will be eligible to have statistics determined, if the wells are sampled again in the next AWQ recomputation period (1999-2018).

Chino East

The nitrate objective for Chino East is 10.0 mg/L. The ambient nitrate concentration increased from 21.0 mg/L in 2012 to 22.0 mg/L in 2015, and there is no assimilative capacity. Two out of the five key wells in Chino East GMZ have a decreasing trend in nitrate concentrations, while the other three shows no trends in the nitrate concentrations. Thirteen of the total 499 wells with nitrate values in Chino East will not be eligible for the next AWQ recomputation if the well is not sampled prior to 2018. Forty-two new wells with statistics were added to the 1996 to 2015 AWQ recomputation and sixty-nine wells that were sampled between 2014 and 2015 will be eligible to have statistics determined, if the wells are sampled again in the next AWQ recomputation period (1999-2018).

Total Dissolved Solids (TDS)**Chino South**

The TDS objective for Chino South is 680 mg/L. The ambient TDS concentration decreased from 990 mg/L in 2012 to 940 mg/L in 2015, and there is no assimilative capacity. Two out of the five key interpretive wells in Chino South GMZ show a decreasing trend while the other three show no trends in TDS concentrations. Five of the total 125 wells with TDS values in Chino South will not be eligible for the next AWQ recomputation if not sampled prior to 2018. No new wells with statistics were added to the 1996 to 2015 AWQ recomputation, and nineteen wells that were sampled between 2014 and 2015 will be eligible to have statistics determined, if the wells are sampled again in the next AWQ recomputation period (1999-2018).

GMZ	Well ID	Well Name	NO ₃ -N (mg/L)	NO ₃ -N Trend	TDS (mg/L)	TDS Trend
Chino-East	1003583	03A	21.5	No Trend	--	--
Chino-East	1206966	II-6	24.7	No Trend	609	No Trend
Chino-East	1207150	CTP-TW1	25.9	No Trend	977	Decreasing
Chino-East	1207986	HCMP-9/1	12.2	Decreasing	734	Decreasing
Chino-East	1207998	HCMP-9/2	0.2	Decreasing	178	No Trend
Chino-South	1003624	JCSD 01 (Sky Country #1)	10.0	Increasing	731	No Trend
Chino-South	1003663	9	1.5	Decreasing	601	No Trend
Chino-South	1206968	II-8	15.7	Decreasing*	800	Decreasing**
Chino-South	1207985	HCMP-8/1	61.9	Decreasing	1,354	Decreasing
Chino-South	1207997	HCMP-8/2	3.3	No Trend	225	No Trend

*significant trend **very significant trend

Table 2 - Key Interpretive Wells

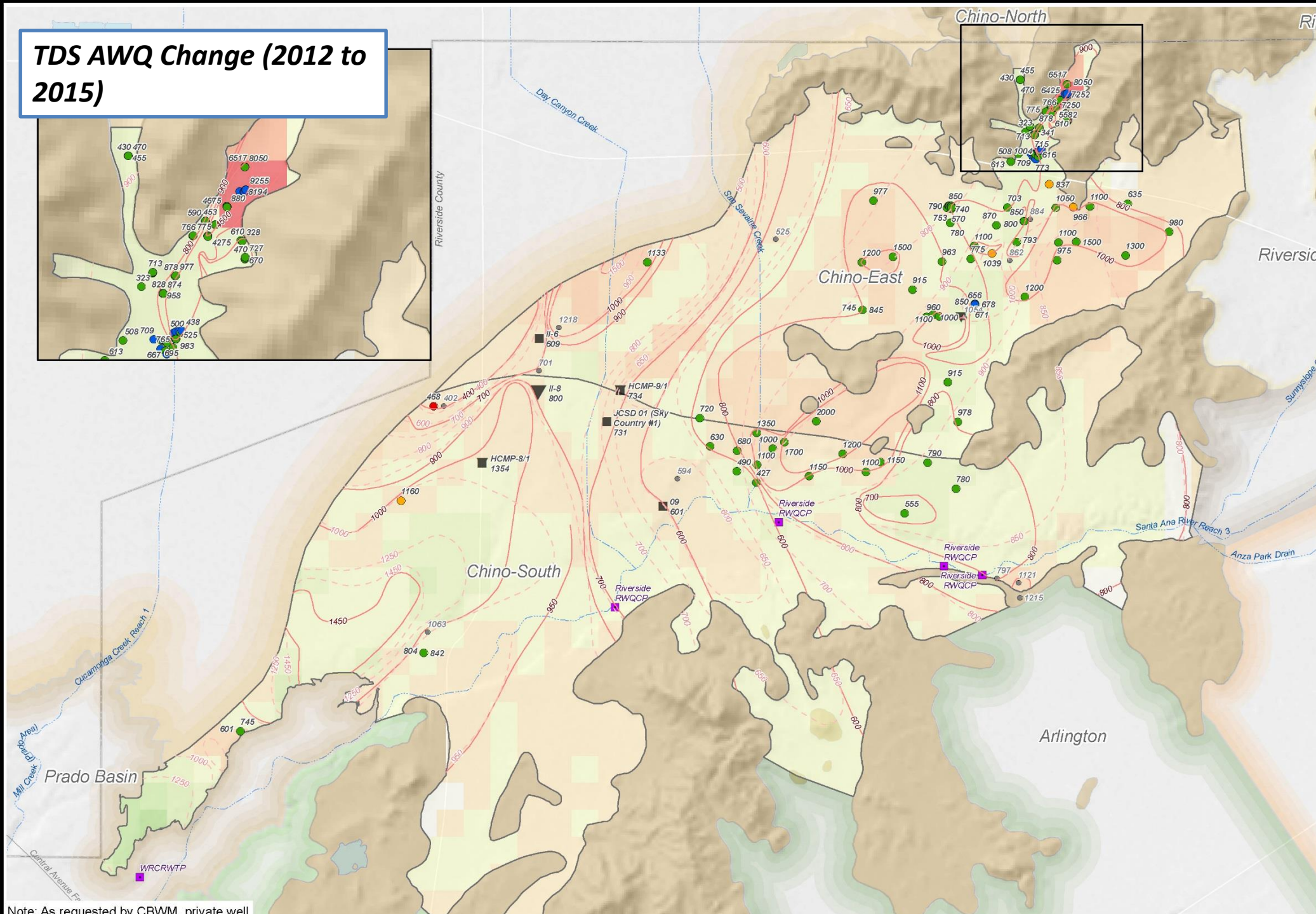
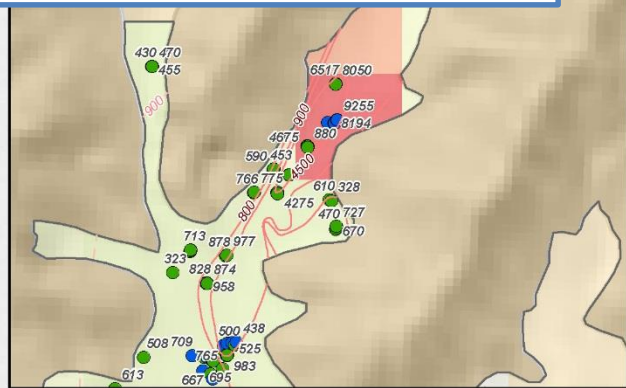
Mann-Kendall trend analyses on the annualized average concentrations for wells that have been identified as key interpretive wells was used to determine the significance of the trends in well concentrations. See Key Well Analysis Charts for more details. See Attachment B6-4 and B6-5 for NO₃-N and TDS well locations, respectively.

GMZ	Well Information			NO ₃ -N Well Attrition				TDS Well Attrition			
	Well ID	Well Name		Risk	Years ¹	Value ²	Method	Risk	Years ¹	Value ²	Method
Chino-East	1003513	JCSD 05		High	1	8.8	Ave	--	--	--	--
Chino-East	1003582	03		High	2	20.6	Ave	--	--	--	--
Chino-East	1207144	AGA4875		High	1	4.4	Ave	--	--	--	--
Chino-East	1207145	AGA4915		High	2	5.0	Ave	--	--	--	--
Chino-East	1207146	AGA4930		Medium	3	5.9	Stat	--	--	--	--
Chino-East	1207147	AGA5040		High	2	7.0	Ave	--	--	--	--
Chino-East	1207181	FC-249A3		Medium	2	8.6	Ave	Medium	2	966	Ave
Chino-East	1207202	FC-5A3		Medium	1	5.7	Ave	Medium	1	837	Ave
Chino-East	1207241	LEM-4A		Medium	1	5.2	Ave	--	--	--	--
Chino-East	1207264	PED5029		High	3	9.3	Stat	--	--	--	--
Chino-East	1207265	PED5071		Medium	2	9.4	Ave	--	--	--	--
Chino-East	1207266	PYR3851		Medium	2	2.2	Ave	--	--	--	--
Chino-East	1207270	PYR4352		Medium	1	0.0	Ave	--	--	--	--
Chino-East	1207272	STN4800		Medium	3	5.8	Stat	--	--	--	--
Chino-East	1207393	60TH8792		Medium	1	4.5	Ave	--	--	--	--
Chino-East	1207407	PED4931		Medium	3	4.5	Stat	--	--	--	--
Chino-East	1207408	PED5106		Medium	3	23.3	Stat	--	--	--	--
Chino-East	1207409	PED5151		Medium	1	5.2	Ave	--	--	--	--
Chino-East	1207410	PED5261		High	1	36.1	Ave	--	--	--	--
Chino-East	1207411	PED5424		Medium	1	7.2	Ave	--	--	--	--
Chino-East	1207412	STN4992		Medium	1	5.2	Ave	--	--	--	--
Chino-East	1208835	LC-4B		High	2	0.0	Ave	--	--	--	--
Chino-East	1208836	OW-62D		High	1	4.8	Ave	--	--	--	--
Chino-East	1208837	OW-63D		High	1	4.6	Ave	--	--	--	--
Chino-East	1208877	FC-738A2		--	10	15.8	Stat	Medium	2	1,039	Ave
Chino-East	1208895	LE-109A		Medium	1	5.3	Ave	--	--	--	--
Chino-East	1208902	OW-63A		Medium	2	5.9	Ave	--	--	--	--
Chino-East	1208903	OW-64A		Medium	1	3.8	Ave	--	--	--	--
Chino-East	1208904	OW-65A		Medium	2	4.1	Ave	--	--	--	--
Chino-South	1003611	NOR 09		High	1	0.1	Ave	High	1	468	Ave
Chino-South	1003612	NOR 10		High	1	10.6	Ave	--	--	--	--
Chino-South	1003630	07		High	2	12.1	Ave	--	--	--	--
Chino-South	1202703	60H		Medium	1	84.9	Ave	Medium	1	1,160	Ave
Chino-South	1207394	60TH9709		Medium	1	5.9	Ave	--	--	--	--
Chino-South	1207398	60TH9957		Medium	1	9.5	Ave	--	--	--	--
Chino-South	1207399	60TH9989		Medium	1	8.1	Ave	--	--	--	--
Chino-South	1207402	APP6111		Medium	1	3.2	Ave	--	--	--	--

¹ number of years with samples² final value used to contour well concentrations -- not applicable**Table 3 - Well Attrition Analysis**

The well locations above have been identified as locations likely to be lost in future AWQ recomputation studies. High Risk wells will be lost during the 1999-2018 study period if not sampled before 2018. Medium Risk wells will be lost during the 2002-2021 study period if not sampled before 2021. See Attachment B6-4 and B6-5 for NO₃-N and TDS well locations, respectively. As requested by Chino Basin Water Master, private well locations used in the 1996-2015 AWQ recomputation are not shown.

TDS AWQ Change (2012 to 2015)



Explanation

- 1996-2015 Point Statistic
- TDS: Key Well 20-Year Trend
- ▲ Very Significantly Increasing
- ▲ Significantly Increasing
- ▲ Increasing
- No Trend
- ▼ Decreasing
- ▼ Significantly Decreasing
- ▼ Very Significantly Decreasing

Well Attrition Analysis

- High Risk Statistic
- Medium Risk Statistic

New Well Analysis

- New Statistic
- Potential Statistic

- - 300 - - 1993-2012 TDS Contours
- - 300 - - 1996-2015 TDS Contours

- Groundwater Management Zone

- Recharge Basin

- Rivers and Streams

- WWTP Discharge Locations

TDS Concentration Change (2015-2012)

- > 1,000 mg/L Increase
- No Change
- > 1,000 mg/L Decrease

Note: Grid cell size is 400 x 400 meters

Geology

- Quaternary Alluvium
- Consolidated Bedrock
- Semi-Consolidated Sediments
- Fault Location

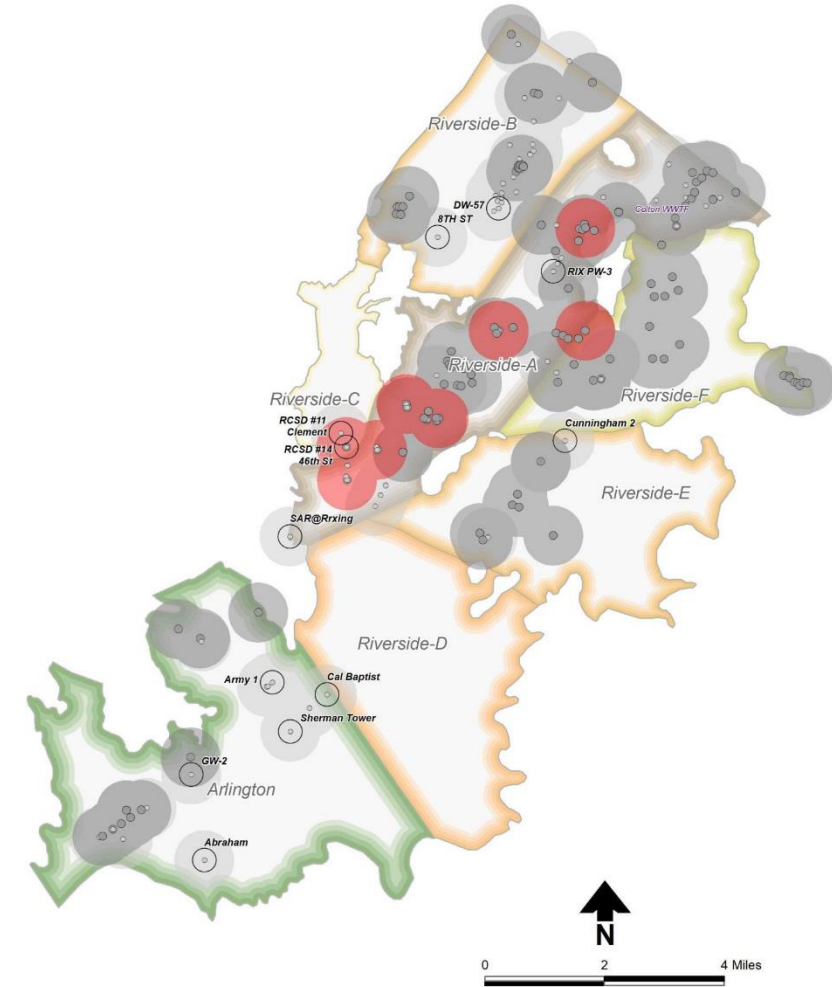
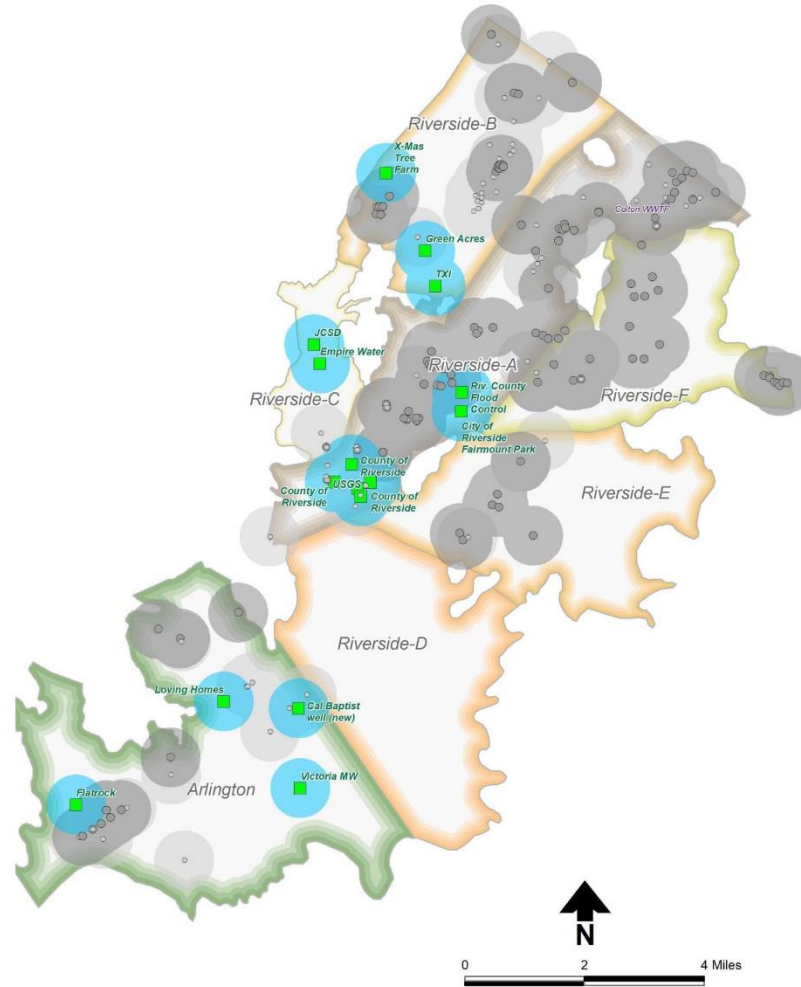
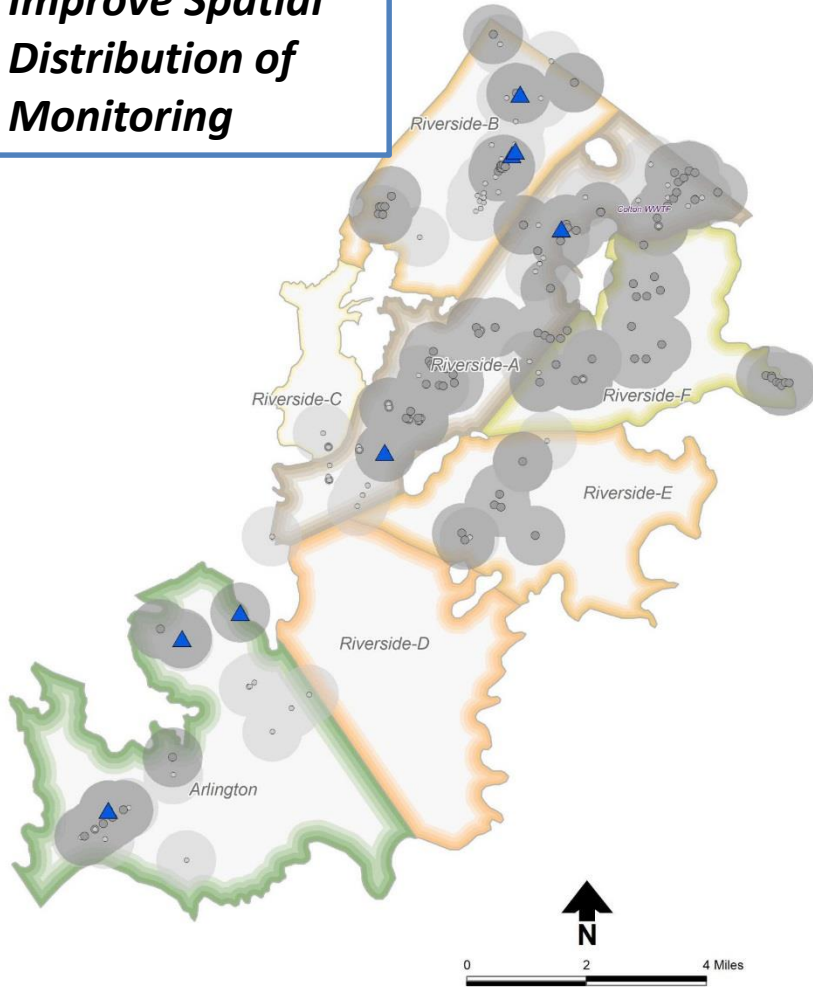


Improve Spatial Distribution of Monitoring

- Riverside A, Riverside B, and Arlington GMZ's
 - Included new data from online datasets (GeoTracker, GAMA, etc..)
 - Identified potential wells that were not previously listed in the AWQ database
 - Compiled a list of wells to be monitored based on key areas



Improve Spatial Distribution of Monitoring

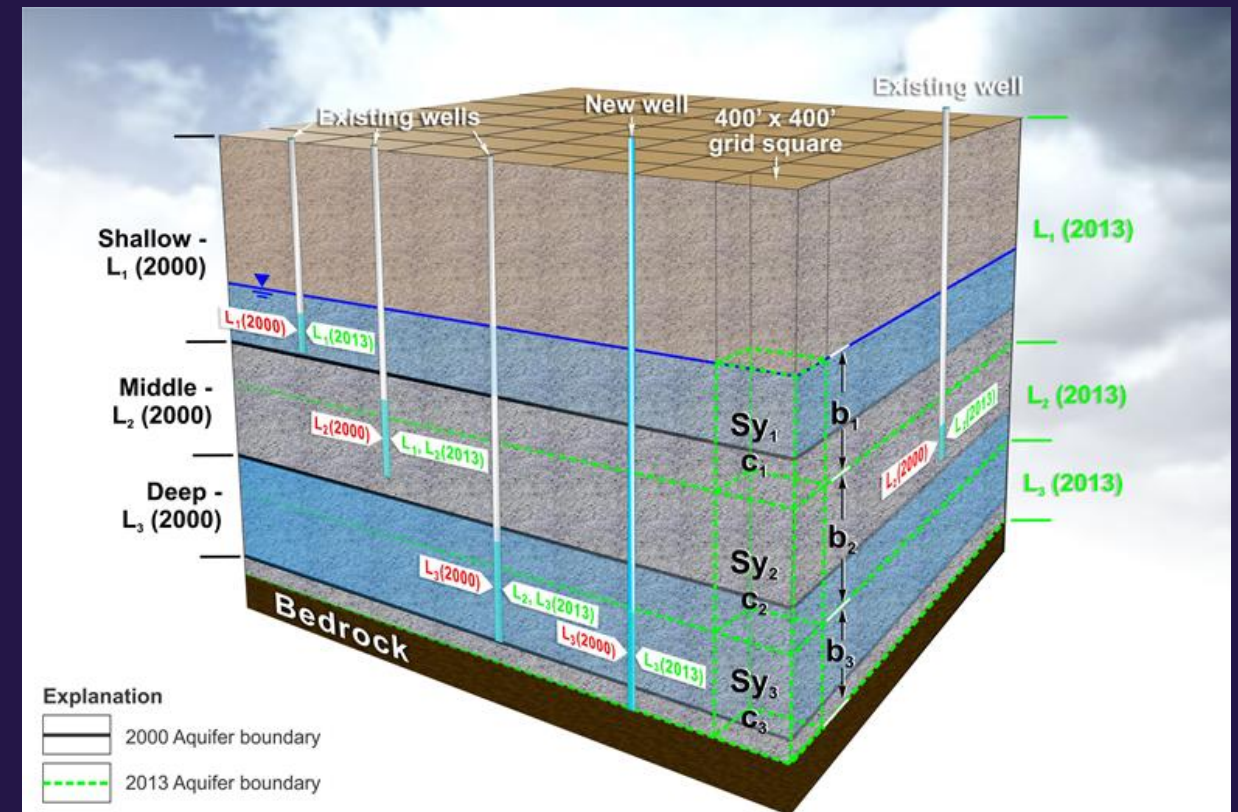


Explanation

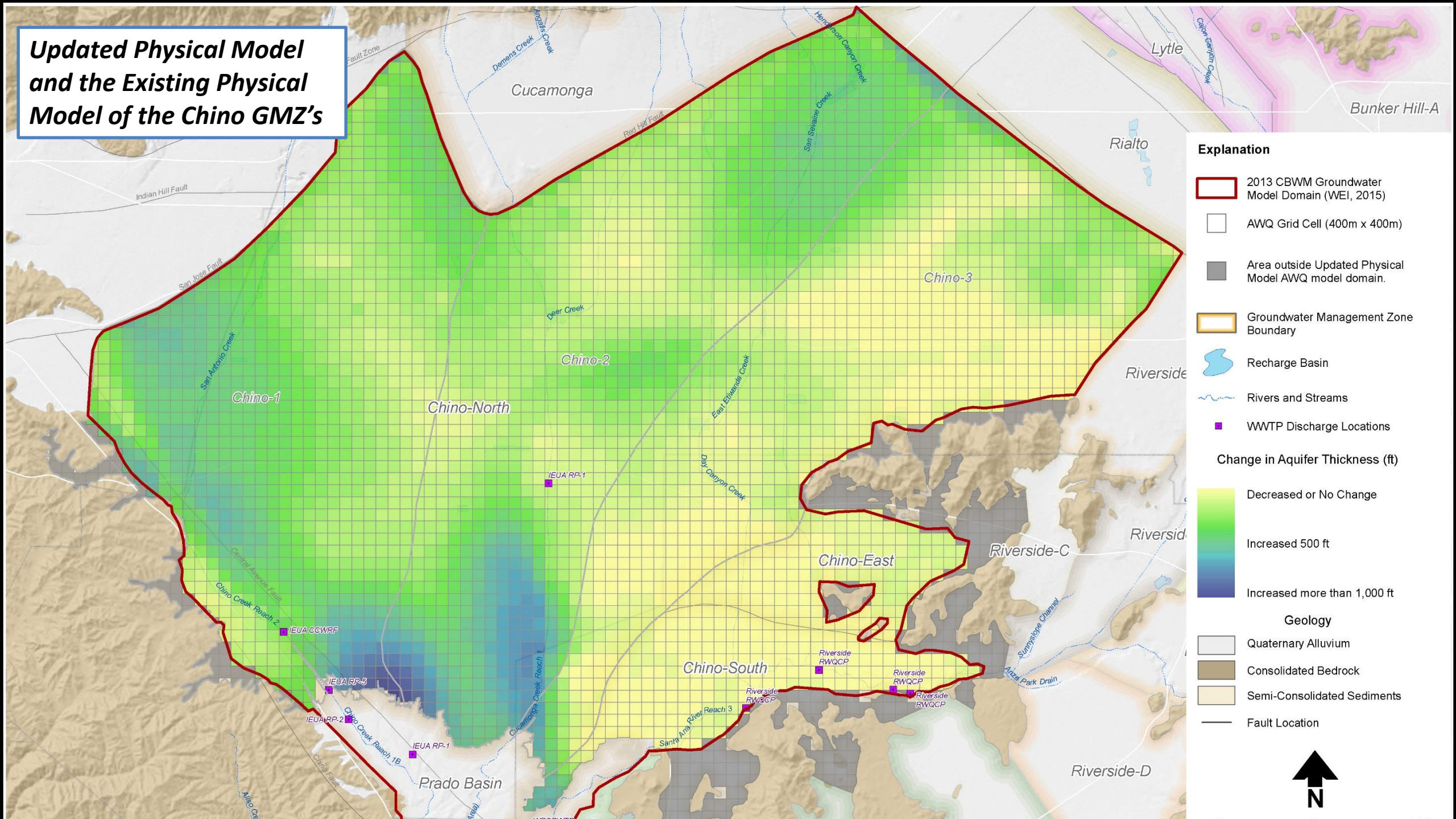
- | | | | | | |
|--------------------------------------|--|---|--|--|--|
| Groundwater Management Zone Boundary | 1996-2015 Average | Geotracker well added to the 1996-2015 AWQ Database | Wells recommended for on-going sampling to maintain spatial coverage | 1999-2018 Baseline Statistics Coverage | 1996-2015 High Risk Statistics Coverage |
| 1996-2015 Point Statistic | Existing wells not currently in the AWQ database | | | 1999-2018 Baseline Average Coverage | Coverage of existing wells not currently in the AWQ database |

Update Physical Model of the GMZ's

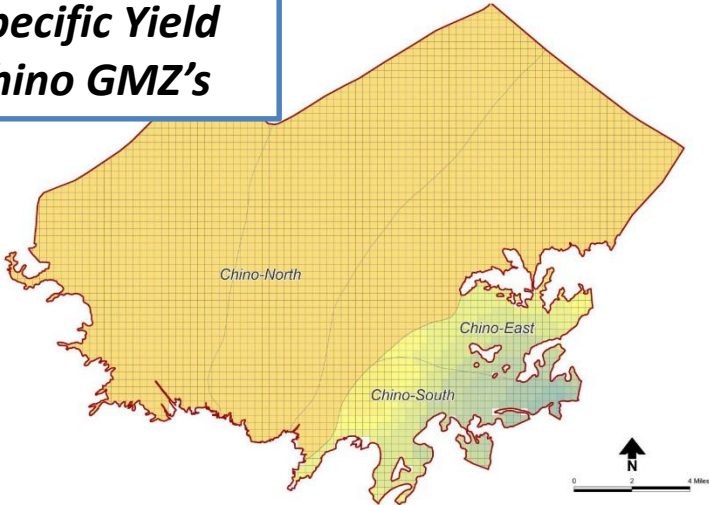
- Chino GMZ's Pilot Study (Task 1b)
 - Model Domain
 - Aquifer Thickness
 - Specific Yield
 - Layering



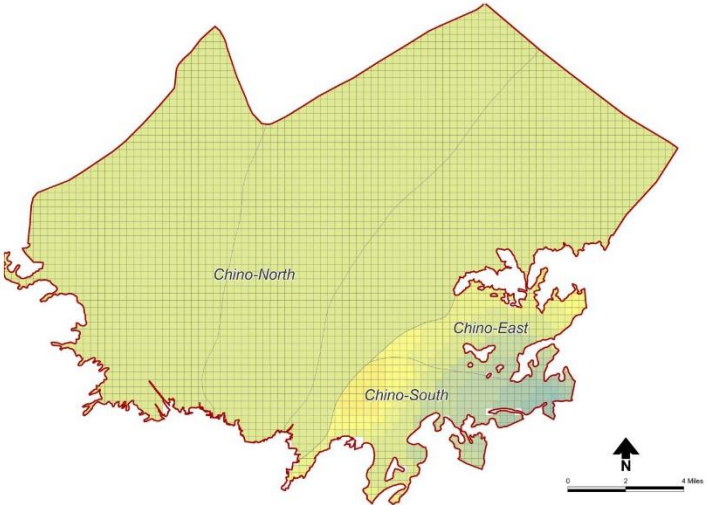
Updated Physical Model and the Existing Physical Model of the Chino GMZ's



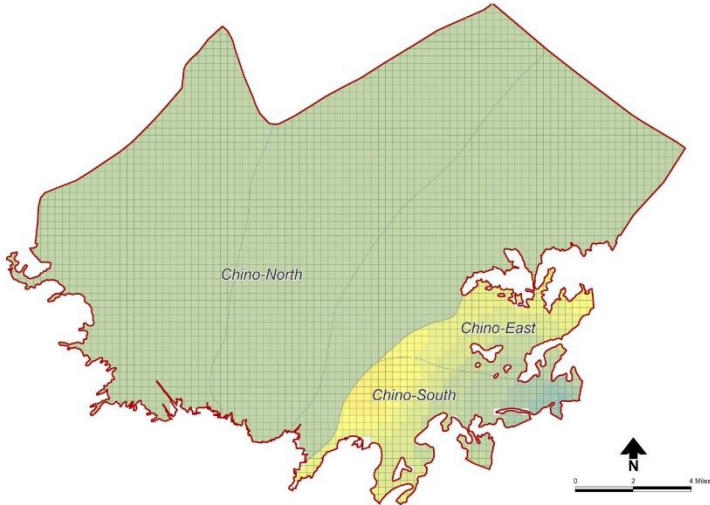
Specific Yield
Chino GMZ's



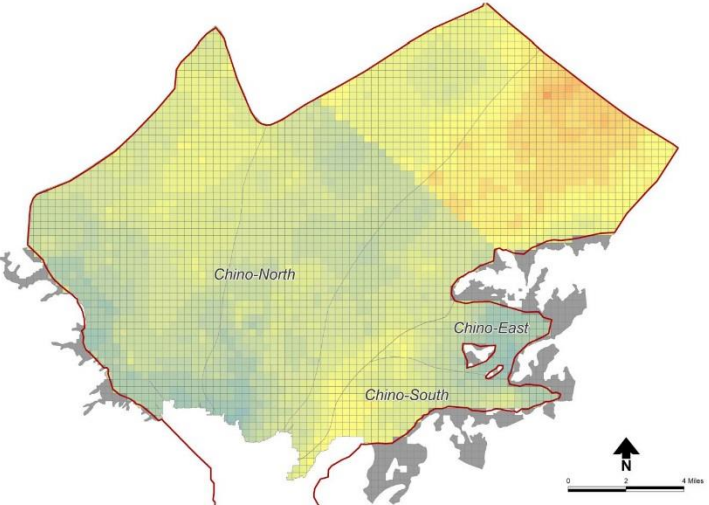
Existing AWQ Physical Model: Layer 1



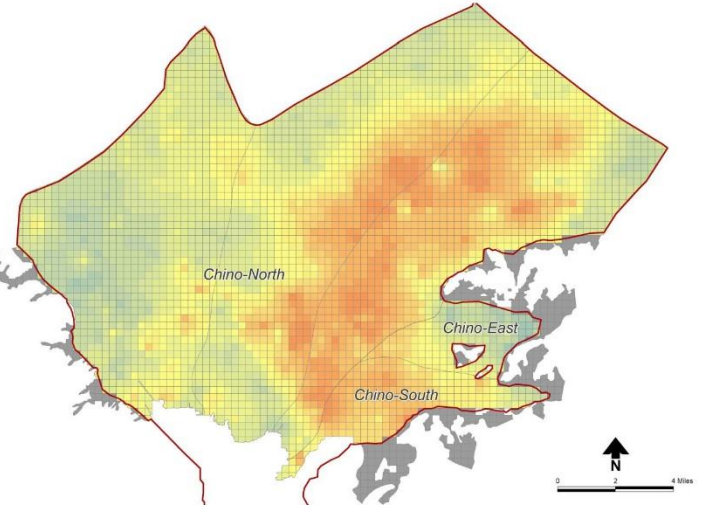
Existing AWQ Physical Model: Layer 2



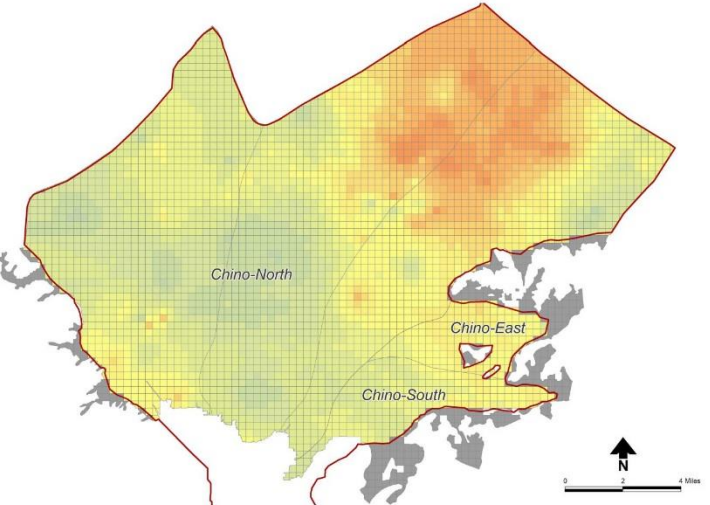
Existing AWQ Physical Model: Layer 3



Updated Physical Model: Layer 1



Updated Physical Model: Layer 2

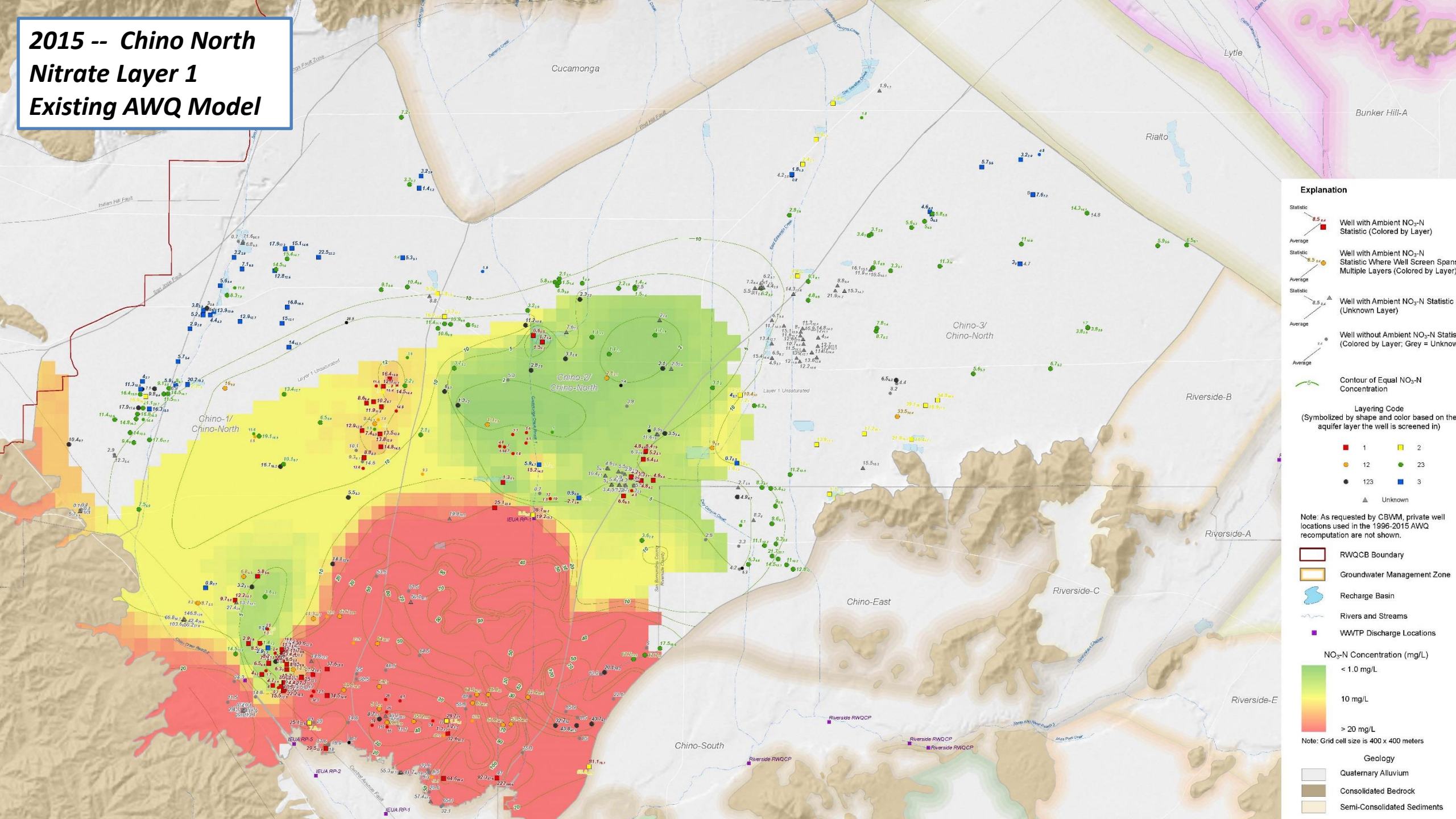


Updated Physical Model: Layer 3

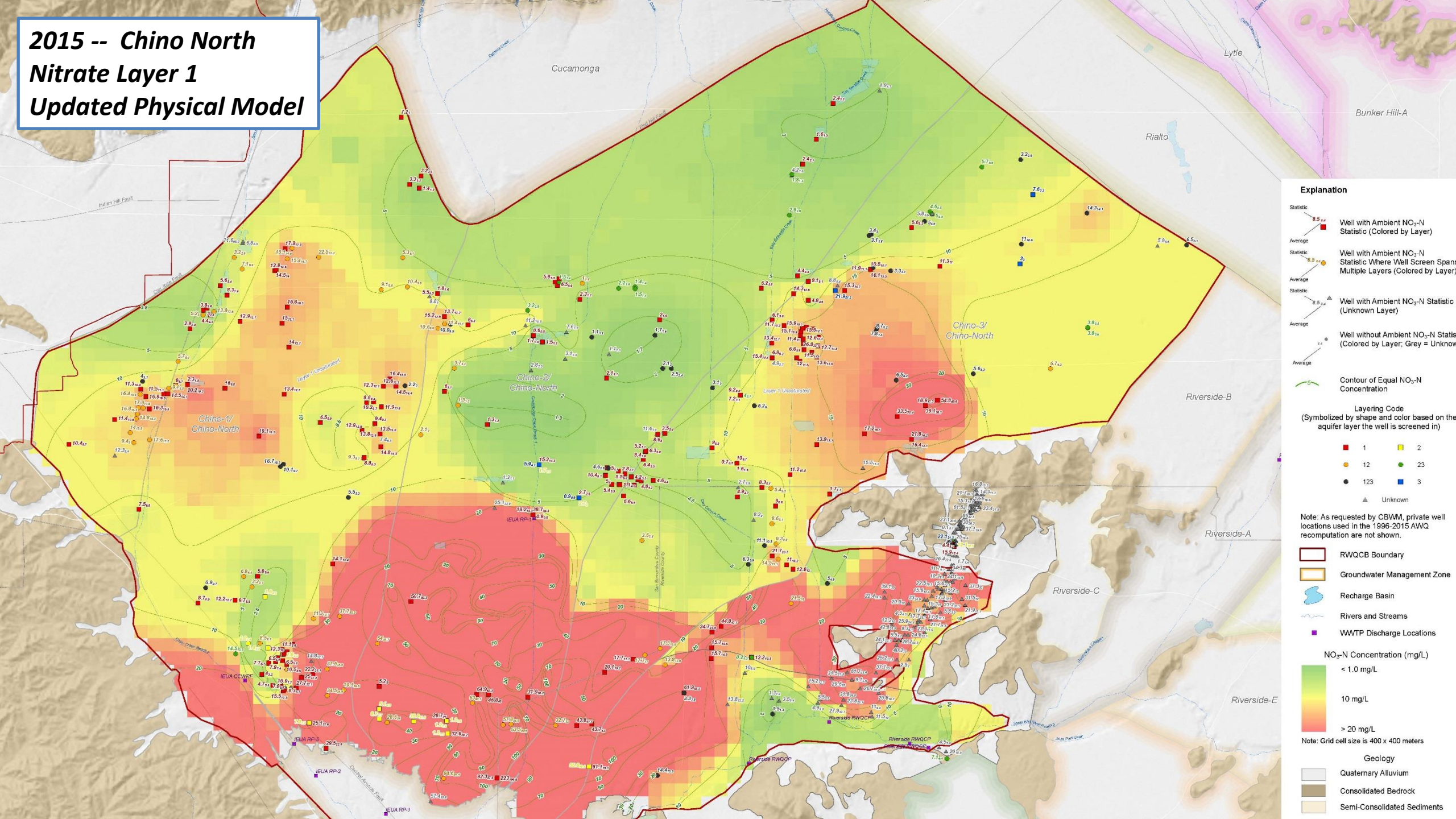
 Model Domain

Specific Yield

2015 -- Chino North Nitrate Layer 1 Existing AWQ Model



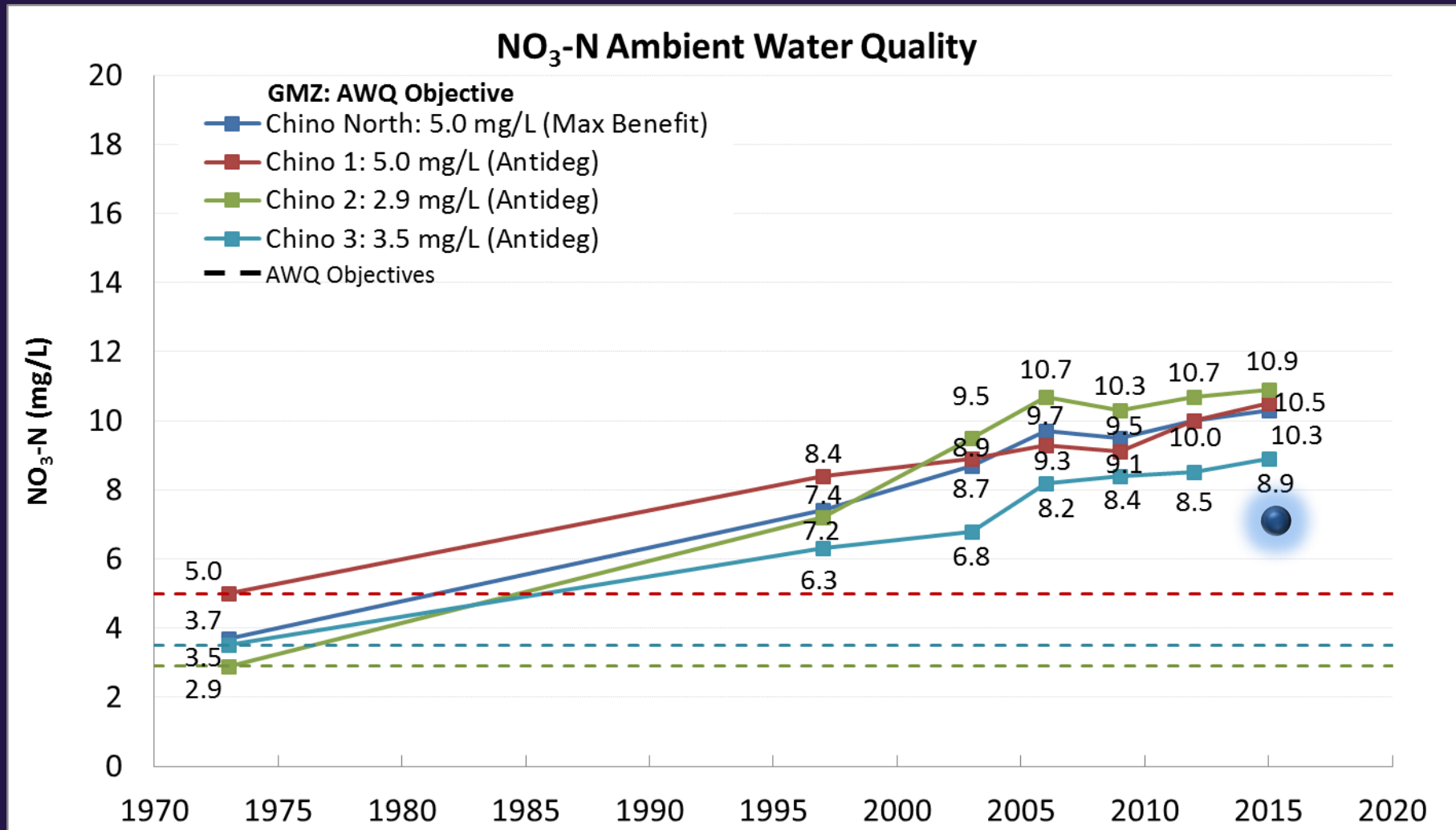
2015 -- Chino North Nitrate Layer 1 Updated Physical Model



Results of the Chino MZ's Pilot Study (Task 1b)

Management Zone	Existing AWQ Physical Model			Updated Physical Model			Changes from Existing to Updated Physical Model		
	NO3-N (mg/L)	TDS (mg/L)	Volume (acre-ft)	NO3-N (mg/L)	TDS (mg/L)	Volume (acre-ft)	NO3-N (mg/L)	TDS (mg/L)	Volume (acre-ft)
Chino-1	10.5	350	2,100,000	8.4	300	3,130,000	2.1	50	1,030,000
Chino-2	10.9	380	2,500,000	5.2	280	3,690,000	5.7	100	1,190,000
Chino-3	8.9	320	1,270,000	8.1	310	2,320,000	0.8	10	1,050,000
Chino-North	10.3	360	5,870,000	7.0	290	9,140,000	3.3	70	3,270,000
Chino-South	27.8	940	190,000	34.7	970	160,000	-6.9	-30	-30,000
Chino-East	22.0	840	80,000	22.7	830	60,000	-0.7	10	-20,000





Summary of Ambient Water Quality

- The ambient water quality recomputation is a powerful tool to assist the stakeholders in managing the water resources in the Santa Ana Watershed:
 - aids the Regional Board in identifying TDS and nitrate trends
 - the assessment of assimilative capacity is critical in permitting projects, such as groundwater replenishment reuse projects
 - assists the stakeholders in identifying areas of potential concern
 - supports Santa Ana River wasteload allocation and discharge permits
 - collaboration of stakeholders and Regional Board



Questions?

